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MAKING SENSE OF BRAIN GAMES: A SCIENTIFIC ANALYSIS OF GAME DESIGN IN THE BRAIN FITNESS SOFTWARE MARKET

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# MAKING SENSE OF BRAIN GAMES: A SCIENTIFIC ANALYSIS OF GAME DESIGN IN THE BRAIN FITNESS SOFTWARE MARKET

By

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# ABSTRACT

MAKING SENSE OF BRAIN GAMES: A SCIENTIFIC ANALYSIS OF GAME DESIGN IN THE BRAIN FITNESS SOFTWARE MARKET

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Brain games have emerged as a new segment of games within serious games, over the last few years there is some research being done as to whether they are effective. This project aims to analyze current brain games from a game design perspective to find out whether they are good games.

The research involved analyzing games from the four different brain domains of Attention, Visual Spatial, Memory and Language processing by characterizing them for the different forms of fun, and whether individual elements within the games such as sound effects, music, non-playing characters, fonts etc. were plain or pleasing.

Using quantitative analysis we analyzed 33 randomly selected individual and brain fitness company brain games. Any casual observer who has tried some of these games has probably noticed that brain games tend to offer much less engaging game play than a typical successful online casual game. They appear not to be fun enough to attract players unless the player is overly concerned about brain fitness. In fairness, serious games are not expected to be as fun or as well designed as high budget blockbuster commercial games and we wanted to test that hypothesis and provide a systematic analysis of the brain games in the market.

# ACKNOWLEDGEMENTS

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I would like to thank all my fellow classmates with whom I have had an amazing time, for their friendship, sharing and expertise. The camaraderie I have enjoyed during my time here is something I will treasure fondly.

I cannot forget to acknowledge the support of my parents without them I probably wouldn't have made it here, their belief in me and constant encouraging has kept me going. Above all I would like to thank my wife for her patience and understanding, while I trudged along towards the completion of the program and had to spend a considerable time away from her.

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(Images in the thesis are presented in color.)

# INTRODUCTION

Scientists had long believed that the brain was a fixed, slowly declining organ. Neurology researchers discovered within the last decade that in fact, brains can change in response to activity or inactivity. Brain plasticity is the term used to describe growth or decline in the number of brain neurons and connections between neurons (Stein & Hoffman, 2003; Ferdnandez, 2009). This research launched the "brain fitness" industry and prescriptions for brain exercises to improve different cognitive functions (SharpBrains, 2009). These efforts initially targeted individuals with injury or disease based brain damage, and eventually expanded to include mature adults concerned with maintaining brain functions, and more recently, to children.

Concurrently, video and computer games were becoming main stream, including a category known as games for learning (Prensky 2001). Games for learning developed into a separate category with games existing for various activities, starting with the Carmen Sandiego series (Mobygames, 2009) going as far back as 1985 to the more recent games from Ubisoft as part of their My Coach series (Nutt, 2008). Initially brain exercises were offered in paper form (such as Small & Vorgan, 2004), but with computer and video games increasing in popularity these games were converted into interactive computer exercises (such as Robinson, 2006). Instead of turning the page to see the right answer, immediate feedback could be provided. Eventually, companies marketed suites of online brain games, typically designed in consultation with medical experts and offered in combination with advice on how often to play and other tips on healthy lifestyles, all with the promise of improved brain health.

Nintendo led the way for the commercial game industry to enter the brain fitness domain. Nintendo's Brain Age game, first released in Japan on the DS, achieved resounding commercial success; introduced in 2005, the game had already sold 4 million copies by July 2006, with 3 million of those sales in Japan (Surette, 2006). Nintendo also released Brain Age 2 and Big Brain Academy for the Nintendo DS platform. The latter was also ported to the Nintendo Wii console in 2007; Brain Age has been hailed as the granddaddy of non-games (Nutt, 2008), despite the fact that Brain Age was no next gen game, either in terms of graphics or the game play. It had a more homebrew feel to it with a small development time and team size. The game play consists of basic math problems, memorization, visual spatial exercises like counting numbers that blink in a certain color etc. however the universal appeal and intuitive feel of the game has made it a big success

A study in the United Kingdom found that children who played *Dr Kawashima's Brain Training* (aka Brain Age: Train Your Brain in Minutes a Day!) for 20 minutes at the start of each day for nine weeks improved their scores on a math test 50% more than students who did not play (Jenkins, 2008).

**What are Brain Games?**

Given this background of brain games we ask a very basic question, what are brain games? This is a difficult question to answer, as there is no one standard definition that is widely accepted, as are the diverse terms used to describe them. Terms like Cognitive Games and Brain Fitness Software are also used alternatively to denote brain games. Brain games are a specialized subset within the serious games category, which are a set of very specific activities

where a player interacts with software targeted to exercise a specific area of the brain by doing certain particular tasks. Overall there are five brain areas Attention, Visual-Spatial, Executive functions, Memory, Language, Auditory, Mathematical, and Executive processing. Most suites of games offered by companies incorporate different games that cover as many of these areas as possible.

**Significance of Brain Games**

Neuroscience research addresses the question of whether playing brain games can improve cognitive functioning. There are some studies that indicate that there is a link between doing certain kinds of brain exercises and the positive effects they have on the brain.

- In 2006, the ACTIVE Study, funded by National Institute of Health, demonstrated that older adults could improve their brain abilities with the correct training. Certain mental exercises can partially offset the expected decline in older adults' thinking skills and show promise for maintaining cognitive abilities needed to do everyday tasks. Some of the gains from training were seen to be beneficial 5 years later (Willis, et al. 2006).
- The Bronx Aging Study, published in the New England Journal of Medicine, followed almost 500 people for more than 20 years. The research found that people who participated in mentally stimulating activities, such as interactive games and other leisure activities multiple times a week had a 65-75% better probability of remaining sharp than those who did not participate in these activities ( Verghese, et al. 2003)

- Another well-known study is the Nun Study. Scientists followed 700 nuns for more than 20 years. An interesting finding was that certain types of intellectual activity and stimulation could protect against many types of cognitive decline (Snowdon, 2001)
- A study from Columbia University supports the concept of brain reserve and that education, occupation and stimulating leisure activities all reduce the potential risk of developing brain disease (Stern, 2006) Cognitive Reserve and Alzheimer Disease, Alzheimer Disease & Associated Disorders).

**Are Brain Games good games?**

Given the importance of brain games and the effects on an individual there is another question which we think is equally important, are the current games available to users good games? Do the games available to players qualify as good games or they are just digital versions of paper based exercises without adding much interactivity and fun? Cursory examination of brain games would suggest they have weak production values and poor game design. We sought to systematically analyze the quality of brain games offered by major competitors in the field and quantify how fun they are.

**Fun in Games**

Over the years one of the major goals that designers have strived for in games is whether they are fun, it is almost expected that games are fun. However there is not a lot of consensus what fun means Chris Crawford (Crawford, 2003) defines the relationship between Games Play and Fun as follows:

Games: is the formal activity you perform

Play: is the actual behavior you engage in

Fun: is the *experience* or *emotion* you derive from that behavior

The two important things that stand out in this definition is it's a combination of the experience that a player gets and the emotions a player feels while playing the game would contribute to the total fun a player gets from a game. So every player would elicit different amounts of fun from the same game based on the kind of person they are and what they will experience. (Koster, 2005)

No wonder most designers and researchers dislike the use of single term fun (Crawford, 2003; Rollings and Adams 2003; LeBlanc 2000) instead they divide the overarching concept of fun into more meaningful emotions or experiences that can be quantified, (Garneau, 2001; LeBlanc, 2000; Lazzaro, 2004; Heeter et al., 2003) these were labeled as the different forms of fun (Garneau 2001, LeBlanc 2000)

This is not just limited to games for entertainment, as serious games have matured the question has been asked should serious games be fun (Davidson et al., 2008; Fortungo, 2008) as there is a risk of the message getting lost. Recent studies (Ritterfield et al., 2009; Fortungo, 2008) support that if the players were enjoying themselves while playing the game the message would be conveyed effectively as the player would be motivated to play the game repeatedly.

## Goals

The goal of the research is as follows:

- Compare a random sample of brain games and quantitatively analyze them for the forms of fun and various design elements of the game
- Offer an in depth portrait of the state of the art of modern brain game design
- Discuss next steps for this emerging market

# METHODS

## Universe of Brain Games

A Google search for the term "brain games" and "brain game companies" gave several million hits. It was necessary to narrow down the number of companies to study and focus on the best of the brain games available in the market. SharpBrains is an organization that has been tracking progress within this segment of games and had conducted an extensive survey and created a detailed report of the leading Brain Game companies in 2008. This was used as a starting point to select the companies leading to the eventual selection of the games themselves.

The companies covered within the SharpBrains report were:

Table 1: Universe of Brain Games

| Company | Website | Products |
|---|---|---|
| Scientific Learning | http://www.scilearn.com/ | Language Series Elementary<br>Language Series Secondary<br>Reading Series<br>Reading Assistant |
| Cognifit | http://www.e-mindfitness.com/ | Mindfit |
| Lumos Labs | https://www.lumosity.com/ | Online subscription based games |
| My Brain Trainer | http://www.mybraintrainer.com/ | Online subscription based games |
| Posit Science | http://www.positscience.com/ | Brain Fitness Program Classic<br>Insight |

Table 1: Universe of Brains (cont'd)

| | | |
|---|---|---|
| Daikim | http://www.dakim.com/ | mPower – Home<br>mPower – Institutional |
| CogMed Program | http://www.cogmed.com/cogmed/ | JM for ages 4-7<br>RM for ages 7 & Up<br>QM for adults |
| Scientific Brain Training | http://www.sbt-corp.com/<br>http://www.happy-neuron.com/ | Online<br>Junior<br>Brain Fitness Series<br>Brain Train Junior |
| Fit Brains | http://www.fitbrains.com/ | Online subscription based games |
| Nintendo | http://www.brainage.com/ | Brain Age |
| Advanced Brain Technologies | http://www.abtmedia.com/ | BrainBuilder |
| BrainTrain | http://www.braintrain.com/ | Captain's Log (Multiple Products) |
| CNS Vital Signs | https://www.cnsvs.com/ | CNS Vital Signs |
| Cognitive Drug Research | http://www.cognitivedrugresearch.com/ | The CDR System |
| Lexia Learning | http://www.lexialearning.com/ | Lexia Cross Trainer |

The Universe of brain games was very fragmented in terms of the how the games were delivered. Some were one or a few brain games, free to play via a website. Others were collections of brain games marketed as a coherent service for a monthly subscription fee to access the games. These services also offered tip on maintaining brain health, and tracked game play and progress of the user over time. Some like the Nintendo Brain Age required a dedicated piece of hardware to play the game. Subscription sites that offered online games

were selected as the kinds of brain games to include in this content analysis. Happy Neuron, FitBrains, and Lumosity were the three brain game services matching these criteria.

Big Fish Games, a casual game site, include "brain teasers" as a category of game genre. Games that are part of a collection of commercial casual games compete for players with the universe of other casual games. While subscribers to a brain game service probably value cognitive exercise and consider fun to be a side benefit, casual game players probably value fun and view cognitive exercise as a side benefit. For these reasons, brain games available on Big Fish probably stress fun more strongly than the brain game services do. Brain Games from Big Fish were included in the analysis, to compare fun in those games with fun in brain games in the brain game suites.

**Game Selection**

Neurologist Andrea Bozoki consulted with Brian Winn and Carrie Heeter on designing brain games. She identified nine major cognitive domains that could be exercised in a brain game: Working Memory, Executive Processing, Visual-Spatial Processing, Episodic Memory, Procedural Memory, Attention and Divided Attention, Language, Semantic Memory, and Tonal Processing. Executive Processing (judgment and reasoning) seemed difficult to define and too diverse in scope, so those games were excluded from the analysis. Four cognitive domains were commonly featured in brain games: Language, Memory, Visual-Spatial Memory, and Attention.

Overall a total of 33 games were selected across the four brain domains. Whenever possible I selected two games in each brain domain from each company. In some cases, a company

offered only one game, or even no games in that domain. The following were the criteria with which the games were selected:

- The game was offered by one of the three brain game services or else was listed as a Brain Game on Big Fish games.
- Games could be played on PC or Mac – they did not require some kind of special hardware platform to run the game (e.g. Brain Age)
- The game could be classified as predominantly exercising one of the four cognitive domains
- I selected sites that offered a preview of the games before having to subscribe to play them.

I began by generating a list of all of the games from each company that fit each of the four cognitive domains. When a company had more than two games for a particular cognitive domain, numbers were assigned to each game in the list, and two were randomly selected using a random number generator.

Only Big Fish brain teaser games that could be clearly classified as exercising a specific cognitive domain were included. (In other words, if memory were a small part of a complex game, that game was not included. If the primary game mechanics involved memory, then the game counted as a memory game.) Here is the list of brain games chosen for analysis, including the company and cognitive domain. The first number in parentheses after the company name shows how many games were analyzed. The second number is the total number of games from that company fitting that brain domain.

<u>Domain 1 Language (8)</u>

Language Game Screen Shots*

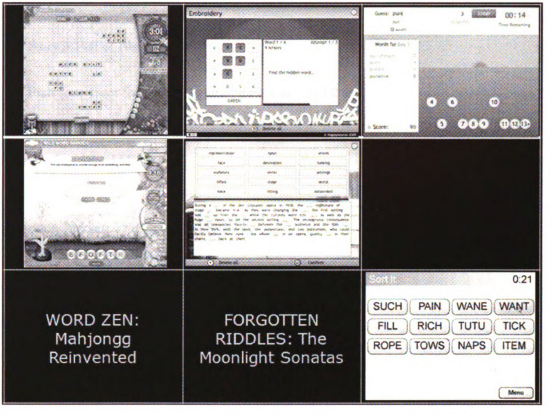



Figure 1: Language Game Screenshots

(Copyright permission for including screen shots could not be obtained for Word Zen or Forgotten Riddles)

**Lumosity** (1 of 1)

Word Bubbles

**Fit Brain (2 of 4)**

Wild Word Garden

Paradise Island

**Happy Neuron** (2 of 5)

Embroidery

The Story is Full of Blanks

**Big Fish** (one from formal brain games mini-suite, 2 of 2 top 20 other word category brain teasers)

Brainiversity: Word Maker

Word Zen

Forgotten Riddles: The Moonlight Sonatas

Domain 2 Visual-Spatial (9)

Visual Spatial Screen Shots

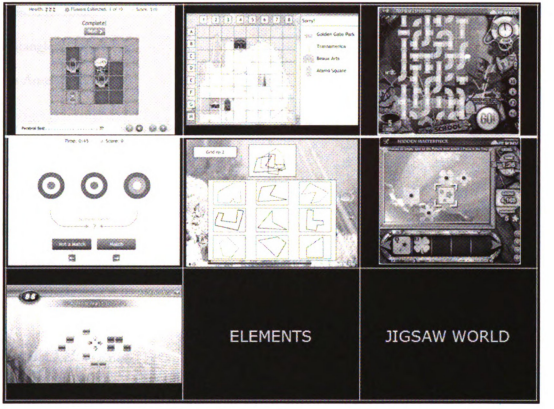



Figure 2: Visual Spatial Game Screenshots

(Copyright permissions to include screen shots could not be obtained for Elements or Jigsaw World)

**Lumosity** (2 of 2)

Monster Garden

Spatial Speed Match

**Fit Brain** (2 of 2)

Hidden Masterpiece

Deep Blue Expedition

**Happy Neuron** (selected the free visual-spatial game and re-categorized An American in Paris, also free, as visual-spatial even though Happy Neuron thought of visual-spatial as

mental rotation)

Entangled Objects

An American in Paris

**Big Fish** (one from formal brain games mini-suite, 2 of 2 top 20 other word category brain teasers)

Brian Challenge: Visual Game

Jigsaw World

Elements

Domain 3 Memory (8)

Memory Game Screen Shots

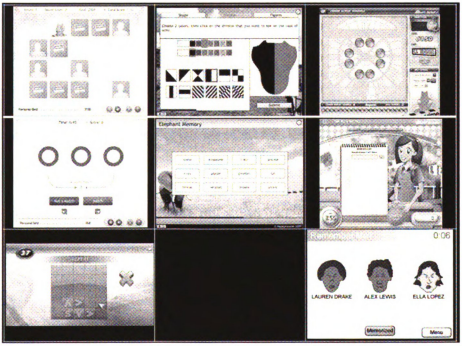



Figure 3: Memory Game Screenshots

**Lumosity** (selected 2 of 4 – omitted speed match because we already used it in visual-spatial, omitted Moneycomb because it was numeric)

Memory Match

Name tag

**Fit Brain** (2 of 2)

Busy Bistro

Crime Scene Shuffle

**Happy Neuron** (omitted An American in Paris because already used and omitted Around the World in 80 Trips because very similar to American in Paris. Randomly selected 1 of 2 verbal memory and one of 4 visual-spatial memory)

Elephant Memory

**Big Fish** (one each from formal brain games mini-suites, there did not seem to be direct memory games amongst the top 20…)

Brain Challenge: Memory Game

Brainiversity: Visual Memory

There were no Big Fish casual games outside of the two brain game suites that exercised only memory.

Domain 4 Attention (8)

Attention Game Screen Shots

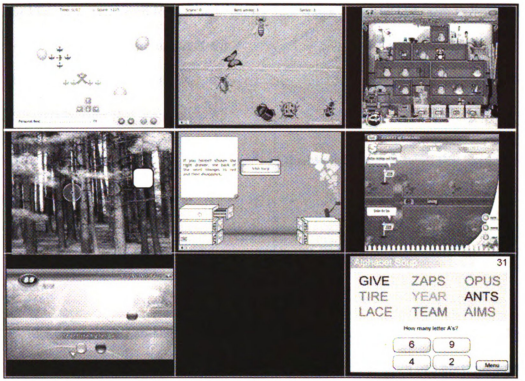



Figure 4: Attention Game Screenshots

**Lumosity** (selected 2 of 3 – one clearly divided attention, one clearly focused, the third unknown so omitted Top Chimp)

Birdwatching

Lost in Migration

**Fit Brain** (2 of 2)

Pandora's Boutique

Street of Dreams

**Happy Neuron** (The 2 that were free were chosen)

Catch the Ladybug

Secret Files

**Big Fish** (one each from formal brain games mini-suites, there did not seem to be direct memory games amongst the top 20...)

Brain Challenge: Focus Game

Brainiversity: Alphabet Soup

There were no Big Fish casual games outside of the two brain game suites that exercised only attention.

## Coders

In order to ensure the coding of the games went smoothly and there was some credibility to the overall approach, we selected three coders, such that each of them had previous formal knowledge of the game design process and have participated extensively in designing games especially games for the web. Out of the total of 33 games that were analyzed all the coders played the same three games to ensure inter-coder reliability. The remaining 30 games were randomly distributed between the coders so that each coder did not play more than ten games. The games were also distributed so that each coder gets to play and code games from all the different brain domains thus ensuring no one coder affects the coding of a particular domain.

## Coding Definition

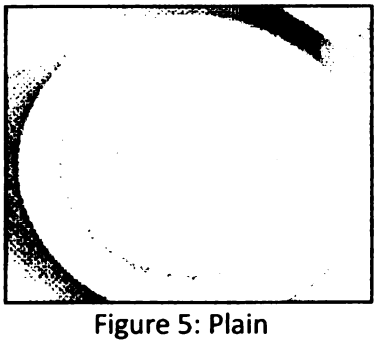
We spent months discussing quantitative ways of analyzing fun and quality of brain games. The coding approach went through five iterations. The final coding system adopted two primary considerations: whether different design elements were purely functional or more

aesthetically designed and what forms of fun the game designers incorporated (or attempted to incorporate) in the game.

Functional versus Pleasing

Game designers can create a game that is functional. The game is playable. Game graphics and player feedback are present, but minimal attention has been devoted to design. If there is text on the screen in a functional game, the text may be in the default system font, black text on a white background. If there are buttons such as Play or Help, they might be simple rectangles surrounding the word. If there are shapes in the game, the circles might be 2D simple shapes. Artwork seems to be used from a collection of clip art. Sound effects seem like basic free downloadable sounds. There are probably no animated transitions or win and lose states. The layout may be haphazard; to indicate not much attention was paid to the art direction of the game. A functional game is just the basics, with little attention to design.

At the other end of the spectrum, great attention may be paid to the design. Graphics may be integrated and elegant and every button and text item that is part of the game looks as if it has been created and customized for that game. Different events in the game have their own sound effects and the music included in the game does the job to make the overall game not only play well but look richer making the game pleasing.



This photograph of plain white placeware exemplified a "plain" design.

Figure 5: Plain

This placeware is more stylized, more "pleasing."

Figure 6: Pleasing

Similarly, this distinction might be considered in terms of whether the design is "generic" – one that could be used in any game. An example is the blue background in this jigsaw puzzle shown in Figure 7.

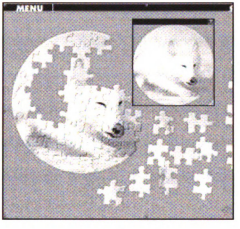



Figure 7: Blue Background

Conversely, a game background could be "themed," consistent and coherent within a particular game design. An example is the lined background in Figure 8 below, fitting in to the metaphor of an office.

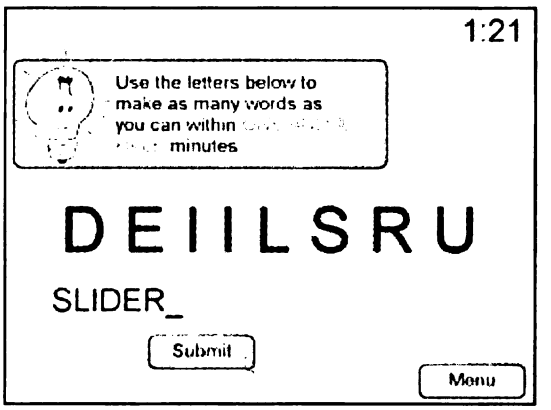



Figure 8: Themed Background

Generic is typically synonymous with plain, in our coding approach.

Forms of Fun

Forms of fun were derived from a quantitative content analysis of Space Learning Games I participated in as a research assistant in 2002, presented in 2003 at the DIGRA conference in the Netherlands (Heeter, Chu, Maniar, Winn, Mishra, Egidio, and Portwood-Stacer, 2003). In that coding we attempted to code how extensively fun each game was along the 14 forms of fun delineated in Pierre Alexandre Garneau's (2001) Gamasutra article.

Garneau's goal in proposing 14 forms of fun was "to be as complete as possible in the enumeration of categories of activities that are fundamentally entertaining." During the space game coding, we noticed the list left out at least two particularly relevant forms of fun. Learning about the world (the real world) can be enjoyable and is extremely germane to consideration of educational games. In addition, none of Garneau's forms of fun seemed to address the pleasure of helping or taking care of others. Altruism might include helping another person, caring for a pet, or even saving humanity. Learning and altruism are forms of fun that might appeal to girls according to an AAUW (2000) report. During brain game

coding we realized yet another form of fun was missing – the fun of a narrative or story. That form was added to the list. We coded the 17 forms of fun as 1 (non-existent), 2 (moderate), and 3 (extensive) and we used Garneau's article as the basis of the definitions of forms of fun. The definitions appear below.

*Advancement* – It can be within a round, accomplishing a larger goal by completing a series of tasks, or between rounds by leveling up. Simply completing a task is not enough to count as advancement (i.e., memorize these five names and repeat them back). Just by having the challenge get a bit harder (2 balls then 3 then 4 then times up) is not enough for advancement, unless getting all five right accomplishes something beyond the right to play it again. If the game indicates advancement in some meaningful way visually ("4 of 5 complete") AND this advancement is based on play performance (not a force number of rounds you have to play to complete the game), then there is advancement and completion.

*Altruism* – If while playing the game the player ends up helping someone or something or humanity than it has altruistic elements (it was mainly a story driven form of fun.)

*Beauty* – This applies to an overall judgment of the aesthetics of the game. If an otherwise unpleasing game to the sense had pleasing buttons and game title, that's not enough to qualify since those are trivial elements. But the game background and coherence may well contribute to beauty.

*Comedy* – If the intention of the game designers was to convey humor through either the settings or the character the game was coded to have this form of fun.

*Competition* – If the game encouraged the player to compare and do better than their own prior score, or to compete with others. Slight competition would be the ability to see leader

boards, where the player could see how were your previous scores or how other player's scored. High competition would be direct player-vs.-player competition (multiplayer game) OR playing against an artificially intelligent computer opponent.

*Creation* – If as part of the game the player has the opportunity to create something using the game elements than it was coded to have this form of fun, making something would include putting together words or puzzle pieces to create a bigger word or form a picture.

*Discovery/ Exploration* – If within the game there are potentially interesting things to explore, and an opportunity to reveal unexpected things then the game was coded as having that form of fun. Slight exploration would be exploring small spaces or problem spaces where things are unknown and hidden and you must reveal them through game play. This does not include putting letters together to form words but does include concentration style matching games. High exploration would be the ability to explore intricate virtual worlds as part of the game.

*Immersion* – If the player was transported to an imaginary place and could reside in that imaginary place while playing the game then the game was coded to have that type of fun.

*Intellectual problem solving* – The scope of this type of fun is larger than just a mental ability. Different aspects like Executive functioning, looking for patterns, problem solving, applying various strategies, tactics, logic, not just memory, identifying a shape/object/motion counted towards it.

*Learning*– If the game allowed the player to learn some relevant and meaningful information about the real world then the game was coded to have that form of fun.

*Love* –While playing a game if the player felt a sense of familial love or romance towards a character in the game then the game was coded to have this form of fun.

*Power* –This is defined as the ability of the player to exert some kind of a strong influence on the game world and change it or allowing the player to gain strength within the game.

*Physical Activity* – For a game to have this type of fun the player had to be actively involved with the game by moving their entire or a good portion of the body just moving the hand while moving the mouse does not count.

*Social Interaction* – As part of the game if the player could interact with other virtual or real characters then the game was coded to have this form of fun.

*Imagination* – This is defined as the ability of the game to allow the player to be immersed in the story or scene where the game is taking place and tap their sense of imagination.

*Thrill of Danger* – As part of the game universe there are objects that hint at or overtly represent danger or threat these could be in the form of sharks, fish hooks, monsters, criminals, crime scene etc.

*Story* – Is there a narrative, either in the form of a back-story or game story, to help engage the player?

**Overall**

*Engagement* – This would involve the player losing a sense of time and place and being in a trance like state while playing the game requiring some effort to stop playing the game.

*Flow* – This form of fun is defined by the delicate balance of the difficulty of the game where the game was neither too hard, nor too easy – did the developers manage to find that sweet spot? Flow is only achieved within the play experience of the game. If the game just has ways of setting the difficulty of level of play, this is not considered as flow.

**Reliability**

Three games were coded by all three coders.

Plain or pleasing reliability had 100% agreement for sound effects, NPC verbal style, NPC appearance, non-interactive demo, and game background. Title and intro screen, pleasant or plain had 89% agreement. Visual style, buttons, and fonts was 77%, Interactive demo, end of game feedback, between rounds feedback, and in-game feedback was 66%.

We added three new variables: appealing overall visual style, appealing interactivity, and appealing feedback, all coded as 1=bland, 2=somewhat appealing, 3=very appealing. These were applied consistently across the three coders.

Comedy, Immersion, Love, Physical Activity, Power, Social Interaction, and Thrill of Danger all had 100% agreement. Altruism, Discovery/Exploration, and Learning had 89% agreement. Advancement, Application of a Mental Ability, Competition, and Intellectual Problem Solving had 66% agreement. The coders discussed definitions and criteria, and then recoded these attributes, achieving at least 89% agreement on the original three games.

After all of the games were coded, SPSS analysis of results by coder revealed three forms of fun (Intellectual problem solving, advancement and completion, and competition ) for which one coder stood out from the other two in terms of frequency. This could be a function of the games that person was assigned. Nonetheless, a coder was warned if he or she was overly generous or overly miserly with that category, and all coders recoded those variables again for all of their games.

Average inter-coder levels of perceived engagement were within .2 points of each other. Two of three coders initially averaged .9 (on a 0 to 2 scale) while the third coder averaged .3 across all ten games. Flow was re-coded again after discussion to better balance coder ratings.

# RESULTS

A total of 33 games were analyzed along two overarching considerations:

- To assess whether brain games and their various elements were either plain or pleasing in various aspects of their design
- To determine how many and which forms of fun if any are most often present in brain games

For both these criteria, we analyzed the overall occurrence across brain games and then compared how brain games differed based on which of four brain domains the game targeted, as well as how brain games differed across companies including a comparison between brain games by company. A third comparison looked at brain games by service type (brain games found on brain game company web sites with brain games on generic casual game web sites). .

## Plain Vs Pleasing

The games were coded for 17 different game design elements as either plain (functional with minimal design to achieve the needed functionality) or pleasing (incorporating aesthetic or other conceptual design enhancements intended to enhance the player experience). This section gives a detailed breakdown and results for each of the design elements. In the tables that follow, n - indicates the number of games for that category, F - is the oneway ANOVA F value, df is the degrees of freedom and p indicates the significance level. A value of 1 was

used to indicate pleasing, and 0 to indicate plain. Thus, the average across games will range from 0 to 1.

Visual Style

Overall visual style referred to the look and feel of the game including the visual style of playable objects and game content was mostly plain or pleasing. For the 33 games that were coded, two thirds of the games were rated visually pleasing and the others were rated as plain.

**Visual Pleasing (By Brain Domain)**

Table 2: Visual Style by brain domain

| | Average | Standard Deviation |
|---|---|---|
| Memory games (n= 9) | 0.56 | 0.53 |
| Visual Spatial (n= 8) | 0.57 | 0.46 |
| Attention Games (n= 8) | 0.63 | 0.52 |
| Language Games (n= 8) | 0.75 | 0.46 |
| | | |
| Overall (n = 33) | 0.67 | 0.48 |

F = 0.32 p = 0.81 df = 3

No significant difference was found for visual style based on which brain domain the 33 games targeted. In other words, memory games were no more likely to be plain than visual spatial games, attention games, or language games.

**Visual Pleasing (By Company)**

Table 3: Visual Style by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 0.50 | 0.54 |
| FitBrains (n = 8) | 1.00 | 0.00 |
| Lumosity (n = 7) | 0.43 | 0.54 |
| Brainversity (n = 3) | 0.00 | 0.00 |
| Brain Challenge (n = 3) | 1.00 | 0.00 |
| Big Fish (n = 4) | 1.00 | 0.00 |
| | | |
| Overall (n = 33) | 0.67 | 0.48 |

F = 5.262 p = .002 df = 5

Pleasing or plain visual style was significantly different across companies (F=5.26, df=5, p=.002). One company, Brainiversity, used a purely functional style for all of their games. Two brain game companies (Fit Brain and Brain Challenge) consistently employed a pleasing visual style. The four Big Fish casual games also consistently used pleasing visual styles. Happy Neuron and Lumosity used pleasing visual styles about half of the time.

**Visual Pleasing (By Service Type)**

Table 4: Visual Style by Service type

| | Average | Standard Deviation |
|---|---|---|
| Brain Game Service (n = 23) | 0.65 | 0.49 |
| Casual Games (n = 10) | 0.70 | 0.48 |
| | | |
| Overall (n = 33) | 0.67 | 0.48 |

F = 0.068 p = 0.797 df = 1

Pleasing or plain visual style was not significantly different by service type. Brain games on brain game company web sites were as likely to be visually pleasing as brain games found on casual game sites.

From here on tables where there were no significant differences between games, when compared by one of the above three categories, are not included here.

Introductory Screen

Introductory screen was defined as the first screen that is encountered by the player. Overall 60% of the brain games were coded as having a pleasing intro screen while the rest of the introductory screens (40%) were rated functional (plain).

Whether a brain game's introductory screen was pleasing or plain did not vary based on what cognitive domain the game targeted.

**Intro Pleasing (By Company)**

Table 5: Intro by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 0.13 | 0.35 |
| FitBrains (n = 8) | 1.00 | 0.00 |
| Lumosity (n = 7) | 0.57 | 0.54 |
| Brainversity (n = 3) | 0.00 | 0.00 |
| Brain Challenge (n = 3) | 1.00 | 0.00 |
| Big Fish (n = 4) | 1.00 | 0.00 |
| | | |
| Overall (n = 33) | 0.61 | 0.50 |

F = 11.031 p = .000 df = 5

The pleasing or plainness of introductory screens was significantly different by company ($F = 11.031$, $df = 5$, $p = .000$). As with overall visual style, one company, Brainversity, used a purely functional introductory screen for all three of their games in this study. Two brain

game companies (Fit Brain and Brain Challenge) consistently employed a pleasing introductory screen. The four Big Fish casual games also consistently used pleasing introductory screens. Lumosity offered a pleasing introductory screen for 57% of their games, and Happy Neuron did so for 13% of their games.

Introductory screen design was not significantly different by service type.

Title (Font Choice and Title Design)

Each of the games that were analyzed incorporated the title of the game either on the introductory screen, in the main game interface, or both. Those using a generic, common, non-decorative font and straight line layout were deemed plain. Those whose title were decorative or themed or designed in some way were deemed pleasing. Overall 70% of the games studied had visually pleasing title text and 30% of them were plain.

Font and the title design did not differ significantly across the four brain domains.

**Title Pleasing (By Company)**

Table 6: Title by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 0.13 | 0.35 |
| FitBrains (n = 8) | 1.00 | 0.00 |
| Lumosity (n = 7) | 1.00 | 0.00 |
| Brainversity (n = 3) | 0.33 | 0.58 |
| Brain Challenge (n = 3) | 1.00 | 0.00 |
| Big Fish (n = 4) | 0.75 | 0.50 |
| | | |
| Overall (n = 33) | 0.70 | 0.47 |

F = 11.023 p = .000 df = 5

There was a significant difference in title design among different companies. FitBrains, Lumosity and Brain Challenge consistently created pleasing titles, three fourths of the games from Big Fish had pleasing titles, and one third of the games from Brainversity had pleasing titles. Only 13% of the games from Happy Neuron had pleasing title designs.

When compared by service type there was no significant difference between brain game companies and casual game companies for title design.

Fonts (Used throughout the entire game)

For all the games that were analyzed a wide variety of fonts were used throughout the game for buttons, to convey in-game feedback, in menu items, on instruction screens, etc. Overall the fonts used in the game were marked as plain if they were generic sans serif or serif fonts or pleasing if at least some of fonts in the game seemed designed to contribute to the overall coherent and designed game look and feel. A little more than half of the 33 games analyzed used plain fonts and the rest used pleasing fonts

**Font Pleasing (By Brain Domain)**

Table 7: Fonts by brain domain

| | Average | Standard Deviation |
|---|---|---|
| Memory games (n= 9) | 0.44 | 0.53 |
| Visual Spatial (n= 8) | 0.50 | 0.54 |
| Attention Games (n= 8) | 0.25 | 0.46 |
| Language Games (n= 8) | 0.63 | 0.52 |
| | | |
| Overall (n = 33) | 0.45 | 0.51 |

F = 0.744 p = 0.535 df = 3

When compared by brain domains, attention games were least likely to use pleasing fonts (only 25% of attention games did so), whereas more than half of the games for the other three brain domains (63%) used pleasing fonts. Using plain fonts in an attention game may be a wise design decision – perhaps the designers wanted to avoid distracting players with decorative fonts.

**Font Pleasing (By Company)**

Table 8: Fonts by company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 0.00 | 0.00 |
| FitBrains (n = 8) | 0.88 | 0.35 |
| Lumosity (n = 7) | 0.43 | 0.54 |
| Brainversity (n = 3) | 0.00 | 0.00 |
| Brain Challenge (n = 3) | 0.67 | 0.58 |
| Big Fish (n = 4) | 0.75 | 0.50 |
| | | |
| Overall (n = 33) | 0.45 | 0.51 |

F = 5.629 p = .001 df = 5

The font used differed significantly across the various brain companies (F= 5.629, df = 5, p = .001). While Happy Neuron and Brainversity used only default system fonts for all their games, Lumosity used pleasing fonts in close to half their games. Brain Challenge and Big Fish used pleasing fonts for nearly three fourths of their games and FitBrains used pleasing fonts for 88% of their games.

**Font Pleasing (By Service Type)**

Table 9: Fonts by Service type

| | Average | Standard Deviation |
|---|---|---|
| Brain Game Service (n = 23) | 0.43 | 0.51 |
| Casual Games (n = 10) | 0.50 | 0.53 |
| | | |
| Overall (n = 33) | 0.45 | 0.51 |

F = 0.113 p = 0.739 df = 1

Font use was not different by service type. Casual game companies and brain game companies both used pleasing fonts in about 50% of their games.

Buttons

Buttons are a frequent component of online Flash games. Buttons were considered plain if they consisted of a rectangle or rounded rectangle containing a word (such as CONTINUE or HELP) in a default font. Pleasing buttons were more designed, such as having animation or color change on mouse over, an audio effect associated with a button, and visual design to fit in with and contribute to an overall look and feel of the game. Among the 33 brain games analyzed 60% had pleasing buttons while the other 40% used a more purely functional, generic button style.

When compared by cognitive functions there was not a significant difference in the use of plain or pleasing buttons.

**Buttons Pleasing (By Company)**

Table 10: Buttons by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 0.00 | 0.00 |
| FitBrains (n = 8) | 1.00 | 0.00 |
| Lumosity (n = 7) | 0.86 | 0.38 |
| Brainversity (n = 3) | 0.00 | 0.00 |
| Brain Challenge (n = 3) | 0.67 | 0.58 |
| Big Fish (n = 4) | 1.00 | 0.00 |
| | | |
| Overall (n = 33) | 0.61 | 0.50 |

F = 22.520 p = .000 df = 5

As shown by the table there was a significant difference in plain and pleasing buttons by company. Happy Neuron and Brainversity used only plain buttons for their games; on the other hand Big Fish and FitBrains consistently used pleasing buttons across all their games. The other two companies Brain Challenge and Lumosity had pleasing buttons for 67% and 86% respectively.

There was no significant difference in button design by service type.

In-game Feedback

Games usually provide various kind of feedback to the player during game play to indicate the status of the game including success and failure, level, and so forth (we refer to this as "in-game feedback"). In-game feedback includes alert boxes, dings / chimes and visual animations to let the player know the outcomes of their actions. Most games included right/wrong feedback. One of the games did not have any in-game feedback. Plain good

and bad feedback used a typical happy sound (usually a musical chord) for right, and a buzzer or similar annoying unhappy sound for wrong. Pleasing in-game feedback included themed animations (fish dancing or sparkles) and more elaborate and unique audio. Among 32 games which included in-game feedback, 60% incorporated pleasing feedback and 40% used plain feedback

There was no significant difference in the pleasingness of in-game feedback by brain domain. However, games designed to exercise visual spatial cognitive functions used pleasing in-game feedback 75% of the time – relatively higher than the other brain domains.

### In-Game Feedback Pleasing (By Company)

Table 11: In-Game Feedback by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 7) | 0.14 | 0.38 |
| FitBrains (n = 8) | 0.88 | 0.35 |
| Lumosity (n = 7) | 0.43 | 0.54 |
| Brainversity (n = 3) | 0.33 | 0.58 |
| Brain Challenge (n = 3) | 1.00 | 0.00 |
| Big Fish (n = 4) | 1.00 | 0.00 |
| | | |
| Overall (n = 32) | 0.59 | 0.50 |

F = 4.558 p = .004 df = 5

Like many of the other categories analyzed, there were significant differences between the pleasingness of in-game feedback by different companies. One of the games from Happy Neuron did not include any in-game feedback. Among the rest of the Happy Neuron games (n = 7) only 14% of the games had pleasing feedback. Only one third of Brainversity games provided pleasing in-game feedback, as did 43% of Lumosity games. Eight-eight percent of

FitBrains games and all three games by Brain Challenge and Big Fish featured pleasing in-game feedback.

Incorporation of pleasing in-game feedback approached but did not achieve significant difference by service type. There was a trend towards casual game companies being more likely to use pleasing in-game feedback.

Between Rounds Feedback

Many brain games required players to complete multiple rounds of the same or very similar challenge to finish a complete game. Between rounds feedback assessed the feedback that was provided to the players when each round was over. Eight out of the 33 games analyzed did not have the concept of rounds as part of their game play hence they were not considered. Sixty-four percent of the 25 brain games with between round feedback featured pleasing feedback and the rest 36% had plain feedback

No significant difference was found for between rounds feedback based on which brain domain the games targeted.

**Between Game Rounds Feedback Pleasing (By Company)**

Table 12: Between Rounds Feedback by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 6) | 0.33 | 0.52 |
| FitBrains (n = 8) | 0.88 | 0.35 |
| Lumosity (n = 5) | 0.60 | 0.55 |
| Brainversity (n = 1) | 0.00 | |
| Brain Challenge (n = 2) | 1.00 | 0.00 |
| Big Fish (n = 3) | 0.67 | 0.58 |
| | | |
| Overall (n = 25) | 0.64 | 0.49 |

F = 1.571 p = .216 df = 5

The pleasing or plainness of between round feedback was different by company (F=1.571, df=5, p=.216). As with overall visual style, one company, Brainversity, used a purely functional form of in-game feedback for all of their games. One brain game company (Brain Challenge) consistently employed a pleasing visual style and pleasing between round feedback. Games from FitBrains, Big Fish and Lumosity used pleasing between rounds feedback far more often (88%, 60% and 67%) did Happy Neuron, which used pleasing between round feedback for only one third of their games

Pleasing or plain between-round feedback was not significantly different by service type.

End Game Feedback

Once a player has played through an entire game (which could consist of multiple rounds) the game provides a way to let the player know how they performed in the game. This may include scores, time elapsed and other details (defined as the End Game Feedback). Two games did not provide any kind of end of game feedback. Among the rest of the 31 games, 68% had pleasing end of game feedback and 32% had plain.

There was no significant difference in end of game feedback by brain domain.

**End of Game Feedback Pleasing (By Company)**

Table 13: End of Game Feedback by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 1.00 | 0.00 |
| FitBrains (n = 7) | 0.71 | 0.49 |
| Lumosity (n = 7) | 0.29 | 0.49 |
| Brainversity (n = 3) | 0.00 | 0.00 |
| Brain Challenge (n = 3) | 1.00 | 0.00 |
| Big Fish (n = 3) | 1.00 | 0.00 |
| | | |
| Overall (n = 31) | 0.68 | 0.48 |

F = 6.855 p = .000 df = 5

The pleasing or plainness of end game feedback was significantly different by company (F=6.855, df=5, p=.000). As with between rounds feedback, one company, Brainversity, used a purely functional form of end game feedback for all of their games. Two brain game companies (Happy Neuron and Brain Challenge) consistently employed a pleasing visual style for end of game feedback. The three games from Big Fish also used pleasing end game feedback. FitBrains provided pleasing end of game feedback for 71% of their games while Lumosity provided for only 29% of their games

Pleasing or plain end of game feedback was not significantly different by service type. Brain games on brain game company web sites and brain games found on casual game sites both had equally pleasing end game feedback.

Tutorials (Interactive)

Many of the games allowed the players to learn how to play the game this was done by allowing the player to actively take part in the learning process and interact with the game, this was defined as tutorial. Any element that increased the overall appeal like visual effects, animation, audio etc. added to the richness of the tutorial and hence was marked as pleasing. Only 14 games out of the total of 33 had an interactive tutorial, 57% of the game tutorials were pleasing and 43% of those were marked plain

**Tutorial Pleasing (By Brain Domain)**

Table 14: Tutorial by brain domain

| | Average | Standard Deviation |
|---|---|---|
| Memory games (n= 3) | 0.67 | 0.58 |
| Visual Spatial (n= 5) | 0.60 | 0.55 |
| Attention Games (n= 4) | 0.25 | 0.50 |
| Language Games (n= 2) | 0.00 | 0.00 |
| | | |
| Overall (n = 14) | 0.43 | 0.51 |

F = 1.034 p = 0.419 df = 3

There was a significant difference across the four different cognitive domains when it came to the plainness and pleasantness of their tutorials. None of the language games had a pleasing tutorial, only one fourth of the attention games had a pleasing tutorial. Visual spatial and Memory games fared much better at 60% and 67% respectively.

**Tutorial Pleasing (By Company)**

Table 15: Tutorial by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 7) | 0.14 | 0.38 |
| FitBrains (n = 2) | 1.00 | 0.00 |
| Lumosity (n = 3) | 0.33 | 0.58 |
| Brainversity (n = 0) | | |
| Brain Challenge (n = 1) | 1.00 | |
| Big Fish (n = 1) | 1.00 | |
| | | |
| Overall (n = 14) | 0.43 | 0.51 |

F = 2.813 p = .091 df = 4

As with cognitive domains there was a significant difference when the tutorials were compared by the companies. Brainversity did not have a game that had a tutorial among the rest two brain companies (FitBrains and Brain Challenge) consistently had pleasing tutorials, the single game from Big Fish that had a tutorial was also pleasing. One third of the games from Lumosity had a pleasing tutorial and only 14% of happy neuron games had a pleasing tutorial.

**Tutorial Pleasing (By Service Type)**

Table 16: Tutorial by Service Type

| | Average | Standard Deviation |
|---|---|---|
| Brain Game Service (n = 12) | 0.33 | 0.49 |
| Casual Games (n = 2) | 1.00 | 0.00 |
| | | |
| Overall (n = 14) | 0.43 | 0.51 |

F = 3.429 p = 0.089 df = 1

Off the 14 games that had a tutorial only two were casual games and both of them had pleasing tutorials however from the rest of games which all belonged to brain game companies only a third of them had pleasing tutorials, thus leading to a significant difference by service type.

Demo

The brain games allowed the player to watch a non interactive demo giving them a step by step guide to play the game and show the objective of the game, this was defined as a demo. 16 games from the ones analyzed did not have a demo and were not considered from the rest 77% of the games had a pleasing demo and 23% had a functional demo.

**Demo Pleasing (By Brain Domain)**

Table 17: Demo by brain domain

| | Average | Standard Deviation |
|---|---|---|
| Memory games (n= 7) | 0.71 | 0.49 |
| Visual Spatial (n= 3) | 1.00 | 0.00 |
| Attention Games (n= 3) | 0.33 | 0.58 |
| Language Games (n= 4) | 1.00 | 0.00 |
| | | |
| Overall (n = 17) | 0.76 | 0.44 |

F = 1.993 p = 0.165 df = 3

There was a significant difference between the various games when compared based on the cognitive domains, Visual spatial and Language games consistently had pleasing demos, while 71% of memory games had pleasing demos. However attention games had far lesser pleasing demos at 33%.

**Demo Pleasing (By Company)**

Table 18: Demo by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 2) | 0.00 | 0.00 |
| FitBrains (n = 6) | 1.00 | 0.00 |
| Lumosity (n = 5) | 0.60 | 0.55 |
| Brainversity (n = 0) | | |
| Brain Challenge (n = 3) | 1.00 | 0.00 |
| Big Fish (n = 1) | 1.00 | |
| | | |
| Overall (n = 17) | 0.76 | 0.44 |

F = 4.647 p = .017 df = 4

Similarly when the demos were compared by which company the game belonged too there was a big difference. Two brain companies FitBrains and Brain Challenge had pleasing demos for all their so did the brain games from the casual game company Big Fish. Happy Neuron only had functional demos for both their games and Lumosity had pleasing demos for 60% of their games.

**Demo Pleasing (By Service Type)**

Table 19: Demo by Service Type

| | Average | Standard Deviation |
|---|---|---|
| Brain Game Service (n = 13) | 0.69 | 0.48 |
| Casual Games (n = 4) | 1.00 | 0.00 |
| | | |
| Overall (n = 17) | 0.76 | 0.44 |

F = 1.569 p = 0.230 df = 1

When demos from different games were compared based on service type all four of the casual games had pleasing demos however only 69% (from a total of 13 games) of the games from brain game companies had pleasing demos.

Instructions

If a game had a static screen with all the instructions given using a combination of text or graphics in addition to or without having an interactive tutorial or a non-interactive demo with any animations etc. those games were coded as having an instruction screen. They were marked pleasing if the instruction were given a treatment which was consistent with the game and added overall appeal to the game. A simple background with text over it was not considered pleasing. A total of 23 games from the total games had instructions screen off which 57% were plain and 43% were pleasing.

Among the 23 games that had instruction screens there was no significant difference in plainness and pleasantness across the four cognitive domains hence games from one domain were as likely to be plain or pleasing as games from any other domain.

**Instruction Pleasing (By Company)**

Table 20: Instructions by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 7) | 0.14 | 0.14 |
| FitBrains (n = 8) | 0.75 | 0.75 |
| Lumosity (n = 3) | 0.00 | 0.00 |
| Brainversity (n = 3) | 0.33 | 0.33 |
| Brain Challenge (n = 0) | | |
| Big Fish (n = 2) | 1.00 | 0.00 |
| | | |
| Overall (n = 23) | 0.43 | 0.51 |

F = 3.912 p = .019 df = 4

There was a significant difference across the games when compared by the company that developed the games, both the games from the casual game company Big Fish had pleasing instruction screen and Lumosity was the only brain game company that did not have any game with a pleasant instruction screen. Three fourths of the games from FitBrains had a pleasing instruction while Brainversity and Happy Neuron had 33% and 14% games with pleasing instruction screen.

**Instruction Pleasing (By Service Type)**

Table 21: Instructions by Service Type

| | Average | Standard Deviation |
|---|---|---|
| Brain Game Service (n = 18) | 0.39 | 0.50 |
| Casual Games (n = 5) | 0.60 | 0.55 |
| | | |
| Overall (n = 23) | 0.43 | 0.51 |

F = .669 p = 0.423 df = 1

There was some difference across the games when compared by service type, 60% of brain games (from a total of 5) from casual gaming companies had a pleasing instruction screen where as only 39% (from a total of 18) of brain games from brain game companies had a pleasing instruction screen.

NPC Verbal Style

NPCs, or non playing characters, are a common component of certain game genres. It turns out that less than one third of the brain games coded (30%) incorporated an NPC. When an NPC did show up, it was coded for verbal style and visual appearance. Non playing characters that helped the players either by showing them things or telling about various things to do within the game were coded for their verbal style. The verbal style was not restricted to just audio -- even text or gestural animations coming from an NPC were considered as part of their verbal style. Of the 10 games including an NPC with a verbal style, 70% used a pleasing verbal style (such as being in character or being humorous) and 30% of the NPCs had a plain verbal style, simply explaining how to play or reporting a score.

**Inclusion of an NPC (By Company)**

Table 22: Inclusion of NPC by Company

| | Percent |
|---|---|
| Happy Neuron (n = 8) | 12.5% |
| FitBrains (n = 8) | 12.5% |
| Lumosity (n = 7) | 14.3% |
| Brainversity (n = 3) | 100% |
| Brain Challenge (n = 3) | 100% |
| Big Fish (n = 4) | 25% |
| | |
| Overall (n = 33) | 30% |

The number of brain games including an NPC is too small to allow for statistical comparisons. It is worth noting that 100% of the games in Brainversity and Brain Challenge incorporated an NPC, as did one of the other four Big Fish games. Among the three online brain game companies, the use of NPCs was consistently low, ranging from 12.5% to 14.3%.

NPC Appearance

While there were only ten of the 33 games that had an NPC which spoke (either via onscreen text or audio) and there were only nine games that had an NPC which was visually represented in the game. Out of the nine games, eight (89%) had a pleasing visual appearance for NPC's and only one game had a plain visual NPC representation. Here too, the numbers are too small to analyze by brain domain, company or service type.

Sound Effects

Any audio associated with the game including, effects for each mouse click or event with the game, background audio, transition screen audio effects etc. were coded under this category. Overall if the game had a lot more customized audio for a particular game and not just generalized dings and chimes which could be used in any game then it was coded as pleasing. If the game only had generic audio with no special effort to functionally make the game work it was coded as plain. Off the 33 games analyzed 61% of the games had plain sound effects and 39% of the games had pleasing sound effects.

**Sound Effects Pleasing (By Brain Domain)**

Table 23: Sound effects by brain domain

| | Average | Standard Deviation |
|---|---|---|
| Memory games (n= 9) | 0.44 | 0.53 |
| Visual Spatial (n= 8) | 0.63 | 0.52 |
| Attention Games (n= 8) | 0.13 | 0.35 |
| Language Games (n= 8) | 0.38 | 0.52 |
| | | |
| Overall (n = 33) | 0.39 | 0.50 |

F = 1.456 p = 0.247 df = 3

The plain and pleasing factor for sound effects varied over the four brain domains, the highest being 63% for visual spatial games and the lowest being 13% for attention games. Memory and Language were comparatively close to each other at 44% and 38% respectively

**Sound Effects Pleasing (By Company)**

Table 24: Sound effects by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 0.00 | 0.00 |
| FitBrains (n = 8) | 0.63 | 0.52 |
| Lumosity (n = 7) | 0.14 | 0.38 |
| Brainversity (n = 3) | 0.33 | 0.58 |
| Brain Challenge (n = 3) | 0.67 | 0.58 |
| Big Fish (n = 4) | 1.00 | 0.00 |
| | | |
| Overall (n = 33) | 0.39 | 0.50 |

F = 5.065 p = 0.002 df = 5

Pleasing or plain sound effects was significantly different across companies (F=5.065, df=5, p=.002). One company, Happy Neuron, used a purely functional style for all of their games. Only the four Big Fish casual games consistently used pleasing sound effects. The other varied in between with Lumosity and Brainversity at the lower end of the spectrum with 14% and 33%, while FitBrains and Brain Challenge were closer to the higher side with 63% and 67%.

**Sound Effects Pleasing (By Service Type)**

Table 25: Sound effects by Service Type

| | Average | Standard Deviation |
|---|---|---|
| Brain Game Service (n = 23) | 0.26 | 0.45 |
| Casual Games (n = 10) | 0.70 | 0.48 |
| | | |
| Overall (n = 33) | 0.39 | 0.50 |

F = 6.376 p = 0.017 df = 1

There was quite a large gap between the plain or pleasing factor when brain games were compared by service types. Seventy percent of the brain games hosted on casual gaming sites included pleasing sounds effects whereas only about one fourth of the brain games hosted on brain game websites (26%) featured pleasing sound effects.

**Pleasing or Plain Summary**

In summary, whether various elements of brain game design were pleasing or plan did not vary by brain domain or by service type. There was highly significant variation by company. A pleasing demo was most common, found in 76% of brain games. Title, visual style, buttons, and feedback were more often pleasing than plain, overall. Less than half of brain games included pleasing fonts, tutorials, or instructions. Sound effects were the single most neglected design element. Only 39% of brain games incorporated pleasing sound effects.

Table 26: Pleasing or Plain Summary

| | | Domain | Company | Service |
|---|---|---|---|---|
| **Demo** | 76% | n.s. | 0.017 | n.s. |
| **Title** | 70% | n.s. | 0.000 | n.s. |
| **End Feedback** | 68% | n.s. | 0.000 | n.s. |
| **Visual Style** | 67% | n.s | 0.002 | n.s. |
| **Between Rounds Feedback** | 64% | n.s. | n.s. | n.s. |
| **Intro Screen** | 61% | n.s. | 0.000 | n.s. |
| **Buttons** | 61% | n.s. | 0.000 | n.s. |
| **In-Game Feedback** | 59% | n.s. | 0.004 | 0.116 |
| **Fonts** | 45% | n.s. | 0.001 | n.s. |
| **Tutorial** | 43% | n.s. | 0.091 | n.s. |
| **Instructions** | 43% | n.s. | 0.019 | n.s. |
| **Sound Effects** | 39% | n.s. | 0.002 | n.s. |

### Overall Game features

While all of the games were coded for individual elements that comprised the visual style, game feedback and the interactivity within the games, the games were also coded for overall visual style, interactivity and feedback. They were coded as bland, somewhat appealing or very appealing. If a game had only functional elements within a category it was coded as bland, if it had a balanced mix of plain and pleasing elements it was marked somewhat pleasing and if the game had mostly pleasing elements it was marked as very appealing. A value of 1 was used to indicate if the overall element was bland a value of 2 indicated if the element was somewhat appealing and a value of 3 indicated that the element was very appealing, thus the average across games for these tables' ranges from 1 to 3.

Overall Visual Style

In addition to coding specific components of visual style such as fonts, introductory screen, buttons, we attempted to code a more gestalt, overall impression of visual style. Of the 33 games, 21% of the games were coded as having plain overall visual style, 36% of the games had a somewhat appealing visual style and 43% of the games had a very appealing visual style.

When the games were compared by cognitive domains there was no significant difference for the overall visual style of the games.

## Visual Style (By Company)

Table 27: Overall Visual Style by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 1.50 | 0.54 |
| FitBrains (n = 8) | 2.88 | 0.35 |
| Lumosity (n = 7) | 2.14 | 0.38 |
| Brainversity (n = 3) | 1.00 | 0.00 |
| Brain Challenge (n = 3) | 2.67 | 0.58 |
| Big Fish (n = 4) | 3.00 | 0.00 |
| | | |
| Overall (n = 33) | 2.21 | 0.78 |

F = 18.557 p = 0.000 df = 5

There was a significant difference in the appeal of the overall visual style by company. All the games from Brainversity were coded as plain. On the other end of the spectrum all the games from Big Fish were coded as having very appealing visual style. FitBrains games had an average visual style appeal of 2.88 (where 3 is very appealing and 1 is bland); Brain

Challenge was next in line with an average visual style appeal of 2.67. Lumosity averaged 2.14 and Happy Neuron visual style averaged 1.5.

There was no significant difference in the overall visual style of games when they were compared by service, so games hosted on brain company websites had an overall visually pleasing style similar to those that were hosted on casual game company websites.

Overall Interactivity

In addition to coding specific components of interactivity such as buttons and visual feedback, we attempted to code a more gestalt, overall impression of the interactive experience of playing the game. Off the 33 games that were analyzed 30% of the games were coded as using relatively plain interactivity, 27% were coded as having somewhat appealing interactivity and 43% of the games were coded as having very appealing interactivity.

**Overall Interactivity (By Brain Domain)**

Table 28: Overall Interactivity by brain domain

| | Average | Standard Deviation |
|---|---|---|
| Memory games (n= 9) | 2.11 | 0.93 |
| Visual Spatial (n= 8) | 2.13 | 0.84 |
| Attention Games (n= 8) | 2.13 | 0.84 |
| Language Games (n= 8) | 2.13 | 0.99 |
| | | |
| Overall (n = 33) | 2.12 | 0.86 |

F = 0.001 p = 1.000 df = 3

When compared by the four brain domains there was no significant regarding the overall

interactivity of the games, games from one domain were found to be equally interactive as compared to other domains.

### Overall Interactivity (By Company)

Table 29: Overall Interactivity by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 1.25 | 0.46 |
| FitBrains (n = 8) | 2.63 | 0.52 |
| Lumosity (n = 7) | 2.29 | 0.95 |
| Brainversity (n = 3) | 1.33 | 0.58 |
| Brain Challenge (n = 3) | 2.33 | 0.58 |
| Big Fish (n = 4) | 3.00 | 0.00 |
| | | |
| Overall (n = 33) | 2.12 | 0.86 |

F = 7.127 p = 0.000 df = 5

When the games were compared based on the company that hosts there was a significant difference on the overall quality of interactivity in games. There were three distinct clusters where Happy Neuron and Brainversity were together at the bottom with an average interactivity appeal of 1.25 and 1.33 (on a scale from 1 = bland to 3 = very appealing) and Big Fish was the leader of the pack with all their games scoring a perfect 3 on appealing interactivity. The other three companies FitBrains, Brain Challenge and Lumosity were in between (2.63, 2.33, and 2.29 respectively) in terms of overall interactivity appeal.

## Overall Interactivity (By Service Type)

Table 30: Overall Interactivity by Service type

| | Average | Standard Deviation |
|---|---|---|
| Brain Game Service (n = 23) | 2.04 | 0.88 |
| Casual Games (n = 10) | 2.30 | 0.82 |
| | | |
| Overall (n = 33) | 2.12 | 0.86 |

F = 0.617 p = 0.438 df = 1

There was no significant difference when the games were compared by the type of the service; hence brain games on brain game company websites were as interactive as games that were hosted on casual gaming websites.

Overall Game feedback

Games were rated for the overall gestalt appeal of feedback, combining in-game, between rounds and end of game feedback. Among the 33 games analyzed 27% had bland feedback, 40% of had somewhat appealing feedback and 33% incorporated very appealing feedback.

## Overall Feedback (By Brain Domain)

Table 31: Overall feedback by brain domain

| | Average | Standard Deviation |
|---|---|---|
| Memory games (n= 9) | 1.78 | 0.83 |
| Visual Spatial (n= 8) | 2.13 | 0.64 |
| Attention Games (n= 8) | 2.00 | 0.76 |
| Language Games (n= 8) | 2.38 | 0.92 |
| | | |
| Overall (n = 33) | 2.06 | 0.79 |

F = 0.831 p = 0.488 df = 3

When the games were compared across the different brain domains there was no significant difference between them and almost all the different domains scored 60% of better rating for overall game feedback.

**Overall Feedback (By Company)**

Table 32: Overall feedback by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 1.88 | 0.35 |
| FitBrains (n = 8) | 2.50 | 0.54 |
| Lumosity (n = 7) | 1.29 | 0.76 |
| Brainversity (n = 3) | 1.33 | 0.58 |
| Brain Challenge (n = 3) | 2.67 | 0.58 |
| Big Fish (n = 4) | 3.00 | 0.00 |
| | | |
| Overall (n = 33) | 2.06 | 0.79 |

F = 8.656 p = 0.000 df = 5

There was a significant difference in the overall appeal of feedback when the games were compared by the company that hosts them. Lumosity and Brainversity had the lowest overall appealing feedback, averaging 1.29 and 1.33 respectively and the Big Fish casual brain games, similar to overall visual style and interactivity, again had the highest score on feedback, a perfect 3. Brain Challenge and FitBrains were closer to the higher end of the spectrum with 2.67 and 2.50 respectively. Happy Neuron averaged 1.88 for overall game feedback.

**Overall Feedback (By Service Type)**

Table 33: Overall feedback by Service Type

| | Average | Standard Deviation |
|---|---|---|
| Brain Game Service (n = 23) | 1.91 | 0.73 |
| Casual Games (n = 10) | 2.40 | 0.84 |
| | | |
| Overall (n = 33) | 2.06 | 0.79 |

F = 2.811 p = 0.104 df = 1

When compared by the service type there was a little difference between games that were hosted on brain game company websites, scoring 64%, for overall game feedback as compared to 80% scored by games hosted on casual gaming companies.

**Forms of Fun**

The games were coded for 20 different forms of fun the games either did not have a particular form of fun (was coded as Not Existing) it had a little of the form of fun, for example a person had very minimal intellectual problem solving as part of game (was coded as A little) or if the entire game and its functionality depends on intellectual problem solving (was coded as A lot). This section gives a detailed breakdown and results for each of the different forms of fun. In the tables that follow, n - indicates the number of games for that category, F - is the oneway ANOVA F value, df is the degrees of freedom and p indicates the significance level. A value of 1 was used to indicate if the form of fun was non-existent a value of 2 indicated if there was a little of that form of fun and a value of 3 indicated a lot of the form of fun. Thus, the average across games will range from 1 to 3.

Advancement and Completion

Overall, 30% of brain games included a strong component of the fun of advancement and completion; 24% of brain game play included a glimmer of advancement and completion, and the plurality (45.5%) did not invoke advancement and completion fun.

**Advancement & Completion (By Brain Domain)**

Table 34: Advancement & Completion by brain domain

| | Average | Standard Deviation |
|---|---|---|
| Memory games (n= 9) | 1.89 | 0.78 |
| Visual Spatial (n= 8) | 1.88 | 0.99 |
| Attention Games (n= 8) | 1.88 | 0.99 |
| Language Games (n= 8) | 1.75 | 0.89 |
| | | |
| Overall (n = 33) | 1.85 | 0.87 |

F = 0.041 p = 0.989 df = 3

There was no significant difference in the inclusion of advancement and completion by brain domain.

**Advancement & Completion (By Company)**

Table 35: Advancement & Completion by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 1.25 | 0.71 |
| FitBrains (n = 8) | 2.25 | 0.71 |
| Lumosity (n = 7) | 1.71 | 0.95 |
| Brainversity (n = 3) | 1.33 | 0.58 |
| Brain Challenge (n = 3) | 1.67 | 0.58 |
| Big Fish (n = 4) | 3.00 | 0.00 |
| | | |
| Overall (n = 33) | 1.85 | 0.87 |

F = 4.112 p = .007 df = 5

The four Big Fish casual games all incorporated a strong element of advancement and completion, averaging 3.0 on a scale from 1=not at all to 3= a lot. FitBrains averaged 2.25 (they had one or two of their 8 games that did strongly invoke advancement and completion, and the remainder only weakly did so). Lumosity and Brain Challenge often included at least a little advancement and completion (1.71 and 1.67) while Brainiversity and Happy Neuron rarely included any (1.33 and 1.25).

**Advancement & Completion (By Service Type)**

Table 36: Advancement & Completion by Service Type

| | Average | Standard Deviation |
|---|---|---|
| Brain Game Service (n = 23) | 1.74 | 0.86 |
| Casual Games (n = 10) | 2.10 | 0.88 |
| | | |
| Overall (n = 33) | 1.85 | 0.87 |

F = 1.206 p = .281 df = 1

There was no significant difference in advancement and completion fun by service type.

Again as with Plain and Pleasing if there was no significant difference observed when the games were compared by Brain domains, Company or Service types those tables are not included.

Altruism

Out of a total of 33 games only one game (3%) had a little of altruism as part of its game-play the other thirty two games (97%) did not have this form of fun. As the number was

significantly lower we did not compare them by cognitive domains, brain game companies and service type.

Physical Ability

None of the thirty three games had any application of a physical ability as part of their game-play.

Mental Ability

Given that all the games that were analyzed were brain games all the games had at least some amount of game-play that exhibited this form of fun. From a total of 33 games 67% of games demonstrated a lot of this type of fun and 33% of the games had a little of this form of fun.

When compared by brain domain there was no significant difference in the inclusion of the application of mental ability as part of the game-play. Almost all games consistently had a strong inclination to include this form of fun as indicated by the average being 2.50 or higher

Like brain domain there was no significant difference between games when compared by companies that host them.

There was no significant difference in this form of fun by service type, brain games hosted on casual gaming websites as well as games hosted on brain game companies websites were all cerebral in nature.

Beauty

Only three games out of the total of 33 games that were analyzed had a lot of this form of fun, indicating most brain games lacking in the overall aesthetic appeal. A significant number of games (49%) did not have this form of fun, while some of the games (42%) showed a little of this type of fun.

There was no significant difference when compared by the brain domains as to the beauty of the game, none of the domains were higher than A little category, with language games having the highest average at 1.88.

**Beauty (By Company)**

Table 37: Beauty by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 1.13 | 0.35 |
| FitBrains (n = 8) | 2.00 | 0.54 |
| Lumosity (n = 7) | 1.43 | 0.54 |
| Brainiversity (n = 3) | 1.00 | 0.00 |
| Brain Challenge (n = 3) | 1.67 | 0.58 |
| Big Fish (n = 4) | 2.50 | 0.58 |
| | | |
| Overall (n = 33) | 1.61 | 0.66 |

F = 6.580 p = 0.000 df = 5

When brain games were compared by companies they showed quite a wide gap in the amount of beauty present in games. All four of the games from Big Fish showed a great deal of beauty averaging 2.5 on a scale from 1 to 3, while none of the games from Brainiversity had this form of fun with the lowest average of 1.0. FitBrains was a healthy mix of games

having a little or lot of this form of fun (average of 2.0). While rest of the companies had very little beauty in their games with averages of 1.67 (Brain Challenge), 1.43 (Lumosity) and 1.13 (Happy Neuron)

There was no significant difference in beauty of the games when compared by service type.

Comedy

Overall among the 33 games analyzed none of the games had a lot of humor as part of their game play hence none of the games were rated as having A Lot of this form of fun. Only 15% of the games had some form of comedy in the game but a majority of the games (85%) had no humor at all.

When the games were compared by cognitive domains, companies that hosted the games and the service type there were no significant differences indicating a general lack of humor in brain games as none of them had a high average.

Competition

Most of the brain games that were analyzed targeted at individuals who wanted to either keep their brains active or improve the brain function hence they did not include direct competition with others, but were more of self paced games allowing the individual player to play at their own pace and improve. Thus none of the games showed A Lot of competition as part of the game-play, 52% of the games did not have any form of competition and 48% had a little form of competition mostly in the form of a statistical evidence of how a player

fared as compared to other players on average instead of direct completion with another player.

Given that not a lot of games had this form of fun, when they were compared by cognitive domains, companies that hosted games and service type of the companies there were no significant differences as to the amount of competition included in the games.

Creation

A high percentage of the 33 games analyzed (82%) did not encourage players to create things within the game thus accounting for the lack of this form of fun. Two games showed a little of this form of fun and four games showed a lot of this form. Given the low number of games that showed this form of fun it was not surprising to see there were no significant differences between games when compared by cognitive domains or service type hence we did not consider those.

**Creation (By Company)**

Table 38: Creation by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 1.13 | 0.35 |
| FitBrains (n = 8) | 1.13 | 0.35 |
| Lumosity (n = 7) | 1.29 | 0.76 |
| Brainiversity (n = 3) | 1.00 | 0.00 |
| Brain Challenge (n = 3) | 1.00 | 0.00 |
| Big Fish (n = 4) | 2.50 | 1.00 |
| | | |
| Overall (n = 33) | 1.30 | 0.68 |

F = 4.484 p = 0.004 df = 5

When compared by companies hosting the games however all four games from Big Fish scored high on this form of fun averaging a total of 2.5 on a scale of 1 to 3. The rest of the companies had averages closer t one indicating a low amount of creation as part of the game-play.

Exploration

70% of the games did not allow for any kind of exploration within the games, 18% of the games allowed some exploration as part of the game-play and only 12% allowed significant exploration as part of the game-play.

There was no significant difference in the amount of exploration involved in games when compared by brain domains.

**Exploration (By Company)**

Table 39: Exploration by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 1.13 | 0.35 |
| FitBrains (n = 8) | 1.63 | 0.74 |
| Lumosity (n = 7) | 1.14 | 0.38 |
| Brainversity (n = 3) | 1.00 | 0.00 |
| Brain Challenge (n = 3) | 1.00 | 0.00 |
| Big Fish (n = 4) | 2.75 | 0.50 |
| | | |
| Overall (n = 33) | 1.42 | 0.71 |

F = 8.242 p = 0.000 df = 5

There was a significant difference when games were compared by companies as to the amount of exploration that was allowed by a game. Big Fish had the highest average of 2.5 on a scale from 1=not present to 3 = a lot and on the other end of the spectrum Brain Challenge and Brainiversity did not have any kind of exploration in any of their games. FitBrains, Lumosity and Happy Neuron had a couple of games each that allowed a little exploration with averages of 1.63, 1.14 and 1.13 respectively.

There was no significant difference in the amount of exploration involved as part of the game-play when compared by the service type of the companies

Immersion

Overall among the 33 games that were analyzed a little more than half (52%) of the games did not allow the player to be immersed in a completely different setting and 48% of the games allowed only a little immersion. There were no games that allowed the player to be totally immersed in a different universe. Most brain games did not have a different world in which the player could get involved in and get lost.

When the games were compared by brain domains, there was no significant difference to the amount of immersion allowed by the games setting.

**Immersion (By Company)**

Table 40: Immersion by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 1.38 | 0.52 |
| FitBrains (n = 8) | 1.75 | 0.46 |
| Lumosity (n = 7) | 1.57 | 0.54 |
| Brainversity (n = 3) | 1.00 | 0.00 |
| Brain Challenge (n = 3) | 1.00 | 0.00 |
| Big Fish (n = 4) | 1.75 | 0.50 |
| | | |
| Overall (n = 33) | 1.48 | 0.51 |

F = 2.222 p = 0.081 df = 5

None of the companies averaged above two when the games were compared by companies; however a casual game company (Big Fish) and a brain game company (FitBrains) scored an average of 1.75 as compared to Brainiversity and Brain Challenge which had an average of 1.0 indicating none of their games had any sense of immersion.

When the games were compared by service type like brain domains there was no significant difference to the amount of immersion allowed by the games, indicating brain games hosted on casual gaming websites as well as games hosted by brain companies were relatively the same.

Intellectual Problem Solving

Two thirds of the total games analyzed did not have any intellectual problem solving as part of the game-play. 24% of the games had a little intellectual problem solving and only 9% of the games had a lot of this form of fun.

When the games were compared by brain domains, there was no significant difference to the amount of intellectual problem solving required as part of the game-play.

**Intellectual Problem Solving (By Company)**

Table 41: Intellectual Problem Solving by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 1.25 | 0.71 |
| FitBrains (n = 8) | 1.25 | 0.46 |
| Lumosity (n = 7) | 1.29 | 0.49 |
| Brainversity (n = 3) | 1.67 | 0.58 |
| Brain Challenge (n = 3) | 1.00 | 0.00 |
| Big Fish (n = 4) | 2.50 | 0.58 |
| | | |
| Overall (n = 33) | 1.42 | 0.66 |

F = 3.979 p = 0.008 df = 5

Intellectual problem solving differed significantly based on which company was hosting the game, Big Fish had the highest average of 2.5 indicating most of their games had a lot of this form of fun, where as Brain Challenge with an average of 1.0 indicates none of its game had any intellectual problem solving. The rest of the four companies Happy Neuron, FitBrains, Lumosity and Brainiversity had some of their games that had a little intellectual problem solving.

When the games were compared by service type, there was no significant difference to the amount of intellectual problem solving required as part of the game-play.

Story

Out of the total of 33 games that were analyzed, 24 did not have any kind of story but just had a set of tasks the player needed to complete. From the remaining nine only three had a

rich story with a setting and characters while the other six had a little amount of story in terms of a place where the game took place and the actions of the player affected the story of the game in a very minimal way.

When the games were compared by brain domains, there was no significant difference as to games belonging to which domain had more story compared to other domains.

**Story (By Company)**

Table 42: Story by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 1.13 | 0.35 |
| FitBrains (n = 8) | 1.38 | 0.52 |
| Lumosity (n = 7) | 1.43 | 0.79 |
| Brainversity (n = 3) | 1.00 | 0.00 |
| Brain Challenge (n = 3) | 1.00 | 0.00 |
| Big Fish (n = 4) | 2.25 | 0.96 |
| | | |
| Overall (n = 33) | 1.36 | 0.65 |

F = 2.592 p = 0.049 df = 5

When the amount of story present in a game was compared by the different companies hosting the game there was a significant difference. Big Fish had the highest average of 2.25 for its four games indicating almost all its games had a little of story with a few of them having a rich story. However Brainiversity and Brain Challenge did not have any games that had any kind of story for their games. FitBrains and Lumosity with averages of 1.38 and 1.43 had a couple of games that had some story elements within the game, while only one of the games from happy Neuron had some kind of story for its game.

When the games were compared by service type, there was no significant difference in the amount of story present in the games. Thus brain games hosted on a casual gaming website had a similar amount of story as part of the overall game-play as compared to brain games hosted on brain game websites.

Learning

Only five out of the total of 33 games analyzed involved a little of real world learning, rest of the games had no learning component as part of the game-play. As the number of games having this form of fun was lower they were not compared by brain domains, companies and service type.

Love

None of the 33 games analyzed had any component of love as part of the game-play.

Physical Activity

None of the 33 games analyzed required the player to do any kind of physical activity while playing the games except pushing buttons on a keyboard which was not considered for this analysis.

Power

None of the 33 games analyzed allowed you to gain any kind of power as part of the game-play..

Social Interaction

As observed earlier since the games are targeted at individuals to be able to play them at their own pace there is no active form of social interaction while playing the game in any of the games that were analyzed.

Danger

Out of the 33 games analyzed 94% of the games had no sense of danger as part of the game-play only 6% of the games had a little sense of danger. Since there were only two games that showed this form of fun we did not compare them by brain domains, service type and companies hosting the game.

**Forms of Fun Summary**

In summary, mental abilities was the most common form of fun in brain games, found in 100% of the games analyzed. Advancement and Completion was next most common, found in 54% of the brain games. Beauty and Competition each appeared in nearly half of the games. The remaining 14 forms of fun were either rare or completely absent. Most brain games rely on a limited set of forms of fun. Like the pleasing or plain findings, forms of fun, when present at all, were highly significantly different by company, and not different by

brain domain. The inclusion of intellectual problem solving was more common in online casual games.

Table 43: Forms of Fun Summary

| | none | glimmer | strong | Domain | Company | Service |
|---|---|---|---|---|---|---|
| **Mental Ability** | 0% | 33% | 67% | n.s. | n.s. | n.s. |
| **Advancement and Completion** | 46% | 24% | 30% | n.s. | 0.007 | n.s. |
| **Beauty** | 49% | 42% | 9% | n.s. | 0.000 | n.s. |
| **Competition** | 52% | 48% | 0% | n.s. | n.s. | n.s. |
| **Intellectual Problem Solving** | 67% | 24% | 9% | n.s. | 0.008 | 0.029 |
| **Exploration** | 70% | 18% | 12% | n.s. | 0.000 | 0.143 |
| **Story** | 73% | 18% | 9% | n.s. | 0.049 | n.s. |
| **Creation** | 82% | 6% | 12% | n.s. | 0.004 | n.s. |
| **Comedy** | 85% | 15% | 0% | | | |
| **Learning** | 85% | 15% | 0% | | | |
| **Danger** | 94% | 6% | 0% | | | |
| **Altruism** | 97% | 3% | 0% | | | |
| **Immersion** | 52% | 48% | 0% | | 0.081 | |
| **Physical Ability** | 100% | 0% | 0% | | | |
| **Love** | 100% | 0% | 0% | | | |
| **Physical Activity** | 100% | 0% | 0% | | | |
| **Power** | 100% | 0% | 0% | | | |
| **Social Interaction** | 100% | 0% | 0% | | | |

TOTAL FORMS OF FUN

One final approach to considering fun in brain games was to add up the total number of forms of fun that was strongly present in each individual game. If a game was coded 1(not present) or 2 (slightly present), then that form of fun was re-coded to zero and if the game was coded 3 (strongly present) then that form of fun was re-coded to 1. So, zero means not present and 1 means strongly present.

Total forms of fun ranged from a low of 1 (for 15% of the games) to a high of 10 (for one game).

### Total Forms of Fun (By Brain Domain)

Table 44: Total Forms of Fun by brain domain

| | Average | Standard Deviation |
|---|---|---|
| Memory games (n= 9) | 4.44 | 2.96 |
| Visual Spatial (n= 8) | 4.75 | 3.01 |
| Attention Games (n= 8) | 4.25 | 1.58 |
| Language Games (n= 8) | 4.63 | 2.56 |
| | | |
| Overall (n = 33) | 4.52 | 2.49 |

F = 0.056 p = 0.982 df = 3

There was no significant difference in total forms of fun by brain domain.

### Total Forms of Fun (By Company)

Table 45: Total Forms of Fun by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 2.50 | 1.69 |
| FitBrains (n = 8) | 6.13 | 1.13 |
| Lumosity (n = 7) | 4.43 | 2.94 |
| Brainversity (n = 3) | 3.00 | 1.00 |
| Brain Challenge (n = 3) | 3.00 | 1.73 |
| Big Fish (n = 4) | 7.75 | 0.50 |
| | | |
| Overall (n = 33) | 4.52 | 2.49 |

F = 6.583 p = 0.000 df = 5

Total forms of fun was significantly different by company. The four Big Fish causal games averaged 7.75 forms of fun, with a small standard deviation of only 0.5. FitBrains games were the next most fun, averaging 6.13 different forms per game. Lumosity was next, with 4.43 forms of fun per game. Lumosity games were the least consistent – some had a large number of forms of fun and some had one or a few, resulting in a standard deviation of 2.94. Brainiversity and Brain Challenge each averaged 3 forms of fun, and Happy Neuron 2.5.

**Total Forms of Fun (By Service Type)**

Table 46: Total Forms of Fun by Service Type

| | Average | Standard Deviation |
|---|---|---|
| Brain Game Service (n = 23) | 4.35 | 2.46 |
| Casual Games (n = 10) | 4.90 | 2.64 |
| | | |
| Overall (n = 33) | 4.52 | 2.49 |

F = 0.336 p = 0.566 df = 1

There was no significant difference in forms of fun by service type.

Additional Considerations

Flow

When measuring flow for games we wanted to make sure that the games the players played were challenging them enough to keep them playing but not making it so hard for the player that they would give up in frustration. This was coded as too easy indicated by 1, just right indicated by 2 and too hard indicated by 3. Ideally if a game had an average score closer to or

equal to 2 would make the game most suited for players, a score closer to one would indicate the game was too easy for the players risking the players getting bored easily and a score closer to three would indicate that the chances of a player getting frustrated were higher. When we analyzed the 33 games 67% of the games were just right for the players indicating they had a good flow for the games, 18% of the games were too easy for the players and 15% of the games were too hard for the players.

**Flow (By Brain Domain)**

Table 47: Flow by brain domain

| | Average | Standard Deviation |
|---|---|---|
| Memory games (n= 9) | 2.00 | 0.50 |
| Visual Spatial (n= 8) | 2.13 | 0.64 |
| Attention Games (n= 8) | 2.00 | 0.54 |
| Language Games (n= 8) | 1.75 | 0.71 |
| | | |
| Overall (n = 33) | 1.97 | 0.59 |

F = 0.554 p = 0.650 df = 3

As seen from the table when games were compared by brain domains, almost all of the games performed satisfactorily, Memory and Attention games both had a perfect average score of two. Visual spatial games with an average of 2.13 indicates that there was one of the games in that domain that was a little difficult for players and Language games with an average of 1.75 indicates there was a game that was a little too easy for players.

**Flow (By Company)**

Table 48: Flow by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 1.88 | 0.84 |
| FitBrains (n = 8) | 2.00 | 0.54 |
| Lumosity (n = 7) | 1.71 | 0.49 |
| Brainversity (n = 3) | 2.00 | 0.00 |
| Brain Challenge (n = 3) | 2.00 | 0.00 |
| Big Fish (n = 4) | 2.50 | 0.58 |
| | | |
| Overall (n = 33) | 1.97 | 0.59 |

F = 0.967 p = 0.455 df = 5

When compared by different companies hosting the games, FitBrains, Brain Challenge and Brainiversity all achieved perfect averages of 2.0 indicating most of their games had a good flow. Big Fish with a score of 2.5 indicates that two out of their four games were a little difficult for players. Happy Neuron and Lumosity with averages of 1.88 and 1.71 indicate that they had a couple of games which were a little easier.

**Flow (By Service Type)**

Table 49: Flow by Service Type

| | Average | Standard Deviation |
|---|---|---|
| Brain Game Service (n = 23) | 1.87 | 0.63 |
| Casual Games (n = 10) | 2.20 | 0.42 |
| | | |
| Overall (n = 33) | 1.97 | 0.59 |

F = 2.311 p = 0.139 df = 1

When compared by service type there was no significant difference so games hosted on casual gaming website as well as games hosted on brain game companies both had a good sense of flow for the games.

Engagement

Engagement in games was coded with three different values, 1 indicated not engaging at all, 2 indicated the game was somewhat engaging and 3 indicated that the game was very engaging. Hence the games had an average score between 1 and 3. Out of the 33 games that were analyzed 27% of the games were not engaging at all, 43% of the games were somewhat engaging and 30% of the games were very engaging.

**Engagement (By Brain Domain)**

Table 50: Engagement by brain domain

| | Average | Standard Deviation |
|---|---|---|
| Memory games (n= 9) | 2.00 | 0.71 |
| Visual Spatial (n= 8) | 2.00 | 0.93 |
| Attention Games (n= 8) | 2.00 | 0.54 |
| Language Games (n= 8) | 2.13 | 0.99 |
| | | |
| Overall (n = 33) | 2.03 | 0.77 |

F = 0.048 p = 0.986 df = 3

There was no significant difference in the engagement value of the game when they were compared by the different brain domains.

**Engagement (By Company)**

Table 51: Engagement by Company

| | Average | Standard Deviation |
|---|---|---|
| Happy Neuron (n = 8) | 1.38 | 0.52 |
| FitBrains (n = 8) | 2.13 | 0.64 |
| Lumosity (n = 7) | 2.29 | 0.76 |
| Brainversity (n = 3) | 1.67 | 0.58 |
| Brain Challenge (n = 3) | 2.00 | 1.00 |
| Big Fish (n = 4) | 3.00 | 0.00 |
| | | |
| Overall (n = 33) | 2.03 | 0.77 |

F = 4.045 p = 0.007 df = 5

There was a significant difference when the games were compared by different companies hosting the games; all the four games from Big Fish were consistently very engaging, where as Happy neuron had the least engaging games. Most of the games from Lumosity, FitBrains and Brain Challenge were somewhat engaging and one of the games from the three Brainiversity games was not engaging.

**Engagement (By Service Type)**

Table 52: Engagement by Service Type

| | Average | Standard Deviation |
|---|---|---|
| Brain Game Service (n = 23) | 1.91 | 0.73 |
| Casual Games (n = 10) | 2.30 | 0.82 |
| | | |
| Overall (n = 33) | 2.03 | 0.77 |

F = 1.805 p = 0.189 df = 1

When the games were compared by the service type there was no significant difference as to whether the games were engaging if they were hosted on a casual gaming company's website or a brain game company's website

## CONCLUSIONS

So what does this tell us about brain games? Overall, more than half of the brain games coded were rated pleasing along 8 of 12 categories coded, ranging from 58% with pleasing in-game feedback to 76% with a pleasing demo. The other four categories (fonts, tutorial, instructions, and sound effects), were pleasing in between 39% and 45% of the brain games. In contrast, considering the four big fish casual games that happened to exercise a specific brain function, 100% of those games were pleasing along 9 categories, and no category had lower than 67% pleasing games. While this study is not structured to answer the question, are brain games less pleasing than non-brain games, this small sample would support that conclusion. We cannot say why brain games are less fun. They probably have lower production budgets. It may be that exercising an isolated cognitive function is by nature not as fun. Or it may be that to conform to the cognitive requirements for brain exercise, the pleasingness found in other games must be to some extent suppressed.

When we take a look at the summary of results for plain vs. pleasing data there is no significant difference across the four brain domains, games were as pleasing or plain if they exercised one domain as compared to any of the other three domains. Similarly baring the one variable regarding in-game feedback there was no significant difference when the games were compared by service type, so games belonging to brain games companies were as plain or pleasing as compared to games that were hosted by casual gaming companies. However, across all the categories coded there was a significant difference when they are compared by the different companies that host the game. FitBrains had consistently high game production values. Happy Neuron's games were more like exercises than games. Lumosity offered a mix of both approaches in different games. The two casual game brain game companies

(Brain Challenge and Brainiversity) were also very exercise-like, albeit with some polish in presentation. The Big Fish games that were not part of any brain game company were similar to and sometimes exceeded Fit Brains in pleasingness.

The above trend also continues when we consider the different forms of fun and which games have the most forms of fun. There was no significant difference when games are compared by brain domains or service type but a big difference in the number of forms of fun when they are compared by the companies that host these games.

**State of the art of brain game design**

Brain games are an emerging market with no specific set standards, including how they are defined. During the initial phase while defining the universe of brain games we came across a lot of companies that gave their own nomenclature to the different brain domains and there was little consistency from company to company. This gives an idea as to how fragmented the market is with a lot of room for improvement and growth.

Among the various games analyzed sound effects used in the games were the most neglected elements within games often times games had default system sounds and buzzer like beeps which did not add any polish, style, or pleasingness to the game. Most of the sound effects were generic, almost obligatory feedback. When comparing overall data for all games, only non-brain game suite games distributed on Big Fish casual games stood out and performed well across all the various parameters. Games hosted by FitBrains were the only ones from a brain games company that managed to come closer in terms of overall quality to Big Fish.

While coding for forms of fun it was observed that many forms of fun did not appear at all in any game coded. These included Love, Social interaction, Physical Activity or application of a physical ability and Power. For forms of fun, the casual gaming games on Big Fish scored the highest in terms of the number of different forms of fun incorporated in the games with FitBrains again coming a close second.

Given the initial assumption that brain games are not as polished as compared to other casual games it was pleasantly surprising to see that there were no significant difference in the quality of the games when they were compared by the service type. A conclusion is that it is possible for brain games to employ high production values.

**Differences by company**

The biggest differences noticed when comparing games for plain vs. pleasing and the number of forms of fun was when they were compared by companies, almost every category showed a significant difference. Games from casual gaming distributor Big Fish, among the companies measured, stood out as having the highest pleasing and fun scores. From the brain game companies, FitBrains fared markedly better that the other companies.

An interesting point observed was even though a particular company was performing far better than other companies within a particular service type (Big Fish and FitBrains) when the games were compared overall by service type these differences cancelled each other out, indicating that within the two service types there was a greater divide. Thus the initial idea that brain game companies do not pay attention to the design and have weak production values does not necessarily hold true. On the other hand, Brainiversity and Brain Challenge

were suits of brain games distributed on Big Fish which focused on brain exercises. Each made use of a virtual trainer or guide. Their games often incorporated a pleasing style, but used one or two forms of fun.

**Future of brain game design**

There is a great deal of room for improvement; the key areas where I felt the game designs could be improved were story, immersion and social interaction. The games from the casual gaming companies and brain game companies mostly did not exhibit these kinds of fun. Adding a more immersive and story rich environment allows the player to be transported to a different setting and also allows the designer to be a lot more creative with the kind of visuals, audio and game play mechanics that could be implemented. It would also allow the players to feel a sense of progression if the story and the setting in which the game is based changes with time. Adding social interaction either within the game in the form of allowing multi-player versions of the games where possible or creating a community on the website where the games were hosted would allow players to either cooperate or compete with each other, leading to a greater level of enjoyment of the games.

From the games we analyzed, as mentioned earlier, the quality of audio used within the games especially with related to various sound effects associated with different events within the games can be made to be more consistent and appealing to the players.

**Further research and analysis**

The approach taken in thus study coded and analyzed individual brain games. In doing so, we did not take into account the surrounding information, statistics, charts, and advice that comprise the bigger picture and overall service offered by companies like Happy Neuron, Lumosity, and FitBrains. Players' ability to track progress over time and compare their play to other players, external trophies and awards, and brain trainer advice were all outside of the scope of a game by game comparison. These areas are important, and should be considered, along with the effectiveness of the games, in future studies.

The two main criteria we used to analyzed games (plain vs. pleasing and forms of fun) are qualities of any game and thus do not apply to brain games alone. Thus, we could use the same coding system to analyze games which fill up different niches and where we are trying to determine the quality of production in games. Almost any kind of game regardless of platform or whether it is a serious game or game for entertainment could be analyzed using this kind of framework.

This study only looked at web-delivered online games, mostly from brain game companies. These criteria excluded the popular commercial Nintendo game, Brain Age, playable on the DS and the Wii. It would be interesting to apply the pleasing versus plain and forms of fun frameworks to Brain Age. How would Brain Age compare to the games in our study?

Specific to this research while I have used a quantitative approach while analyzing the brain games, a lot of the data collected was qualitative and it needs to be analyzed further especially the details of the game play of the different games and how rich and varied they are to add a sense of newness to the games.

Also given that the brain games market is still nascent it would also be beneficial to allow the market to grow a little and do a similar analysis down the line to get an idea whether there are significant differences again between companies and if overall more forms of fun are included.

Finally I think a different question to ask would also be relevant, do brain games have to be bad to be effective? In other words, might adding lots of forms of fun interfere with achieving the intended brain exercise? Does more fun enhance brain exercise, or is fun irrelevant? The largest differences in both fun and pleasing/plain variables was found between Happy Neuron games, which more closely resembled exercises, and Fit Brains, which more closely resembled games for entertainment. A study that compares the neurological effects of games from Happy Neuron vs. FitBrains (the ones that exercise the same brain functions) could address that question.

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