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Shmapped: development of an app to record and promote the well-being benefits of noticing urban nature

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Abstract

Background: The majority of research to date on the links between wellbeing and green spaces comes from cross-sectional studies. Purpose: Shmapped is an app which allows for the collection of wellbeing and location data live in the field and acts as a novel dual data collection tool and wellbeing intervention which prompts users to notice the good things about their surroundings. Methods: We describe the process of developing Shmapped from storyboarding, budgeting and timescales, selecting a developer, drawing up data protection plans, collaborating with developers and end-user testers to ultimately publishing Shmapped. Results and Conclusions: The development process and end-user testing resulted in a highly functional app. Limitations and future uses of such novel dual data collection and intervention apps are discussed and recommendations made for prospective developers and researchers.

Key words: GPS; Geofence; Health; Smartphone app; Urban; Wellbeing.

Introduction

To inform and help facilitate smooth app development by others, this paper describes the process of researchers and practitioners working together to develop a dual data collection and intervention app for research purposes, and provides key recommendations. The app called 'Shmapped' (as in Sheffield mapped) acts both as a method for collecting data, and as an intervention to increase users' nature connection and by association, their wellbeing. Shmapped is part of a wider research project called IWUN, funded by the Natural Environment Research Council (******). The IWUN project has taken Sheffield, the proclaimed 'Outdoor City', as a case study for evaluating how urban green spaces affect our wellbeing. The development of Shmapped is therefore one of four work packages within IWUN. The aim of Shmapped is to collect data on users' wellbeing, relationship with nature, location and the context around their use of the outdoors, and to act as an intervention to improve connection with nature and thereby improve wellbeing. Through this data we hope to inform councilors, town planners, private developers, public health organisations, and policy-makers about how to optimise urban green spaces to improve residents' wellbeing.

How can urban nature improve wellbeing?

There is increasing evidence for the wellbeing and health benefits of spending time in nature and feeling an emotional connection to nature. With populations increasing and the world becoming more developed and urbanised [1], there is an urgent need to develop interventions to increase public engagement with nature, for the sake of human health and wellbeing, but also for the health of the natural world. From a public health perspective, there is a need for large scale interventions that are in an urban environment, accessible regardless of socio-economic status, and can be built into day to day life [2]. In a cross-sectional study [3] it was found that urban green spaces were associated with lower levels of mortality at 22 year follow-up in a cohort of 575,000 adults. Whilst these data are promising, there is a strong need to go

beyond cross-sectional data that merely correlates postcode data with routine health and wellbeing data, and to search deeper into what aspects of green and blue environments contribute the most to wellbeing moment to moment throughout a person's daily life. Where we talk about 'green space' or the 'green space condition' in the app, we are referring to natural spaces which comprise both green and blue space. Longitudinal studies that make use of such momentary everyday experience such as 'Experience sampling Method' have previously provided some of the best evidence on the influences of a variety of variables on wellbeing [4]. Shmapped aims to obtain this momentary data on wellbeing and location to inform planners and policy makers about what is needed to optimise green urban space for wellbeing.

Why an app?

As highlighted [5], some have blamed an increase in tech and screen-time for increased time spent indoors and a lack of nature connection. Yet apps that encourage people to get outdoors (Pokemon Go[6]) or engage with nature (Nature 2.0 [5]) can translate into behaviour change and encourage engagement with the outdoors. According to a survey on smartphone use [7], 81% of adults now own a smartphone in the UK. Smartphone users unlock their phones 10 to 200 times per day and the majority of smartphone user time is spent in apps [8]. It is clear then that smartphone apps can be utilised in research to obtain repeated measurements in larger, more representative samples and can offer the ecological validity of recording day to day life outside of lab settings [9]. In addition to being a promising method of large-scale data collection, apps are also a promising medium for behaviour-change interventions because: i) devices are portable and tend to be with the user all day; ii) apps bring behavioural interventions to real life contexts where people make decisions about their health and encounter barriers to behaviour change; iii) apps may provide cheaper, more convenient, or less stigmatising interventions; iv) connectedness of smartphones facilitates the sharing of behavioural and health data with health professionals or peers; v) internal sensors can provide user location, movement and emotion [10]; and vi) they are cost-effective once the costs of app development and maintenance have been met. Decision-making and behaviour change can be hampered by what is known as the value-action gap [11]. This is argued to be because ones intentions are often an insufficient signal when compared to the noise of environmental stimuli and behavioural cues. As a decision space becomes more complex, humans run out of processing capacity and habitual behaviours tend to dominate. By utilising behavioural intervention technologies such as smartphone apps, the apparent complexity of lifestyle choices can be reduced and one can raise the salience, or time effectively the presentation of 'healthy' cues [12].

Current wellbeing/nature apps available & limitations

Although there are an estimated 40,000 health and wellbeing apps available, very few apps have been developed in a standardised way by academics and/or health professionals, and very few have been evaluated for usability and effectiveness [9, 13]. [13] recommend co-production with end-users and found that an Information Systems Research (ISR) framework provided a standardised iterative approach to app development that resulted in high usability ratings.

In an online participatory GIS study looking at urban happiness, [14] found that participants reported more positive experiences in urban green spaces and more negative experiences in

built-up areas with busy roads. As this study was online and relied on participants logging their experiences of urban spaces, experiences were limited to 1.75 data entries per participant. Online interventions which go beyond recording experience and encourage nature connection appear to have greater engagement. A previous online intervention called 'Rewild your life' seeking to improve nature connection and wellbeing by spending 30 minutes in nature over 30 days, resulted in improved mood, wellbeing, mindfulness and meaning in life [15]. Similar to this, the Wildlife Trust's 30 Days Wild online intervention was shown to be effective in improving happiness, nature connection and pro-environmental behaviours [16]. Utilising an app to deliver an intervention such as Shmapped should in theory provide a more immersive experience than an online intervention, as participants will have their phones with them at all times, presenting a unique opportunity for data collection and behaviour-change in day to day settings.

To date, there have been two published studies which have used an app to assess the link between green and urban spaces and wellbeing ('Mappiness' [17] & 'Urban Mind' [18]). The Mappiness app sent prompts to participants at random times during the day (participants chose the number of prompts) asking them to self-report their wellbeing whilst tracking their location using GPS. There is also a recently developed app called Urban Mind [18] which again prompts people randomly 7 times per day to assess wellbeing in urban areas, with different sets of questions if the participant responds stating that they are indoors or outdoors. Both the Mappiness and Urban Mind apps were downloaded by the authors and along with discussions with some of their developers and researchers, were used to gain insight into how Shmapped might be optimised. [17] found that participants were happier outdoors in blue and green areas of all habitat types compared with inland bare ground and continuous urban areas. [18] found greater wellbeing in natural environments, with particular benefit to participants who scored high on trait impulsivity. Despite being happier outdoors, participants only spent 7.48% of their time outdoors each day [17]. This meant that a much greater amount of data was collected when participants found themselves indoors than outdoors, the authors noted this as a limitation. To remedy this in Shmapped it was decided to program in geofences of publicly accessible green spaces so that prompts could be optimised to alert users when they were in green spaces. Mappiness and Urban Mind did not seek to increase participants' connection with nature or increase wellbeing, rather they asked users to report their wellbeing using random prompts throughout the day. Shmapped furthers this research by: i) collecting data on wellbeing in a greater amount and wider variety of green areas through geofence programming; and ii) acting as an intervention prompting users to notice the good things about their surroundings to increase nature connection and wellbeing.

Shmapped acts as both a method of recording data, but also an intervention to increase users' nature connection and by association their wellbeing. The intervention side of Shmapped is based on cultivating gratitude for ones surroundings. Practicing gratitude in controlled psychological intervention settings has been shown to have lasting effects on dispositional gratitude and psychological wellbeing [19]. Seligman's 'three good things' intervention has been successful in increasing positive affect and has recently been adapted to target nature connection and wellbeing through noticing 'three good things' about nature over 7 days in a

web-based intervention, which was found to significantly increase participants' nature connection [20, 21]. Consistent with this, an app which prompted participants every 2 hours to express gratitude saw an increase in gratitude and wellbeing compared with a control group [22]. A logic model outlining the aims and desired impacts of Shmapped as an intervention is presented in Figure 1.

To provide a more robust approach to app development, we co-produced Shmapped with end-users through a standardised iterative process from early prototype stages. Evaluation at various stages of design requires goals, methods and metrics to vary. The design evaluation was used to identify issues, explore design options, improve design, demonstrate efficiency, effectiveness, and user satisfaction. Shmapped will be assessed in a randomised controlled trial with a targeted population of 900 users to evaluate whether prompting participants to notice nature can improve wellbeing.

Budget setting and specification

The authors selected the app development company who had the desired expertise and experience, and were able to deliver to a tight timeframe and within budget, allowing for the app to be cross-platform. This company were the developers of Go Jauntly, a new walking app that encourages nature connection and active travel and are called 'Furthermore Ltd'. Before development took place, a subcontract was drawn up between the researchers and app developers detailing expectations of deliverables, intellectual property (which sits with the University of Derby), data protection and costings/invoicing schedule. To further secure intellectual property the researchers purchased a domain name for Shmapped. Furthermore Ltd provided a detailed costing and breakdown of research and development activity which they refer to as 'sprints' (which are time-boxed effort units that establish core work streams to be completed within a set timeframe). Furthermore Ltd adopt Agile working methodology which enables a "Lean Start-Up" approach to ideating, prototyping and execution of validated ideas. Table 1 below summarises the activity, projected duration and actual duration of tasks and the costs. There were significant delays to development and publication that were largely caused by: i) the researchers' finance department not issuing Purchase Orders in a timely manner, ii) bug-fixes relating to the geofence programming, tracking and intelligent prompts which required more time than anticipated; iii) publication in the Apple App Store which can take anything from a few days to several weeks.

There were costs that the authors had not originally budgeted for. These were data storage and longer-term ongoing bug-fixes, security updates and general maintenance of Shmapped. The authors were able to obtain a grant for a free subscription to Microsoft Azure for data storage (CRM:0518623). The total cost of maintenance and bug-fixes beyond the one month warranty period of the app has so far been £1,200.

App development and end-user testing

The 'three good things' procedure from [20], a literature review of wellbeing apps and a review of commercially available health and wellness-based apps, informed the development of a storyboard for the app. The storyboard was modified in an iterative process through discussions between the app development team 'Furthermore Ltd' and the researchers. The aim for the

researchers was to produce an accessible and engaging app that would: prompt users once a day to notice the good things about green or built spaces (depending on randomisation by the app); allow users to write brief notes about the good things about green or built spaces, answer questions about their experience of that place, and have the option to take and share photographs; record data on wellbeing and nature connection at baseline, post 30 days app use and post 3 months app use; and record users' location in green spaces. We chose to use one prompt per day and to request the minimum information from participants when prompted, as we were mindful of not wanting to distract from the participants nature experience as screen-time has previously been blamed for a disconnect from nature [5]. Multiple prompts were also reported as an annoyance in a review of participant responses to apps [10].

In the process of reviewing different concepts within the storyboard, the app developers 'Furthermore Ltd' suggested two potential user interface (UI) routes with a preference for the use of a chatbot UI. A chatbot is like a friendly avatar that guides users through an app. Conversational UI is becoming a more popular feature of apps, websites and Internet of Things (IoT) devices such as Alexa and Google's Home speaker. Chatbots have revolutionised human-computer interaction by using strings of natural language [23]. Virtual humans, avatars, and chatbots are recognised for their ability to evoke social responses in real humans, thus aiding engagement and motivation with apps [24]. The chatbot helps to control the flow of the conversation so participants are less likely to feel overwhelmed with a large questionnaire. We also wanted the app to work well in 'micro-moments' so participants could pick up and drop out of their app usage easily and it was hoped that the chatbot would facilitate this. A copy of the chatbot script is available from the authors on request.

As part of an iterative process of co-production using ISR framework, the storyboard and study materials (i.e. adverts, information sheets, consent forms) were shown to a group of 8 Sheffield residents (6 females, 2 males, age range 20-63 years) who were recruited through the I**** newsletter and a local magazine (Now Then) Facebook page. Participants in the first end-user testing session were shown mock-ups of the app screens in a Powerpoint display. The running order of slides was the same order in which a Shmapped user would see them: i) users are introduced to the study by a chatbot; ii) asked to read an information sheet about the study and consent; iii) asked for permission for notifications, location tracking and user's post code and email address; iv) asked to complete baseline questionnaires about wellbeing and connection to nature; v) invited to start recording good things about green or built spaces (depending on randomisation). App screens showing users' progress and the history of the good things users had noted were also shown. Discussions took place about the design and function features desired in the app, the wording of the study materials and recruitment strategy. Feedback included: i) inclusion of previous and next buttons to allow users to correct mistakes; ii) including FAQ about photo storage & transfer; iii) including a flow-diagram showing what will happen to the user throughout the study; iii) offering multiple assurances about data protection; iv) reminding users that they can enter notes about good things at any time and not just when prompted; v) to use a fox, rather than an owl (an owl is the emblem and nickname for Sheffield Wednesday Football Club) for the chatbot as it was felt to represent urban nature without alienating Sheffield United Football Club fans; vi) finally, an occasional misconception was that participants would need to be online to use Shmapped and this would require wifi or mobile data. This is not the case, and we added this as a FAQ to try and avoid this misconception deterring participants from using Shmapped. End-users also provided

feedback on information sheets, consent forms, debrief sheets, posters/leaflets for Shmapped and generated ideas for communities and organisations which we could promote Shmapped to.

We presented multiple scenarios for location tracking, ranging from the least intrusive e.g. tagging location in publicly accessible green spaces during daytime hours, plus more frequent tracking every 20seconds within one green space per day when prompted; to more inclusive tracking options of the tracking as described above, plus tagging location every 30minutes. End-users were not comfortable with location tagging every 30minutes, they felt this would be intrusive because it would give a more complete picture of where they lived, worked and their daily routine. They also felt it should be made very clear that location tagging would only take place during the day and in publicly accessible green spaces which they felt was an acceptable amount.

End-user testing comments were incorporated into Shmapped and the design was signed-off. A prototype of the app was then built and the same group of end-user testers were given access to a pre-release version of Shmapped through the iOS Testflight app and through Google's Play store and were invited to test the app in the field. The development team at Furthermore Ltd used the feedback from end-user testers about issues with usability to make multiple modifications to Shmapped. The processes described above took 6 months, culminating in publication on the Apple App Store and Google Play store, followed by a stakeholder event and wider promotion of Shmapped to the public via local organisations, social media, and guided walks to try Shmapped.

Data protection

In a qualitative study assessing the opportunities and challenges for using apps to affect wellbeing, [10] identified that accuracy and legitimacy, security, along with effort required, and immediate effects on mood emerged as important influences on app usage. Security was noted as a key concern by users, indeed [25] describe how smartphone apps can inadvertently broadcast personal information with around 67% accuracy through use of wifi despite the correct use of encryption. In addition, 55% of apps tested in one study were found to send some of the information to other companies [26]. Although Shmapped does not share data with third parties or require wifi to work on a day to day basis, users may still be connecting with wifi for other reasons, therefore a robust data protection plan was drafted in the form of a Privacy Impact Assessment (PIA).

The need for a PIA was identified because: i) the project involves the collection of new information about individuals; ii) the project asks individuals to provide information about themselves; iii) anonymised data about individuals will be stored indefinitely at the UK Data Centre and may be shared with other researchers who have not previously had access to the information. The PIA was based on the Data Protection Act (1998), advice from the UK Data Centre and guidance from the Information Commissioners Office (ICO) document 'Privacy in mobile apps: Guidance for app developers'. In brief, sensitive data (e.g. ethnicity & email addresses) are held separately from questionnaire responses and notes in a Microsoft Azure secure server. Microsoft Azure are audited by a third party at least once a year for compliance

with ISO/IEC 27001 and ISO/IEC 27018 certification. The data are assigned an anonymised linking code so that they can be matched by the researchers for the purpose of analysis. The app developers encrypt end-to-end from device to any storage media, and the storage area is encrypted with a tool which meets ISO27001. Data will be extracted from Azure using python script to convert data from Json files into csv files which can then be opened as a database. The full PIA is available from the study website and the authors http://iwun.uk/shmapped/.

Proposed research design

In order to answer the research questions below, feasibility testing followed by a large-scale randomised controlled trial with a control group will be undertaken. There was a desire to learn about the experimental treatment (green space condition) and to maximise power, so more participants were randomised to receive the green space condition (Dumville et al., 2006). Participants (N=900) will be randomised to either the intervention condition (70% noticing green spaces) or the control condition (30% noticing built spaces). This will be achieved by generating a random number between 0 and 1 on app installation, and assigning those participants where the value is <= 0.7 to the intervention condition. This does not guarantee a *precise* split, and subsequent observation of data shows the actual figure is 67.4%. The intervention condition will prompt participants once a day to notice nature, record the 'good things in nature' and perceived levels of biodiversity. In the control condition, participants will be prompted to record 'good things about the built environment' and the perceived degree to which the area is built-up. In both conditions, the daily prompts let participants write notes and choose whether to report their location using a GPS tag, or take a photograph of their location. Contextual information is also gathered through multiple choice questions asking participants who they were with (if anyone), what they were doing (e.g. commuting, exercising, socializing etc) and how that place made them feel. Participants can also open Shmapped and enter notes about good things at any time and not just when prompted. Participants will be asked to use Shmapped for 30 days.

Spatial data

Participants in both conditions receive their daily prompt between the hours of 8am and 8pm and GPS is only recorded during these hours and when participants are in geofenced green spaces. Wifi is not needed to make a response, hence it should be possible to respond to green and built space prompts in the moment. A limitation of previous studies has been that due to the requirement of wifi to make a response, rural areas have received less data coverage [17]. The prompts for the built space condition are timed randomly during the day. If users choose to 'snooze' the prompt, they receive one prompt at 8pm each evening. Those in the green space condition are prompted when their phone's GPS detects they are near a green space that has been programmed into Shmapped as a geofence. Greenspaces include 945 publicly accessible green and blue spaces in Sheffield taken from a quality audit undertaken by Sheffield City Council in 2008. Since the development of Shmapped, OS maps have launched a new free 'Greenspace layer' which aims to capture the majority of green spaces across Britain and includes access points, this could be of great value in future research seeking to program in more extensive publicly accessible green spaces. The polygons representing greenspaces were expanded by 5metres to implement the concept of 'nearness'. However, the mobile operating systems only support *circular* geofences, so circles were drawn round every greenspace and

then consolidated, such that each greenspace was only contained within one circular geofence. The accuracy of this spatial data is within 10 metres.

Whenever participants enter a geofence, their location is tracked to provide information about how much and what type of green space participants encounter throughout the day. This also allows the app to detect when they enter any greenspace polygon contained within the geofence. Participants in the green space condition are prompted as they near a greenspace area, this allows the use of intelligent prompts that capture participants' momentary experiences in green and blue spaces. The prompts in the green space condition allow tracking every 20secs as participants pass through the geofenced green space. This data will allow us to see what aspects of green space are most popular (e.g. do participants head for trees, water or short grass within a green space). This detailed data will also be matched with biodiversity surveys and will allow us to answer the research question about what types of environment participants may or may not be benefitting from.

Self-report data

Questionnaires are completed at baseline with follow-up questionnaires completed at 30 days and three months. Demographics include: age, gender and ethnicity. Participants home post code is collected to ascertain: i) amount of green space around the home; ii) distances travelled to green spaces near and away from home; iii) socio-economic status as denoted by the Multiple Index of Deprivation; iv) geographical spread of users to allow targeted recruitment of underrepresented areas. Primary outcome measures include the 10-item Recovering Quality of life scale-ReQoL [27], and the 5-item European Quality of Life-EQ-5D [28]. Secondary measures include the 18-item Types of Positive affect scale-TPAS [29], the 6-item short form Nature Relatedness scale [30], 4-item Engagement with Natural Beauty scale [31], and the single item Inclusion of Nature with Self scale-INS [32]. Three items will measure previous exposure to nature growing up, and in the last year and access to a garden. Routine sensing data collected by the smartphone device such as location and activity is collected. When participants enter their daily notes about green or built space, 4 single item measures ask about the variety of wildlife or how built-up the area was, how that place made them feel, who they were with, and what they were doing. Some of these variables e.g. perceived biodiversity [33, 34] and social use of green space [35] have been shown in previous literature to be mediating variables. At the end of the study participants are asked to recall their best and worst green or built space experience. Collecting this information on context and quality of green space, and qualitatively analysing their notes about 'good things' will also allow for process evaluation of the app. The photographs taken by Shmapped users will be used along with GPS data as part of a 'geo-narrative' [36] to provide further detail on environment type and quality.

In terms of data storage requirements, for approximately 7 months of data collection, data collected for the questionnaire output, and notes about good things participants noticed is small (2MB), the photos are medium sized (225MB), and the location information are large (1,300MB).

Study sample

A total of 900 adult participants over 18 years old and living in Sheffield will be recruited into the study. Approximately 700 will be randomised to the intervention condition (noticing nature) and approximately 200 will be randomised to the control condition (noticing the built

environment). To test the potential of Shmapped as a social prescription, a further 100 participants with common mild to moderate mental health problems will be recruited into the study via IAPT, GP practices and NGOs.

Recruitment strategy

App-based studies have previously been found to attract participants who are younger, richer, more educated and employed compared with the general population [9, 17]. To attempt to achieve a representative sample, we are providing Shmapped cross-platform (i.e. Android and iOS) and will target recruitment of participants from a range of Sheffield postcodes according to indicators of deprivation. We will monitor the postcodes of those recruited to the study and alert the research team to postcodes in Sheffield that are underrepresented. Recruitment will be led by representatives from the Sheffield and Rotherham Wildlife Trust. GPs, NGOs, social prescribing organisations, Community centres, places of religious worship, social media and traditional media to promote the study. Hard to reach populations (e.g. upper levels of deprivation) will be approached personally in their community setting and via trusted community leaders, this may take the form of leaflet distribution followed by door-knocking. A series of guided walks and community picnics facilitated by the Sheffield and Rotherham Wildlife Trust and 'friends of parks' groups will be used to introduce people to Shmapped. We hope this method will attract harder to reach groups who are nervous about using an app or nervous about going outdoors to use Shmapped. As an additional incentive, the first 900 Sheffield-based participants to complete the study will be eligible for a prize draw to win vouchers ranging from £25-500.

Research questions

1. Which types of urban green and blue space are most effective in delivering health and wellbeing benefits? Participants' ratings of how the place made them feel will be explored across different categories of green space. Types of green and blue space most frequently encountered will also be correlated with self-reported wellbeing data.

2. What level of exposure to green and blue space (duration) brings about benefits in health and wellbeing? Number of sites visited and time spent in green and blue space will be associated with change scores in health and wellbeing.

3. How does quality of experience in nature impact on health and wellbeing benefits? Participants' ratings of how they felt about a space will be explored in relation to their self-reported health and wellbeing. Quality measures (PPG17, Flikr photos and sentiment analysis of captions of Sheffield spaces) of green and blue space will be explored in relation to participants' self-reported health and wellbeing. The top 5 and bottom 5 rated sites will be visited and assessed by ecological consultants to assess biodiversity and quality and develop case studies.

4. How do individual differences and demographics mediate health and wellbeing benefits? Individual differences such as gender, age, ethnicity, socio-economic status will be explored in relation to change scores on health and wellbeing measures.

5. What is the impact on wellbeing during the time course of engaging with Shmapped as an intervention? Wellbeing will be assessed at baseline, post-intervention and 3 months follow-up. Momentary wellbeing will also be assessed during the daily prompt. Seasonal

changes in wellbeing will be accounted for by comparing outcomes during different seasons.

6. What are the differing impacts of green and blue space exposure on the wellbeing of mental health service users and non-users? Cut-off scores for the REQoL will be used to identify participants with and without common mental health difficulties. These groups will be compared in terms of green space use and change scores in health and wellbeing outcomes.

How the data will be processed and analysed

Self-reported quantitative data will be analysed using SPSS. A repeated measures mixed design MANOVA will assess the fidelity with which Shmapped results in changes to nature connection and wellbeing. For participants who do not complete the study but provide baseline data, attrition rates will be reported and logistic regression will be used to examine the characteristics of those who engage with Shmapped versus those who do not engage, and the characteristics of those who appear to improve in nature connection and wellbeing versus those whose scores remain the same or reduce.

Qualitative data (notes about good things) will be used as part of a process evaluation to see if Shmapped was used as intended. Qualitative data will also be thematically analysed using NVIVO. The activities and comments of the app users with the greatest health and wellbeing improvements will be compared to those with the least improvement, or with a reduction in health and wellbeing.

Spatial data will be analysed using ArcGIS. The data will be screened for artefacts (e.g. where the users' phone indicates that they are driving/travelling on public transport past a geofence or where GPS accuracy is not optimal and participants are not inside a green space). Exposure and duration of stay in different types of green space (e.g. woodland, grassland, heathland), and participant perceived biodiversity and surveyed biodiversity will be assessed. These data will be correlated with wellbeing measures to ascertain which types of environment confer the greatest wellbeing benefits. Sites commonly visited by participants in each group will be assessed for number of habitats present (habitat diversity). The top five preferred sites will also be assessed for more detailed biodiversity indicators such as surveys of avian and vegetation diversity and abundance, this will be correlated with participants self-reported perceptions of biodiversity.

Future directions and limitations

This paper aimed to detail the process of developing a dual data collection and intervention app for research purposes in order to help facilitate smooth app development by others. Shmapped is novel in both its functionality as a theory based research app combined with engaging interface style, but also the process of researchers and developers working together. As is common with many IT projects, the timescale and budget were challenging owing to unforeseen external factors and costs. Many delays experienced could not be planned for specifically, only by allocating a generous development time and budget, informed by a detailed specification.

Timeframe and budget meant that there were design-features that the team desired but had to compromise on. For example, previous literature has shown that providing feedback about participants' wellbeing and progress in general, is a successful strategy for maintaining motivation and engagement with apps [17]. These were features that we wanted to include in our progress screens on Shmapped, such as feeding back to participants about where their wellbeing was greatest, and the context around this wellbeing and its inclusion would have helped to validate the app as an intervention tool as well as a research study. This feature would have been too costly and too time-consuming to add and was therefore dropped from the storyboard. We also wanted participants to be able to share 'good things' with other users or to view anonymised location pins from other users' as a way of inspiring and motivating further outdoor visits. Issues around privacy of data made this challenging and we tried to encourage sharing of good things through the app and the related twitter pages for Shmapped and IWUN, in addition to photo competitions which residents voted on. It would have been informative to ask participants for their location when they were recording their 'good thing' because if they choose to snooze the prompt, then their location would be tagged once they entered their good thing (e.g. later that evening at home) and this is not likely to be the same location where they originally noticed the good thing. Accurate location tracking is an important aim of the study to allow us to generate data on the type of green spaces which offer the most wellbeing benefits. However, in order to become an intervention, it was also recommended that the user tracking data should be optional in the future.

Given more time we would have dedicated longer periods to piloting the app to conduct further bug-fixes and to refine the app to be more engaging and intuitive. We note that similar apps such as Urban Mind [18] have done this and conducted their studies in a pilot phase and roll-out phase. One persistent bug which users contacted us about was that Shmapped opened and displayed as a full screen every time Android users neared a geofence. This was due to a change in operating system with Android phones. A budget for ongoing maintenance to allow for bug-fixes with operating system updates and security updates is recommended. The study included an incentive of a prize draw to win vouchers which the researchers issued over email. The Apple app store has restrictions on mentioning prize draws and therefore terms and conditions and notification of prize draw needed to be shared via email. Extracting the data on a weekly basis and searching through new participants and eligible participants was time consuming, hence in future versions of apps, we would recommend automating these emails. A further challenge comes with our pilot study to engage health professionals with signposting to Shmapped as a social prescription. One major mental health organisation (IAPT) has not been comfortable promoting Shmapped because it currently is not on the NHS approved app register. NHS digital are currently piloting a process to make registration more feasible as since its launch in 2014 only one app on COPD management has been approved. The authors would recommend considering this process if app developers would like their app to be adopted as a form of social prescription by health professionals.

Key Recommendations

- Prepare a detailed specification to estimate budget and time frame
- App developers and Questionnaire authors to work together to design the questionnaire with the user experience in mind and prevent barriers to entry (long form).

- Consider reducing questionnaire completion time and designing questionnaire's to be more user-friendly in busy lives.
- Allow 30% more time for pilots, testing and bug fixes (especially if using geofences) on a variety of devices or handsets.
- Specify smartphone handsets that you will support. Android is particularly tricky as the size and specification varies widely.
- Consider a pilot phase and roll-out phase
- Allow time for approval and publication on app stores
- Allow ongoing costs for maintenance, security updates & data storage
- Apply for NHS approved apps approval early on if seeking patient participants
- Consider proposition of intervention and research app carefully to ensure that its purpose is clearly defined and understood by participants and audience.

The next phase of research will assess participant engagement and attrition with Shmapped, the effectiveness of Shmapped at improving nature connection and wellbeing, and assess which type of green spaces and the differing levels of quality of green spaces are most highly associated with wellbeing. Since drafting this manuscript Shmapped has undergone feasibility testing and evaluation. During feasibility testing 435 people started using Shmapped and 50 completed post measures. Shmapped was rated by users as highly functional (M=4.38, SD=.53), moderately engaging (M=3.42, SD=.59), and with moderate promise of impacting on behaviour change (M=3.44, SD=.88), according to the Mobile App Rating Scale-MARS [37]. Self-referral to Shmapped was successful, however referral from health professionals was less successful and reasons for this and recommended approaches to future recruitment are discussed [38, 39]. Engagement with Shmapped was not optimal during feasibility testing (i.e. participants completed an average of 6.25 (SD=7.15) out of 30 days app use), hence for the full evaluation the intervention duration was shortened from 30 days to 7 days. For the full evaluation 582 participants started using Shmapped and 332 completed post measures. Engagement was improved with an average of 6.54 (SD=3.23) out of 7 days app use. The evaluation found that Shmapped resulted in significant improvements in wellbeing (in both the green and built conditions), with effects reaching clinical significance for adults with common mental health difficulties.

Shmapped offers a novel and exciting use of technology within the field of the human-nature relationship and behavioural medicine. Shmapped could easily be amended to include the geofences of green spaces in other cities, and could therefore be extremely valuable as a tool for evaluating the impact of urban green space design on wellbeing and to provide guidance to Councils and town planners about the best ways to optimise urban design for human and environmental health and wellbeing. Shmapped could also be used to assess the quality of green spaces, something which was highlighted at the launch of the OS Greenspace layer events as being a current knowledge gap.

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Figure 1: Logic model showing the aims and desired outcomes of Shmapped as an intervention

Inputs	Activities	Outputs	Immediate outcomes	Medium-term outcomes	Long term outcomes
Researchers & Wildlife Trust representatives raise awareness of the app (with outreach to areas of deprivation) Researchers help less confident smartphone users to download app and demonstrate use App prompts users to notice nature	Download app via researcher or self referral, referral through friends/family, or GP for Green prescription group Randomised to intervention or control condition App sends two daily prompts to: i) notice nature and photograph/map location; ii) recall the good things in nature during the day and write notes	1 month of noticing nature daily 1 month of daily recall and reflection about the good things in nature Record of good things in nature notes which users can review at any time Maps and graphics to summarise users progress and reward their efforts at noticing nature	Increased noticing of nature Increased visits to nature Increased connectedness with nature Increased physical activity Improved mood Increased interactions with others	Increased independent visits to nature Increased noticing of nature after app use Increased engagement with nature Increased positive mood Reduced stress and anxiety	Improved physical health Improved mental health Increased connection to nature Increased pro-environmental behaviour

Figure 2: Examples of Shmapped screens

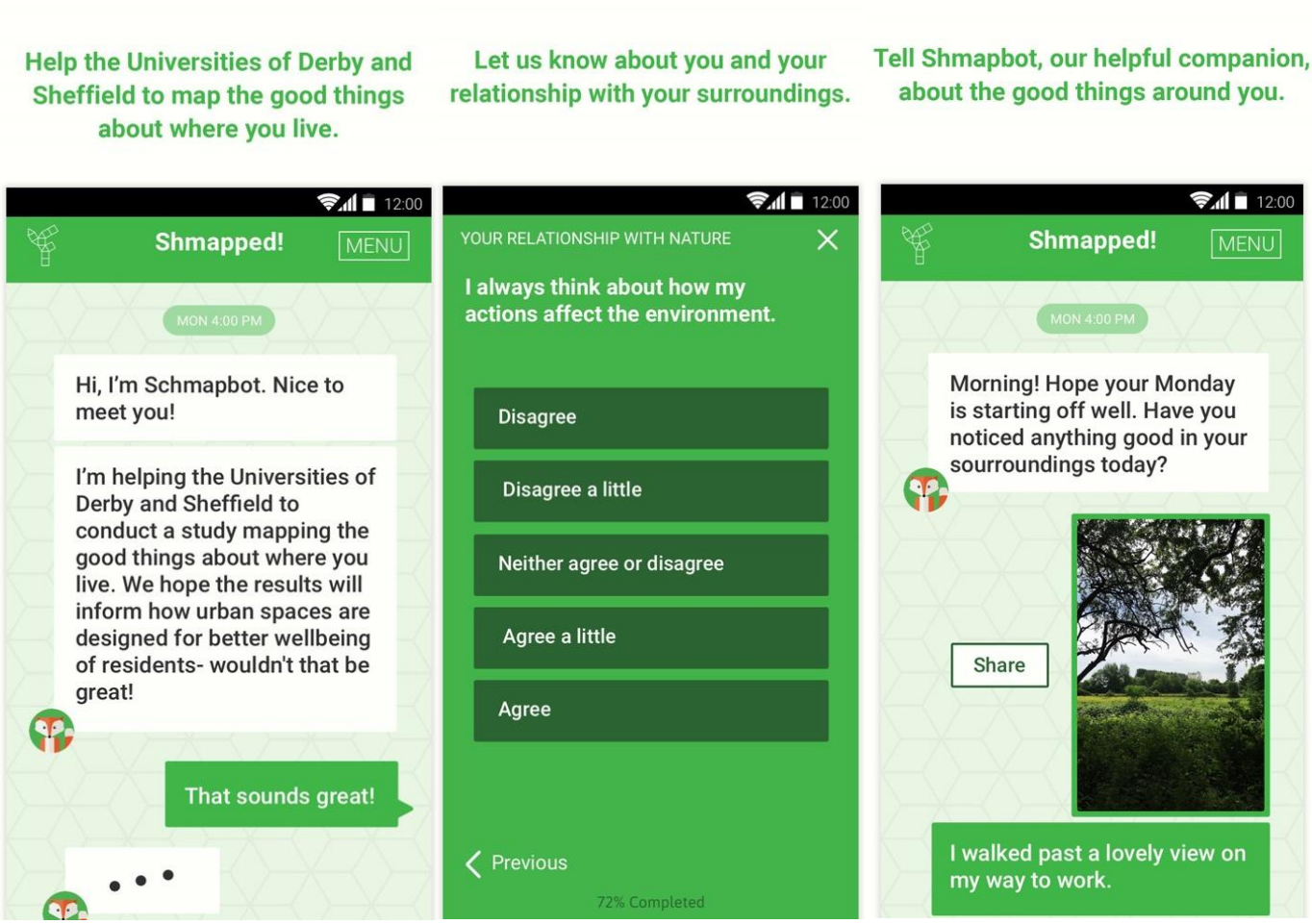

Table 1: Development activity, duration and cost of developing Shmapped

Sprint	Task	Projected duration	Actual duration	Cost
1	Collaborative workshop	1 week	1 week	£4,275
2	Design screens, chatbot script, end-user testing	2 weeks	2 weeks	£8,400
3	Design refined, prototype built	2 weeks	4 weeks	£6,000
4	Functionality developed, more end-user testing	2 weeks	4 weeks	£4,725
5	Background tracking, integrate with back end & server	2 weeks	2 weeks	£5,100
6	Geofences programmed	2 weeks	4 weeks	£4,650
7	Testing of tagging location, prompts & tracking	2 weeks	6 weeks	£4,425
8	Publication & bug-fixes	1 week	6 weeks	£2,850