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Engagement in Digital Interventions

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Abstract

The notion of "engagement," which plays an important role in various domains of psychology, is gaining increased currency as a concept that is critical to the success of digital interventions. However, engagement remains an ill-defined construct, with different fields generating their own domain-specific definitions. Moreover, given that digital interactions in real-world settings are characterized by multiple demands and choice alternatives competing for an individual's effort and attention, they involve fast and often impulsive decision making. Prior research seeking to uncover the mechanisms underlying engagement has nonetheless focused mainly on psychological factors and social influences and neglected to account for the role of neural mechanisms that shape individual choices. This paper aims to integrate theories and empirical evidence across multiple domains to define engagement and discuss opportunities and challenges to promoting effective engagement in digital interventions. We also propose the AIM-ACT framework, which is based on a neurophysiological account of engagement, to shed new light on how in-the-moment engagement unfolds in response to a digital stimulus. Building on this framework, we provide recommendations for designing strategies to promote engagement in digital interventions and highlight directions for future research.

Keywords

engagement; digital interventions; affect; motivation; attention

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Introduction

The use of mobile and wireless technologies to deliver psychological interventions has increased rapidly since the turn of the century. These interventions range from self-guided tools for helping individuals employ behavioral strategies (e.g., self-monitor physical activity, mood or eating behaviors; practice meditation or relaxation techniques) to more complex and comprehensive psychological therapies (e.g., cognitive–behavioral therapy; acceptance and commitment therapy) (see Graham et al., 2020; Schueller & Torous, 2020). Digital interventions, defined as products or services that leverage technology to facilitate or support behavior change (West & Michie, 2016), are attractive for several reasons, including their potential for cost-effectiveness, convenience, high reach, and capabilities to provide support to individuals in real-world settings (Moshe et al., 2021; Newby et al., 2021). Moreover, the ability of smart devices to sense or collect in-the-moment data can be leveraged via Just-In-Time Adaptive Interventions (JITAIs) to deliver the intervention option that is best for an individual at a particular moment, while minimizing unnecessary burden (Nahum-Shani et al., 2018). This capacity to adapt intervention delivery to the rapidly changing needs of individuals is increasingly viewed as an important innovation in psychological research and practice (Kitayama, 2021; Koch et al., 2021). Thus, while the strong link between digital interventions and scientific inquiry in psychology is evident, research on how digital interventions impact and interact with individuals remains underdeveloped (Harari, 2020; Stieger et al., 2021).

In recent years, it has become clear that research on engagement is critical to realizing the promise of digital interventions. Here, based on synthesis across literatures (described below), we define engagement as *a state of energy investment involving physical, affective, and cognitive energies directed toward a focal stimulus or task.* The "law of attrition" (Eysenbach, 2005)–the tendency of individuals to drop out before completion or to stop using the technology–plagues studies involving digital interventions (Linardon & Fuller-Tyszkiewicz, 2020; Moshe et al., 2021). In fact, worldwide usage of most mobile applications (apps) drops off sharply over time, with average retention rates of less than 5% after 30 days (Statista, 2020). Although low engagement has been consistently cited as the construct underlying these phenomena (e.g., Chien et al., 2020; Pratap et al., 2020), there has been limited theoretical and empirical work to understand how engagement in digital interventions unfolds. Further, the notion of engagement plays a critical role in various domains of psychology, including occupational (Bakker & van Wingerden, 2021), clinical (Georgeson et al., 2020), educational (Reinke et al., 2019), and health psychology (Nahum-Shani, Rabbi, et al., 2021). However, there is disagreement about the definition of this construct across and within various fields, and it is often unclear how engagement is different from other related constructs, making it difficult to ascertain its scientific value.

Many definitions of engagement are characterized by the underlying assumption that it is inherently effective (i.e., that being engaged leads to a desirable outcome) and positively valenced (i.e., manifesting in positive behaviors, feelings, and thoughts). This assumption contributes to a lack of differentiation between engagement and its consequences. Moreover, while some definitions primarily conceptualize engagement as a relatively enduring, trait-like construct (e.g., Dawes et al., 2015), others highlight the dynamic, state-like nature of engagement (e.g., see Perski et al., 2017). Further, although engagement is often defined as a multi-dimensional construct involving physical, affective, and cognitive dimensions (e.g., Torous et al., 2020), it is unclear how these aspects operate distinctly or in concert.

The present paper aims to synthesize definitions of engagement and integrate theories and empirical evidence across psychology and relevant scientific domains to elucidate the processes leading to in-the-moment engagement in digital interventions. This paper offers several important contributions to psychological theory and practice. First, given the absence of an agreed-upon definition of engagement, we review and then build upon the existing definitions of engagement from multiple fields to clearly distinguish engagement from other constructs. Second, we discuss several concepts relating to engagement that have yet to be synthesized in the literature, including the conceptualization of engagement as a construct that is both stable and dynamic, the difference between engagement and effective engagement, and the difference between positive and negative engagement. Third, we highlight specific challenges to promoting engagement in digital interventions, which often involve the delivery of external stimuli in real-world settings to promote behavior change; these challenges include the informational richness characterizing the digital domain that may hinder attention to digital stimuli and the highly dynamic nature of real-world settings in which multiple demands compete for an individual’s effort. Finally, we propose a new conceptual framework that aims to clarify how positive engagement unfolds in-the-moment in response to a digital stimulus that is intended to facilitate or support behavior change. We extend the affect-integration-motivation (AIM) framework (Samanez-Larkin & Knutson, 2015), which describes the neural basis of individual choice, through clarifying its application to digital interventions and incorporating three additional elements (i.e., ACT: attention, context, and translation of motivation to behavior) that are critical for this specific application. By specifying the elements underlying engagement with digital interventions, the proposed framework seeks to guide future research on stable and dynamic factors that likely shape engagement in digital interventions and to inform strategies for promoting real-time, real-world engagement.

What is Engagement?

Existing definitions of engagement emphasize different aspects, depending on who is intended to be engaged and with what. For example, in education research, engagement is defined in terms of the *effort students devote to educationally purposeful activities* that contribute to desired learning outcomes (Hu & Kuh, 2002; Krause & Coates, 2008). In the area of industrial/organizational psychology, engagement is often defined as *emotional and intellectual commitment* to an organization (Richman, 2006; Shaw, 2005) or the amount of *discretionary effort* exhibited by employees in their jobs (Frank et al., 2004). In computer science and human-computer interaction (HCI), engagement is typically defined as the *quality of user experiences* with technology (O’Brien & Toms, 2008; Sidner et al., 2004) or as a process by which *social connection* begins, sustains, and ends (Doherty & Doherty, 2018; Sidner et al., 2004). In healthcare, patient engagement is defined in terms of *the actions patients take* to support their health (Cunningham, 2014), and in marketing, customer engagement is defined as the intensity of an individual’s *participation and connection* with an organization’s offerings and activities (Pansari & Kumar, 2017; Vivek et al., 2012).

These examples illustrate the lack of universal agreement on the definition of engagement. However, several common themes emerge, which we discuss below and then integrate to formulate our proposed definition.

Engagement as Energy Investment

The conceptualization of engagement as energy investment is grounded in industrial/organizational psychology, specifically the work of Kahn (1990), who introduced the construct of employee engagement as the investment of energy into one's work role. Since Kahn's influential publication, the construct of employee engagement has taken various forms, with engagement commonly conceptualized as a positive "energetic" investment (Young et al., 2018). For example, Maslach and Leiter (1997) and Schaufeli and colleagues (2002) viewed the energetic connection that engaged employees have with their work activities as the key element of work engagement. Subsequent reviews of engagement have observed that it is commonly defined by "passion, enthusiasm, focused effort, and energy" (Macey & Schneider, 2008, p. 4). Similarly, Christian and colleagues (2011) concluded that although "engagement research has been plagued by inconsistent construct definitions and operationalizations," they all involve "the simultaneous investment of personal energies in the experience or performance of work" (p. 95). This perspective motivated Young and colleagues (2018) to view energy as "the currency of employee engagement" (p. 1331), where energy is described as "a type of positive affective arousal" (Quinn & Dutton, 2005, p. 36). Of course, the presence of energy by itself does not solely comprise engagement (Young et al., 2018). Rather, engagement involves the direction and channeling of energy into a specific activity or role (Kahn, 1990). Hence, we conceptualize engagement as *energy investment directed by an individual toward a focal stimulus or task.* Here, the term *stimulus* describes an external cue that elicits, or that is intended to elicit, a behavior (e.g., a text message encouraging the individual to take a walk), and the term *task* refers to a pre-specified performance requirement (e.g., complete a 5-minute walk).

Engagement as a State

An important debate concerns whether engagement is best thought of as a temporally dynamic state, a relatively stable trait, or both (Dalal et al., 2008). Research on work engagement mainly conceptualizes engagement as a relatively stable construct that varies between individuals (e.g., Schaufeli et al., 2002), whereas in the field of HCI, engagement is most frequently characterized as a dynamic state of user experience (Doherty & Doherty, 2018). Empirical evidence indicates that engagement is subject to fluctuations throughout the day around some average level for an individual. For example, Reina-Tamayo and colleagues (2017) found that 88% of the total variance in employee engagement fluctuates from activity to activity and that during these activities (e.g., checking emails, attending meetings), episodic engagement is positively related to performance. Similarly, Rotgans and colleagues (2018) found that cognitive engagement among medical students systematically fluctuates based on distinct activities during a team-based learning session, and Larson and colleagues (2020) found that teams' engagement (e.g., in strategy and planning) increased over time toward a deadline. These findings are consistent with Kahn's (1990) notion of engagement as a condition that ebbs and flows. Indeed, in their review of literature on work engagement, Christian and colleagues (2011) concluded that engagement varies both between and within individuals, which is a common characteristic of many psychological constructs, such as affect and satisfaction. Hence, we refer to engagement as a *state of energy investment* that can be relatively enduring but may fluctuate over time (Schaufeli et al., 2002).

Engagement as a Multi-Dimensional Construct

Another important theme that cuts across multiple research domains is the perspective that engagement is multifaceted and includes physical, affective, and cognitive elements. *Physical energy investment* refers to the actual performance of an activity or task (Newton et al., 2020). This dimension is labeled "behavioral engagement" in many fields (e.g., Kilday & Ryan, 2019; King et al., 2014). Physical energy investment takes on various forms, depending on the field of research. For example, in intervention research, physical energy investment can be captured via attendance, appointment keeping, or adherence to treatment protocols (King et al., 2014), while in consumer research, it may involve consumption activities, providing reviews and recommendations, blogging or vlogging, and even co-creating products with companies (Zeng & Mourali, 2021). Across fields, physical energy investment is often labeled as "participation" (King et al., 2014; Mai et al., 2021).

Affective energy investment has traditionally been referred to as psychological engagement (e.g., Pham et al., 2021; Williams et al., 2020). It captures a wide range of positive affective reactions to a task or activity (Lee, 2021; May et al., 2004), from feeling pride, enthusiasm, and satisfaction (Bowden et al., 2021; Mirbagheri & Najmi, 2019), to affective states that may underlie more enduring experiences of attachment (i.e., a strong affectional bond; de Oliveira Santini et al., 2020), identification (i.e., a sense of belonging or being in unity with an entity; Ashforth & Mael, 1989), and commitment (i.e., a desire to continue the interaction or relationship; Morgan & Hunt, 1994). Across various fields, there is often a lack of clarity and agreement about whether these different positive affective states make up (i.e., are indicators of) engagement or lead to (i.e., are antecedents of) engagement.

Cognitive energy investment mainly refers to selective attention and processing of information related to a task or activity (Kahn, 1990). This does not necessarily imply "flow" (Csikszentmihalyi & Csikszentmihalyi, 1988), which has been defined and measured primarily in terms of a high degree of concentration and interest in an activity, hence representing a unique 'peak' in cognitive absorption (Caniëls et al., 2021; May et al., 2004). In other words, a state of flow indicates the highest level of cognitive energy investment, but cognitive energies can be invested without experiencing flow.

Although there is no consensus on which dimensions of energy investment are most important in defining engagement (Lee, 2014), there is some agreement that engagement represents the *simultaneous* investment of physical, affective, and cognitive energies (Rich et al., 2010, p. 622). This perspective is based on Kahn (1990; 1992), who described engaged individuals as being fully there: physically involved, feeling positive toward the task and others in the service of task performance, and cognitively focused and attentive (Kahn, 1990). Building on this definition, Rich and colleagues (2010) and others (Wang et al., 2019; Yuan et al., 2021) suggested that, when engaged, individuals harness their *full* selves in active performance by "driving personal energy into physical, cognitive, and emotional labors" (p. 619). Similarly, King and colleagues (2014) defined client engagement in mental health services as "a multifaceted state of affective, cognitive, and behavioral commitment or investment in the client role over the intervention process" (p. 2). Metaphorically speaking, engagement is manifested in the simultaneous investment of hands, heart, and head (Rich et al., 2010, p. 619). Following these perspectives, we define engagement as *a state of energy investment involving physical, affective, and cognitive energies directed toward a focal stimulus or task.* In Table 1, we use this definition to highlight the differences between engagement and other related constructs.

What is Effective Engagement?

What constitutes *effective* engagement depends on the distal outcome (i.e., ultimate goal) that is motivating the need for engagement in a specific target population (Yardley et al., 2016). As noted by Saks (2008), "it is meaningless to refer to engagement without being specific about the role in question" (p. 42). In some fields, the notion of effectiveness is inherent in the definition of engagement, meaning that engagement is conceptualized as an *effective state of energy investment*. For example, *engaged employees* are viewed as those who not only invest energy in their work, but also have an effective connection with their job (see Maslach & Leiter, 1997). Effectiveness is assumed in many definitions of work engagement because work-related performance is the distal outcome guiding the need for engagement in this context. However, engagement in and of itself may or may not be effective, and its effectiveness can be determined only in relation to a pre-specified desired outcome to be achieved via the investment of physical, cognitive, and affective energies. For example, work engagement as defined by Maslach and Leiter (1997) can be effective in terms of promoting higher levels of work performance as the distal (i.e., long-term) outcome, but not necessarily in terms of promoting employee work-life balance.

It is critical to identify what constitutes effective engagement in relation to the pre-specified distal outcome. Specifically, what level (or intensity) of engagement is needed, with what, and for how long, in order to achieve the distal outcome? An important point to consider here is that effective engagement may also involve periods of non-engagement, or what is labeled in the literature on work engagement as 'recovery'— "a process of psychophysiological unwinding that is the opposite of the activation of psychophysiological systems during effort expenditure" (Geurts & Sonnentag, 2006, p. 483). An overview of the literature on daily fluctuations in work engagement, has led Bakker (2014) to conclude that "daily balance between engagement while at work and detachment while at home seems the key to enduring work engagement" (p. 227). Overall, empirical evidence consistently demonstrates that adequate recovery is critical for subsequent engagement, particularly when the level of energy investment is relatively high (Bakker, 2014). Hence, we define effective engagement as follows: *Effective engagement is the extent, frequency, and duration of investment of physical, cognitive, and affective energies in a focal stimulus or task needed to bring about a pre-specified outcome.*

Positive and Negative Engagement

The majority of research on engagement focuses on its "bright" side, capturing favorable thoughts (e.g., positive evaluations), feelings (e.g., satisfaction), and behaviors (e.g., cooperation) directed toward a focal task or stimulus. However, in recent years there is growing acknowledgment that engagement has a "dark side" that manifests in unfavorable thoughts (e.g., negative evaluations), feelings (e.g., anger), and behaviors (e.g., complaining) (Hollebeek & Chen, 2014). This dark side may be fueled largely by social media networks, which enable individuals to express their negative thoughts and feelings quickly and broadly (Do et al., 2019). Importantly, negative engagement goes beyond passive disengagement, as it has a clear target and results in deliberate and motivated negative action (Lievonen et al., 2018). Hence, we define positive (vs. negative) engagement as *a state of energy investment involving positively (vs. negatively) valenced physical, affective, and cognitive energies directed toward a focal stimulus or task.*

Interestingly, some studies indicate that individuals may be both positively and negatively engaged at the same time. For example, Moody and colleagues (2014) found that trust and distrust coexist in online e-commerce relationships, resulting in an ambivalent engagement pattern. Turel and Serenko (2012) investigated the benefits and consequences of enjoyment of social networking websites, suggesting that technology-related addictions involve both enjoying and suffering from excessive use. Additionally, Costa Figueiredo and colleagues (2018) showed that in the case of self-monitoring health data, individuals may appreciate and increase their efforts to self-monitor, while simultaneously feeling stress and anxiety about tracking practices. This suggests not only that the connection between positive and negative engagement is complex, but also that positive engagement may not always be effective and negative engagement may not always be ineffective. As noted earlier, whether a specific form of engagement is effective depends on the outcome to be achieved. Next, we build on the above definitions to discuss engagement with digital interventions.

Engagement in Digital Interventions

Digital interventions leverage technological innovations (e.g., mobile and wearable devices) to facilitate or support positive behavior change (i.e., the alteration of existing unhealthy/maladaptive behavior or the uptake of new healthy/adaptive behavior). This is often done by using digital stimuli and/or tasks as a vehicle for engaging individuals with other tasks, non-digital or digital (Ebert et al., 2019; Yardley et al., 2018). Since different stimuli or tasks likely require different strategies to increase engagement, understanding the concept of engagement in digital interventions requires careful consideration of the question, "Engagement with what?" For example, many health-promotion mobile applications deliver push notifications to remind or encourage participants to engage in a digital (e.g., using a mobile app to self-monitor daily behaviors and experiences; Rabbi et al., 2018) or a non-digital (e.g., physical activity, healthy eating; Freyne et al., 2017) task. In this case, the answer to the question "engagement with what" can be "engagement with the push notification" and/or "engagement with the task." In other cases, push notifications are used to engage individuals in digital content on a mobile app (e.g., playing and listening to a guided relaxation audio on a mobile app), which, in turn, is designed to engage individuals in a non-digital task (e.g., performing a relaxation activity; for examples, see Morrison et al., 2017; Pham et al., 2016). Here, the answer to the question "engagement with what" can range from "engagement with the push notification" to "engagement with the digital content on the app" and/or to "engagement with the non-digital task." These examples illustrate two important characteristics concerning engagement in digital interventions.

First, digital interventions are developed with the implicit assumption that the distal outcome can be achieved by engaging individuals in certain stimuli and tasks, some digital and some non-digital, in a consecutive or sequential manner. Hence, an important first step in answering the question "engagement with what" is to clearly articulate the process through which the distal outcome can be achieved. This includes specifying the sequence of stimuli and tasks that require engagement to achieve the distal outcome and differentiating which stimuli/tasks can be implemented via digital technology. Second, the delivery of a digital stimulus to engage individuals in a specific task is an important component of digital interventions. These digital stimuli may include "nudges" (Valle et al., 2020; Weintraub et al., 2021), which Thaler and Sunstein (2021) define as a subtle intervention designed to modify people's behavior "without forbidding any options or significantly changing economic incentives." Nudges can take various forms, such as text reminders (e.g., to take a walk), graphic warnings (e.g., about the impact of sedentarism), or making a specific option salient (e.g., highlighting the presence of a park nearby). However, digital stimuli used to promote engagement in digital interventions are not limited to nudges. For example, monetary incentives for a specific option do not qualify as nudges (Campos-Mercade et al., 2021), but are sometimes used to promote engagement in digital interventions (Nahum-Shani, Rabbi, et al., 2021). Further, nudging typically seeks to bypass consciousness, deliberation, and reasoning, but digital stimuli for promoting engagement in digital interventions may require deep and lengthy thinking, as they sometimes offer useful information about the person's behavior and context to facilitate self-reflection (Bidargaddi et al., 2018; Rabbi et al., 2018). Hence, we focus here on digital stimuli, more broadly, not only those that qualify as nudges.

Given that digital interventions concern the facilitation of positive behavior change, both the stimulus and the focal task primarily require positive (rather than negative) engagement (Heffner et al., 2021; O'Neill & Nicholson-Cole, 2009). However, there are two major challenges to positively engaging individuals with a digital stimulus in real-world settings. The first challenge stems from the informational richness of the digital domain. While convenient and accessible, technologies facilitate information exchange at a rate faster than one can process, making it difficult for individuals to determine what is relevant and useful (Schmitt et al., 2021). Individuals may experience information overload, which occurs when the amount of information being directed to an individual exceeds their information processing capacity (Eppler & Mengis, 2004; Matthes et al., 2021). This may lead individuals to respond too quickly to stimuli without paying adequate attention, or to fail to respond altogether (Levitin, 2014). The second challenge concerns contextual influences in real-world settings, where the context is defined as any condition, stable or dynamic, that can be used to characterize a given situation. When attempting to engage individuals in their natural environment, multiple demands may compete for their effort. These conditions may change rapidly over time, shaping an individual's response to digital stimuli and creating barriers to their ability to perform the task. However, there has been limited theoretical and empirical attention to the processes underlying engagement in situations characterized by multiple alternatives and demands that compete for an individual's attention and effort (Linardon & Fuller-Tyszkiewicz, 2020; Torok et al., 2020).

Given that decision making in a digital, real-world setting may happen in-the-moment, quickly and often impulsively (Verhagen & Van Dolen, 2011), we draw on neuroscientific findings to propose the Affect-Integration-Motivation and Attention-Context-Translation (AIM-ACT) framework. AIM-ACT outlines the key psychological processes essential to in-the-moment engagement in response to a digital stimulus. This framework is intended to aid in the development of theory, operationalization of key factors, and generation of hypotheses to inform strategies for promoting engagement in digital interventions. Since digital interventions concern the facilitation of positive behavior change, we focus on clarifying the process underlying positive (rather than negative) engagement in response to digital stimuli.

The AIM-ACT Framework

This conceptual framework is based in part on recent empirical evidence from neuroscience linking neural activity to anticipatory affect and motivated behavior (Knutson et al., 2014). Specifically, the affect-integration-motivation (AIM) framework proposed by Samanez-Larkin and Knutson (2015) describes how the neural basis of affective, integrative, and motivational responses predict and promote individual choice. According to the AIM framework, incoming stimuli are processed in a sequential and hierarchical manner, with each stage being associated with separable neural components (i.e., activity in brain regions or circuits). While these stimuli can be either external (e.g., advertisement, human contact) or internal (e.g., hunger, discomfort), we focus here on external stimuli, which are essential to the effectiveness of digital interventions.

To ground the discussion, we consider an example of a digital stimulus (a prompt delivered via a push notification recommending taking a walk) delivered to engage an individual in a focal task (taking a 5-minute walk). In this example, engagement with the stimulus is a pathway through which engagement with a focal task can be achieved. Hence, we describe how engagement with the stimulus unfolds to facilitate engagement with a focal task. The AIM framework specifies that the individual first affectively processes the stimulus. Specifically, a prompt initiating a positive anticipatory *affective* response activates the nucleus accumbens (NAcc) area of the brain, whereas a negative affective response activates the anterior insula (AIns). In the next stage, over time in the medial prefrontal cortex (MPFC), affective signals are integrated with situational factors (e.g., perfect weather for walking) and other relevant considerations such as social consequences (e.g., not being able to have coffee with friends), reward likelihood (e.g., anticipated sense of well-being after walking), or timing (e.g., ability to complete the walk in time before the next meeting). The integration mechanism has been studied extensively in the neurosciences, with hundreds of empirical studies identifying subregions of the MPFC as being involved in value-based judgments of inputs (Bartra et al., 2013). This mechanism enables direct comparison of qualitatively different inputs via a common pathway, namely a subjective valuation system. The valuation process involves explicitly and implicitly weighing perceived costs (or disadvantages of walking) and benefits (or advantages of walking) that may be qualitatively different, to derive an overall value of inputs. The overall value is linked to affective signals that potentiate motivated behavior (Bartra et al., 2013; Levy & Glimcher, 2012). For instance, we would expect greater activity in the NAcc and MPFC for individuals with positive affective responses to the prompt and who place higher subjective value on factors related to the advantages of walking (or of responding favorably to the prompt); these individuals would, in turn, be more motivated to walk. By contrast, AIns activity accompanied by MPFC activity would indicate negative affective responses, and greater weighting of factors related to the disadvantages of walking that would motivate behavioral avoidance and perhaps doing something else instead. In the final stage, connections to the dorsal straitum and presupplementary motor area (pSMA) are activated to facilitate any necessary behavioral action response (e.g., walking or another behavior) (Samanez-Larkin & Knutson, 2015).

Empirical support for the AIM framework has been found across a broad range of scenarios. For example, activity in the NAcc and MPFC in response to a relevant stimulus predicts individual's choices to purchase goods (Knutson et al., 2007; Levy & Glimcher, 2012), make financial investments (Preuschoff et al., 2006), donate to charities (Moll et al., 2006), and fund microloans (Genevsky & Knutson, 2015) and crowdfunding projects (Genevsky et al., 2017). The AIM framework fills a theoretical gap by offering a neurobiological account of how individuals process an incoming stimulus. By establishing the links from neurophysiological activity to anticipatory affect, integration, and motivated behavior, the AIM framework provides a useful basis for clarifying the processes underlying engagement in digital settings. There are, however, three additional elements–attention, context, and the translation of motivation to actual behavior–that we seek to incorporate to form AIM-ACT (see Figure 1), a conceptual framework that can be used to guide efforts to engage individuals in digital interventions.

Attention to a Stimulus

When attempting to engage individuals in a digital setting that is often characterized by information overload, attention to a stimulus is likely a necessary element. Here, attention is defined as the selection and processing of the relevant or salient parts of sensory inputs while discarding other potentially irrelevant parts (Rao, 2006). For example, a push notification will not elicit an affective response if it is not registered by the recipient; incoming information about the health benefits of walking will not be cognitively integrated if the individual does not attend to it; and motivation to walk will not translate to an actual behavior if the individual gets distracted.

Although affective responses may occur with or without attention to a specific stimulus, insufficient attention to the stimulus would inevitably undermine engagement in the stimulus and hence in the focal task (Scherer, 2001; Vuilleumier, 2002). Further, empirical evidence suggests that attention is often critical for cognitive processing (Ding et al., 2018; Pessoa & Ungerleider, 2004). For example, experiments with masked primes indicate that some minimal duration and clarity of stimulus presentation are needed for the stimulus to be consciously processed. While cognitive processing can occur at an implicit level, specific mental operations require conscious effort. These include maintaining information related to the stimulus in working memory (e.g., maintain an active and accurate representation of one's goal), combine several mental operations to perform a novel task (e.g., inhibit a routine behavior and plan a new strategy), and perform an intentional behavior (e.g., get ready to go outside to take a walk) (Dehaene & Naccache, 2001). Hence our framework highlights attention as an element that modulates the affect, integration, and motivation preceding a behavior, by gating the inputs that elicit and shape these responses.

Contextual Influence

When attempting to engage individuals via a digital stimulus in real-world settings, not only does the context need to be amenable for ensuring attention, but context can dramatically alter responses at each stage of the engagement process, and thereby impact engagement. There is substantial evidence that context can shape affective response to a stimulus. For example, emotional expression and experience are influenced by the presence and expressiveness of other people (Goldenberg et al., 2020). Time of day can also influence emotions, with some people experiencing more positive arousal earlier than later in the day (English & Carstensen, 2014). Emotions can also be shaped by the environment, from experiences of excitement in response to natural settings (Hicks, 2018) to feeling overwhelmed in a crowded store (Greven et al., 2019).

In addition, context can shape the valuation of the focal task via the integration of information such as social cues and environmental constraints. For example, the subjective value of taking a walk may be reduced in the context of an unsupportive social environment or uncooperative weather. This implies that motivation to perform the focal task can be heightened by prompting individuals under contextual conditions that serve to enhance, rather than attenuate, the value of the prompted task. In sum, the proposed framework acknowledges that context may impact engagement by modulating an individual's attention, as well as affective, integrative, motivational, and behavioral responses.

Translation of Motivation to Behavior

The AIM framework suggests that motivation to approach a task in response to a stimulus (e.g., a prompt to encourage walking) can translate into behavior (e.g., walking) immediately or at a later point in time (Knutson & Genevsky, 2018). In digital intervention settings, real-world demands and constraints often interfere with the translation of motivation to immediate behavior by drawing an individual's attention to other stimuli. For example, an individual may decide to take a walk in response to the prompt, but contextual circumstances (e.g., an important phone call) may prevent effective engagement with this task. Motivation to approach a given task may not necessarily translate into behavior right away, especially in cases where the focal task requires deliberate or effortful processing such as planning a strategy and controlling its execution (Dehaene & Naccache, 2001). The individual may, however, take the walk later in the day, such that the translation of motivation to behavior occurs after some delay. Indeed, recent empirical evidence supports the notion that the translation of motivation to behavior takes place across different time scales (Genevsky et al., 2017; Tong et al., 2020).

The form of motivation may also impact the translation of motivation to behavior. Self-determination theory posits that optimal functioning depends on the extent to which a person's behavior is autonomous (i.e., coherent with one's self) rather than controlled by internal or external pressures (Ryan & Deci, 2000b). In this context, intrinsic motivation is viewed as the most autonomous form of motivation, as it captures a drive to do something for its own sake because it is inherently satisfying (e.g., an individual will walk in response to a prompt because they enjoy walking). Naturally, individuals are more likely to invest energy in tasks that involve anticipated intrinsic benefits such as enjoyment, competence, and interest (Studer & Knecht, 2016). However, not all activities are inherently satisfying, and yet individuals may still engage in them because they are extrinsically motivating; that is, they represent a means to an end (e.g., an individual takes a walk in response to the prompt because they believe it will improve their health).

Self-determination theory proposes several forms of extrinsic motivation that vary in the extent to which they are experienced as autonomous (Ryan & Deci, 2000a). The least autonomous form of extrinsic motivation is labeled external regulation, reflecting a drive due to external demands or imposed contingencies (e.g., walking to receive reward points or a badge from a wellness app). The most autonomous form of extrinsic motivation is labeled integrated regulation, reflecting a drive to achieve external outcomes that are internalized and assimilated to one's self (e.g., walking because staying healthy is an integral and meaningful part of one's identity). The motivation in the latter case is still extrinsic, as it is driven by the instrumental value of some outcome that is separate from the behavior, but since the behavior is volitional and valued by the self, it involves less inhibition and less conflict and is, thus, likely to be more energizing and facilitate greater levels of performance, persistence, initiative, and creativity (Rigby et al., 1992; Ryan & Deci, 2000b; Spreitzer & Porath, 2014).

Overall, while psychological, educational, and healthcare literatures emphasize the role that different forms of motivation play in human behavior, neuroscience studies have almost uniformly focused on responses to extrinsic incentives such as money, food, or prizes (Murayama et al., 2010). An underlying assumption is that extrinsic and intrinsic benefits are indistinguishable in terms of signaling the value of an action (Murayama, In press; Studer & Knecht, 2016). Further, while a central feature of psychological nudging is that it does not limit the choice set (meaning that the individual can always choose alternative options), given that nudges typically seek to bypass conscious awareness, they have been criticized for undermining autonomy—more specifically, agency (Vugts et al., 2020)—which concerns the person's ability to process stimuli and not simply react passively (Hitlin & Elder Jr, 2007). While recent empirical evidence suggests that individuals experience digital (vs. human) nudges as less judgmental and therefore as more autonomous (Raveendhran & Fast, 2021), the impact of digital nudges on autonomy remains an open question. The proposed framework underscores the need for theoretical and empirical work to better explain the differential impact of intrinsic and extrinsic motivations on engagement.

Summary of the AIM-ACT Framework

The AIM-ACT framework (Figure 1) sheds new light on the process through which in-the-moment engagement unfolds in response to a digital stimulus. For simplicity, we describe how in-the-moment engagement with a stimulus (e.g., a mobile-based prompt containing a message recommending that the person take a walk) occurs to facilitate engagement with a focal task (e.g., 5-minute walk) according to this framework. Here, in-the-moment engagement with the stimulus is conceptualized as a hierarchical process that involves AIM responses. These responses are modulated by attentional (A) processes and context (C) and lead to engagement in the focal task through pathways (mediators) that facilitate the translation (T) of motivation to behavior. Consistent with the notion of simultaneous investment of heart, head, and hands (Rich et al., 2010), in-the-moment engagement with the digital stimulus involves investing affective, cognitive, and physical energies. However, whether this investment leads to engagement with the focal task depends on the extent to which an individual invests energies *in the focal task*.

Similar to engagement with the stimulus, engagement with the focal task involves a series of hierarchical affective, integrative, motivational, and behavioral responses that are shaped by attention and context. For example, walking in response to a digital stimulus (e.g., a prompt to encourage walking) can be hindered or facilitated by other stimuli and/or contextual factors. Suppose it starts raining a few minutes after John begins his walk; here, rain is a contextual stimulus that generates attentional (John notices the rain), affective (discomfort), integrative (the downsides of getting wet outweigh the benefits of walking), and motivational (an internal drive to avoid getting wet) responses, leading to a translation to behavior (John starts to walk back home). Now, suppose on his way home, John receives a prompt from his smartwatch indicating that he is close to reaching his daily step goal; here, the prompt is another digital stimulus that generates attentional (John notices the prompt), affective (excitement), integrative (the benefits of meeting his walking goal outweigh the downsides of getting wet) and motivational (an internal drive to achieve his walking goal) responses leading John to decide to continue walking despite the rain. This translation of motivation to behavior may, however, be thwarted by attention to and integration of other contextual factors (e.g., dark clouds accompanied by sounds of thunder) that lead to non-completion of the focal task of walking. Whether this series of hierarchical responses (i.e., engagement with walking) is effective or not depends on how effective engagement with the focal task is operationalized (e.g., walking 10,000 steps per day) in relation to a pre-specified distal outcome (e.g., achieving a clinically meaningful weight loss by the third month).

Limitations

AIM-ACT sheds light on the process through which in-the-moment engagement unfolds in response to an external stimulus intended to promote task completion in digital interventions. If repeated engagement with the task (e.g., walking 10,000 steps each day over the course of 30 days) is needed to achieve the distal outcome, then feedback loops across multiple in-the-moment engagement processes that facilitate effective engagement need to be considered (see Figure 1). This is because past experiences of performing a focal task involving a particular constellation of AIM-ACT elements will affect the person's memories and expectations that, in turn, influence how they engage with future stimuli or focal tasks related to the distal outcome (Hyman et al., 2006). For example, John is likely to respond more positively when he notices a digital prompt intended to encourage him to walk on Tuesday if he enjoyed his walk on the previous day. However, if he is unlikely to attend to the digital prompt due to habituation (e.g., diminishing tendency to respond to a frequently repeated stimulus; Thompson & Spencer, 1966), then a different stimulus that is more salient or novel may be needed to facilitate the engagement process. It may also be that John is too distracted by other concerns to notice the prompt but is then reminded later to go for a walk by an internal cue (e.g., remembering that he had earlier wanted to go walking) or an external cue (e.g., exposure to a digital ad showing a person walking).

Additionally, the AIM-ACT framework suggests that once a habit is formed, the digital stimulus would require less engagement to facilitate task performance. Here, a habit is defined as "a motor or cognitive routine that, once it is triggered, completes itself without conscious supervision" (Bernacer & Murillo, 2014). Since habits are guided by the stimulus itself, they do not involve value-based judgments of inputs and are not sensitive to reward devaluation or extinction (Adams & Dickinson, 1981). This means that when a behavior becomes "habitual," less cognitive effort is invested in the stimulus guiding the behavior, and thus the role of integration in the engagement process is attenuated. For example, if John ends up developing a habit of walking following a digital prompt, then walking will be initiated in response to the prompt even if John does not cognitively process the content of the prompt.

While AIM-ACT offers a useful conceptualization of engagement in digital interventions, the proposed mechanisms may not always function as specified. For instance, prior literature on the neuroscience of addiction suggests that substance (e.g., drugs, alcohol) and behavioral (e.g., gambling, video gaming) addiction may alter the mechanisms posited by AIM-ACT. Some studies have shown that affective responses to a cue associated with ones' addiction are accompanied by steep increases in NAcc activity (MacNiven et al., 2018), and that supraphysiological activation of the NAcc over time leads the brain to attach an abnormally high level of value to an addiction-related stimulus (Courtney et al., 2016). A "hijacking" metaphor suggests that addictions facilitate excessive sensitivity to reward combined with a failure of inhibition (Leshner, 1997). This metaphor includes multiple channels, such as sensitization (i.e., an amplified response to a given stimulus following repeated intermittent exposure), blunting of responses to competing cues, and disinhibition (i.e., poor impulse control) which reduces control over integration, motivation, and behavioral responses (Goldstein & Volkow, 2002). Although a comprehensive specification of how the addicted brain responds to an addiction-related stimulus still awaits future empirical inquiry, empirical evidence nonetheless suggests that the presence of an addiction-related stimulus is likely to divert the AIM-ACT mechanisms away from the pursuit of the focal task. The implications warrant consideration not only in designing digital interventions for addictions, but also in developing any digital intervention attempting to increase affective responses supported by the NAcc—such interventions must be designed carefully to avoid "hijacking" of the brain that leads to ineffective or undesirable outcomes.

Finally, while the AIM elements are grounded in empirical evidence that specifies their neural components in space and time, given the real-world nature of engagement in digital interventions, it is less clear how the spatial localization of the ACT elements should be specified. Nonetheless, we conjecture that in a real-world setting characterized by multiple competing demands, attention and context can modulate the AIM elements at any given time during the AIM process and its translation to behavior. Future research is called for to provide greater specificity about when each of the elements in the AIM-ACT framework operates in real-world settings.

Methodological Implications

Table 2 describes how each element in the AIM-ACT framework can guide the development of strategies to promote engagement in digital interventions. New experimental approaches such as the micro-randomized trial design (Qian et al., 2022) have been developed to investigate the proximal impact of various strategies for stimuli delivery in digital interventions (e.g., message timing, length and framing; see Table 2). Micro-randomized trials can be used to investigate the causal effects of digital stimuli on affective, integrative, motivational, and/or attentional responses and how they are shaped by contextual factors (Dempsey et al., 2020; Nahum-Shani, Potter, et al., 2021). However, most studies investigating the impact of strategies for delivering stimuli in digital settings have focused primarily on whether individuals performed the task and operationalized the process leading to task performance as a “black box.” Understanding the nature of an individual’s response to a digital stimulus, in terms of affect, integration, motivation, and attention is critical for deciding when and how to deliver the stimulus. For example, specific conditions (e.g., habituation) may hinder attention to a digital prompt, requiring modifications to the way the prompt is presented and sent; whereas other conditions (e.g., feeling relaxed) may facilitate the integration of self-relevant information, presenting a window of opportunity to deliver more elaborate prompts (rather than shorter but less informative ones).

However, current instruments for measuring constructs such as attention (e.g., via eye tracking technology; Armstrong & Olatunji, 2012), cognitive processing (e.g., using neuroimaging: Knutson et al., 2007) and motivation (which is dominated by self-report methodology, e.g., Donald et al., 2020) are based on lab studies and/or rely on assessment tools that are limited in their ecological validity and applicability to real-time, real-world settings (Fulmer & Frijters, 2009; Venkatraman et al., 2012). Further, despite improvements in passive data collection systems via wearable, smartphone-based, and external sensors, unobtrusive measurement of many internal (e.g., level of stress) and external (e.g., presence of other people) contextual factors remains a challenge. Hence unobtrusive measurement of the AIM-ACT elements in real-time, real-world settings represents an important scientific gap to be addressed in the development of engaging digital interventions.

Conclusion

In this paper, we propose a framework that elucidates the processes leading to in-the-moment engagement in digital interventions. This hierarchical (but not necessarily linear) process involves AIM responses, which are moderated by attentional (A) processes and context (C), and likely lead to engagement in the focal task through mediators that facilitate the translation (T) of motivation to behavior. This framework aims to provide a fruitful avenue for identifying scientific questions and generating hypotheses that can be tested to inform the development of strategies for achieving effective engagement in digital interventions.

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Public Significance Statement:

Despite the widespread view that engagement is critical to the effectiveness of digital interventions, the concept of engagement remains theoretically ill-defined which has hampered efforts to gain deeper insights about how and why people engage in digital interventions. We integrate prior findings from multiple domains to generate a clear definition of engagement. We then propose a framework to improve the understanding of engagement and to inform strategies for building effective digital interventions.

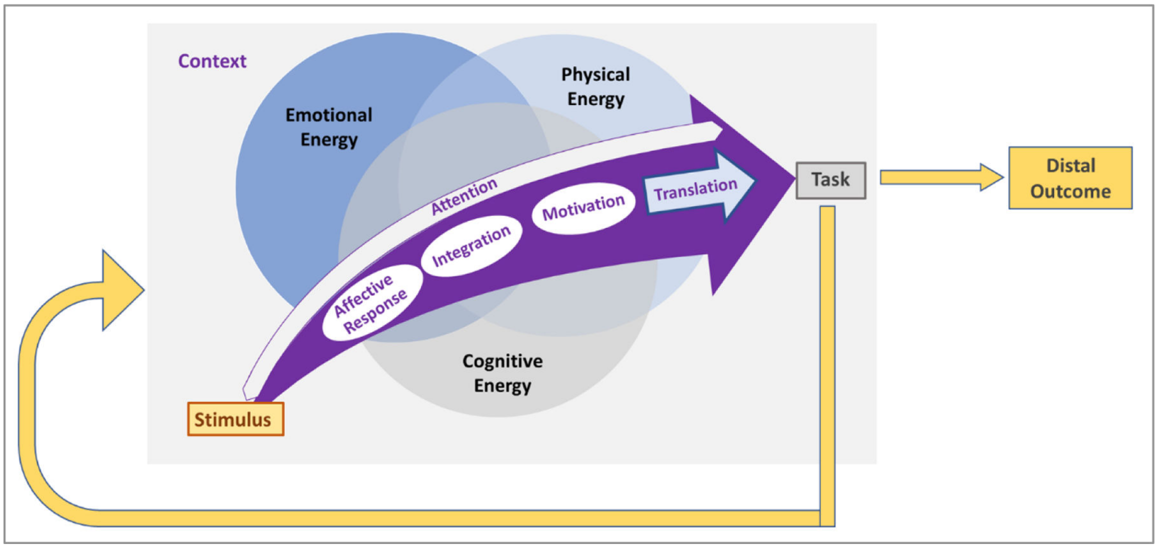

Figure 1.
AIM-ACT: Conceptual Framework of In-the-Moment Engagement in Digital Interventions

Table 1.

Comparison of Engagement to Other Related Constructs

Construct	Definition	Distinctions from Engagement	Examples focusing on a particular task: self-monitoring dietary intake via a mobile app
Engagement	A state of energy investment involving physical, affective, and cognitive energies directed toward a focal stimulus or task	N/A	An individual uses the app to self-monitor their dietary intake while making an effort to accurately record the information and appreciating the opportunity to self-reflect.
Adherence	The extent to which an individual follows the intended suggestions to complete a focal task (e.g., Bissonnette, 2008)	A person may engage in a task without following instructions.	A patient follows their doctor's instructions to self-monitor dietary intake twice per day via a mobile app for 2 weeks.
Involvement	"Cognitive or belief state of psychological identification" (Kanungo, 1982, p. 342)	(a) Engagement with a task does not require psychological identification with the task; (b) involvement is mainly a cognitive state (rather than a state of energy investment).	An individual considers self-monitoring dietary intake via the mobile app as very central to their health and well-being.
Participation	The investment of physical energy in an activity (Davis et al., 2007)	Participation does not necessarily include the investment of affective or cognitive energies.	An individual uses a mobile app to self-monitor dietary intake.
Commitment	A long-term orientation toward a course of action, including feelings of psychological attachment and intentions to persist (e.g., Meyer & Allen, 1997)	(a) Engagement in a task may not require a long-term orientation or intentions to persist; (b) Commitment primarily describes emotional attachment or intentions rather than actual investment of energies.	An individual intends to continue using a mobile app to self-monitor dietary intake in the long-term.
Motivation	An affective drive for action that leads one to approach reward or avoid punishment (Kahn, 1990)	Captures an individual's drive (the reason for engagement) rather than the investment of energy.	An individual experiences an internal drive to self-monitor dietary intake via the app because they appreciate the benefits of doing so.
Flow	A high degree of concentration and interest in an activity (e.g., Csikszentmihalyi, 2020)	Represents a unique 'peak' in cognitive absorption.	An individual is highly concentrated on self-monitoring dietary intake via the mobile app.
Persistence	Continued adherence (e.g., Clowes et al., 2004) or continued investment of effort in a task despite obstacles or difficulty (e.g., Howard & Crayne, 2019)	Persistence primarily describes continued investment of cognitive or physical (rather than affective) energies in a task.	An individual makes continued attempts to self-monitor dietary intake via the mobile app.

Table 2:

How AIM-ACT Can Guide the Development of Strategies to Promote Engagement in Digital Interventions

Element in AIM-ACT	Implications for the design of engaging digital interventions	Examples of considerations
Affect	Designing digital stimuli that promote positive affective response	Considering aspects such as the use of emoticons (Aldunate & González-Ibáñez, 2017; Li et al., 2019); questions (e.g., "Would you like to take a walk?") versus statements ("Time to take a walk") (Müller et al., 2016); inspirational or entertaining content (Nahum-Shani, Rabbi, et al., 2021) and focusing on benefits versus consequences (Gallagher & Updegraff, 2012)
	Developing/selecting a task that facilitates positive experiences and hence positive expectations about future performance	Selecting or designing a task that is not too complex or daunting to result in frustration, yet not too simple or easy to result in boredom (see O'Brien et al., 2020; Perone et al., 2020)
Integration	Framing the content in a way that is self-relevant to increase the subjective valuation during integration	Using the person's first name (Sahni et al., 2018); including suggestions that are most relevant to the individual (Resnicow et al., 2008); highlighting the individual's core personal values, strengths, or valued social relations (Epton et al., 2015); framing content in a way that is culturally sensitive (Yu & Shen, 2013) or self-affirming (Falk et al., 2015); using short and simple messages (Jones et al., 2004)
Motivation	Using strategies to increase the overall value of performing the task	Making salient the benefits of task performance (Mollen et al., 2017); facilitating a sense of urgency or scarcity (Cialdini, 2007)
Attention	Using strategies to increase the salience of the digital stimulus	Using delivery formats (e.g., text, voice, image, vibration, pressure) and modalities (e.g., via text message, phone call, push notification) that are most likely to capture attention to the stimulus; integrating or rotating between multiple forms of presentations and/or delivery modes rather than relying on a single type of prompt (Muench & Baumel, 2017)
Translation of Motivation to Behavior	Reducing the likelihood of barriers or constraints to task performance	Delivering a digital stimulus close to the time at which the task should be performed (Freyne et al., 2017); providing participants sufficient time to engage with the task while minimizing the likelihood of interruptions that may break the link between motivation and behavior
	Increasing autonomous motivation	Framing the content to encourage self-initiation and choice (Gillison et al., 2019; Rigby et al., 1992)
Context	Delivering digital stimuli under conditions in which the individual is likely to (a) attend to the content; (b) experience positive affective responses; (c) cognitively integrate self-relevant information; and (d) translate their motivation into actual investment of energy in the task	Considering aspects such as the time of day (Pejovic & Musolesi, 2014), phone-related features (e.g., whether the phone screen is on; Pielot, 2014), the type of task currently performed (Choi & Lee, 2019), physical activity and location (Kunzler et al., 2019), and individual differences (Muench & Baumel, 2017)