# "Free Will": A Serious Game to Study the Organization of the Human Brain

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**Abstract.** We report on a serious game that is designed to teach the functional anatomy of the human brain to undergraduate and graduate students in Psychology and Neuroscience courses. The game provides a unique, immersive, first-person experience for students to understand the discrete faculties of the human brain and the associated brain regions. In addition to our core designers and developers, we included design-feedback testers on our team to give us iterative feedback throughout the development process. Initial feedback from this group indicates that "Free Will" is effective as a game-based learning supplement.

**Keywords:** Serious games · Digital game-based learning

## 1 Introduction and Background

According to a Pew Research Center report, 97% of teenagers and 81% of adults between the ages of 18–29 years of age play video games [1]. Education in particular was found to be a significant factor, with 76% of students playing video games versus 49% of non-students. Traditionally, video games have been primarily designed for and played as a form of entertainment and recreation. However, in recent years researchers, educators, and employers have explored the potential benefits this medium can have on educational outcomes and employee training. Considering video games' broad appeal to students, researchers and educators have focused on harnessing the simulative, and interactive aspects of video games to better engage students and enhance comprehension and retainment of subject material. Educators have argued that our approach to educating today's students must differ significantly from that of previous generations because as "Digital Natives" they process information differently from the those of the last generation [2].

In a meta-analysis examining the effects serious simulation games have on instructional effectiveness, Sitzmann found that instructional games were effective in improving measures of self-efficacy, declarative knowledge, procedural

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knowledge, and retention results [3]. Another study examining educational outcomes of gamified learning found that students who were provided with a gamified experience performed better in practical assignments and overall received higher grades than a control group [4].

Games that are not only interactive but also immersive present additional benefits in that they allow students to discover through highly effective Experiential Learning [5]. Experiential learning through immersive simulations of real world environments has been used widely for training in medical and military professions and has grown in business education [6]. However, application of immersive game based learning in the liberal arts is relatively novel, and appears to be unprecedented in the study of functional neuroanatomy.

Functional neuroanatomy, the study of how the brain is organized and which brain regions are necessary for different perceptions, thoughts and behaviors is fundamental to many courses in Psychology, Biology and Neuroscience. "Free Will" seeks to enhance learning outcomes of brain anatomy and functionality by presenting the material in an interactive, appealing, and immersive virtual environment. Game based learning presents the opportunity for students to simulate how the world would be experienced without certain brain faculties thereby encouraging experiential learning.

## 2 Game Design

Free Will was designed by an interdisciplinary team of neuroscientists and computer scientists. We are developing the game in an iterative manner with input from undergraduate and graduate Psychology and Computer Science students. We used James Paul Gee's Principles of Learning as a framework for how to design the learning components of the game [7]. His principles include co-design, customizing, identity and presenting well-ordered problems. Gee emphasizes that the games should be pleasantly frustrating so that the player wants to play (and thereby learn) and persist. The game shouldn't be too easy so that the player is bored and stops playing, nor should it be too difficult to avoid quitting as a result of frustration. Instead the game should progress in difficulty at a pleasant pace to increase learning and persistence. The feedback to the player should be positive when learning is occurring and not overly negative when the player doesn't succeed. We also included his recommended "on demand" information and "just-in-time" instructions.

Our game, Free Will? is written in Unity3d with C# scripting, and applies many of these design principles in order to encourage learning in a fun interactive way. The opening scenes set up the storyline introducing our main character, Will. The premise is that an autopsy has mistakenly been performed on Will. He finds himself without much information of who he is or why the sensations available to him are so limited. Through game play, the player helps Will to reassemble his brain. Will still maintains his inner dialogue (his free will), which provides the player with clues and the ability to move around. The goal of the game is for the player to reassemble Will's brain by learning about brain regions and their function.

Parallel scenes within the game allow the player to explore and self-assess. In the exploration mode students are presented with a 3D model of the human brain containing 21 movable parts and an animated human model. This module encourages students to explore the various regions of the brain, with their spatial locations, names and functions, and visualize their contribution to normal human functioning through animations. Both sides of the brain are displayed and each can be rotated independently. As the player mouses over a region a probe appears, that part changes color, and the name is displayed. When the player presses the mouse on a region, the probe inserts into that area and information about the functionality is displayed. A sound clip of the name of the region is played so that the user learns how to pronounce the parts. For some regions, the human model animates a function. This is done to reinforce the textual message. For example in Fig. 1, the player has moused over and pressed down on the occipital lobe, the area of the brain responsible for processing visual information. The name is displayed and an animation of a boy looking around is played. There are two assessment levels; the first evaluates whether the player has mastered the structure (names and locations) of the regions of the brain. A grey-scale model of the brain is presented (in a morgue scene) and the names of individual brain regions are displayed in random order. If the player selects the correct position on the brain model, the part animates into place from off screen. In Fig. 2 several parts have already been correctly placed (the score is 6) and Cerebellum is displayed. The player can switch to the Explore scene to review the names and positions of the regions and then return to the morgue scene to choose the part. Along with the score, we give positive feedback when the player reaches key scores, such as "Good Job," "Half way there," "Almost done" and "You are a brain master!" Once the brain is complete the brain spins around and Will announces "I feel complete again."

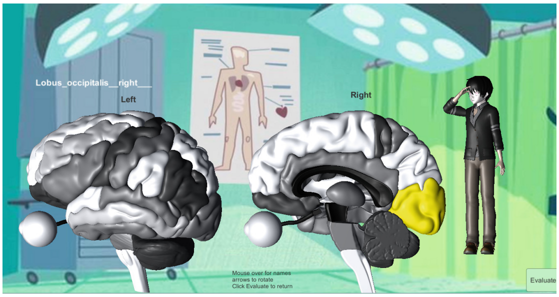



**Fig. 1.** Explore level (Color figure online)

The second assessment level evaluates the player's knowledge of the functionality of brain regions. Students are presented with a 3D brain template to fill and a puzzle to solve from the perspective of a human figure (representing Will). Brain parts are stored in specimen jars on shelves in the room. There are three ways that Will displays some deficit in brain functioning relating to specific brain regions; using animations, audio clues, or a displayed hint. For

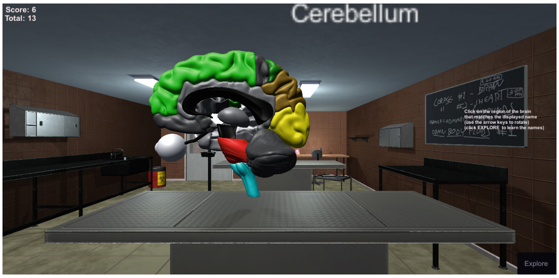


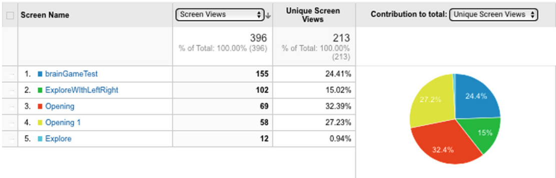

**Fig. 2.** Assessment level (Color figure online)

example, one animation shows Will off-balance and the player needs to drag the cerebellum (which plays an important role in motor control and balance) over to the correct place in the template in order for him to regain his balance. In another puzzle, an audio clip of a neurologist asks Will a question and Will struggles to speak using short phrases, which is symptomatic of Brocca's aphasia. To solve this puzzle, the player must drag over the region that contains Brocca's area. This module is ideal for demonstrating the interdependency of brain areas required for complex thought and behavior by simulating for the player how ones experience of the world differs with and without the function of specific brain regions.

## 3 Methods

In order to optimize the effectiveness and educational value of our game we sought design feedback from psychology undergraduate and graduate students and Computer Science majors. We asked the team testers to play the current version and to fill out a survey with their impressions and suggestions for improvement. The questions asked about the appeal, educational benefits, and design of the game. We also watched players while they played the game to assess whether it was intuitive. In addition to recording scores, we are using Google Analytics to keep track of milestones achieved by players, and which levels each player completed. A useful feature of Google Analytics is the summary data showing how many players viewed each level. For each level one can view the total and percentage of unique views (see Fig. 3). Google also provides the data on exits from scenes so one can determine when and how often player quit the game. We also added custom events to track when a player reaches certain scores and when they switch scenes.

We are particularly interested in determining how often the player switches to the explore mode to look up answers and how long they stay on each level. Figure 4 shows a snippet of the screens viewed by a particular player - showing that this player switched back and forth from the assessment to the explore levels.



| Screen Name | Screen Views | Unique Screen Views | Contribution to total: Unique Screen Views |
|---|---|---|---|
| | 396<br>% of Total: 100.00% (396) | 213<br>% of Total: 100.00% (213) | |
| 1. brainGameTest | 155 | 24.41% | |
| 2. ExploreWIthLeftRight | 102 | 15.02% | |
| 3. Opening | 69 | 32.39% | |
| 4. Opening 1 | 58 | 27.23% | |
| 5. Explore | 12 | 0.94% | |



**Fig. 3.** Google analytics - screen views

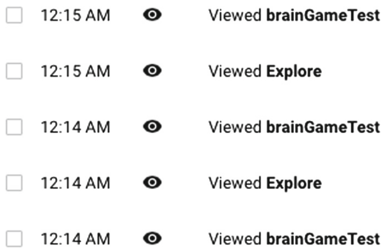



**Fig. 4.** Google analytics - single player feedback

## 4 Design Feedback

Here we report some important design feedback reported by several design-feedback testers. Most of our testers reported that they liked the game and all of them said that they feel this is a good way to learn about the parts of the brain. The majority felt that the game-play was intuitive and they liked the storyline and premise. Some players did not enjoy the background music especially during the assessment level where they found it distracting and suggested that we add a mute button (keeping the sound effects though). Most responded that their knowledge of the brain regions increased and said they would recommend the game to friends. When we observed testers playing the game, we noted that some did not notice the button to switch to the Explore scene or did not realize that one could toggle back and forth. They were also frustrated that they couldn't skip questions and come back to them (as one typically can during a traditional paper and many computer-based assessments). We are updating the game to incorporate their feedback.

## 5 Discussion

Immersing students in a 3D game environment where deficits in these discrete brain functions are experienced should provide an effective way for students to better comprehend and retain lessons in functional neuroanatomy and will provide a novel tool for students who struggle with a rote memorization approach to learning. Learning outcomes will be measured by comparing exam results posed to undergraduate and graduate students in these courses with and without our game-based learning supplement.

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