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Developing smartphone apps for behavioural studies: The AlcoRisk app case study

Anthony Smith [a], Kristy de Salas [a,*], Ian Lewis [a], Benjamin Schüz [b]

[a] School of Engineering and ICT, University of Tasmania, Hobart, Australia
[b] School of Medicine, University of Tasmania, Hobart, Australia

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ABSTRACT

Smartphone apps have emerged as valuable research tools to sample human behaviours at their time of occurrence within natural environments. Human behaviour sampling methods, such as Ecological Momentary Assessment (EMA), aim to facilitate research that is situated in ecologically valid real world environments rather than laboratory environments. Researchers have trialled a range of EMA smartphone apps to sample human behaviours such as dieting, physical activity and smoking. Software development processes for EMA smartphones apps, however, are not widely documented with little guidance provided for the integration of complex multidisciplinary behavioural and technical fields. In this paper, the AlcoRisk app for studying alcohol consumption and risk taking tendencies is presented alongside a software development process that integrates these multidisciplinary fields. The software development process consists of three stages including requirements analysis, feature and interface design followed by app implementation. Results from a preliminary feasibility study support the efficacy of the AlcoRisk app's software development process.

1. Introduction

Human behaviours have long been studied for their effect on health including high impact behaviours relating to alcohol, diet, physical activity and smoking [1,2]. In human behaviour research, an important factor known as ecological validity refers to the extent that observed behaviours can be generalised to real world contexts [3]. Laboratory behavioural research is a common example of low ecological validity where controlled environments are utilised to study specific aspects of a behaviour [3]. In contrast, real world behavioural research is an example of high ecological validity where uncontrolled environments are utilised to study naturally occurring aspects of a behaviour [3]. Researchers have consequently sought real world research methods, such as Ecological Momentary Assessment (EMA), as means to study many human behaviours [4].

Ecological Momentary Assessment (EMA) is a widely-used research method to study human behaviours, such as alcohol consumption and risk taking tendencies, within ecologically valid contexts [4,5]. EMA "involves repeated sampling of subjects' current behaviours and experiences in real time, in the subjects' natural environments" [4]. In EMA studies, research participants maintain a real-time diary or logbook detailing their behaviours and actions in relation to a phenomenon [4,6]. For example, an EMA study focusing on alcohol consumption may require that research participants complete a set of standard questions when consuming alcoholic beverages [5]. The use of EMA facilitates ecological validity while also overcoming research limitations relating to recall bias, dynamic responses and intra-subject variability:

- Recall bias: a challenge to interpreting data when research participants are requested to retrospectively answer questions about previous real world experiences [4,7];
- Dynamic responses: such as affective states are also difficult to evoke or monitor within laboratory experiments [8]; and
- Intra-subject variability: is difficult to control for and assess in laboratory experiments because many real-world variables are not present [8].

1.1. Research tools for EMA studies

Research tools for EMA studies have had an important influence on the conduct of sampling human behaviours [4]. Three common research tools that emerged prior to smartphones include diaries, legacy cellular phones and palmtop tablets.

* Corresponding author.
E-mail address: kristy.desalas@utas.edu.au (K. de Salas).

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Diary studies require that research participants follow an assessment design through completing paper questionnaires stored in a book [4,5]. The use of diaries has been identified as important in forming the basis for real world assessments [4]. Limitations exist, however, in that diaries are vulnerable to research participant compliance issues such as backfilling [4,9]. The term backfilling refers to when a research participant completes questionnaires at a later time rather than when engaging in a behaviour [4,9]. In one EMA study, paper diaries containing a secret light sensor were used to detect when research participants opened the diary to complete entries [9]. Results from this EMA study resulted in research participants on average reporting a 90% compliance rate while in fact their compliance rate was only 11% [9]. Compliance issues presented a motivation to move towards tools facilitating electronic assessments.

Legacy cellular phone studies require that research participants follow an assessment design through completing telephony questionnaires administered by phone calls and text messages [4,10,11]. This tool has been included in research where participants were required to complete telephony questionnaires before, during and after participating in the behaviour being studied [4,10,11], Cellular phones had useful advantages, including instantaneous entry of data into a central database, date and time stamping of data, and easy integration into daily life [5]. Limitations still exist, however, in that cellular phone systems can be time intensive regarding calls with other difficulties including background noise, reception issues, and service cost [5,10,11]. In addition, legacy cellular phones are increasingly uncommon as consumer preferred electronic devices [12,13]. These concerns were a motivator for investigations of palmtop tablets as alternative EMA tools.

Palmtop tablet studies involve research participants following an assessment design through completing electronic questionnaires administered on an interactive electronic device [4,14,15]. Use of this tool in behaviour studies includes research participants completing electronic questionnaires before, during, and after participating in the studied behaviour [5,14]. Benefits of using palmtop computers include previous cellular phone benefits while eliminating problems surrounding background noise, reception issues, and service cost [4,14,15]. Limitations still exist, however, in that palmtop tablets require research participants to carry, learn and manage an unfamiliar device [4,14,15]. Researchers also need to provision palmtop tablets, therefore, potentially limiting the scalability of research studies.

1.2. Smartphone apps as research tools for EMA studies

Smartphone apps as research tools for EMA studies have emerged more recently due to increasing consumer ownership and usage [12,16,17]. Ownership of smartphones is widespread with global predications estimating that the number of smartphones in use exceeds two billion [17]. Usage of smartphones is also an important consideration with research indicating an increasing use of non-telephony services such as apps, websites, games and multimedia [16]. In addition, research into the proximity of users to smartphones indicates that users almost always have their smartphone within either arm reach or the same room [18]. Current trends in smartphone ownership and usage consequently present an opportunity to leverage highly present, familiar, scalable and interactive devices to conduct human behaviour research.

Human behaviour research has successfully utilised EMA smartphone apps within some diet, physical activity, smoking and other studies [19–21]. Research into EMA smartphone apps for monitoring alcohol consumption and risk taking tendencies, however, have received limited attention within literature [5]. Alcohol consumption's relationship with risk taking tendencies is an important research area [22], given that the World Health Organisation [23] identifies alcohol related harms as having significant health and safety implications for people consuming alcohol, and also people in direct contact with alcohol consumers and society in general. As a result, there is an established interest in studying alcohol consumption within controlled and safe laboratory settings, and more recently, increasing interest to leverage EMA tools to investigate the effects of alcohol consumption within the natural contexts of this behaviour [5,22,23].

Feasibility studies have also been a primary focus of human behaviour research examining the efficacy of EMA smartphone apps [19–21]. Research into best practices for EMA smartphone app software development processes, however, have received little attention within literature. Software development processes for EMA smartphone apps are complex multidisciplinary projects that require input from psychology experts, software developers and research participants [4,5,19]. Developing EMA smartphone apps can consequently be an unknown area in regards to reconciling both behavioural theories and software development practices. Results of feasibility studies for EMA smartphone apps including their replication in future studies is also further limited when not knowing how to effectively create such tools.

The AlcoRisk app is one such EMA smartphone app developed to study alcohol consumption and associated risk taking tendencies at the time of occurrence within natural environments. To date, the AlcoRisk app is one of the first apps specifically developed to conduct EMA studies within this behavioural area [5]. In the following sections, the AlcoRisk app's development process is presented as a general approach that can be adapted for other EMA smartphone app studies. Results from an AlcoRisk app feasibility study further verify efficacy as a research tool to collect human behaviour data.

2. Methods

Development of the AlcoRisk app began with the formation of a research team comprising of a principle software developer supported by subject matter experts in psychology, software development, and project management. The research team consisted of the following members:

- The principle software developer with 7 years of experience in software development and support;
- An international subject matter expert in the Health Psychology and Behavioural Medicine field who has significant experience in designing, managing, and analysing complex longitudinal and experimental studies;
- A software designer and developer with command of more than 10 core industry standard programming languages and software development methodologies and has 30 years of experience as a programmer, both on commercial and non-profit projects; and
- A Business and ICT Systems analyst, who has worked with over 100 organisations to augment or transform their business with ICT.

The software development methodology consisted of an iterative process of requirements analysis, feature and interface design and app implementation, all common characteristics associated with an iterative software development methodology [24] (see Fig. 1). Each of these stages will be described.

2.1. Phase 1: Requirements analysis

Requirements analysis refers to the process of determining a software project's stakeholder expectations, needs and wants