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Sloan, Robin J. S.; Saurin, Adrian

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Robin J. S. Sloan
Adrian Saurin

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The Enemy Within: Designing a Cell-Based Gameplay System for Cancer Education

Robin J.S. Sloan

School of Design and Informatics
Abertay University
Dundee, UK
r.sloan@abertay.ac.uk

Adrian Saurin

School of Medicine
University of Dundee
Dundee, UK
a.saurin@dundee.ac.uk

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Abstract

This paper outlines the design and preliminary evaluation of *The Enemy Within*, a browser-based game produced to raise awareness of the nature of cancer as a progressive disease. Aimed at high school and young adult audiences, the ambition with the game is to make visible to players the myriad ways in which healthy cells can mutate and ultimately inherit hallmarks of cancer, whilst also demonstrating how both real-world behaviours and underlying genetics impact both positively and negatively on cell health.

Author Keywords

Computer games; serious games; educational games; applied games; games for health; cancer.

CSS Concepts

• **Applied computing~Computer games** • **Software and its engineering~Interactive games**

Introduction and related work

Cancer is a progressive disease that is determined by the number of mutations that accrue throughout life dependent on a range of risk factors. It is critical that people can visualise why eliminating these risk factors slows cancer progression, because then they will be more likely to make lifestyle choices to help prevent cancer. The literature on cancer prevention demonstrates that the public can be confused by both the nature of cancer and the public health recommendations for prevention. Health literacy has been connected to cancer fatalism: the perception that cancer cannot be prevented, and the inevitability of death following diagnosis [7]. Fatalistic views on cancer such as 'everything causes cancer' or 'cancer is fatal' have been linked with poorer prevention behaviours, such as eating fewer vegetables [3]. Studies have also shown that the variety in types of cancer can lead to significant differences in public understanding of prevention, screening, and survival [14].

Research into games for cancer education is diverse, ranging from exercise games [2] to simulation games designed to improve screening [15]. Demographics are often considered in design, for example targeting games at children who need to understand treatment [8], Native American women with breast cancer [13], or older men who require decision-making guidance [11], while

research shows that persuasive health game design can benefit from consideration of gamer types [9].

Perhaps the most well-known example of a digital game used in the context of education of cancer progression and health is *Re-Mission* [10]. *Re-Mission* has been used widely in research into the effects of games on cancer education, for instance in determining the impact of play on self-care intervention [1] and the impact of experiencing cell behaviour on understanding risk [5][6].

It is in this context that we decided to follow guidance on games for health [4] and combine our expertise (in games and health) to develop a game prototype to raise awareness of cancer risks. We were interested in how a gameplay system that emulates cell mutation could aid in the visualisation of cancer as a progressive and preventable disease. The game we designed is titled *The Enemy Within*, a web-browser game that is available to play at: www.robinjss.co.uk/enemywithin.

In this paper, we provide an outline of the final version of the game. We then present the results of preliminary player evaluation that sought to test how players' understanding of cancer had changed following play.

Game design and description

The Enemy Within is a strategy game developed in GameMaker 2 and deployed as an HTML5 browser game. In the game the player is challenged to grow and maintain a population of cells. The game is built upon one core gameplay system: management of cell health. The player interacts with this system via a series of gameplay mechanics that correspond with interventions that involve either direct manipulation of cells or behavioural change (see Figure 1).

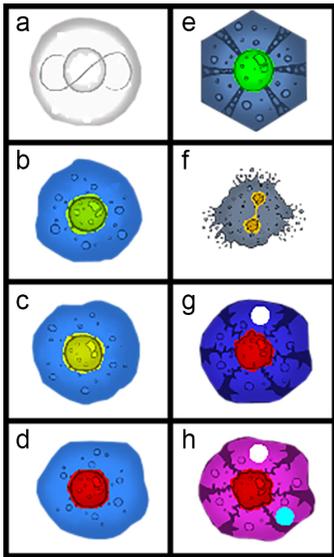


Figure 2: Examples of cells of different types and in different states: a) stem cell, b) cell with good DNA health, c) cell with moderate DNA health, d) cell with poor DNA health, e) arrested cell, f) cell death, g) cell that has acquired a hallmark of cancer, h) cell that has acquired two hallmarks of cancer



Figure 1: Representative gameplay in *The Enemy Within*, showing varying degrees of cell DNA health (green through red nuclei), cells with hallmarks of cancer, blood vessels generating willpower and fruit & vegetables, and presence of bad habits (in this case, smoking).

Design goals

Our primary goal was to raise awareness of the nature of cancer as a progressive disease, contrasting this with the more fatalistic view that cancer cannot be prevented and emerges suddenly. To achieve this, we wanted to design a game that helped players to understand:

- 1) The myriad risk factors for cancer, both active and passive
- 2) How exactly these factors increase cancer risk at the level of the cell
- 3) How the body can help prevent and combat cancer

Through the combination of these design goals, our aspiration was that players would a) appreciate that cancer can be prevented or slowed by mitigating against risks, and b) that changes in behaviour (even late in life or following cancer diagnosis) can have positive impacts on cell health.

Cell gameplay system

The core gameplay system of cell health aims to visualise how cancer can emerge progressively based on a number of risk factors. Types of cell are shown in Figure 2. In play, the player has control over stem cells, which can be moved around the board and help grow standard cells, which multiply automatically. The player has the ability to exercise limited control over standard cells, either by clicking to kill unwanted cells, or arresting cells (freezing them and preventing further cell multiplication). Standard cells have a light blue background and coloured nuclei which represents DNA health. As DNA health deteriorates, the nuclei colour shifts from green to red. Poorer DNA health increases the chances of hallmarks of cancer emerging within cells, as shown in Figure 2. Hallmarks provide cells with additional negative properties. For instance, a cancerous cell may resist being killed, or may affect the health of adjacent cells.

Factors that influence cell health

The game incorporates a range of risk factors that affect DNA health. Both age and genetics impact on DNA health in the background and beyond player control. In gameplay, the duration of a game is measured in age. As the age increases towards 75, the player will witness increased DNA health deterioration and thus increased emergence of hallmarks of cancer. Genetic risk is a difficulty setting that can be adjusted

Factor	Gameplay
Diet	Fruit & veg dragged over cells to boost DNA health
Obesity	Weight reduced through exercise (willpower)
Exercise	Exercise also boosts DNA health of all cells
Smoking	Attacks DNA health, willpower spend to cease behaviour
Alcohol	Attacks DNA health, willpower spend to cease behaviour
UV Rays	Attacks DNA health, willpower spend to cease behaviour

Table 1: Risk factors in gameplay

before starting a game, making clear that there is indeed a level of individual genetic risk inherent in cancer emergence. The majority of risk factors are linked to behaviours, which the player does have control over. Some of these are accessed by spending willpower, a currency players accrue based on each new blood vessel they create (a byproduct of growing a cell population across the board). The risk factors that occur in play are shown in Table 1.

Scoring as reinforcement

At the end of a game, the player is presented with a traditional high score screen which shows how their performance contributed to an overall score. But this also provides a breakdown of DNA health, hallmarks, total healthy population, and cessation of bad habits on a timeline (Figure 3). By viewing this chart, players can see not only that cancer is progressive but also that it can be prevented or reversed by mitigating risks.

Initial game design evaluation

Following the completion of the prototype, preliminary evaluation of the game was undertaken to explore to what extent the gameplay system we had designed led to changes in player understanding of cancer as a progressive disease. Our aim with this evaluation was to generate initial findings that would aid further development and testing, and as such the findings presented here should be considered a first step towards a more thorough evaluation of the game.

Research design

As the game is browser-based, we designed an evaluation that could take place entirely online. Google Forms was used to develop a questionnaire which participants were asked to complete both prior to- and

immediately after- playing the game. The same set of four cancer knowledge questions were asked of participants before and after play. These related to participant understanding of: the nature of cancer as a progressive disease; the influence of risk factors on getting cancer; reasons why risk factors increase cancer risk; and how the body helps prevent cancer. Although the study was prepared for online evaluation, for this preliminary study we opted to collect data from participants within computer labs. A total of sixteen participants (8 male, 4 female) completed the study.

Findings

Figure 4 shows the responses for Q1, where the correct answer was that cancer occurs progressively throughout life. Following play, more participants identified the correct answer than the wrong answer. Given that the gameplay system embodies this idea – that cancer can emerge gradually overtime – this outcome reflects that the core message was communicated via play.

Figure 5 shows the average score players assigned to each of the nine identified cancer risk factors, where 0 represented no risk and 3 high risk. Across all factors participant ratings for risk increased after play suggesting that playing the game had raised participant awareness of cancer risk in general. Of individual factors, participant perception of the risk of alcohol stands out as the most notable, but participants also scored the risk of poor exercise, poor diet and UV rays more highly following play. Figure 6 shows participant responses for Q3. In this case, the only correct answers were DNA mutation and genetic change. Here, it is clear that the game helped players to understand that DNA mutation was a consequence of the identified risk

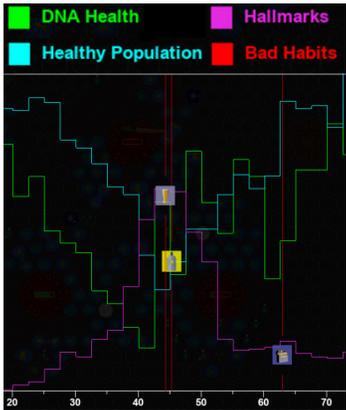


Figure 3: The final score chart visualises player performance in relation to average DNA health within the cell population, the prevalence of hallmarks of cancer within the population, the total healthy population of cells, and the points at which bad habits were successfully quit.

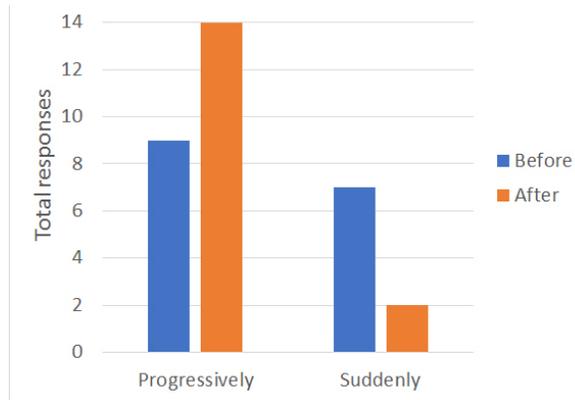


Figure 4: Responses to: The cellular changes that can lead to cancer... [Occur progressively throughout life, Occur suddenly sometime before cancer diagnosis]

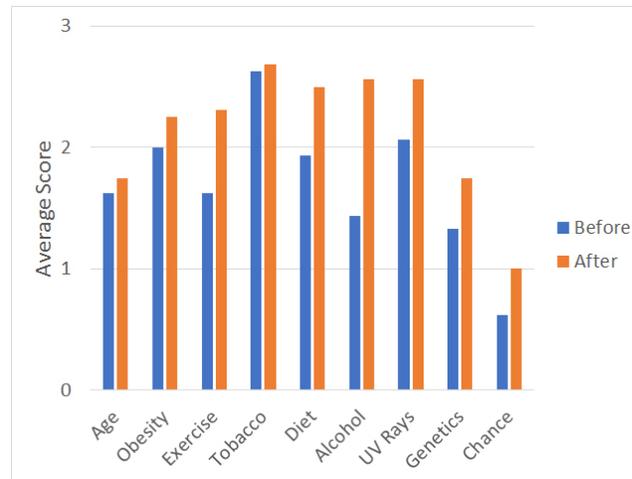


Figure 5: Responses to: How much of an influence do these factors have on your risk of getting cancer (0=no influence, 3=high influence)? [Age, Obesity, Exercise, Tobacco, Diet, Alcohol, UV Rays, Genetics, Chance]

factors. More participants did identify genetic change following play, but this represented a small number of the overall participant population, and many more identified cellular damage as a reason for increased risk. This would suggest more work is needed to focus on the communication of genetic change within the gameplay system. Figure 7 shows responses for Q4. In this case, all the named answers are correct, and it appears that the game helped this participant group to understand these facts. This was most evident in three cases: that the body can repair damaged cells, kill damaged cells, and stop damaged cells from growing. That these stand out is an interesting preliminary finding, as the core gameplay system focuses on direct control of cells along these lines.

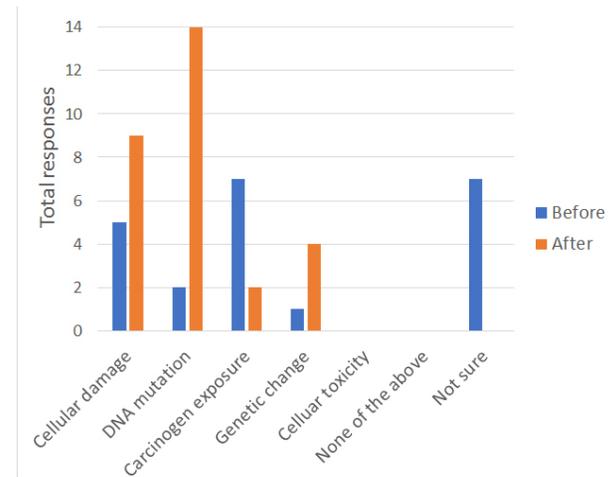


Figure 6: Responses to: Is there a common reason why the risk factors above increase your cancer risk? Choose a maximum of 2 options from the list below. [Cellular damage, DNA mutation, Carcinogen exposure, Genetic change, Cellular toxicity, None of the above, Not sure]

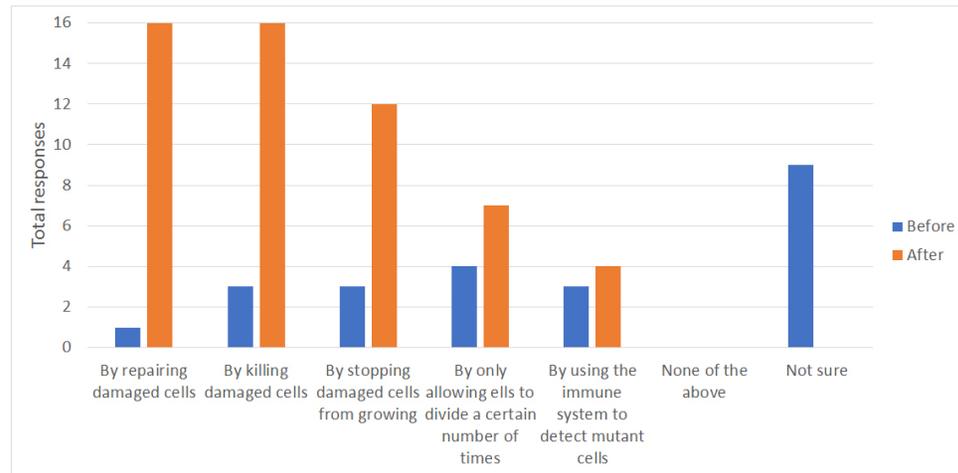


Figure 7: Responses to: How does your body help to prevent cancer? (tick any that apply) [By repairing damaged cells, By killing damaged cells, By stopping damaged cells from growing, By only allowing cells to divide a certain number of times, By using the immune system to detect mutant cells, None of the above, Not sure]

Conclusion and future development

Our preliminary findings demonstrate that *The Enemy Within* has the potential to counter fatalistic understandings of cancer. While these findings do point to further revisions that could aid player understanding, we are confident that *The Enemy Within* has the potential to be used within educational contexts. Our next steps are to prepare a more extensive study to determine with more statistical significance the effects of playing the game on participant knowledge. We are aiming to ensure that test participants are selected from our target demographic: high school aged players (the current study participants were University students). Further, we are looking to engage with stakeholders within secondary and tertiary education to better understand how *The Enemy Within* could be adopted into classroom settings.

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