Health Behaviour Change Through Computer Games: Characterising Interventions

Nathan POULTNEY\textsuperscript{a,1}, Anthony MAEDER\textsuperscript{a} and Jeewani Anupama GINIGE\textsuperscript{b}

\textsuperscript{a}School of Health Sciences, Flinders University, Bedford Park SA, Australia
\textsuperscript{b}School of Computing, Engineering & Mathematics, Western Sydney University, Penrith NSW, Australia

Abstract. Recently games in the form of video, computer, or mobile apps have been utilised as an effective component of interventions for health behaviour change. This paper provides an overview of related projects reported in peer-review literature in the period 2006 to 2016. Nine highly relevant references were considered for analysis. The findings are presented according to 3 dimensions of characterisation: health intention, behaviour change principle, and health purpose.

Keywords. Health behaviour, behaviour change, computer games, video games, mobile apps

Introduction

Health behaviour change refers to adoption of healthy life style choices and habits, in order to prevent illness. Common examples of health behaviour change include encouragement of positive life style, such as increased physical activity, and discouragement of negative life style, such as smoking cessation. As well as these preventive purposes, health behaviour change can also be applied retroactively for management of chronic conditions [3, 4]. For example, the modification of personal nutrition and exercise practices can assist diabetes sufferers to better manage their health status and slow the advance of their disease [7]. A wide body of literature exists in this area and a comprehensive framework approach to characterising associated behaviour change principles has been proposed.

Various types of computer-mediated and computer-delivered “serious” games have been developed as health behavior change mechanisms for dealing with specific health intentions [1]. The results are often positive and can be maximized with some design optimisation and customisation efforts [1]. Such games can provide a means to elicit significant health behaviour change, due to the depth of engagement with human subjects that is provided by their interactive nature and challenge aspects. This makes computer games potentially an important medium for inclusion in future health behaviour change interventions and associated activities such as health education and health promotion [6].

\textsuperscript{1} Corresponding Author: poul0005@flinders.edu.au
An open question concerning such games for health is: what aspects of design lead them to be most effective as health behaviour change agents? This paper contributes a perspective on this question by conducting an eclectic review of computer games reported in recent health behaviour change publications. We first describe our filtering methodology to identify the most relevant papers, then present a summary of the interventions and associated findings. The overall characterisation of these sources is provided according to 3 dimensions: health intention, behaviour change principle, and health purpose.

1. Review Methodology

1.1. Search

The literature review we conducted spanned the last 10 years, i.e. 2006 to 2016. This period was deemed the most suitable because it covers the large scale deployment of contemporary consumer internet/web services and mobile computing, including the proliferation of smart phone and tablet devices, which has provided wider scale and easier access for users of online and interactive technologies.

Searching was initially focused on papers dealing with health behaviour change in some form (e.g. behaviour modification; habit formation; lifestyle improvement). This is a problematic topic to search because there are many synonymous terms denoting concepts in this area, such as “behaviour modification”, “habit formation”, “practice improvement”. For expedience, “health behaviour change” was adopted as the primary search term as it is widely used across a range of health disciplines.

The secondary element of the search strategy was to find instances where the health behaviour change used computer-related games as a substantial element of the intervention. The terms ”Game” and “App” were used in order to find as many games related papers as possible, whether they were computer games, serious games, video games or mobile games (apps), accepting that some would not be computer-related.

Scopus was used for the purpose of identifying candidate papers, using the following search attributes:

*Search by title, abstract, and keywords:*

“health” AND
“behaviour change” AND
(“game” OR “app”) AND
PUBYEAR > 2005

Results were then sorted by citation count.

This search resulted in 254 papers being identified directly. Of these, 51 were regarded as potentially relevant, or marginally relevant, on the basis of their title. Many of these papers dealt with apps, but were only considered relevant if they were either a game in app form or an app with gamification elements. This led to the reduction in the number of relevant papers to 30, based on brief inspection of the contents. These remaining papers were subjected to further scrutiny to determine their eligibility for detailed consideration in this review, by applying the filtering criteria described below.
1.2. Inclusion/Exclusion Criteria

Remaining papers were considered further for inclusion by first reading their abstract, and if this was perceived as insufficient, then reading the full text. Any literature review papers on games for health behaviour change were automatically included (3 papers). Only 1 formal review was discovered during the search process [1].

Papers describing research projects were included if they involved a formal analysis through review or trial (or a comparable systematic deployment) of a computer gaming artifact to facilitate health behaviour change (4 papers) [2-5]. Papers that discussed concrete game design (or app design) concepts and/or game implementation issues for the specific purpose of supporting health behaviour change, and which argued for likely better health outcomes associated with use of these elements although not validated by a formal analysis, were also included (4 papers) [6-9].

Papers dealing only with higher level concepts or principles for computer gaming, which it was speculated by their authors might contribute to achieving effective health behaviour change, were excluded.

2. Review Results

The finally selected 9 papers were scrutinized in detail for their contributions, and the findings are tabulated below in Tables 1 and 2. Table 1 presents the range of types of papers according to their most obvious properties arising from the search selection process. Table 2 summarises the papers according to coverage of fundamental aspects of the paper contents, including research methods and sample sizes.

2.1. Paper Summary

For the purpose of this summary, a ‘game’ is defined as software which is used interactively by a user with an ultimate goal of an intended health behaviour change effect. An ‘app’ in this context is software implementing a simple game or with some gamification features, developed specifically for mobile users. A ‘concept’ is an idea or theory to better improve a ‘game’ or ‘app’ in order for users to reach the intended health outcome. ‘Analysis’ is a formal and systematic approach to determining the effects of the game on anticipated aspects of health behaviour change.

Table 1. Summary of included papers

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>[1]</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>[2]</td>
<td>-</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>[3]</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>[4]</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>[5]</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>[6]</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>[7]</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>[8]</td>
<td>✓</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>[9]</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
</tbody>
</table>
3. Discussion

Games have been reported to be an “engaging and entertaining format” for health behaviour change, for people of all ages [1]. Paper [1] was a literature review of 27 articles covering 25 video games that were intended for the promotion of health-related behaviour change. It was found that most of the articles considered did result in “positive health-related change” through the use of games.

Paper [2] discussed young adults’ (13 females, 6 males) perspectives on health behaviour change apps in regards to weight loss and dieting. The self-motivating goal setting nature of the apps reviewed within the focus groups was seen as one way in which apps can be gamified to increase user interest in using them. It was found that the greatest influences were “accuracy and legitimacy, security, effort required, and immediate effects on mood”. However, functionality that was either deemed unnecessary or disliked, was “context-sensing capabilities” and social media features.

Paper [3] discussed a conceptual model of how serious video games, for the promotion of diabetes self-management among youth, could be supported by a behavioural science-informed framework. Goal setting was deemed essential for focusing users and changing their efforts. Goal monitoring helps users to track their progress and reinforces their behaviour changes. Problem solving skills learnt from this process allow users to overcome barriers as a result of goal setting and goal monitoring methods. Games developed in this way show promise but further research is necessary to determine how effective it is in practice.

Paper [4] further discussed the concepts mentioned in [3]. Behavioural principles can be adopted in the development of games for reducing the risk of obesity and type 2 diabetes. Through observational learning and personalised experiences to the user, it is more manageable finding the balance between “fun” and “seriousness” to the user. The idea of “personally relevant messages” was proposed, suggesting how a user’s attention

---

**Table 2. Coverage of included papers**

<table>
<thead>
<tr>
<th>Paper #</th>
<th>Topic</th>
<th>Study Type</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>[1]</td>
<td>Health-related behavior change promotion through video games</td>
<td>Literature Review</td>
<td>27 papers</td>
</tr>
<tr>
<td>[2]</td>
<td>Young adult perspectives on behavior change apps</td>
<td>Focus Groups</td>
<td>19 participants</td>
</tr>
<tr>
<td>[3]</td>
<td>Conceptual model for serious video games for self-management</td>
<td>Design Synthesis</td>
<td>N/A</td>
</tr>
<tr>
<td>[4]</td>
<td>Serious video games for behavior change leading to decreased obesity and type 2 diabetes</td>
<td>Design Synthesis</td>
<td>N/A</td>
</tr>
<tr>
<td>[5]</td>
<td>Multiplayer health behavior change among youth</td>
<td>Long term empirical study</td>
<td>&gt;200 participants</td>
</tr>
<tr>
<td>[6]</td>
<td>Gamification and how it fits into health behavior change</td>
<td>Design Synthesis</td>
<td>4 gamification taxonomies</td>
</tr>
<tr>
<td>[8]</td>
<td>The extent to which gamification is used in health apps</td>
<td>Artifact Review</td>
<td>132 Apple App Store apps</td>
</tr>
<tr>
<td>[9]</td>
<td>User embodiment in a 3D virtual world to increase health self-efficacy in overweight adults</td>
<td>Randomised Controlled Trial</td>
<td>90 participants</td>
</tr>
</tbody>
</table>
would be better maintained when personally relevant messages were utilised. This would increase chance of success of a users’ behaviour changing in a positive way.

Paper [5] explored group-based competitions in a multiplayer game setting. The effectiveness of group interventions is questioned at an individual level. Whilst a group intervention may be successful in overall health behaviour change, it may not be as effective for each individual within the groups. Five different player types were reported on with the dimensions of “motivation”, “behavior”, and “influence on others”. The five player types are as follows: achievers, active buddies, social experience seekers, team players, and freeloaders. “Achievers” are characterised as setting themselves “game-related goals” and setting out to achieve them. “Active Buddies” are small groups of close friends who are able to create and enjoy physical activities together. “Social Experience Seekers” are players that use the communicative functionality and role-play in the context of the game to communicate with other players. “Team Players” are those that are “most motivated” by achieving goals as a group and working on their ranking through improving their team’s performance. “Freeloaders” are players whom are signed up to a group but do not contribute to their group and this affects the group’s performance. Game design suggestions are given on how to better integrate group functionality into multiplayer game interventions to increase effectiveness.

Paper [6] presented a behavioural science perspective on using gamification for health behaviour change. This relied on using a set of specific gamification strategies, achieved by a range of nominated gamification tactics. A potential framework was introduced to use in the design of “digital health interventions”, which provided criteria for the use of gamification in health. The criteria proposed contain 7 aspects, as follows:

1. users’ personal attributes
2. users’ social or community context
3. psychological and behavioural outcomes being pursued
4. fit of intervention logic model or change theory with gamification persuasion
5. nature of interactive product or platform being planned
6. compatibility of interactive product, users, and community with the gamification strategies
7. compatibility of interactive product, users and community with gamification tactics.

Paper [7] covered 14 diabetes self-management games and whether they are effective in diabetes self-management behaviour change. The games reviewed span a wide range of different genres with the most common characteristics among the games being player involvement in problem-solving and decision-making simulations in regards to diabetes self-management. This was managed in one particular randomised-controlled trial by asking the players to “balance food and insulin” in order to maintain their character’s blood glucose levels within an acceptable range. This was intended to encourage players to use the same skills on multiple occasions to become better at it in order to “win the game”. This serves as an example of cause and effect as well as providing the player with the basic knowledge of how to better manage their diabetes independently. It was concluded that further studies similar to this could emphasize the effectiveness of game based self-management modalities for those with diabetes and lead to better health outcomes.

Paper [8] analyzed 132 health and fitness apps that have gamification elements. The review looks at the influence gamification has on the user’s health behaviour with
the apps. A regression analysis was conducted which allowed the correlation between health behaviour constructs, gamification components, and effective game elements to be measured. It was found there is “widespread use of gamification principles” across the health and fitness apps. It was also found there is “low adherence to any professional guidelines or industry standard”. Overall it has been found that gamification in health and fitness apps is on the rise and the overarching issue is a “lack of integrating important elements of behavioral theory” in the apps industry.

Paper [9] looked into user embodiment within a 3D virtual world to alter users’ health behaviour for better self-efficacy with weight loss management. It was found through qualitative analysis that avatar-based virtual interventions can improve “motivation and efficacy to try new physical activities” however users who have little interest in video games are likely not to benefit from this form of intervention.

4. Characterisation Framework

To formulate an understanding of the Computer Games for Health Behaviour Change landscape as revealed in this review, we propose a framework of 3 dimensions to describe candidate games, as follows.

4.1. Game Intention

Each game, whether it be a health related game or a recreational game, has an intention as part of its design. Often for a typical game the intention is player enjoyment and satisfaction. However when it comes to health games, the intention is dependent upon the intended outcome as a result of playing the game. A health game may have an intention of competition in which one is either competing against oneself in order to better oneself e.g. a step counter type game that encourages a user to complete more steps each week than in the previous weeks, or than the step count of another participant. Another form of intention in a health game is to challenge the user. This may be a set of tasks or goals to achieve that escalate in difficulty with the intention of helping the user help themselves through self-improvement. Yet another health game intention can be an informational experience to the user. By playing the health game the user learns about relevant information specific to their type of condition. This would allow them to be better informed and it is speculated that as a result they will better manage their condition.

4.2. Behaviour Change Principle

A game focused on health behaviour change targets a particular behaviour and aims to modify it within the user. Adjusting a users’ health behaviour can be done in several different ways and three of them which were identified in the papers reviewed will be used as exemplars: modifying habits, reminders, and encouragement.

- Modifying habits: altering the way in which a user currently manages a task related to their condition to manage it in a way that allows the user greater self-efficacy.
• Reminders: notifications for the user regarding schedule based tasks or goals for managing their condition. E.g. a diabetic is reminded to check their glucose levels at regular intervals.
• Encouragement: reinforcing positive behavior of a user to allow for good habits to continue rather than trend downwards.

It should be noted that many other behaviour change principles could be included in this list, if a wider range of publications on such games was available for consideration.

4.3. Health Purpose

The health purpose refers to the way in which using the health game will help the user manage their condition not only in the short term, but in the long term also. This is the ultimate purpose of the game to have long lasting positive effects on the user. For example, health purpose may include increasing the amount of physical activity through the use of a weight management game, or adopting new activities to help manage a health condition, or varying the users’ activities to ensure a more balanced lifestyle. It was difficult to find a natural grouping for this aspect into a few categories, so it will be treated as an annotation rather than a categorical dimension. The work considered here was mostly aimed at health lifestyle maintenance through physical activity and nutrition management, with two papers targeting diabetes [4],[7] and two targeting obesity [4],[9].

Table 3 shows how this framework could be applied for characterising the papers in this review in the first two dimensions, using a ‘best-fit’ protocol. Papers [2] and [9] fit in two categories as equal best-fit. Paper [6] is not included as it covers too many areas for a narrow best-fit. The predominant Game Intention category was Informational, with Challenging being the next highest. The predominant Behaviour Change Principle category was Modifying Habits, with Encouragement next. Competitive and Reminder categories were the least popular. The framework is extendable as needed, to cater for a broader range of studies.

Table 3. Characterising the reviewed papers into the Characterisation Framework.

<table>
<thead>
<tr>
<th>Behaviour Change Principle</th>
<th>Game Intention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Competitive</td>
</tr>
<tr>
<td>Modifying Habits</td>
<td>[5]</td>
</tr>
<tr>
<td>Reminder</td>
<td></td>
</tr>
<tr>
<td>Encouragement</td>
<td>[5],[9]</td>
</tr>
</tbody>
</table>

Conclusion

The recent growth of interest in the use of serious games for health generally, has led to widespread generation of ideas and experimentation with computing artifacts, but little conclusive evidence about “what works”. Attempts thus far to understand this space
have relied more on mapping of behaviour change principles [10] than on attempting to link the types of gamification elements with specific behaviour change aspiration. The characterisation framework suggested in this paper provides an improved approach which factors in some of the additional environmental variables. Doubtless higher dimensionality extensions could be developed, but the proposed framework is considered to be sufficient for the purposes of undertaking trials and other validation processes for evaluating future exemplars of games of this type.

For a game to be effective in achieving the particular health behaviour change objectives, it must be ‘serious’ enough to reflect on the users’ condition and provide a guiding environment that directly works towards a health goal for the user at a personal level. It is also equally important that a game has a certain degree of “fun” to allow an amount of enjoyment for the user and generate an on-going interest for the user in the game. Finding the fundamental balance between “serious” and “fun” [4] game elements will allow for the greatest chance of health behaviour change success. This aspect has not been addressed in depth in any of the work reviewed here.

References