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From black box to toolbox: Outlining device functionality, engagement activities, and the pervasive information architecture of mHealth interventions

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ABSTRACT

mHealth interventions that deliver content via mobile phones represent a burgeoning area of health behavior change. The current paper examines two themes that can inform the underlying design of mHealth interventions: (1) mobile device functionality, which represents the technological toolbox available to intervention developers; and (2) the *pervasive* information architecture of mHealth interventions, which determines how intervention content can be delivered concurrently using mobile phones, personal computers, and other devices. We posit that developers of mHealth interventions will be able to better achieve the promise of this burgeoning arena by leveraging the toolbox and functionality of mobile devices in order to engage participants and encourage meaningful behavior change within the context of a carefully designed pervasive information architecture.

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1. Background & aims

eHealth interventions have been shown to be effective in encouraging a broad range of health behavior change (e.g., Myung et al., 2009; Wantland et al., 2004) including, for example, interventions for smoking cessation (Civljak et al., 2013; Graham et al., 2011; Strecher, 2007), curbing alcohol consumption (Riper et al., 2011), and managing depression (Griffiths et al., 2010; Spek et al., 2007; Titov, 2011). The promise of eHealth interventions is not limited to Internet interventions delivered on personal computers because it also applies to mHealth interventions delivered on mobile devices (Whittaker et al., 2009). Little is known, however, about, what distinguishes effective from less effective interventions (Webb et al., 2010).

The burgeoning field of eHealth interventions has focused more on outcomes than on underlying factors and mechanisms — a Black Box approach (Brendryen et al., 2010; Strecher, 2008). Researchers have proposed several possible remedies to shed more light into the Black Box, including the use of more detailed, standardized reporting of behavior change strategies (Abraham and Michie, 2008), providing comprehensive reporting of the complete intervention rationale along with a description of specific techniques (Bartholomew et al., 2011; Brendryen et al., 2013; Schaalma and Kok, 2009), and testing new theories of health behavior change (Riley et al., 2011).

There is a growing evidence of the efficacy of mHealth programs to encourage a wide variety of behavior changes, but considerably less research to help inform the intervention designer in choosing the technological tool(s) and devices that will engage participants and help them achieve their desired therapeutic outcomes. It is premature to try to synthesize findings regarding the optimal designs and benefits of mHealth interventions because the field is so new, and the interventions are being used to address so many diverse behaviors/disorders over diverse populations. Instead, in this paper we hope to inform mHealth intervention development by shedding light into the mHealth Black Box by outlining: (1) mobile device functionality — the technological toolbox available to intervention developers; and (2) the *pervasive* information architecture of mHealth interventions — the way that an integrated intervention can be delivered concurrently using mobile phones, personal computers, and other devices.

2. Defining the domain

mHealth interventions include health behavior change interventions that are ostensibly delivered using "…computer devices that are intended to be always on and carried on the person throughout the day" (Riley et al., 2011). mHealth interventions are intended to "…travel through time and space with the participant [whereas] the traditional desktop access method implies [that] participants are tethered to a particular device and are therefore more sedentary (p. 314)" (Turner-McGrievy and Tate, 2014). We also agree with the distinction recommended by Riley et al. (2011) to exclude iPads and other tablets from primary consideration in this paper because they are not typically carried by person throughout the day. Finally, our paper was informed by our adaptation of Ritterband and Thorndike's (2006) distinction between internet interventions and patient information websites in order to distinguish mHealth interventions from myriad mHealth programs: mHealth interventions are "typically behaviorally or cognitive-behaviorally-based treatments that have been operationalized and transformed for delivery via" *mobile devices*. We also exclude using mobile devices for ecologically momentary assessments except when they are used to inform behavioral interventions.

mHealth interventions have emerged in large part in response to the nearly ubiquitous use of mobile phones: more than 90% of Americans are mobile phone users (Fox and Raine, 2014), with few differences in their gender and race/ethnicity (Lenhart et al., 2010). Trend data indicate that by 2018 almost all Americans will be using smartphones (Smith, 2013). Worldwide use is also very large and rapidly growing, with 2014 estimates of 4.55 billion mobile phone users and 1.75 billion smartphone users (eMarketer, 2014).

mHealth interventions can leverage the fact that mobile phone users typically carry their phones with them throughout the day and even keep them nearby when asleep, making it possible to deliver helpful behavior change content to – and even have interactions with – individuals as they go about their normal everyday lives (Heron and Smyth, 2010; Lenhart, 2010; Patel et al., 2006). mHealth intervention components can be proactive in that they *reach out* to users to deliver content, prompt interchange, and can deliver persuasive content that encourages behavior change (Fogg, 2007). Heron and Smyth (2010) have described these as ecologically momentary interventions that occur at specifically identified moments in everyday life providing real-time support in the real world.

mHealth interventions can be designed to provide *just in time* support and guidance when most needed (Beale, 2009; USDHHS, 2014; Wikipedia, 2014e). There are at least two ways that mHealth interventions are *just-in-time*. First, intervention content can change based on data obtained during the course of the intervention, as in delivery of text messages that are relevant to a participant's recent success/problems in managing eating (Intille et al., 2003) or quitting tobacco (Riley et al., 2011; Ybarra et al., 2012). A technological elaboration of this point can be found in the just-in-time-interventions described by Kumar and his colleagues (Kumar, 2012; Sarker et al., 2014) in which wearable wireless sensors can inform intervention content to enhance successful behavior change (e.g., quitting smoking). The second just-in-time aspect of mHealth interventions involves their immediate accessibility. Because mobile phones are literally within reach they can act as an "as-needed" and available resource, as when coping with a difficult smoking urge the participant could immediately review – and obtain benefit from – helpful content on the smartphone, which might include a personal list of reasons to quit (Ybarra et al., 2012) and/or a relaxation audio (Whittaker et al., 2008).

2.1. Taxonomy for defining smartphones

In contrast to current smartphones, early mobile phones did not have a touchscreen, a QWERTY keypad, or the benefits of an advanced operating system. These phones have been described variously as mobile phones having *standard features*, *feature phones*, and/or *basic phones* (iHeed Institute, 2011), *conventional* (The Nielsen Company, 2013; Wikipedia, 2014c) or *common* (WHO, 2011). These older mobile phones have even been referred to as "dumb phones" to clearly distinguish them from the current generation of smartphones (Wikipedia, 2014c). However, while the label "smartphone" is driven by marketing considerations, an important caution needs to be acknowledged because the "smartness" of today's phones inevitably will appear much less "smart" when they are compared to the next generation mobile devices. Since smartphones offer so much more functionality than merely making phone calls, the label "mobile device" better captures the breadth of their toolset and the fact that people are able to use them as "converged devices that combine mobility, connectivity, and programmability" (Yuan, 2005).

2.2. Taxonomy for defining mHealth

The World Health Organization describes mHealth as a component of the broader category of eHealth (WHO, 2011). A casual Google search using the term will quickly reveal that the mHealth label has been applied to a very considerable breadth of programs and initiatives, including using mobile computing and communications technologies to facilitate care of medical patients (Kotz, 2011) and the use of mobile phones within developing countries to support health workers, collect public health data, and enable health information messaging and helpline services (iHeed Institute, 2011). A taxonomy for mHealth is still emerging and some have questioned whether it will endure as a