Making Physical Activity A Habit: Using Gamified Physical Activity Trackers to Sustain Behaviour

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MAKING PHYSICAL ACTIVITY A HABIT: USING GAMIFIED PHYSICAL ACTIVITY TRACKERS TO SUSTAIN BEHAVIOUR

Research in Progress

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Abstract

Gamified activity trackers are being used by millions of people to assist in changing their daily habits, increasing levels of physical activity and improving overall health and wellbeing. For such goals to be achieved, individuals need to sustain these new habits over time. While existing research has demonstrated that these devices can be effective in changing behaviour in the short term, little is known about their ability to aid in transitioning behavioural change into ongoing habit. This research-in-progress study is exploratory and studies how the use of gamified activity trackers may help in creating sustainable behavioural changes associated with physical activity. Employing the repertory grid technique, we interviewed 15 activity tracker users to explore the barriers to sustained exercise habits as well as the capability of activity trackers to produce long-term sustainable behavioural changes. The preliminary findings revealed gamified activity trackers were effective in temporarily increasing exercise behaviour, however they failed to address key habit-forming requirements (that of association development and context stability).

Keywords: Habit, Physical Activity, Wearables, e-Health, Activity Trackers, Sustained Behaviour, Qualitative Research

1 Introduction

Physical inactivity and sedentary behaviour remain prevalent issues in society, recognized by many researchers and experts as requiring urgent attention (Lee et al., 2012; Levine 2014; MacVean 2015; Starrett and Cordoza 2016). Lifestyles have become highly sedentary in nature (Lavie et al., 2019), with behaviours such as watching tv or scrolling through social media for extended periods of time whilst in a seated position becoming habitual for many (Conroy et al., 2013, Rhodes et al., 2012, Lepp et al., 2013). Unsurprisingly, physical inactivity has been identified as the fourth biggest preventable killer, causing 3.2 million deaths annually (World Health Organization, 2016). Both physical inactivity and sedentary behaviour heighten the risk of heart disease, diabetes, metabolic syndrome and orthopaedic problems (Levine 2014; Starrett and Cordoza 2016).

Activity trackers have become increasingly popular as a wearable health tool, providing individuals with personalized activity tracking and reporting functionalities (Alabi and Coady 2014) such as ‘steps taken’ or ‘calories burnt’ to earn badges, progressing through a leaderboard or point progression features (Nicholson, 2015). Such features often seek to provide motivation to users through introducing a reward-based system (Hamari et al., 2014) in combination with an induced competitive environment, such as...
with the use of leaderboards (Alsawaier, 2018). Gamified activity trackers, such as Fitbit and Strava, have become increasingly popular due to their effectiveness in motivating a change in behaviour (Koivisto and Hamari, 2019; Nicholson, 2015). However, the greatest health benefits from physical activity arise from sustaining healthy physical activity behaviour in the long term (Kyu et al., 2016). Consequently, the formation of exercise habits has become a subject of growing interest in the field of health psychology (e.g., Rothman et al., 2009). This study used McGuire’s information processing model (McGuire, 1972) and Gardner and Lally’s habit determinants model (Gardner and Lally, 2018) as a theoretical foundation, outlining the transition of a behavioural change into a habit. Habitual activities have been observed to persist even when motivation wanes (Rothman et al., 2009), leading to calls for habit formation as an intervention objective to support long-term maintenance of exercise behaviours (Rothman et al., 2009; Gardner and Lally, 2018).

Existing literature has focused on the short-term-oriented capability of gamified activity trackers in producing behavioural changes and motivational affordances (e.g. Chen et al., 2015, Hamari and Koivisto, 2013; Nicholson, 2015). However, relatively little is known about the use of activity trackers to transform a change in behaviour into a sustainable habitual form of physical activity. Consequently, a research gap exists in understanding the development of sustainable long-term exercise habits through the support of gamified activity trackers. This research gap’s significance is echoed by Ellingson et al. (2019), emphasising the need for further research into the long-term effectiveness of gamified activity trackers. As a result of the opportunity presented by gamified activity trackers and the limited literature focused on transforming a behavioural change into sustainable habitual behaviour, there is potential for expanding research in this area. The objective of this research is to explore how gamified activity trackers may help in creating sustainable behavioural changes associated with physical activity.

The paper is structured as follows: We first introduce the concept of habit, its development and application, as well as the barriers that may inhibit sustainable behavioural changes in individuals. Next, we highlight the potential of gamified activity trackers to change behaviours into sustainable habitual forms of physical activity. We then present the research design, providing details of the study and data collection techniques employed. An overview of the interview process and preliminary analysis is then presented, followed by an overview of our preliminary findings. The paper concludes by briefly discussing future work and potential implications.

## 2 Habitual Behaviour and Habit Formation

Habitual behaviour was previously considered an outcome of performing a task frequently (e.g. Sutton, 1994), however this perspective failed to take into consideration the influence of environmental triggers and the need for a stable context (Lingawi et al., 2016; Gardner, 2015; Orbell and Verplanken, 2010). Behavioural theorists have also highlighted a certain degree of unawareness and autonomy associated with habitual behaviour (Ouellette and Wood, 1998; Verplanken and Wood, 2006). The ‘automatic’ nature of a habit is associated with the behavioural concept ‘automaticity’, which has the characteristics of efficiency, lack of awareness, unintentionality and uncontrollability (Lally et al., 2010). However, recent research has also challenged the ‘automatic’ nature of habitual behaviour, highlighting habit as an impulse rather than an automatically executed behaviour (Gardner and Lally, 2018). Habitual behaviour is almost automatic; however, it can be impeded with sufficient self-regulatory resources (willpower) (Wood and Neal, 2007). Therefore, habit can be understood as the automatic impulse to execute an action, rather than the execution itself being automatic. Consequently, a more robust interpretation of habit is ‘a process by which a stimulus automatically generates an impulse towards action, based on learned stimulus-response associations’ (Gardner, 2015 pg. 280). This interpretation remains consistent with prior definitions by capturing cue-dependence, automaticity and conditioned stimulus-response associations (Lally et al., 2010; Rothman et al., 2009; Orbell and Verplanken, 2010), however adding the generation of an ‘impulse’ to indicate the execution as being somewhat controllable. Impulses can then be defined as high-level schematic portrayals of action which, if insufficiently opposed, trigger the execution of said action (Michie et al., 2013).
Habits are developed through repetition of behaviours in a stable context with the presence of salient cues (Gardner, 2015; Gardner et al., 2016; Wood and Neal, 2007; Verplanken and Orbell, 2003). Existing literature emphasises that to create habitual behaviour, associative memory must be developed through consciously attaching a salient environmental cue to an action (Gardner and Lally, 2018; Verplanken and Aarts, 1999). A variety of cues or stimuli can be associated with a response, such as physical environments, people or preceding actions (Wood and Rünger, 2016; Wood and Neal, 2007). For instance, this could take the form of attaching the sight of an exercise partner (cue) at the park (context) to the action of running (response). By repeatedly executing this cue-response association within a stable context, the individual is effectively building their associative memory and developing a degree of automaticity (Gardner and Lally, 2018).

Goals are necessary to develop habitual behaviour, however goals themselves are understood to be relied upon less or completely absent once the habit is formed (Wood and Rünger, 2016; Wood and Neal, 2007). A goal as understood here can be defined as a desired end-state. To capture information processing within a change in behaviour and its transition into a habit, this study utilises McGuire’s information processing model (McGuire, 1972), combined with later modifications (Scholten, 1996), as the theoretical foundation. Figure 1 illustrates the adapted form of this model.

![Habit Formation Framework](image)

**Figure 1. Habit Formation Framework (Adapted from McGuire, 1972 and Scholten, 1996)**

The processing model underlines three core components to behavioural change: 1) awareness, 2) attitude change, and 3) behavioural change (Scholten, 1996; McGuire, 1972). The awareness component focuses on informing an individual of the need to develop a goal for a behavioural change (Scholten, 1996; McGuire, 1972). Attitude change targets the alteration or development of an attitude to support the formation of a goal (Scholten, 1996; McGuire, 1972). These two elements function to produce a goal or intention to act, for instance the intention to go for a run. An intention then progresses into a behavioural change with sufficient motivation to function as an action initiator. Moving forward, we extend McGuire’s information process model to produce a more extensive theoretical foundation by capturing habit formation through integrating Gardner and Lally’s habit determinants model (Gardner and Lally, 2018). This adds two additional elements: 1) changed behaviour must be repeated in a stable context, and 2) consciously attaching a salient cue to the changed behaviour. Figure 1 also highlights that execution of a changed behaviour (Stage 3) and repeating a behaviour (Stage 4a) can influence an individual’s attitude towards a particular task. Consequently, this feedback loop plays a part in whether the intention to perform the activity again is replicated, which is a core requirement to strengthening cue-behaviour associations (Stage 4b) (Gardner and Lally, 2018; Gardner and Rebar, 2019; Verplanken and Aarts, 1999).

Next, we consider opposing views in literature regarding whether physical activity can become completely habitual. For instance, some argue that only low-level motor patterns can truly become habitual (e.g., Egbert and Barandiaran, 2014), suggesting that activities such as changing gears in a car can become a habit, whereas the complex and variable sequence of steps within physical activity is unable to reach a state of habit (Graybiel, 2008). The mechanical notion of a habit has been challenged by recent literature, where a study accounts for task complexity through a two-pronged approach,
suggested that complex behaviours can be habitually initiated, habitually performed, or both (Gardner and Rebar, 2019; Gardner, 2015). This view suggests the initiation of physical activity (e.g. going to the gym) can be triggered unconsciously by a contextual stimulus, however it requires the individual to put conscious thought into the activities performed thereafter (i.e. exercises performed in the gym). A potential scenario which focuses on habitual performance is rowing, where the motion of the oar, being a motor pattern, can become a habit. However, beginning the behaviour, i.e. taking the boat to the river, may require conscious triggering rather than the ‘unawareness’ associated with habit, therefore suggesting that in the overall act of exercise different sub-behaviours (initiation and performance) can become habitual. Applying these views back to Figure 1, we consider that for complex habits, the intention formation or action initiation stages can separately become habitual. Task complexity influences the time it takes for a behaviour to become habitual. Early habit literature saw the formation of habits as a linear process, in which repeating a behaviour would consistently grow an individual’s habit strength (cue-response association memory) (e.g. Verplanken and Aarts, 1999; Ronis et al., 1989). Experiments conducted by Lally et al. (2010) indicated that the largest gains in habit formation are seen in earlier repetitions in behaviour, eventually reaching a plateau where further repetitions in behaviour do not contribute to habit strength, revealing that individuals have an inherent limit to the degree of automaticity that can be achieved with behaviours, including exercise.

2.1 Physical Activity Barriers and Competing Habits

Both environmental and individual related factors influence the long-term maintenance of physical activity behaviours (Salmon et al., 2003; Humpel et al., 2002). A key message presented by the literature is that for individuals to realise these benefits, increased levels of physical activity must be sustained in the long term (Kyu et al., 2016, Franco et al., 2005; Lakka and Laaksonen, 2007; Pratt et al., 2000). To develop effective interventions, factors that influence physical activity behaviour must first be identified (Humpel et al., 2002). The literature proposes that a lack of social support, loss of value and expected outcomes that are not realised all function as key barriers to maintaining physical activity (Biddle et al., 2005; Sallis et al., 2000; Van Der Horst et al., 2007). These factors are essential to consider within habit development as they collectively are suggested to result in a motivation ‘failure’, leading to the reduction of ongoing exercise behavioural potential (Bauman et al., 2012).

Sedentary habitual behaviours function as a competing behavioural impulse, increasing the difficulty of exercise habit formation (Wood and Rünger, 2016; Lavie et al., 2019). Literature has suggested that individuals are likely to execute habitual behaviour even when it goes against their intentions (Wood and Rünger, 2016; Gardner and Lally, 2018; Gardner, 2012). This proposes the idea that even if an individual has the intention to perform physical activity, habitual sedentary behaviour can apply an opposing behavioural impulse on the individual. Consequently, physical activity fails to progress through intention formation (Stages 1 and 2 in Figure 1) to action initiation (Stage 3 in Figure 1) (Jager, 2003). Therefore, if the competing inactivity habits are not addressed, then the effectiveness of habit formation will likely be reduced (Gardner, 2015; Stawarz et al., 2015). Consequently, in contexts where opposing habits exist, habit formation interventions must not solely focus on habit formation, but rather aim to achieve habit substitution (Gardner and Lally, 2018). Replacing an unwanted behaviour with a desired alternative is more effective than focusing on solely inhibiting a behaviour (Holland et al., 2006, Adriaanse et al., 2011).

Competing habits can be dissolved through removing the environmental cue-response trigger or utilising self-regulatory resources (willpower) (Wood and Neal, 2007). Research suggests that an individual must first identify the cue which triggers their inactivity habits through self-monitoring the settings in which the behaviour occurs; this concept is known as ‘cue monitoring’ (Verhoeven et al., 2014). Removing these triggers could prevent habitual activity (Gardner, 2015; Neal et al., 2012), however practically the triggers may be unavoidable. Therefore, an alternative suggested by research is to rely on self-regulatory resources (willpower) and inhibit the impulse to perform an action generated from a habit (Wood and Neal, 2007). However, an individual’s self-regulatory resources are finite and varied (Muraven and Baumeister, 2000; Hermsen et al., 2016). Self-regulatory resources deplete as an individual effortfully
impedes or overrides emotions, thoughts and behaviours (Vohs et al., 2005, Tice et al., 1995). Studies have experimented with forming ‘implementation intentions’ to overwrite habit associations (e.g., Webb et al., 2009; Tam et al., 2010). This is where an individual will form intentions by planning ahead of time a highly specific action when experiencing a specific scenario (Gollwitzer, 1999). The theory here is that if goals are set with a high degree of detail in the behaviour and context, then it’s more likely that the action attached to the intention will be executed (Locke and Latham, 1990). Practical implementations have conflicting results regarding the effectiveness of forming implementation intentions to enhance self-regulatory capabilities of individuals. Activity trackers showcase significant potential by offering accurate and ambient self-monitoring capabilities, which can be used to provide the user with personalised feedback and cue trigger awareness (Kari et al., 2016). A study conducted by Gardner et al. (2010) on self-monitoring activity tracking interventions revealed that it’s theoretically feasible in causing a behaviour change. Although the literature has begun to explore the substitution of competing habits, further research is required in identifying effective and practical self-regulatory strategies (Gardner and Lally, 2018).

### 2.2 Gamified Activity Trackers

ICT can aid in overcoming both environmental and individual barriers to physical activity (Nicholson, 2015; Hamari and Koivisto, 2013; Kari et al., 2016). In particular, there has been an influx of fitness-related apps and activity trackers in the last decade (Ellingson et al., 2019, Eriksson et al., 2017). Activity trackers are an aggregation of sensors which collect health-related data about the wearer, such as heart rate, steps walked, and time spent exercising (Henriksen et al., 2018). Examples include a wearable device, such as a Fitbit, or direct recording of data through an individual’s mobile phone (Ellingson et al., 2019). Activity trackers aim to provide a degree of trackability with fulfilling users’ health goals (Eriksson et al., 2017). However, historically trackers have seen a discontinuance of a behaviour as a commonly experienced issue (Fritz et al., 2014; Henriksen et al., 2018; Lunney et al., 2016). Consequently, activity trackers have been integrated with a layer of gamified elements to enhance the motivational capabilities (Lunney et al., 2016). The most common game design elements are badges, leaderboards, achievements and points (BLAP) (Nicholson, 2012), however the variety in features has been seen to grow as gamification has matured (Koivisto and Hamari, 2019). Gamification seeks to increase motivation and engagement in various non-game contexts, such as education, work and healthcare, where traditionally gaming is not present (Walz and Deterding, 2015). Gamified activity trackers have also gained significant attraction due to their effectiveness in inducing behavioural changes (Schoeppe et al., 2016). Consequently, these trackers have showcased their direct effect upon Stages 1 – 3 of Figure 1, being able to alter one’s attitude, awareness and motivation to initiate a behaviour. However, the literature is scarce in terms of how gamified activity trackers can maintain long-term behavioural changes in the form of habitual physical activity (Greaves et al., 2011; Hagger, 2019).

Research highlights that eliminating the ‘unawareness’ attached to habitual behaviour can disrupt a habit, resulting in a behaviour change (Hermsen et al., 2016). This requires self-monitoring, defined as a process where an individual records occurrences of desired behaviour (Nelson and Hayes, 1981), introducing a high degree of awareness (Stage 1 Figure 1) (Quinn et al., 2010). However, studies have indicated self-monitoring is not sustainable due to the amount of cognitive effort it requires (Verhoeven et al., 2014; Kwansnicka et al., 2017). However, with an activity tracker’s ambient self-monitoring capabilities, it can be used to provide the user with personalised feedback (Hamari et al., 2014). Although the habit formation and substitution literature capture several theoretical explanations, limited literature exists on capturing practical interventions to aid these behavioural phenomena. Research on gamified activity trackers has highlighted their effectiveness in altering behaviour (Koivisto and Hamari, 2019; Kwansnicka et al., 2017), however studies on the development of long-term technologically-intervened habitual behaviour are limited. With long-term behaviour adoption being crucial within the context of physical activity, the potential of gamified activity trackers in creating sustainable habitual exercise behaviour remains unknown.
3 Research Design

The objective of this RIP study is to explore how gamified activity trackers may help create sustainable behavioural changes associated with physical activity. The research objective is operationalised into the following research questions:

RQ1: What factors result in exercise behaviours not being sustained?

RQ2: What habit-limiting factors can gamified activity trackers overcome to assist in the development of sustainable behaviour?

RQ3: How do gamified activity trackers overcome habit-limiting factors to assist in developing exercise habit?

The first research question aims to identify the initial barriers that prevent individuals from sustaining an exercise behaviour. This research question aims to confirm previous findings of barriers to sustainable physical activity. Additional insights may also be identified as to what factors inhibit a change in physical activity behaviour from becoming habitual. The second research question focuses on identifying which barriers gamified activity trackers were able to assist in overcoming to produce habitual physical activity behaviour. This provides the researcher with insight into the attitudes and actions associated with varying gamified activity tracker elements. Finally, the third research question aims to explain how gamified activity trackers can overcome physical activity sustainability barriers and produce habitual behaviour. Through splitting the objective into research questions to focus on first identifying the physical activity barriers (RQ1), then capturing which gamified activity trackers can overcome them (RQ2) and finally explaining how they are overcome, the study can explore the use of gamified activity trackers in producing sustainable physical activity behavioural change.

3.1 Interview and Data Analysis Process

This study employed a semi-structured repertory grid interview technique (RGT) for data collection. RGT allows individuals to describe their experience within an environment (Kelly 2005) and how they think about phenomena (Tan and Hunter 2002). As such, RGT enables exploration of an individual’s attitudes and actions and perceived attitudes and actions of others. RGT is an effective qualitative technique utilised to identify the personal constructs that can be attributed to sustaining and decaying physical activity behaviour. Online interviews were conducted over a period of eight weeks, targeting individuals (18-25 years of age) that currently use, or have used, a gamified activity tracker for health purposes. The trackers that were used were: Fitbit watch (4 users), Apple Watch (4 users), Samsung Health app (1 user), Runkeeper app (1 user), Strava app (3 users), Nintendo Switch Ring Fit (1 user) and MyZone belt (1 user). To date, 15 interviews have been conducted and transcribed (18 hours in total). Prior RGT studies recommend that 15 – 25 interviews are sufficient in reaching construct saturation (Curtis et al. 2008).

As part of the RGT interview process, each interview resulted in the creation of an individual’s Rep Grid, detailing the constructs and elements related to participants’ experiences with sustaining physical activity through gamified activity trackers. An RGT approach differs from other qualitative interviews, as the Rep Grid provides structure and ensures the conversation remains highly relevant to the research objective. Through this process, participants were asked to select elements based on their own experiences; this is referred to as element elicitation (Tan and Hunter, 2002). Participants generated elements that are distinct features of their gamified activity tracker, which supported exercise. Once the elements were elicited, the participant and interviewer reviewed them to ensure they were homogenous and discrete in nature. After element selection concluded, construct elicitation began, for which triadic elicitation was used as the selected method (Curtis et al., 2008). To clarify, three elements (tracker features) were selected, and the participant discussed how two of the elements were similar, yet different from the third within the context of developing sustainable exercise behaviours. This question focuses the thinking of the participant within the provided context and enables them to generate their personal construct. The objective is to identify a bipolar distinction between the three elements, which can then be recorded as a construct (Tan and Hunter, 2002). If a response from the participant failed to initially
produce a bipolar construct, ladderning was used to gain further detail. The initial triadic elicitation question asked to participants was: “What are two features that are the same but different from a third feature with respect to producing sustainable exercise behaviour?”. In addition, Self-Report Habit Index (SRHI) surveys were utilised as quantitative data to further support the existence of habitual behaviour. The data gathered from the interview process was transcribed and imported into NVivo for analysis. NVivo is currently being used to assist with the analysis process as it allows passages of text from the Rep Grid interviews to be identified, connected to a concept or idea (represented by a node) and easily compared or connected with other concepts and ideas (Gibbs 2002), facilitating open and axial coding, memoing and advanced querying of the interview data.

4 Preliminary Findings

Preliminary data analysis identified 92 individual elements and 99 bipolar constructs elicited by 15 Rep Grid interviews. Examples of these include: ‘Makes health maintenance easier’, ‘Attitude Improvement’ and ‘Performance Accumulation’. Early analysis suggests that gamified activity trackers typically fail to explicitly support all key requirements for developing habitual exercise behaviour, however they still aid in overcoming multiple exercise sustainability barriers.

In response to research question one, preliminary analysis has highlighted a variety of barriers to sustained exercise goals, ranging from self-identified ‘laziness’, social reliance, delayed value return, lack of enjoyment, poor scheduling, goal formation difficulty, and other demotivators. The presence of unmanaged sedentary habits produces a sense of ‘laziness’ among participants, functioning as an opposing force to exercise repetition. Reflecting upon the habit formation framework (Figure 1), laziness is a hindrance to habit development in Stage 4a, being repetition of behaviour within a stable context. Individuals began using terminology such as ‘automatically’, ‘instinctively’ and ‘muscle memory’ to describe the sedentary behaviours they’d perform when feeling ‘lazy’. With these descriptions and the SRHI questions targeting sedentary behaviour, the data points towards the presence of sedentary habits. The existence of sedentary habits is further reinforced by the ease of habitual sedentary behaviour formation, as it is repeated in a highly stable context (Stage 4a of Figure 1) and produces associations with behavioural triggers (Stage 4b of Figure 1), such as phones or TVs. In addition, repeatedly using social support for motivation was revealed to encourage a state of social reliance, where the unreliability of the motivation source is detrimental to long-term exercise sustainability.

In response to research question two, our initial analysis indicates that laziness in the form of sedentary habits has been reduced through highly achievable notification goals. To explain how (RQ3), the notification initially breaks the unconsciousness associated with sedentary habits (e.g., losing track of time watching the television). The notification goal must serve a dual function in providing awareness (“you’ve been sitting for an hour”), and an achievable objective (“go for a minute walk”). The importance lies in the suggested objective being achievable, therefore encouraging the individual to both form an intention (Stage 1 and 2 of Figure 1) and motivate the initiation of a behaviour (Stage 3). Thus, achievable notification goals aid in reducing sedentary habits, which are detrimental to the formation of healthy exercise habits. Another initial finding was the need for gamified activity trackers to focus on producing a self-improvement attitude, instead of fuelling a highly social form of motivation, which results in social motivation reliance. For instance, social forms of motivation, such as training with an external party to initiate physical activity. Instead, gamified activity trackers can produce a self-improvement attitude by continually comparing the user’s own performance rather than with others. For some, the resulting self-improvement attitude is significantly more sustainable than being continuously compared to or reliant on external parties. The self-improvement attitude is further enhanced with positive reinforcement through celebratory messages or animations, such as those seen in Apple Watch through fireworks and haptic vibrations.

Ultimately, from a habit development perspective, the gamified activity trackers were seen to explicitly contribute to behavioural repetition, reflecting Stages 1 – 3 of the habit formation framework (Figure 1). However, they fail to address barriers that were associated with stabilising context and developing a
cuez-behaviour association (Stages 4a & 4b Figure 1). In the cases where exercise habits were formed, the habit formation requirements that were not directly supported through trackers were fulfilled through indirect effects of the gamified activity trackers and personal user traits. Consequently, these preliminary findings suggest that gamified activity trackers are currently unsuitable for reliably producing habitual exercise behaviours.

5 Future Work and Implications

The completed research study will explore how gamified activity trackers may help in creating sustainable behavioural changes associated with physical activity. The research will have practical implications as the analysis has already captured some of the pitfalls of gamified activity trackers in developing habitual exercise behaviour. For instance, gamified activity trackers were shown to be highly focused on motivating behaviour repetition, however they failed to address the remaining habit-forming determinants such as producing a stable performance context and developing a cue-behaviour association. Interviewees also had a particular perception of habit formation, seeing it as something that only resulted as a product of activity repetition. A suggestion to overcome this pitfall would be to provide users with greater awareness of how to form habits, emphasising the need to explicitly focus on all three elements to successfully form exercise habits. Increased awareness could be achieved through having ‘did you know’-style notifications, targeted at informing users about habit formation mechanics. When users understand the required determinants to form habits, they can make more of a conscious effort to fulfill them. The study will also provide additional insights into various barriers experienced by users in sustaining their engagement, such as the need to address competing habits and how social forms of motivation could transition into being socially reliant. The findings from the completed study may be of value to practitioners, such as gamified activity tracker developers seeking to build apps to facilitate sustainable behavioural change in users. Our preliminary analysis also brings into question prior ideas of gamified activity trackers only being effective/sustainable in the short term by posing theoretical contributions explaining how the gamified activity trackers were insufficient in overcoming the barriers to forming sustainable exercise habits. Furthermore, it documents the significance and impact of competing habitual inactivity and additional exercise sustainability barriers. Moreover, the study presents a behavioural model as a theoretical contribution, showcasing the transition from a change in behaviour to the formation of a habit. This behavioural framework is applied within the context of altering physical inactivity, and then producing a state of habitual exercise behaviour. To conclude, this study was exploratory in nature, however future studies should empirically examine the effectiveness of gamified activity trackers that have been explicitly designed to meet the habit formation determinants. Ultimately, the design of a gamified activity tracker intervention should consider addressing ingrained sedentary habits and aim to produce habits rather than purely behavioural repetition.
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