YOU ARE WHAT YOU EAT:

ANALYZING THE RELATIONSHIPS BETWEEN VIDEO GAMES, PLAYSTYLES, AND PLAYER CHARACTERISTICS

A Thesis Presented to

the Faculty of the Department of Computer Science

University of Houston

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

By

Randal Staewen

December 2016

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ABSTRACT

Targeting a specific audience correctly is a primary goal for game developers, as strong global competition prevents a generic game from succeeding in the modern market. Developers among the recent rise of indie developers tend to ignore such considerations entirely, and would benefit from a more methodical approach.

The analysis of goal-directed behavior, or teleology, can provide a reliable tool towards clearly identifying audiences with well-supported tendencies in goal-directed behavior. We developed a game featuring multiple playstyles, each with distinct choices in goals and rewards. We then tracked player behavior in game to verify the approach.

Our defined playstyles include carnivores, herbivores, and omnivores, with membership decided by in-game diet. We found strong correlations between the set of carnivore-associated players, frequent game-playing, and a preference for competition and aggression with other players and the environment. On the other hand, herbivores were correlated with more casual players and more passive play.

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INTRODUCTION

A video game is not created solely for the enjoyment of its creator. It requires an audience to become a complete product with commercial value. Without an audience, developers will never be recognized or compensated for their work.

Although an observation may seem self-evident, in practice, it is not at all uncommon for developers to reach the end of their development cycle without ever lending any serious thought towards defining their targeted audience. Instead, the developers will simply assume without evidence that everyone will run to purchase their game because they find their own game entertaining. This leads to an undesirable and unpredictable situation where the process of finding an audience is left almost entirely to luck, throwing the entire outcome of the project into jeopardy. The developers are often their own worst enemy in this sense, especially among small indie teams [1].

At the same time, the global pool of potential customers grows wider and more diverse with every passing year. The transition to cheaper mobile games has added vast new markets for games in previously under-served areas. These new customers do not necessarily want the same types of games that have succeeded in other markets in the past. Therefore, although opportunities exist for the modern developer, thought and effort are required to fully take advantage of the changing landscape.

It is thoroughly insufficient to simply say a game is "for everyone" when the contemporary market is full of groups that expect vastly different features, and sometimes even mutually

exclusive ones. It is not feasible, in terms of cost and time, to make a game with some magic combination of features to satisfy everyone.

Even so, developers can approach this ideal, to some extent, through first identifying the natures of all respective target audiences, second identifying their individual expectations, and third, satisfying those expectations to the best of our ability. The result is a collection of guidelines for how best to appeal to each target audience.

Finally, separate gameplay experiences can be combined into a single game through the concept of player-centric gaming. The player's own choices then guide him or her down divergent paths aimed at different personality profiles, combining multiple games inside a single integrated presentation.

This is a common technique used in the industry to capture larger audiences, but the approach's value has not been subjected to a great deal of academic research, the efficacy of this approach remains untested.

Objectives

Our objectives in this endeavor were to create playstyles within a real game, putting the player-centric game design paradigm into practice.

A successful experiment would result in discrete playstyles with statistically significant differences between player characteristic groups with respect to gameplay choices. It also makes convincing predictions about how to further satisfy our various player characteristics within their chosen playstyles.

Organization

"Background" describes related work we used to inform our design of the experiment. "Methods" introduces the techniques and tools we used to design our game and gather our experimental data, as well as our definitions for parsing and analyzing our data. "Results" describes the broad outlines of our results, as well as a selection of statistically significant correlations.

"Conclusions" discusses some conclusions drawn from our results, as well as proposes avenues for further research.

BACKGROUND

To establish the theoretical basis for the design of our experiment, we will approach from two separate fields. First, we look at personality research in the field of psychology when learning how to define player characteristics. Second, we look at research specific to the concept of player-centric gaming.

This paper builds on conclusions reached by a previous study in this area by Staewen et al [2], which used a simple open-source game to gather data on how player characteristics correlate with short-term and long-term goal and reward choices.

Psychological Characteristics

One valuable field of research within psychology is the understanding of human personality characteristics, which leads to connecting an individual with predicted behavior.

A goal-directed behavior is defined by the selection of a specific reward and the development of a plan to acquire that reward. This is not a sequential process but a continuous cost-benefit analysis where the value of each reward is weighed against each other [3]. Strong individual bias in the value assigned to various types of rewards is the basis for differences in goal-directed behavior.

Sheldon et al. investigated the long-term change of goals [5]. The study concluded that goals will change over time in order to better reflect the best interest of the person involved. Goals, and behavior designed to achieve them, are free-flowing mental constructs that change as we learn how to better satisfy our needs.

Harackiewicz et al. surveyed students enrolled in a long-term psychology course[4]. Achievement goals were measured three times throughout the semester, based on both expectations and actual achievement. After three semesters of surveys, results were collected on student interest in future achievement from the beginning, and then correlated positively with long-term and short-term success.

The Psychology of Food

An area of a goal-directed behavior we explored involves the analysis of how these concepts apply specifically to the acquisition of food. The pursuit of food is a primal necessity that applies to organisms of all kinds, and not just humans alone. This is also the mechanism through which our experimental game applies the principles of goal-directed behavior.

An important term regarding goal-directed behavior is teleology, loosely defined as the study of goal-directed behavior. In the words of Charles Taylor, a pioneering researcher in the field of exploring intent, "In its extreme form teleology is the name of the belief that the terminal stage of certain environmental-organismic interaction cycles somehow is at the same time one of the antecedents determining conditions which bring the behavior cycle about."[6].

Teleology is predicated on the assumption that the goal itself is a cause of the behavior designed to achieve that goal, in a sort of loop of causation. Food acquisition is a clear example of this concept. According to Okrent, "Herbivores that need to eat plant food in order to survive are said to search for suitable plants so as to eat for the sake of staying alive. And carnivores that need to eat meat to survive are said to hunt so as to kill other animals so as to eat for the sake of staying alive. [...] Animals [...] are given nested goal-directed descriptions culminating in their doing what they do."[7].

The analysis suggests that the behavior of organisms can largely be explained in terms of the goals it is intended to bring about. However, this analysis also has obvious deficiencies,

since organisms other than humans and a few other highly intelligent animals cannot be said to express their intent in the same way. Moreover, as Nissen explains, even primal goal-directed behaviors such as searching for food and water cannot be clearly separated, "Wright also calls attention to a kind of multiple goals problem. He imagines a predator that is both hungry and thirsty, sees no water, but does see what appears to be prey, and begins stalking behavior. While doing so, he comes upon water and drinks. [...] At this point Taylor's formula would require that way say the predator's behavior all along had been directed toward obtaining water. But this obviously conflicts directly with the fact that the predator's behavior was obviously stalking; it was obviously for the sake of catching its' prey."[8].

In other words, it is not necessarily true that all identified goal-directed behaviors are in fact terminal, and may indeed be part of a larger system of behavior intended to achieve a different goal entirely.

In the case of non-human animals, analyzing teleology can be nearly impossible due to the inability to guess the animal's true intent (and indeed, the animal is likely not consciously aware of its own intent). However, in the case of human behavior, we can use various tools to isolate differing intents, and thereby learn about the inherent differences between individuals who undertake otherwise similar behavior.

Player-Centric Gaming

Bostan stated that the player motivation is one of main concerns of computer gaming [9], and player motivations are not necessarily homogenous. The primary problem to solve, therefore, is how to account for parallel motivations simultaneously.

The concept of player-centric gaming is central to the value of our research. Player-centric gaming holds that we can better satisfy players overall through first targeting specific desired elements at specific audiences, and then tying those elements to a customizable experience for the player. The ideal player-centric game diverges into a unique, targeted game for each individual player based on their individual choices.

Yun et al. investigated whether incorporating player preference as one of the parameters for a game with a player-centric and dynamic difficulty adjustment system, known as Profile-Based Adjustment Difficulty System (PADS) [10], could successfully improve overall gaming experience. They demonstrated that PADS improved overall gaming experience for great majority of subjects (87 percent) in their study. This demonstrates the value of the player-centric approach, and the immense gains that can be made in appropriately tailoring content to the individual user.

Kulman et al. researched whether the nature of a given goal influences the behavior intended to achieve it [11]. Subjects played 30 trials of the “prisoner's dilemma” game. The three possible outcomes of the prisoner’s dilemma are a cooperative solution, an egocentric solution, and a ‘tit-for-tat’ solution. The players were then classified as cooperative, competitive, or individualistic. Among these classifications, future game behavior was

strongly predicted. This sort of abstract game design applies to both real-world behavior and games [12].

Previous research has already made multiple attempts at providing a general taxonomy that describes gamer motivations that accounts for common motivations.

In Lucas and Sherry's research using self-reported surveys, differences in goals and behavior in video games were found between genders [13]. This adds further support to the contention that self-reported surveys are of real value in establishing the existence of differences in personalities and playstyles.

In one well-known study, Bartle argued that players have distinct playstyles that dictate different choices in the same events [14]. He categorized the players based on the enumerated playstyles of Killers, Achievers, Socializers, and Explorers.

Figure 1: Bartle's Taxonomy Chart

Each of these four styles can also be classified in terms of goal-directed behavior, representing the types of goals that most appeal to that class of players.

Yee also built on Bartle's taxonomy, expanding the categories to Relationship, Immersion, Grief, Achievement, and Leadership [15]. Most importantly, he took the concept further by suggesting that the categories are not mutually exclusive. Our own taxonomy takes this important concept into account.

METHODS

Our game, called Unnatural Selection, is a fully playable 2.5D side-scrolling platformer game. Because it is still in development, its developers can reap immense benefit from a clearer concept of how each playstyle works and the extent to which each playstyle defined within our game tracks together with targeted personality characteristics.

Our specific goal is to define subgroups with statistically significant features that make that make membership of that subgroup a meaningful predictor. We seek to find statistically significant differences between multiple subgroups, in order to prove these categories have meaning. Such groupings are representative of a gamer population that play the game a certain way, one that differs from the global average.

To that end, we designed the experiment in order to first categorize players in several groups, and correlate those groups with various in-game metrics. This allows us to sort players into meaningful, predictive categories for the purposes of player-centric development.

The first set of categories used corresponds with the specific in-game theme of dietary choice: carnivore, herbivore, or omnivore. These categories account for our initial attempt at accounting for multiple playstyles. We chose these playstyles intentionally due to conjectures related in part to our research. As omnivores, humans are familiar with all three of these diets, and our personal habits in diet vary widely. We supposed that relating playstyles back to very basic features of animal psychology would provide more stark contrasts in gameplay choices.

We believed that each playstyle would correlate with one or more personality types. Herbivores would identify with the desire for exploration, and socialization, while carnivores would identify with the "killer" desire, achievement, and desire for challenge-seeking. Omnivores would be some mixture of the two, or possibly fit in with the "avoid boredom" desire, dovetailing with the lack of making an effort to pick a decisive playstyle. In the absence of a conscious decision, we hypothesized that the players would eat equal quantities of food from the categories of plant-food and meat, since both food types were available in equal amounts and with equal distance.

The second two sets of categories correlate in-game choices with self-reported gaming frequency and personality characteristics. These categories were drawn from a self-reported survey, outlined below.

Game Design

The player begins the game with control of a single one-eyed mutant fish called a 'larva'. Over time, the player will discover various sources of food to consume. Eating food refills the health bar, restores energy, and allows the player to grow larger and eventually evolve.

Figure 2: Meat vs. Plant-Type Food

Our game is intended to encompass at least three distinct playstyles. The herbivore path involves eating "green" food, which is found throughout the level and sometimes has defenders that must be stealthily avoided.

The carnivore path involves hunting enemies and obtaining "red" food that is not available without killing other fish. Finally, the "omnivore" path involves simply eating both red and green food without distinction.

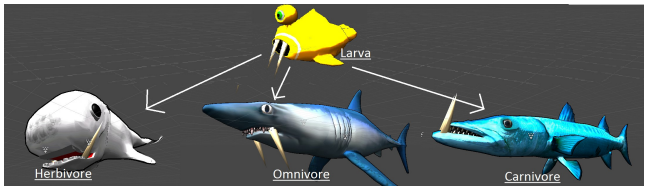

Figure 3: Evolutionary Tree

Respectively speaking, the herbivore path evolves into a whale-like shape, the carnivore path evolves into a barracuda-like shape, and the omnivore path evolves into a shark-like shape.

We had certain expectations about the playstyles of each group, which will be discussed further in "Results" and "Conclusions".

The whale-type evolution has higher hit points, armor, and stun resistance. They also have a larger "stomach", meaning they have a higher energy reserve and can last longer between meals. This comes in handy for the herbivore player, because the whale is also slower than other forms, and the playstyle is dependent on locating new food sources through exploration.

The barracuda-type evolution has higher instantaneous damage and movement speed. This results in superior ability in assassinating prey quickly and efficiently. Carnivore players will enjoy efficient and targeted hunting, supported by excellent speed for finding new prey.

The shark-type evolution has the highest sustained damage potential and overall decent defenses. This form is ideal for surviving the long-term conflicts likely to result from gathering all food sources at the same time, which should apply to omnivores.

Experimental Design

Pre-game survey

We began our experiment by offering each participant a survey with a series of questions designed to score them within certain personality subgroups. We also included a final question that asked participants their general play frequency. The questions categorized players into ten non-mutually exclusive categories: (*Power/Supremacy*), (*Challenge*), (*Social Interaction – Passive*), (*Social Interaction – Aggressive),* (*Diversion*), (*Fantasy*), (*Arousal/Excitement*), (*Entertainment*), (*Completionism*), and finally the extra question to find out (*Play Frequency*). Participants were then grouped per whether they overall agreed (OA) or overall disagreed (OD) with that characteristic.

Participants answered these questions:

1. (Power/Supremacy) Do you want to play video games to be the best player in the game?
2. (Challenge) Do you play video games to challenge yourself?
3. (Social Interaction - Passive) Do you play video games to share an experience with others?
4. (Social Interaction - Aggressive) Do you play video games since they let you compete against others?
5. (Diversion) Do you play video games when you are bored?
6. (Fantasy) Do you play video games to do things in games that are too challenging or impossible in real life?
7. (Arousal/Excitement) Do you play video games because they deliver exciting experiences?
8. (Entertainment) Do you play video games because you enjoy difficult challenges?
9. (Completionism) Do you try to acquire every item and achievement when you play videogames?
10. (Play Frequency) How often do you play video games? (Rarely/sometimes/monthly/weekly)

Playing the game

Within the game, we created a series of walled-in trial levels with difficulty easy, medium, and hard difficulties. There was no difference in the trials beyond increased health and damage associated with enemy fish. The total amount of plant-type food vs. meat-type food were roughly equivalent. The level was designed for roughly ten minutes of play. After 10 minutes, we advised participants to move on to the next trial. Some participants quit earlier than 10 minutes, but others played long past 10 minutes. There were also "mutations" which constituted long-term rewards, and granted various benefits that make the player more powerful.

We decided to have three different levels of difficulty largely to mirror the design in our previous study.

Post-game survey

Participants were given a second survey following their completion of the game trials. The questions were as follows:

Participants answered these questions:

1. Please rank the three trials from most favorite to least favorite.
2. (Short Answer) Would you classify eating food to maintain energy as a short- or long-term goal?
3. (Short Answer) Would you classify gaining enough mass to evolve as a short- or long-term goal?
4. (Short Answer) Would you classify unlocking theme colors for fish as a short- or long-term goal?
5. (Short Answer) Would you classify unlocking mutations as a short- or long-term goal?

Analytical Techniques

Our game was written in C# using the Unity Game engine. Data was collected automatically and was appended to the player's existing save information.

We used the ANOVA (analysis of variance) technique as the primary tool to investigate the significance of the relationship between the gamer characteristics, playstyles, and other variables.

Each player's data was written to an XML file which was then re-imported for ANOVA processing using the "Accord" C# library.

ANOVA results gleaned from the custom Accord implementation were then cross-referenced with a Java tool to verify agreement.

We grouped our results in terms of diet (carnivore, herbivore, omnivore), play frequency, and player characteristics. A series of averages was calculated for each metric within each grouping. The simplified set of full results (with averages only listed) is included in the Appendix.

When ANOVA comparisons between these data-sets resulted in statistically significant correlations, they were recorded and mentioned within the Results section. A comprehensive list of correlations is not listed in Appendix, as most potential correlations were not statistically significant.

Definitions of Metrics

A consistent, machine-collected set of data was collected for each trial played by each participant.

‘Red Energy’ refers to the energy value acquired from ‘meat’ collectable objects released from enemies on a successful kill. When the ‘meat’ is eaten, the player’s energy is restored. Similarly, ‘Red Energy / Second’ refers to a player’s average energy acquired per second, which better accounts for differences in time played.

‘Green Energy’ refers to the energy value acquired from ‘plant’ or ‘algae’ type collectable objects found floating in streams or released from hidden destructible coral objects. When these objects are eaten, the player’s energy is restored.

‘Time Played’ refers to the average time spent per trial for each participant.

The ‘Mutation Seeking’ metric describes the average number of mutation reward items collected per second by each participant. These objects are representative of long-term rewards.

‘Kills’ measures how many enemies were killed by the player. ‘Kills’ and ‘Red Energy’ don’t necessarily match, because some enemies grant more energy than others (and are more powerful).

‘Kill Quality’ is equal to the average red energy acquired divided by the average kills. It constitutes a measure of how ‘large’ the player’s preferred prey is.

RESULTS

Initial Expectations

Before running our experiment, we had several expectations concerning how players would play the game. Of greatest interest to us was how player characteristics might be associated with our three playstyles, as well as performance in key metrics within those playstyles.

Carnivores

'Carnivore' is a more active playstyle, due to the necessity of constant movement during the hunt. Therefore, we, expected the positive correlation of the 'Carnivore' group with the group of gamers who plays frequently, due to higher engagement with games in general.

Similarly, we expected a positive correlation with certain personality characteristics, including players who identified positively with the 'Supremacy', 'Social Aggression', 'Challenge', and 'Arousal/Excitement' characteristics.

We expected Carnivores to have high 'Red Energy' collection and low 'Green Energy' collection, of course, compared to the other two categories, with the total amounts of green plus red energy being roughly equivalent. We also expected a high number of kills, and a high 'kill quality', due to the projected challenge-seeking personality association.

Herbivores

'Herbivore' is a more passive playstyle, due to the ability to sit still in a stream of food and suck in food effortlessly. The primary considerations, instead of combat, are stealth and

exploration. Therefore, we, expected the positive correlation of the 'Herbivore' group with the group of gamers who plays less frequently.

We expected a correlation with players who identified negatively with the 'Supremacy', 'Social Aggression', 'Challenge', and 'Arousal/Excitement' characteristics. We also expected a possible positive correlation with 'Social Interaction – Passive' and 'Fantasy' characteristics.

We expected Herbivores to have high green energy collection and low red energy collection, with roughly equivalent total energy to the other categories. We expected a low number of kills, with the amount of red energy consumed being proportionally lower (due to consciously avoiding the consumption of rewards).

Omnivores

We were unsure what associations omnivores might have, since the omnivore path also represents a lack of a clear choice. However, we still expected a positive correlation with the 'Arousal/Excitement' characteristic, since the tendency to eat everything in sight is characteristic of a short-term mindset. We also suspected Omnivores might be associated with infrequent game-players, since experienced game-players would be more likely to make a conscious playstyle choice.

We expected Omnivores to have the highest total energy consumption, compared to the other categories, since more total energy is available than there is in either single category. We also expected a negative correlation with the 'Challenge' characteristic, since the player makes the choice to eat everything available.

Post-game survey

A total of just four out of 41 participants answered our short-answer questions, making those answers largely irrelevant.

When players ranked their favorite trials, 23 out of 41 participants did not answer the question. Of the remaining 18 participants:

- 6 participants ranked all trials equally (no preference)
- 7 gave the top rank to the third trial (hard).
- 4 gave top rank to the first trial (easy)
- 1 gave top rank to the second trial (medium).

Though we were not able to prove any statistical correlation from this sample size, we observed that all 7 of the participants who gave top ranking to the third trial were players who play games ‘Overall Often’. Of the 4 who gave top ranking to the first trial, 3 were players who play games ‘Overall Rarely’.

Assessing the impact of Difficulty Trials

Each participant was asked to undertake a total of three trials; one easy, one medium, and one hard. This was accomplished by increasing the damage that enemies are capable of inflicting, as well as slightly increasing their hit-points.

Trial data was separated and averaged for all metrics within the total dataset and the playstyle comparisons, but not in the personality characteristics sections due to lack of data. Values are attached to the tables in the Appendix.

However, the statistical significance of the relation between these trials was unfortunately negligible. P-values were consistently high when comparing the individual trial sets; moreover, the individual trial datasets have wild variations among individuals that lower the quality of comparisons. Individual comparisons sometimes contradict both the findings from our averaged datasets and with each other.

Therefore, for the purposes for comparing data, we decided to average together the results from all three trials for each.

Grouping by Dietary Choice

The three diet subgroups used were carnivore, herbivore, and omnivore. These three subgroups also represent the three major playstyle headings we set out in the overall game design concept. We will elaborate on the rationale behind these conceptual playstyles later, in Conclusions.

Participants were assigned to each subgroup based on their total red energy vs. green energy ratio. Carnivores were defined as eating more than 66 percent meat, herbivores less than 33 percent, and omnivores in between. With this definition, 12 participants were defined as Herbivores, 11 as Carnivores, and 18 as Omnivores. The same proportions were used to determine the player's evolutionary form in-game now their gauge was filled, so these dietary subgroups correspond to the whale-type (herbivore), shark-type (omnivore), and barracuda-type (carnivore).

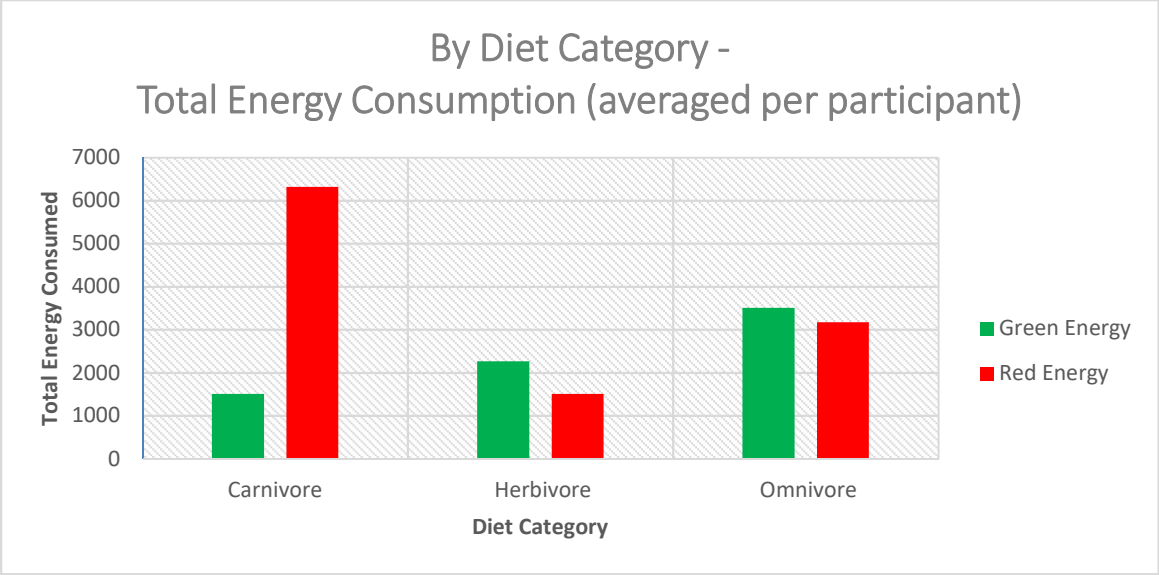

Figure 4 - Green and Red Energy Consumption

Recorded in Figure 4, the set of carnivore players had a much higher "red total", or average red energy acquired per trial. Carnivores averaged 6318 red energy per player, as opposed to 1510 and 3170 for herbivores and omnivores (ANOVA, $F(2,36) = 10.65$, $p<.001$). This is not surprising, given that we selected “Carnivores” based on preference for red energy over green energy.

However, a different pattern than expected shows up in "green totals": omnivores have significantly higher green energy collection than carnivores, or even (ANOVA, $F(2,36) = 7.24$, $p=<.001$). Though herbivores had a higher preference for green food, their total for both types of energy were much lower. Players who preferred green food had far less energy collection overall.

The three diet subgroups were separated by overall measured food preference. Similarly, the evolutionary tree also diverges in-game based on measured food preference. The

evolutionary tree selection and extracted diet subgroups are obviously based on the same underlying metric. However, the form players took did not always match their final food ratio, implying that players changed their food priorities after evolution, thus changing the final ratio. We believe this to be an excellent demonstration of the topics discussed by Sheldon et al., where behavior aimed at achieving a specific goal changed after achieving that goal [5].

Grouping by Game-playing frequency

We grouped participants per play frequency as reported on the pre-game survey. The strongest correlations were found when divided into just two groups: one where participants responded as playing games "weekly or more", and one group comprising the supergroup of every other answer. This included "monthly", "often for years", and "rarely". We called this group "overall plays rarely".

For statistically significant relationships between these two groups, there were three of primary interest.

The expected gameplay time should be 30 minutes, with 10 minutes per trial, but several participants quit early or stayed late. Players who rarely play games tended to play our game for a total amount of 50 percent longer on average compared to those who play often (ANOVA, $F(1,38) = 6.67$, $p=.014$). Players who play rarely played for an average of 38 minutes over all trials, as opposed to 27 minutes for frequent game-players. This is perhaps due to a general unfamiliarity with games, where it took them longer overall to get the hang of game mechanics and complete their exploration. It also supports the idea that our grouping based on self-reported play frequency is accurate and predictive of actual habits.

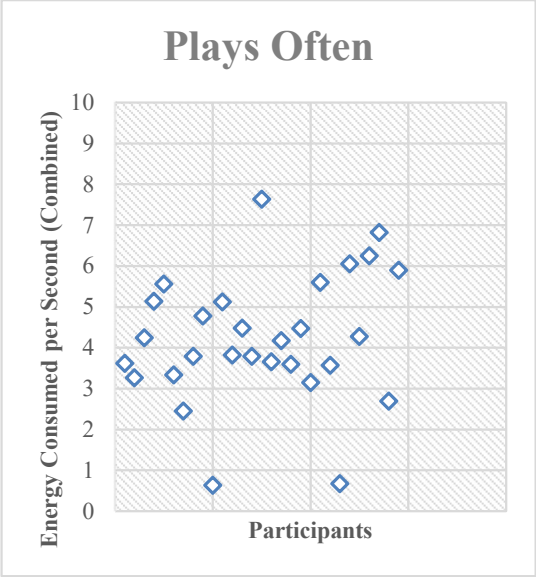

Figure 5 - Energy/Sec scores for 'Plays Often' participants (averages to 4.23/second)

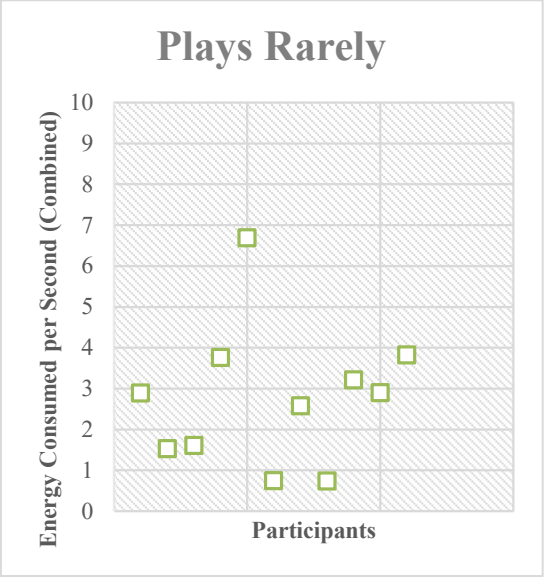

Figure 6 - Energy/Sec scores for 'Plays Rarely' participants (averages to 2.76/second)

Players who play games often had a 52 percent higher rate of total-energy gain with an average of 4.23 energy/sec to 2.76 energy/sec. (p-value: (ANOVA, $F(1,38) = 6.49$, $p=.02$). This strongly suggests superior overall performance for participants who play games frequently, because energy consumption is the primary reward system in this game.

Frequent game-players accrued more energy in less time, overall.

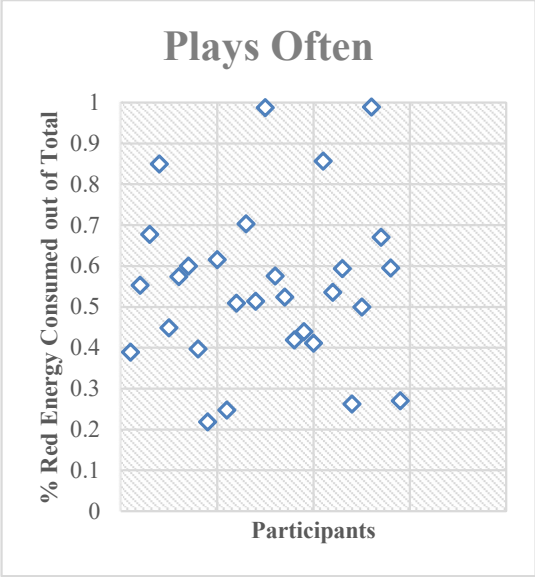

Figure 7 - Carnivore Ratios for 'Plays Often' participants (averages to 56% carnivore)

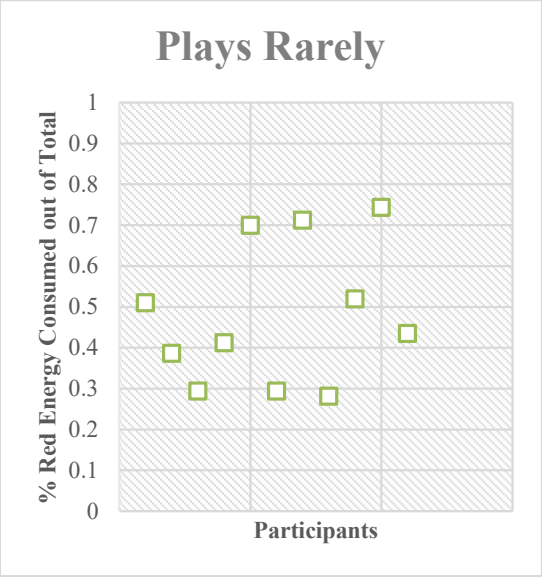

Figure 8 - Carnivore Ratios for 'Plays Rarely' participants (averages to 41% carnivore)

Finally, we compared the overall carnivorous disposition of the "plays frequently" and "plays rarely" groups. Frequent game-players were approximately 15 percent more biased towards being carnivorous, with the "rarely" group an average of 41 percent carnivorous and the "frequently" group an average 56 percent carnivorous (ANOVA, $F(1,38) = 64$, $p<.0001$). These numbers were obtained by comparing the ratio of red food eaten to total food eaten, averaged across each trial and each player.

Grouping by Personality Characteristics

For each personality characteristic, we initially divided the global dataset into two groups: OA and OD, for overall agree and overall disagree.

In the Appendix, all statistically significant personality characteristics are listed, along with the corresponding set of playstyle choices. These playstyle choices aren't always well-correlated, but if they are, we will mention the "Carnivore ratio", which describes how much that personality characteristic trends toward carnivorism.

Refining the Data Set

A clear bias is present in our overall data with respect to negative survey answers. Participants who play games rarely were likely to answer in the negative to every question, possibly because the question did not apply to them. For instance, a person who does not play games would simply answer negatively to the question "Do you play video games to challenge yourself?", because that person does not play videogames in the first place. Such participants would therefore be categorized as disliking challenge, when the reality is simply that the question did not apply – the responder doesn't have the knowledge to answer the question.

Infrequent game-players are also correlated with worse performance in general, as partially discussed in section "Grouping by Game-playing frequency". The result is that negative answers to personality survey questions appear correlated with poor performance, regardless of the question asked. This is likely not because negative answers cause poor

performance, but because unfamiliar players tend to both answer negatively and perform poorly.

Therefore, we discarded the "overall plays rarely" group from all personality correlations in the following analysis within ‘Grouping by Personality Characteristics’, leaving us with just participants who play often enough know their own gamer personalities.

This means that we cannot consider the “Challenge”, "Excitement", "Entertainment", and "Social Interaction Passive" characteristics, on the basis that the ‘agree’ groups now comprise nearly the entire dataset. Possibly because of the way the questions are worded, almost all participants answered positively, and therefore no ANOVA analysis was possible.

Respectively, “Challenge”, "Excitement", "Entertainment", and "Social Interaction Passive" characteristics had just 2, 0, 2, and 2 participants disagreeing. Unsurprisingly, the p-values in all comparisons drawn from these groups approaches 1, and we must drop these player characteristics from our analysis with the present data.

Fantasy

To be identified as having the “Fantasy” characteristic, participants responded affirmatively to the question, “Do you play video games to do things in games that are too challenging or impossible in real life?”.

Unfortunately, we were unable to gain any useful data out of this characteristic, despite a reasonable distribution of positive and negative responses. All p-values were well about 0.5, suggesting the correlation cannot be used in any meaningful way.

Social Aggression

To be identified as ‘Socially Aggressive’, participants responded affirmatively to the question, “Do you play video games since they let you compete against others?”.

There was a significant relationship between red energy score and social aggression. Participants who identified with the Social Aggression characteristic had 55 percent greater red energy gain per second on average than those who disagreed with it. (ANOVA, $F(1,38) = 4.72$, $p<.05$).

Otherwise, no other metrics met the standards for statistical significance.

Completionism

To be identified as ‘Completionist’, participants responded affirmatively to the question, "Do you try to acquire every item and achievement when you play videogames?".

Participants who identified positively with the Completionism trait had a 39 percent lower kill quality on average than those who identified negatively. (ANOVA, $F(1,38) = 4.32$, $p<.05$).

The 39 percent lower kill quality for self-identifying Completionists indicates that they spent less time targeting the larger enemies, and more time targeting the "prey" type enemies.

No other metrics met the standards for statistical significance within the “Completionist” personality characteristic.

Supremacy

Lastly, we found our most significant correlations between the agreeing and disagreeing Supremacy characteristics. This characteristic was decided when participants responded affirmatively to the question, "Do you want to play video games to be the best player in the game?".

Rather than the Social Interaction Aggressive question, which specifically mentions other players, the Supremacy question makes a more general reference to the perception of personal power.

Notably in Figures 9 through 16, the group disagreeing with the Supremacy characteristic performed far better in red scores (ANOVA, $F(1,27) = 13.18$, $p<.001$), long-term mutation acquisition (ANOVA, $F(1,27) = 5$, $p<.05$), and kills (ANOVA, $F(1,27) = 8.85$, $p<.01$). The disagreeing group was also 70 percent carnivorous, as opposed to 47 percent carnivorous for the agreeing group (ANOVA, $F(1,27) = 13.65$, $p<.0001$).

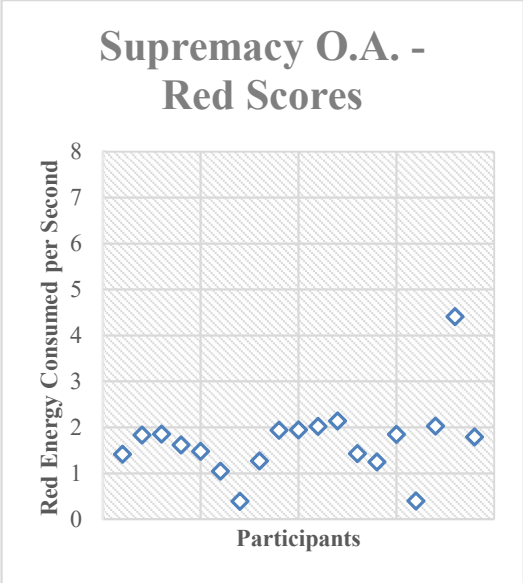

Figure 9 - Red Energy Scores for 'Supremacy' – Overall Agreement

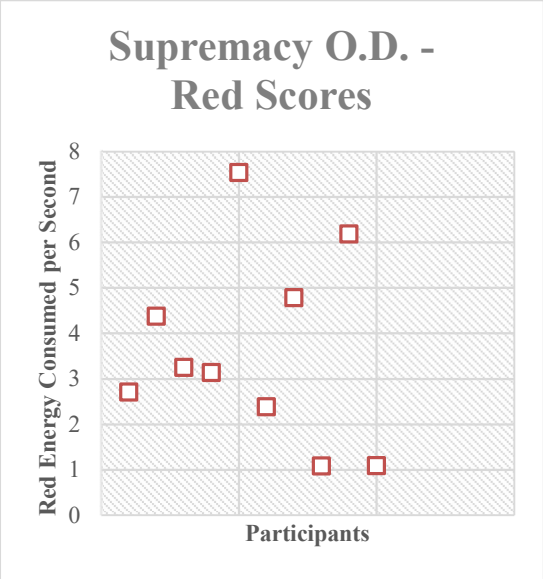

Figure 10 - Red Energy Scores for 'Supremacy' – Overall Disagreement

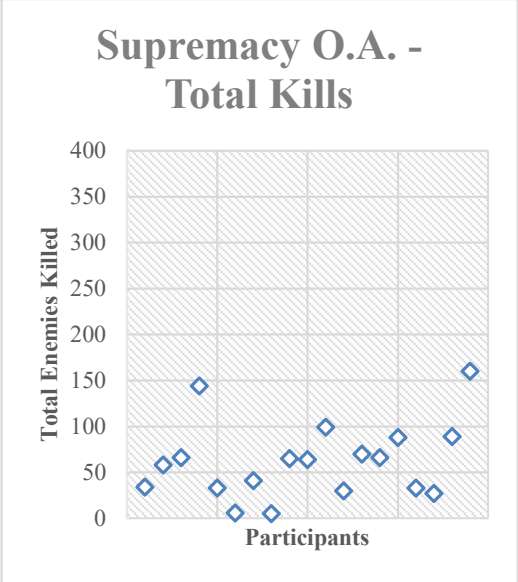

Figure 11 - Total Kill Scores for 'Supremacy' – Overall Agreement

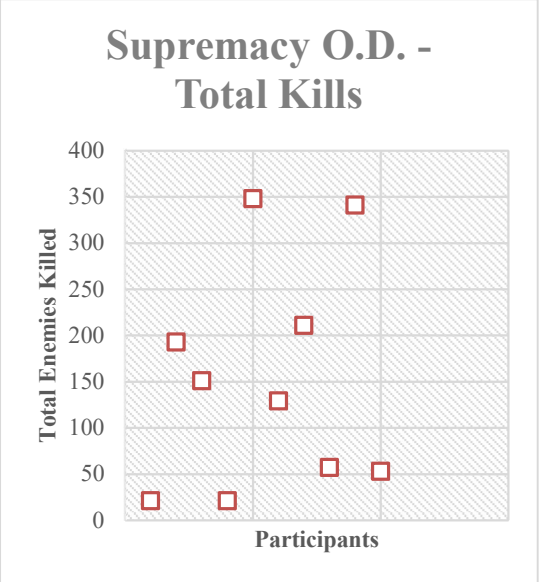

Figure 12 - Total Kill Scores for 'Supremacy' – Overall Disagreement

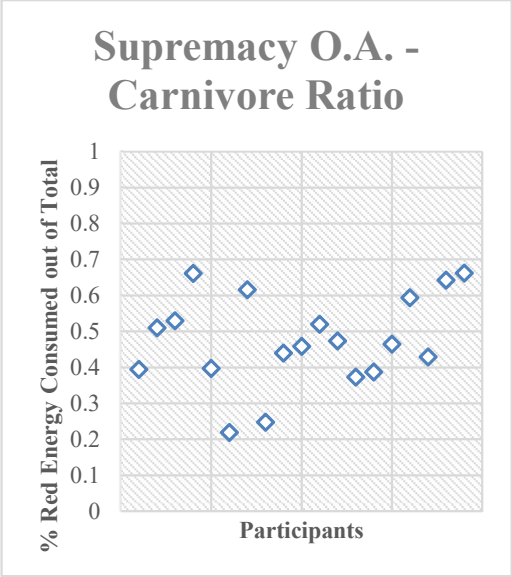

Figure 13 – Carnivore Ratios for 'Supremacy' – Overall Agreement

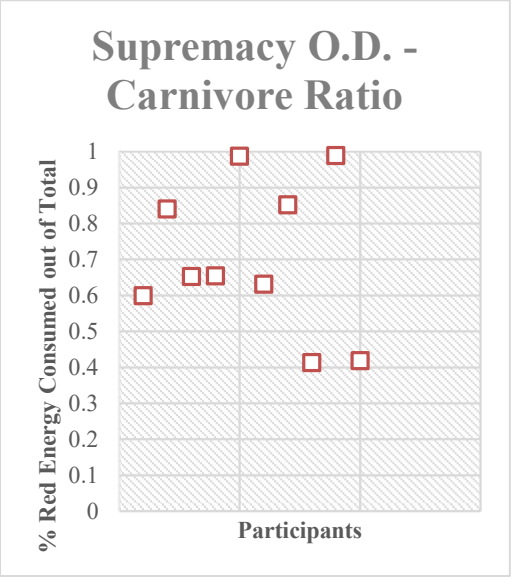

Figure 14 – Carnivore Ratios for 'Supremacy' – Overall Disagreement

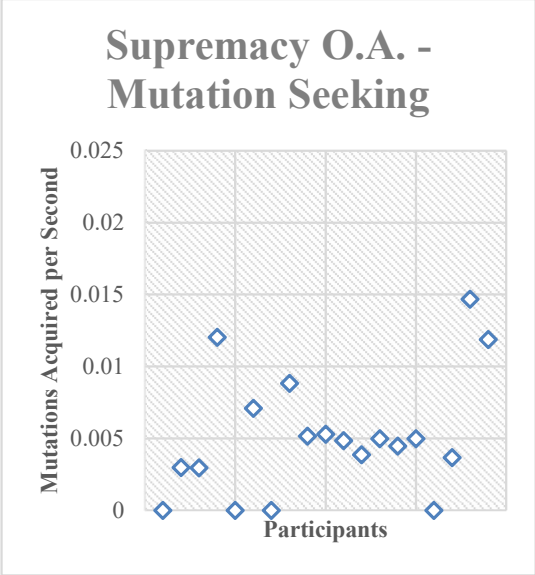

Figure 15 - Mutation Scores for 'Supremacy' – Overall Agreement

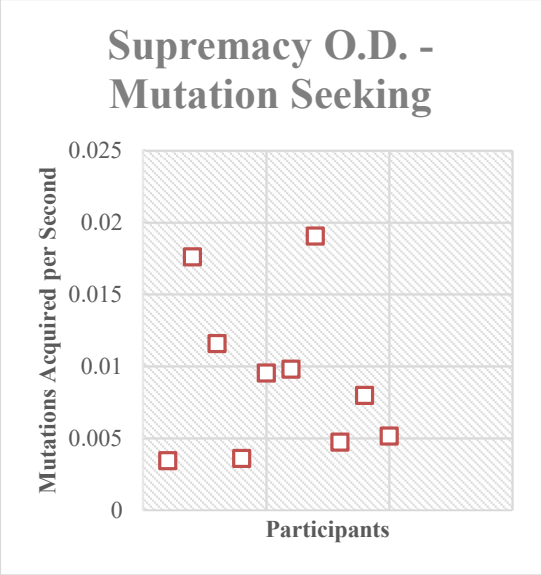

Figure 16 - Mutation Scores for 'Supremacy' – Overall Disagreement

CONCLUSIONS

Connections with Previous Study

Several personality characteristics we isolated have significant implications when related back to the same characteristics isolated in our previous study. Because we used the same survey questions in both studies, the groups can be directly compared.

The "Supremacy" characteristic (called "competition" in our previous study) was previously identified with longer-term thinking in several aspects [2]. This implies that the group positively identifying with "Supremacy" should be associated with preference for long-term rewards, even though our current data strongly suggests passivity.

It is likely, in our opinion, that the group positively identifying with "supremacy" found little to interest them in the sphere of long-term goals within our experiment. Lacking interest, their overall performance may have suffered compared to players satisfied without clear goals and clear challenges to master.

This would imply that future revisions of the game must take care to provide far more clear goals for this sort of player in order to retain their interest.

Additionally, for the "play frequency" groups, participants in the previous study correlated high play frequency and preference for long-term rewards. This is confirmed by our own findings, where both long-term rewards (mutations) and more difficult rewards (meat) are correlated with play frequency.

Playstyle implications

We had strong patterns emerge in the preference for pursuing food rewards, particularly among the diet categories. Players who ate mostly meat had the highest overall energy scores, meaning they were the most successful at eating large quantities, even adjusting for time played. Players who ate a balanced diet still consumed more green energy than players who ate mostly green energy, suggesting that players who eat mostly green energy are a more passive type of player.

When designing our game concept, we originally made assumptions that carnivores, herbivores, and omnivores represented distinct playstyles, and therefore targeted distinct audiences.

First, we assumed carnivores would fit the style of more targeted aggression, attacking high-value enemies strategically for the highest gain. For this reason, the Carnivore form was designed to be agile and have high damage, to support this assassin-like playstyle. The focus for this type of player would be on efficient application of force.

Second, we assumed herbivores would fit the style of careful explorers, looking carefully for every hidden food location and defending their food supply. For this reason, we designed the Herbivore form to have a high maximum energy supply with slow metabolism, and with plenty of health to survive surprise attacks while exploring. The focus for this type of player would be exploration and interaction. We would give them tools to avoid detection, and make exploration easier and more rewarding.

Third, we assumed omnivores would be more of the score-based mindset, where the player would be interested in eating anything and everything available. The focus for this type of player would be full completion, as fast as possible.

Among frequent game-players, the more carnivorous players were also players that logged more gameplay time overall. We must conclude that the current implementation of the "herbivore" style is insufficient to properly draw in a dedicated audience and hold the attention of experienced players. Our priority will be to add more tools to evade detection or escape from surrounding enemies, making it more intuitive to progress without combat necessary. Once this is completed, we will see average play-times and energy consumption rise among herbivores until it reaches closer to that of carnivores.

One serious problem with our "trial" environment was that its closed-off nature prevented "explorer"-type personalities from fulfilling that interest. If herbivores are a playstyle attractive to Bartle's "explorer"-type personality, those represented by the "Diversion" or "Fantasy" characteristics, then our experiment would do little to capture the attention of that type of personality.

One of the strongest sets of statistical significance among personality types were the sets of participants who agreed and disagreed with the "Supremacy" characteristic, where the deciding factor was their answer to whether they wanted to be "the best in the game". This may be revealing of another aspect of our experiment design: the lack of clear goals set out within the trial environment. With no clear goals to accomplish, players who want to experience a feeling of mastery would have no way to do so, and thus lacked engagement.

On the other hand, players who disagreed with the "Supremacy" characteristic would be players who are unconcerned with goals provided by the system, and are instead more comfortable within a sandbox environment. This would explain the vastly larger energy gain, kills, and overall carnivorous approach taken by the "disagree" group.

It follows that to capture both the "agree" and "disagree" groups, we may need to consider adding multiple gameplay modes, where some are like this sandbox level, and others are larger and more story-focused, with each level and area providing clear challenges and goals.

Future Work

To better address our player-centric goals, we must either refine and modify our playstyle concepts, or do a better job with pulling players into more appropriate groups.

In future work, we will re-word the existing survey to better separate participants into useful groups that differ from each other. The "Excitement" and "Entertainment" categories should have the questions reworded to make agreement substantive.

Moreover, we will consider the personality results only among frequent game-players, as the questions have proven mostly meaningless for infrequent game players, and merely ruin the results.

We will implement the Latin square method, where half of participants will begin with trial 3 (hardest) and half with trial 1 (easiest). This will allow us to analyze correlations with difficulty, whereas that choice is restricted in this data set. Furthermore, we will ensure that all participants play each trial at least once, so that we can have a dataset with columns of constant size. After averaging the result for each trial by participant, we will be left with exactly three measurements per participant.

Most importantly, we will further develop the game using lessons we learned from this experiment. One of our primary goals will be to develop a way to branch the experiences within the "omnivore" group so that there are separate evolutionary paths for more casual balanced players and the all-consuming completionists. One idea might be to trigger a special evolution if enough food is consumed quickly enough, with a certain amount of variety. This should be a tantalizing option for completionists.

Finally, we will release our game commercially, and put our theories to the test. Given that our data in this experiment was all collected automatically, it will even be possible to gather more data after release from consumers and verify that our solutions had positive effects.

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APPENDIX

Overall Metrics

ALL PARTICIPANTS (TOTAL OF 38)	Count	Value	Trial 1	Trial 2	Trial 3
redScores (red energy / second)	38	2.29	3.19	2.49	2.7
redTotals (total red energy collected - SUM)	38	4100	1740	1390	1850
greenScores (green energy / second)	38	1.44	2.49	2.09	1.68
greenTotals (total green energy collected - SUM)	38	2570	1360	1170	1150
omniScores (energy / second)	38	3.73	5.68	4.58	4.39
omniTotals (total energy collected - SUM)	38	6680	3100	2550	3000
mutationSeeking (mutations collected / second)	38	0.00596			
timePlayed (average minutes played)	38	29.8	9.1	9.3	11.4
Kills (total enemies killed)	38	75	30.2	30.5	46.8

Diet Categories

OVERALL Carnivore	Count	Value	Trial 1	Trial 2	Trial 3
redScores	11	2.81	4.29	3.88	4.77
redTotals	11	5980	2260	2620	3960
greenScores	11	0.61	1.95	1.43	0.819
greenTotals	11	1300	1030	964	680
omniScores	11	3.42	6.24	5.31	5.59
omniTotals	11	7270	3290	3580	4640
mutationSeeking	11	0.00971			
timePlayed	11	35.4	8.78	11.2	13.8
kills	11	151	39.6	62.6	108
SHARK:17| WHALE: 0| BARRACUDA: 10					

OVERALL Herbivore	Count	Value	Trial 1	Trial 2	Trial 3
redScores	10	1.26	2.15	1.67	1.08
redTotals	10	1510	727	673	564
greenScores	10	1.88	3.48	3.44	3.23
greenTotals	10	2260	1180	1380	1680
omniScores	10	3.14	5.63	5.11	4.31
omniTotals	10	3770	1910	2060	2250
mutationSeeking	10	0.00282			
timePlayed	10	20.1	5.65	6.71	8.69
kills	10	30.7	17.6	14.4	11.8
SHARK:12| WHALE: 6| BARRACUDA: 0					

OVERALL Omnivore	Count	Value	Trial 1	Trial 2	Trial 3
redScores	17	2.19	3.93	1.54	1.9
redTotals	17	3170	1810	982	818
greenScores	17	2.42	3.89	1.72	2.5
greenTotals	17	3510	1790	1100	1070
omniScores	17	4.61	7.82	3.26	4.4
omniTotals	17	6680	3600	2080	1890
mutationSeeking	17	0.00524			
timePlayed	17	24.2	7.68	10.6	7.16
kills	17	51.9	28	19.2	14.8
SHARK:25| WHALE: 16| BARRACUDA: 20					

Play Frequency

OVERALL Plays Often	Count	Value
redScores	27	3.36
redTotals	27	5380
greenScores	27	1.6
greenTotals	27	2560
omniScores	27	4.96
omniTotals	27	7940
mutationSeeking	27	0.0106
timePlayed	27	26.7
kills	27	93
Diet Category	Carnivore: 27%, Herbivore: 21%, Omnivore: 52%	

OVERALL Plays Rarely	Count	Value
redScores	11	1.35
redTotals	11	3100
greenScores	11	0.885
greenTotals	11	2030
omniScores	11	2.24
omniTotals	11	5130
mutationSeeking	11	0.0106
timePlayed	11	38.2
kills	11	41
Diet Category	Carnivore: 36%, Herbivore: 27%, Omnivore: 36%	

Supremacy Characteristic

Supremacy - Overall Agree	# participants	Value
redScores	19	1.66
redTotals	19	2290
greenScores	19	1.9
greenTotals	19	2610
omniScores	19	3.56
omniTotals	19	4900
mutationSeeking	19	0.00514
timePlayed	19	23
kills	19	62
Diet Category	Carnivore: 10%, Herbivore: 21%, Omnivore: 68%	

Supremacy - Overall Disagree	# participants	Value
redScores	10	3.65
redTotals	10	8160
greenScores	10	1.06
greenTotals	10	2470
omniScores	10	4.71
omniTotals	10	10600
mutationSeeking	10	0.00925
timePlayed	10	38.8
kills	10	153
Diet Category	Carnivore: 60%, Herbivore: 20%, Omnivore: 20%	

Social Interaction Aggressive Characteristic

Social/ Aggressive - Overall Agree	Count	Value
redScores	21	2.53
redTotals	21	6030
greenScores	21	1.26
greenTotals	21	2130
omniScores	21	3.79
omniTotals	21	8160
mutationSeeking	21	0.00653
timePlayed	21	28.3
kills	21	100
Diet Category	Carnivore: 39%, Herbivore: 19%, Omnivore: 42%	

Social/ Aggressive - Overall Disagree	# participants	Value
redScores	8	1.94
redTotals	8	3670
greenScores	8	2.13
greenTotals	8	3690
omniScores	8	4.07
omniTotals	8	7360
mutationSeeking	8	0.00663
timePlayed	8	28.8
kills	8	75.3
Diet Category	Carnivore: 0%, Herbivore: 25%, Omnivore: 75%	

Fantasy Characteristic

Fantasy - Overall Agree	# participants	Value
redScores	22	2.31
redTotals	22	5770
greenScores	22	1.34
greenTotals	22	2330
omniScores	22	3.65
omniTotals	22	8090
mutationSeeking	22	0.00608
timePlayed	22	29
kills	22	91.7
Diet Category	Carnivore: 32%, Herbivore: 27%, Omnivore: 41%	

Fantasy - Overall Disagree	# participants	Value
redScores	7	2.54
redTotals	7	4160
greenScores	7	2.08
greenTotals	7	3310
omniScores	7	4.62
omniTotals	7	7470
mutationSeeking	7	0.00804
timePlayed	7	26.5
kills	7	97.9
Diet Category	Carnivore: 14%, Herbivore: 0%, Omnivore: 86%	

Completionist Characteristic

Completion - Overall Agree	# participants	Value
redScores	21	2.27
redTotals	21	5720
greenScores	21	1.44
greenTotals	21	2460
omniScores	21	3.71
omniTotals	21	8190
mutationSeeking	21	0.00622
timePlayed	21	28.6
kills	21	96.3
Diet Category	Carnivore: 19%, Herbivore: 19%, Omnivore: 62%	

Completion - Overall Disagree	# participants	Value
redScores	8	2.61
redTotals	8	4470
greenScores	8	1.69
greenTotals	8	2830
omniScores	8	4.29
omniTotals	8	7300
mutationSeeking	8	0.00744
timePlayed	8	27.9
kills	22	85
Diet Category	Carnivore: 50%, Herbivore: 25%, Omnivore: 25%	

Other Characteristics

"Arousal/Excitement" category excluded, zero participants disagreeing...

"Entertainment" category excluded, only **2 (two)** participants disagreeing…

"Diversion" Category excluded, only **2 (two)** participants disagreeing…

"Challenge" Category Excluded, only **2 (two)** participants disagreeing

"Social Interaction Passive" Category Excluded, only **2 (two)** participants disagreeing