PERSONAL FITNESS TRAINER: THE EFFECT OF FEEDBACK PRESENTATION FORMATS

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Abstract

This paper explores the effect of feedback presentation formats in mobile fitness apps. Drawing from computers are social actors (CASA) paradigm, cognitive load theory (CLT), and social presence literature in this study, we conceptualize that when a user is involved in different types of exercise (aerobic or anaerobic) the exposure to more humanized feedback can create differential influence in user’s cognitive load and user engagement. This differential influence subsequently affects the fitness performance of the user. This conceptualization will be validated through an experiment. The outcomes of this study can help fitness app developers to design effective fitness apps. Similarly the findings can assist users in choosing the most appropriate fitness app that can enhance their fitness.

Keywords: Fitness apps, Feedback presentation, humanized feedback, Computers are social actors (CASA), Cognitive load.
1 INTRODUCTION

Smartphone industry has experienced an exponential growth in the recent past. These smart devices run third party software applications called mobile apps, which provide us with various functionalities beyond just making calls. Mobile apps not only allow us to play games, check email, and watch movies but also help us to lead a healthy lifestyle. These health and fitness apps have a great potential to assist us in leading a healthy lifestyle as they are versatile and are always with us at our fingertips. Latest health and fitness apps are built-in with various functionalities such as GPS technology (e.g. RunKeeper, MapMyRun), calorie calculator (e.g. MyFitnessPal, Fitbit) and heart rate monitor (e.g. Instant Heart Rate) to assist users in grasping fine grained details of activity. At the same time these apps employ various techniques such as exergames or gamification (e.g. Zombies Run, Walkathon + Fitness Games), music (e.g. PaceDJ – Syn Your Running Pace With Your Music!), social networking (e.g. Fitocracy), customization (e.g. mywellness) and reward system (e.g. RunKeeper) to motivate greater physical activity performance. In addition, fitness apps support various kinds of physical activity types such as running (e.g. RunKeeper, Edomondo, Map My Run), jogging (e.g. iRunner), walking (e.g. Map My Walk+), bicycling (e.g. Map My Ride, Wahoo Fitness), weight lifting (e.g. Gym Training) and pushups (e.g. Hundred Pushups). As of February 2014 there are more than 40,000 health and fitness apps available for consumers in major app stores.

Despite the growing demand for mobile apps in healthcare, research related to mobile apps is limited (Yoganathan & Kajanan, 2013). Therefore it is important to study mobile app design factors that can enhance the health and wellbeing of individuals.

Prior literature on physical activity have revealed that self-monitoring (Lin et al., 2006; Tsai et al., 2007; Consolvo, McDonald, et al., 2008; Mattila et al., 2008), music (Oliver & Flores-Mangas, 2006), exergames or gamification (Fujiki et al., 2007), competition (Connelly et al., 2006; Lin et al., 2006), social support (Gasser et al., 2006; Consolvo, Klasnja, et al., 2008; Ahtinen et al., 2009), reminders (Lee et al., 2006), sharing performance with friends (e.g. Houston (Consolvo et al., 2006)) and stylized displays such as virtual pet (e.g. fish N’ steps (Lin et al., 2006)) and garden metaphor (Consolvo, McDonald, et al., 2008) can enhance the physical activity behaviour of individuals. However, design of feedback mechanism has not yet been examined.

Therefore in this study, we investigate on the design of feedback mechanism in fitness apps. Prior research suggest that providing timely and appropriate feedback important as it can motivate individuals and reinforce the exercise behaviour (Dubbert et al., 1984). Thus, the manner in which feedback is presented to the user can greatly influence the exercise outcomes.

Studies related to human computer interaction indicate that humans react to computers as “social actors” (Nass et al., 1994; Reeves & Nass, 1996; Nass & Moon, 2000). Therefore, feedbacks with higher social presence (i.e. more social cues) can elicit greater user engagement as they would satisfy human’s tendency to be social (Tung & Deng, 2006). However, for certain types of exercises (e.g. strength training), a more humanized feedback would produce less performance and more fatigue (Rube N, Secher NH, 1980; Rube & Secher, 1981). Therefore, this research aims to understand when it is suitable to provide a more humanized (i.e. high social presence) feedback? And the underlying mechanism through which social presence in fitness app feedback influences an individual’s exercise behaviour. More precisely, our research question is “How and when social presence in fitness app feedback enhances physical activity behaviour of users?” Drawing on computer are social actors (CASA) paradigm (Nass et al., 1994; Reeves & Nass, 1996; Nass & Moon, 2000), cognitive load theory (Sweller et al., 1998; Paas et al., 2003) and social presence literature (Short et al., 1976; Hess et al., 2009; Horvath & Lombard, 2010), in this study we conceptualize that when a user is involved in

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different types of exercise, the exposure to more humanized feedback can create differential influence in user’s cognitive load and user engagement. This differential influence subsequently affects the fitness performance of the user. The outcomes of this study can help fitness app developers to design effective fitness apps. Similarly the findings can also assist app users in choosing the most appropriate fitness app that can enhance their fitness.

The structure of the paper is as follows. In the immediately following section, we explain the theoretical background and research model. After which we provide the research design, followed by a discussion of potential implication for research and theory.

2 THEORETICAL BACKGROUND AND RESEARCH MODEL

In order to understand how and when feedback presentation with social presence facilitates greater exercise behaviour, we draw literature from computer are social actors (CASA) paradigm (Nass et al., 1994; Reeves & Nass, 1996; Nass & Moon, 2000), cognitive load theory (Sweller et al., 1998; Paas et al., 2003) and social presence literature (Short et al., 1976; Hess et al., 2009; Horvath & Lombard, 2010). We conceptualize that social presence influences physical activity behaviour through user engagement (i.e. affective element) and cognitive load (i.e. user’s working memory). This influence is moderated by the type of physical activity user is performing (see figure 1). The following sections describe conceptual model in detail.

2.1 Social Presence

Short et al (Short et al., 1976) coined the term “social presence” to describe the degree of awareness of the other person in the communication media (Short et al., 1976) i.e. degree to which the receiver perceives the other person as a “real person”. Social presence is high, when the interaction is close to face-to-face interaction or human interaction. Social presence has also been conceptualized as “user’s feeling or perception of being connected with another intellectual entity” (Tu & McIsaac, 2002), feeling of warmth, sociability, intimacy, immediacy (Nass & Moon, 2000) or perception of human contact (Kumar & Benbasat, 2006; Hess et al., 2009). Thus, a user’s perception of social presence or feeling of interacting with a social being can invoke social and emotional reactions such as high involvement and motivation in the user (Lombard & Ditton, 1997; Witmer & Singer, 1998; Nass & Moon, 2000).

Several prior studies reveal that human-computer interactions or relationships are basically social, hence humans respond to computer as real people or “social actors”(i.e. elicit social behaviours such as politeness while interacting with computers) (Nass et al., 1994; Nass & Moon, 2000; Kumar & Benbasat, 2006). The computers are social actors (CASA) paradigm (Nass et al., 1994, 1995; Nass & Moon, 2000) emphasize that people characterize computers as humans or social actors, when computers display sufficient social cues. As smartphones are handheld computers, we define social presence in fitness app feedback as “the degree to which a user perceives the feedback from fitness app, as if a feedback received from a social actor”. The CASA literature provides four characteristics for social actors (Nass et al., 1994, 1995; Reeves & Nass, 1996; Nass & Moon, 2000). The first important characteristic is the language use. A language spoken in a natural manner similar to a human is considered to be more social than other forms of languages(Winograd & Flores, 1986). For example natural language style phrases such as “Come on guys!”, “Let’s do it!” can convey more social cues than formal language styles. The second, characteristic is human sounding speech. An entity that demonstrate a human sounding speech (i.e. human voice) will be perceived as a social actor, because speech is human’s unique capability and human sounding speech is differently processed by human brain than other sounds(Moore & Moore, 2003). The third characteristic is interactivity, i.e. the extent to which the entity incorporates prior inputs (Rafaeli, 1990). Fourth characteristic is social roles, computers that fulfill the social roles, traditionally filled by humans are perceived as social actors (e.g. caregiver, doctor, coach), because individuals are defined or identified by the set of behaviours that are associated with their roles (Kim et al., 2013).
As fitness app fulfill the role of fitness trainer and feedback is a response to user’s fitness behaviour (interactive) out of these four characteristics we have chosen two characteristics (i.e. language use and human sounding speech) to symbolize social presence in fitness app feedback.

Language use (informal/spoken style) and human sounding speech (voice) can convey important social cues that exhibit social presence in fitness apps. E-commerce websites such as Amazon.com have already started using spoken language style to convey social presence (Gefen & Straub, 2004) (e.g., Amazon.com uses phrases like “Where’s My Stuff?” “So You’d Like To….” “Uh Oh! You don’t have any…..” in their website). Video games use informal language to motivate and engage users (Barr et al., 2007; Turgut & Irgin, 2009). Studies related e-learning reveal that the use of more spoken language has resulted in greater engagement among students than written language (Moreno & Mayer, 2000a, 2000b). Thus, we postulate that fitness app using informal spoken style language can bring in enhanced exercise performance in users. For example an informal style feedback such as “Dude!!, you have almost reached there!!, just 1 more mile to go” is more persuading than a formal style feedback such as “Workout summary: Distance remaining: 1 mile...” Similarly, a human sounding voice feedback can deliver more nonverbal cues such as modulation, pitch, tone, and pauses that cannot be communicated via visual format (Short et al., 1976). As human sounding voice is more natural and familiar to users, it can elicited greater attachment and involvement. Therefore, greater exercise performance can be anticipated.

2.2 User Engagement

Engagement, (according to the Merriam Webster dictionary) refers to “emotional involvement” or “a state of being in gear”. Engaged users generally invest more time, attention, emotional attachment and elicit desirable responses to computer interactions (Lehmann et al., 2012). O’Brien & Toms (O’Brien & Toms, 2008) conceptualized user engagement, based on user experience attributes such as positive affect, sensory appeal, endurability and interactivity. Moreover, studies related to web and mobile applications, refer engagement as intensified frequent usage of applications(Claussen et al., 2012; Lehmann et al., 2012). This study defines user engagement with fitness app as “a quality of experience that captivates, attracts and motivates users in using the fitness app with interest”. Technologies aim to humanize computer interactions, as more humanized interactions would be perceived as comfortable and easy to use by users (Sproull et al., 1996). CASA paradigm indicates that, a human-computer interaction that replicates or imitates human-human interaction with more social cues and intimacy would enable individuals to mindlessly apply social rules to computers (Nass & Moon, 2000). This kind of human-computer interaction would create feelings of warmth and sociability (Nass & Moon, 2000; Hess et al., 2009). According to social presence theory(Short et al., 1976), mere perception of non-mediation or social presence aspects such as intimacy, immediacy and social cues can stimulate feelings of anxiety, arousal, enjoyment and evoke positive social and emotional reactions in individuals (Horvath & Lombard, 2010). Therefore, users would exhibit positive emotions towards fitness apps when they perceive the feedback is from a social actor (i.e., when fitness app feedback exhibits higher social presence). These positive emotions triggered through social presence can enhance the user’s engagement towards the fitness app. Based on CASA paradigm and social presence theory we argue that if users perceive higher social presence in fitness app feedback, they are likely to be more involved with the app and would feel highly enthusiastic about using the app. Hence, we hypothesize

H1: Higher social presence in fitness app feedback will result in higher user engagement in using the app.

Studies related to fitness intervention reveal that users’ engagement with fitness interventions (i.e. website delivered, internet and email based) significantly influenced the reduction of body weight (Tate et al., 2001), increased exercise duration(Napolitano et al., 2003) and positive progress in physical activity behaviour (Marcus et al., 1992, 1998). Therefore, we postulate that high engagement with fitness app could yield positive physical activity outcomes. While users are enthusiastically
engaged with the fitness app, it is highly likely that they ignore the barriers, tiredness and difficulties associated with physical activity behaviour. In addition, the ‘flow’ experience (Csikszentmihalyi, 1975; Csikszentmihalyi & Rathunde, 1993) and involvement (Lombard & Ditton, 1997) triggered by the user engagement could stir the intrinsic motivation (Chapman, 1997) to engage in physical activity. Therefore, users would enthusiastically participate in fitness activities. The “positive feeling states” (Vealey, 2005; Hanin, 2007) or positive emotions (Vallerand & Blanchard, 2000) activated due to user engagement could maximize the physical activity performance. Therefore, we expect that higher user engagement with the fitness app will enhance the physical activity behaviour of users. Hence, we hypothesize that

\[H2: \text{Higher user engagement with fitness app will lead to better physical activity behaviour of users.}\]

### 2.3 Cognitive load

Physical activity involves several cognitive processing functions. This includes not only executive control processes such as coordination and planning but also effective processing of feedback provided during exercise and improving the exercise performance accordingly. The cognitive load theory (CLT) (Sweller, 1994; Sweller et al., 1998; Paas et al., 2003), defines cognitive load as the “total amount of mental activity executed by the working memory at a given time and this working memory is discrete and limited in capacity”. Cognitive load can have three distinctive parts: intrinsic load, germane load and extraneous load (Paas et al., 2003). Intrinsic load refers to the inherent complexity of the subject matter (Sweller et al., 1998). For example, a fitness workout that has simple steps (e.g. jogging, running) has low intrinsic load than a workout that has number of complex steps (e.g. yoga exercises) that require several elements to be handled simultaneously in working memory. Germane load refers to the effort exerted in processing new information and integrating it into existing knowledge structures (Paas et al., 2003). Thus, familiar exercises may be performed automatically without high levels of conscious effort. This phenomenon is referred to as automaticity (Clark & Mayer, 2008). Extraneous load is imposed by presentation format, which is also referred as ineffective cognitive load (Paas et al., 2003). While intrinsic load is often integral and invariant to the subject matter (Sweller, 1994), fitness app designers should target reducing the extraneous cognitive load in order to allow greater amount of mental resources to be allocated to other relevant cognitive processes that might be necessary to enhance the exercise motivation and efficiency.

Prior research suggest that extraneous cognitive load can be reduced by the effective design of presentation format (Paas et al., 2003). For example, voice presentation will usually have lower extraneous cognitive load than visual format, as voice would be processed separately by auditory channel without overloading the working memory. Besides, a humanized voice is more comfortable and familiar to individuals than a visual format, therefore less cognitive resources are required to process voice than visual information (Chalfonte et al., 1991; Roda, 2011). Similarly, prior studies indicate that information, presented in a familiar style, similar to a normal conversation would consume less cognitive processing effort than processing a formal style information (Mayer, 1984; Moreno & Mayer, 2000b; Roda, 2011). Individuals are more familiar and comfortable with the informal spoken language style than formal language style (Walther, 1992; Nass & Steuer, 1993). Hence, the cognitive load in processing the informal spoken style is lower compared to the formal written style. Since informal spoken style is more humanized, it is likely to elicit greater social presence. Therefore, a more humanized fitness app feedback with higher social presence would consume less extraneous cognitive load. Hence, we hypothesize that

\[H3: \text{Higher social presence in fitness app feedback will result in decreased cognitive load on working memory.}\]

As indicated above cognition is an important factor during physical activity. Specific cognitive processes such as attention (e.g. awareness), planning (e.g. exercise steps, route), and decision making (e.g. avoiding accidents) activities combinedly ensure safe and enduring physical activity behaviour. For example, an effective brisk walk along the street/pathway, requires more cognitive effort and
attentional resources to be allocated for the activity itself (Lindenberger et al., 2000). While cognition is essential to maintain a steady physical activity behaviour, cognitive overload can result in poor exercise behaviour. Previous studies have shown that cognitive overload could results in ineffective physical activity performance, such as taking longer than required time to complete physical activity targets (Neider et al., 2010), reduced gait speed (Verghese et al., 2002), reduced motor skills (Verghese et al., 2002), collisions and falls (Nagamatsu et al., 2011). Thus cognitive overload can jeopardize the safety of users and cause injuries during physical activity. Therefore, we argue that cognitive overload will negatively affect physical activity performance. Hence, we hypothesize that

**H4: Cognitive overload on working memory will lead to poor physical activity behaviour.**

### 2.4 Physical activity types

Physical activities can be categorized broadly into two main types as either aerobic or anaerobic based on the energy source, by products, intensity of muscular contraction and duration of the exercise (Pate et al., 1995; Haskell et al., 2007). Aerobic exercises means “with air”, in which our body utilizes oxygen to create energy for the exercise and respiratory by-products (i.e. waste products) such as CO2 and water are easily cleared from body through breathing (Pryor & Kraines, 1999). Aerobic exercises include activities such as walking, running, swimming, and bicycling. Health experts recommend a minimum 30 minutes of daily aerobic exercises (Pate et al., 1995; Haskell et al., 2007). These aerobic activities help in weight management, reduce the risk of lifestyle diseases (e.g. heart disease, type 2 diabetes) and improve physical fitness. In contrast, anaerobic exercise means “without oxygen”, in which our body creates energy without oxygen (by breaking down sugar). This anabolic metabolism produces lactic acid, which accumulates in our system and cause extreme fatigue and sometimes acute pain in muscles (Medbo et al., 1988). Anaerobic exercises include strength trainings such as weight lifting, gymnastics, body weight exercises, high intensity interval training and calisthenics such as push-ups and pull-ups. Compared to aerobic exercises, anaerobic exercises are high intensity activities that can last from 15 seconds to 2 minutes (Medbo et al., 1988). Health experts recommend 8-10 exercises in 2-3 times per week in order to build stronger muscles and reduced body fat within a short period. While individuals are involved in aerobic and anaerobic exercises, the exposure to a humanized feedback can create differential influence.

The studies conducted on anaerobic exercise (e.g. strength training) reveal that verbal encouragement has resulted in reduced exercise performance and greater pronounced fatigue compared to those who have not received verbal encouragement (Rube N, Secher NH, 1980; Rube & Secher, 1981). Researchers offer reasons as to why this happens. While, an individual is involved in an anaerobic activity, lactic acid will be accumulated in the muscles causing musculoskeletal pain and fatigue to the exerciser (Vandewalle et al., 1987). Therefore body cannot resume activity until the lactic acid is removed (Beaver et al., 1986). Providing a voice feedback at this time, seems to cause tainted psychological conditions that can directly inhibit ‘motoneurons’, a neuron responsible for conveying motor impulses (Rube & Secher, 1981). Thus the inhibition of motoneurons would degrade performance, and produce pronounced fatigue and frustration (Rube N, Secher NH, 1980). This psychological condition could create negative feeling towards the fitness app. Therefore, the positive relationship between social presence in fitness app feedback and user engagement will not be significant for anaerobic exercises. However, providing concurrent visual (e.g. electromyographic - EMG) feedback during anaerobic exercise (i.e. strength training) has not shown any negative impact on activity performance but has shown an acute enhancement in muscle strength and activation (Lucca & Recchiuti, 1983; Ekblom & Eriksson, 2012). This could be explained by the fact that since anaerobic activities are repetitive type of exercises performed for shorter duration (e.g. 30 seconds) generally in a stationary position (Haskell et al., 2007) it does not involve much cognitive processes (such as planning or decision making), thus an unobtrusive less humanized visual feedback will not consume much cognitive resources. Therefore, the negative relationship between social presences in fitness app feedback cognitive overload is less likely to have a significant impact for anaerobic type activities.
In contrast, aerobic activities are performed for longer duration (i.e. at least 30 minutes). Thus, it is highly likely that the user gets bored, feel monotony and develop negative feelings during the exercise sessions (Van der Vlist et al., 2011). Therefore, it is essential to intrinsically motivate the user, in order to complete the training session (Ryan et al., 1997; Schelling et al., 2009). Previous studies on runners have shown that verbal encouragement during treadmills and outdoor running has yielded positive outcomes (Andreacci et al., 2002) including prolonged exercise duration with improved heart rate (Moffatt et al., 1994). Therefore, verbal encouragements can positively stimulate runners. According to CASA (Nass et al., 1994; Nass & Moon, 2000) paradigm (as discussed above), providing a spoken style, friendly voice feedback (such as “Way to go”, “Come on” and “Let’s go”) can greatly enhance runner’s (or any aerobic activist’s) intrinsic motivation, involvement and engagement. Thus we argue that, fitness apps with higher social presence can distract the user from the boredom of aerobic exercises and enhance the user’s engagement with the fitness app. Similarly, since aerobic activities are performed for a longer duration, providing frequent feedbacks while user is exercising would guide the user to move forward towards the target with appropriate speed and pace (Pryor & Kraines, 1999). Since, aerobic activity itself require various attentional resources, processing a less humanized feedback will lead to cognitive overload in users. However, a more humanized feedback with higher social presence can reduce user’s cognitive load and help in effectively moving the user towards the exercise goal. Therefore, the negative relationship between social presence in fitness app feedback and cognitive overload will be stronger for aerobic type exercisers. Hence we hypothesize that

H5: Physical activity type (Aerobic/ Anaerobic) will moderate the relationship between social presence in fitness app feedback and user engagement, such that the relationship will be stronger for aerobic exercise type and insignificant for anaerobic exercise type.

H6: Physical activity type (Aerobic/ Anaerobic) will moderate the relationship between social presence in fitness app feedback and cognitive load, such that the relationship will be stronger for aerobic exercise types and insignificant for anaerobic exercise type.

Figure 1. Research Model

3 RESEARCH METHOD

A laboratory experiment will be conducted to test the hypotheses with \(2 \times 2 \times 2\) design (i.e. 2 groups of feedback presentation formats (between-subject) and 2 types of physical activity (within-subject)). The feedback presentation format will be manipulated on language style ((spoken informal vs. written formal) and modality (voice vs. visual)). The types of physical activity will be manipulated by the activity performed (1) aerobic (i.e. walking) (2) anaerobic (i.e. strength training). In addition to main study variables control variable including the complexity of the workout, user demographics such as history of using health apps, frequenting/avoiding gym will also be measured as it can affect app usage and exercise behaviour. Measures for user engagement will be adapted from several studies (Chapman, 1997; Jones, 1998; Dellarocas & Narayan, 2006; Lehmann et al., 2012). The measures for cognitive
Physical activity behaviour will be measured using mobile app with an embedded accelerometer, that can show speed and intensity of activity/body movements (Hendelman et al., 2000). Complexity of the workout will be measured by the number of steps involved. User demographics such as history of using health apps will be measured by the number and duration of fitness apps used by the user. In addition, user’s habit of frequenting, avoiding gym will also be measured. A pilot study will be conducted to refine the experimental manipulations and assess the measurement properties. At least 180 students and staff subjects will be recruited from academic faculties representing diverse backgrounds. Given the high level exposure to smartphones, fitness apps, and exercise enthusiastic, these subjects can represent ideal fitness app users. According to power analysis, 45 (180/4) subjects for each between-subject factor group can assure sufficient statistical power of 0.8, for medium effect size($f=.25$)(Cohen, 1988). Around 45 (180/4) participants will be randomly assigned the 4 feedback presentation formats. The order by which the subjects participate in the activity type will be randomized, such that half of the participants in each treatment will perform aerobic first, while the other half will perform anaerobic first. To analyse the proposed model the data stored in the prototype apps will be used. Initially MANOVA will be conducted on dependent variable (DV) and mediators with social presence as the independent variable. Upon significance, a series of univariate ANOVAs will be conducted on DV and mediators separately.

## 4 DISCUSSION

This research can have several theoretical contributions in the area of mobile health literature. First, this study has conceptualized that CASA paradigm, cognitive load theory and social presence literature can be combinedly used to inform the design of effective feedback mechanism for fitness apps. Theorizing about mediating and moderating elements help us to better understand how and when social presence in fitness app feedback can facilitate greater exercise performance. Second, the artefact we proposed in this study has great potential to deliver a better quality fitness intervention at lower cost, with wide reach and hence this study has important contribution to mobile health intervention research.

The findings of this study can also offers several important implications to practice. First, it can inform the app developers that feedback presentation format can have an important influence on user’s engagement with the app. Second, app developers should be aware that, feedback presentation format needs to be effectively designed based on the type of physical activity, in order to yield positive outcomes. In particular, fitness app developers should concentrate on enhanced the social presence features while developing the feedback mechanism of aerobic fitness apps (e.g. running apps) and concentrate on providing more visual feedback while developing anaerobic fitness apps (e.g. strength training apps). Third, fitness app users should choose apps that can provide appropriate feedback to support their preferred physical activities.

In summary, this study focuses on an important design aspect (i.e. feedback mechanism) of fitness apps that can effectively improve an individual’s physical activity performance. However, we do not provide a comprehensive list of features and contextual factors that can promote physical activity in fitness app users. Future studies can examine other factors that can enhance physical activity behaviour. Besides this study only looks into two characteristics (i.e. language use and human sounding speech) to symbolize social presence in fitness app feedback. However, future studies can look into entire characteristics of CASA paradigm in order to gain a conclusive insights.

With obesity and overweight becoming a global health concern, we believe studies of this nature can have important potential to improve the health and fitness of mobile app users and we hope many scholars will follow the suit.
References


