original article

Mobile Health Development – The Need For a Rigorous Approach.

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The exponential growth of mobile health (mHealth) apps have converted smartphones into tools for medical education and functions (e.g. medical reference apps, clinical decision support apps), self-management of chronic conditions (e.g. diabetes apps) and especially, health promotion (e.g. weight loss apps). With regards to their development, there is growing consensus that mHealth interventions should be based on evidence, behaviour change theory and formative research with the target population (Buller et al., 2013; Whittaker, Merry, Dorey & Maddison, 2012; Stroulia et al., 2013; Fjeldsoe, Miller, O'Brien & Marshall, 2012). Moreover, underpinning interventions with theory is a key recommendation of the UK Medical Research Council's framework for developing and evaluating complex interventions (Craig et al., 2008). Indeed, behaviour change is central to advancing 'implementation of evidence based practice and public health', where 'Behaviour change interventions' are defined as 'coordinated sets of activities designed to change specified behaviour patterns' (Michie, van Stralen & West, 2011:1).

While there is a need to incorporate evidence and theory into behaviour change mHealth interventions, other important aspects to consider, relate to their social validity and acceptability amongst stakeholders (Danaher & Seeley 2009). This is especially pertinent in the case of apps where approximately 26% of all apps downloaded are discarded after first use (Localytics 2011). Consequently, there is a growing trend towards adopting a user-centred design approach (UCD), a participatory design approach focusing on the user and on 'incorporating the user's perspective in all stages of the design process' (Devi, Sen & Hemachandran, 2012:1).

The importance of including engaging design principles also requires consideration, where current evidence implies that mHealth apps with more evidence-based strategies are amongst the least popular with consumers (Pagoto, Schneider, Jojic, Debiasse & Mann, 2013). This may suggest that commercial mHealth apps, compared to research led apps are designed in a way that promotes greater engagement for consumers, despite their lack of theoretical content. For example, commercial app companies may use more engaging design features with regards to aesthetics and interactive components. Arguably then, mHealth development would benefit from greater collaboration between experts in behaviour change and the commercial app industry to help address these gaps (West et al. 2013; Curtis & Karasouli, 2014). Taking all of these factors into account, I will now demonstrate how I addressed them drawing on two case studies of mHealth apps where appropriate: Health Heroes (a family healthy eating app: (Curtis et al. 2015) and MyMate (a medication adherence app for children with sickle cell disease: (Lobitz, Curtis, Lebedev & Sostmann, 2016).

Theory and evidence

To ensure both apps were underpinned by relevant theory and evidence, a comprehensive

intervention design method known as the 'The Behaviour Change Wheel' (BCW: Michie, Atkins & West, 2014) helped direct the app development process. The BCW is a highly practical resource that guides you on: how to define the problem; select the target behaviour and audience and; understand the problem. Hence, at the core of the BCW is the Capability, Opportunity, and Behaviour Model (COM-B: Michie et al., 2011) which allows you to carry out a detailed behavioural analysis of the problem. The BCW then helps you to map the theoretical conditions identified from the behavioural analysis to direct intervention components for changing behaviour (see Curtis et al. 2015, for a detailed step by step guide on how the BCW was implemented for app development). The results of this stage are summarised for the two case studies in Table 1 below.

User-Centred Design

One approach to increasing target audiences' engagement with the app is to ensure that the app incorporates their preferences and requirements for app features using a user-centred design approach (UCD). According to Rogers, Sharp and Preece (2011), in a UCD approach 'while technology will inform design options and choices, it should not be the driving force' (2011:327). The advantage of

Table 1

Stage 1: Underpinning the app with theory and evidence

Define problem	Target group	Method for involving target group & Analysis	Overview of Behavioural Analysis
Too many overweight children in the local area (UK based)	Parents	Focus groups. Thematic Analysis using framework	Parents revealed their: limited knowledge and skills around age appropriate portion sizes (Capability); fear of eating disorders and low confidence in making dietary changes (Motivation); and environmental influences relating to a household objects and social influences such as Grandparents (Opportunity).
Children with SCD not regurarly taking their medication (Germany based)	Children	Interviews. Thematic Analysis using the COM-B as a coding framework	Children had a limited knowledge of the disease and self-management steps as well as lapses in their memory for taking their medication (Capability); the belief that medication does not make a different to their health and religion is more powerful; a lack of confidence in self-managing their condition; emotions of stress and anxiety increasing their pain symptoms (Motivation); a limited time to take medication; a high reliance on parents for reminding them to take their medication and; other health professionals who lacked knowledge on how to treat their condition (Opportunity).

considering usability issues early on in the engineering lifecycle of the app includes enhanced predictability, greater efficiency with less errors, better alignment with user needs and savings in resources (i.e. development period and budget) (Yen & Bakken 2009). While there are many ways to incorporate a UCD approach for intervention development (e.g. Dennison, Morrison, Conway & Yardley, 2013; Hebden, Cook, van der Ploeg & Allman-Farinelli, 2012), Rogers et al. (2011) interaction design model helped to guide the app development process. An inductive thematic analysis was then conducted to identify key themes. Therefore, the app development process conducted formative research with the target population simultaneously on the theoretical, user-centred and technological aspects (using focus groups and interviews) which were then revisited, adapted and refined through an iterative and cyclic design process.

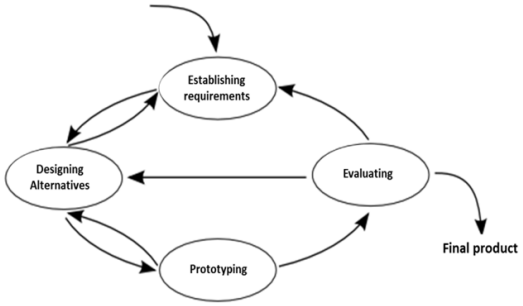


Figure 1. A simple interaction design model (Rogers et al., 2011)

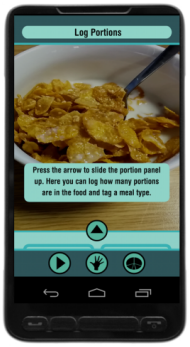
Collaboration with industry

Drawing on the steps in the BCW, theoretical conditions are then mapped onto potential intervention strategies and combined with the first stage of UCD approach (i.e. user preferences for app features). This helps to translate intervention strategies (which are in the form of behaviour change techniques) into engaging app features. At this stage, it is important to include the app development company (i.e. the digital media industry) in the process as they are essentially the experts in designing fun and engaging app features.

Once you have developed your design concept and proposed app features, you can then test these out on your target audience using interactive mock-ups of the app. Interactive-mock ups refer to wireframing software that can help designers to develop prototypes of interactive products such as websites or smartphone apps. They allow users to interact with them by clicking on icons and images that take them through to another area in the design, reflecting how it would work in practice. The aim of testing is to receive feedback on the overall concept of the app and specific app features which, in turn, provide insight into the acceptability of certain behaviour change and gamification techniques. Focus groups and interviews also provided the opportunity to explore certain elements of usability and user experience. Although there is no precise model that encompasses all the possible usability and user experience elements to explore with participants, Preece et al., (2002) model provides a good overview of usability and user experience goals to explore with participants as they gave feedback on the app.

The next iteration of the app involves the development into a prototype app. Testing at this stage consists of utilising an informal inspection method known as the 'think-aloud' method, which permits a 'good compromise between cost and implementation time on the one hand, and the results they make it possible to obtain on the other'(Yen & Bakken, 2009:714). In addition, a quantitative usability survey can be administered to participants using the app for a period of two weeks. This is a really good method for allowing the app company to identify numerous bugs and

Table 2

App	*Summary of UCD findings*	*Example Behaviour Change Technique*	*Example Design Feature*
Health Heroes	Parents' preferences for healthy eating app features included quick and easy to use, minimal data input, visual aids of food and receiving points for healthy eating (gamification).	Self-monitoring of the behaviour	A simple portion tracking tool that awards points for logging food. 
MyMate	Children's preferences for app features included: reminders; features to distract from the pain such as a game and breathing exercises and; having a virtual character to look after.	Prompts/cues	Avatars remind children to take their medication 

usability issues.

Once improvements have been made to the app based upon the previous steps, the next phase in this approach is to test it in a natural setting with the target population to understand how they interact with the app. In line with the MRC guidance on evaluating complex interventions (Craig et al., 2088), this stage could involve modelling the process and outcomes of the app in changing behaviour. Following a similar method used by Willey and Walsh (2016), a quasi-experimental research study could be conducted, using a single arm pre and post-test assessment of the primary outcome (e.g. portion sizes/ medication adherence) and secondary outcomes (e.g. weight and hypothesised theoretical domains).

Conclusion

Within the context of mHealth interventions we cannot ignore the reality that theoretical, user-centred and technological components are inexorably linked. There are still significant gaps in our knowledge regarding which components of apps are effective for behaviour change and whether apps, as a medium, are even effective for behaviour change; as well as which target populations certain components might work best for. However, partnering with the digital media industry and following a systematic development process that draws on relevant theory, evidence and research with the target population will undoubtedly help to address these gaps and advance the field of mHealth.

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