StarCraft II Interactive Visualization of Skill-Based Gamer Behaviors

ABSTRACT

StarCraft II is a real time strategy video game that is currently very popular worldwide. In order to help StarCraft II gamers understand how specific skill-based behaviors relate to league level progression, our group created an interactive visualization based on a publically available game log dataset. No other tool currently exists that analyzes such a large set of data from actual game play.

Author Keywords

Visualization, StarCraft II, interactive visualization, real time strategy game

INTRODUCTION

In this paper, we present the StarCraft II interactive visualization that we created in Tableau using a publicly available dataset. The purpose of our visualization is to help the gamers understand how skill-based behaviors (including actions per minutes, minimap right clicks, and units made) are related to league level progression.

The Dataset

The dataset is maintained by UC Irvine Learning Repository and was created by Mark Blair, Joe Thompson, Andrew Henrey, and Bill Chen. This dataset can be obtained from this link: SkillCraft1 Master Table Dataset. There are 20 variables in this dataset and the following is the description we pulled directly from the website:

1. GameID: Unique ID number for each game (integer)
2. LeagueIndex: Bronze, Silver, Gold, Platinum, Diamond, Master, GrandMaster, and Professional leagues coded 1-8 (Ordinal)
3. Age: Age of each player (integer)
4. HoursPerWeek: Reported hours spent playing per week (integer)
5. TotalHours: Reported total hours spent playing (integer)
6. APM: Action per minute (continuous)
7. SelectByHotkeys: Number of unit or building selections made using hotkeys per timestamp (continuous)
8. AssignToHotkeys: Number of units or buildings assigned to hotkeys per timestamp (continuous)
9. UniqueHotkeys: Number of unique hotkeys used per timestamp (continuous)
10. MinimapAttacks: Number of attack actions on minimap per timestamp (continuous)
11. MinimapRightClicks: number of right-clicks on minimap per timestamp (continuous)
12. NumberOfPACs: Number of PACs per timestamp (continuous)
13. GapBetweenPACs: Mean duration in milliseconds between PACs (continuous)
14. ActionLatency: Mean latency from the onset of a PACs to their first action in milliseconds (continuous)
15. ActionsInPAC: Mean number of actions within each PAC (continuous)
16. TotalMapExplored: The number of 24x24 game coordinate grids viewed by the player per timestamp (continuous)
17. WorkersMade: Number of SCVs, drones, and probes trained per timestamp (continuous)
18. UniqueUnitsMade: Unique unites made per timestamp (continuous)
19. ComplexUnitsMade: Number of ghosts, infestors, and high templars trained per timestamp (continuous)
20. ComplexAbilitiesUsed: Abilities requiring specific targeting instructions used per timestamp (continuous)

Our Visualization

Though StarCraft II is a very popular game, it was evident from our exploration that there is no visualization that helps gamers understand how skill-based behaviors affect game performance. Therefore, the overall goal of our interactive visualization is to help StarCraft II gamers understand how specific

skill-based behaviors relate to league progression. Some examples of skill-based behaviors are the number of actions taken per minute, number of unique hotkeys made, action latency, and the number of perception action cycles. These behaviors are uniquely different from strategy-based behaviors that focus on aspects like when/how gamers choose to spend their resources and the order in which they build up their resources. Our visualization will focus primarily on understanding skill-based behavioral patterns but has expanded to include strategy-based behaviors and serves as a tool gamers could use to improve their performance.

Overall Research Question

What skill-based behaviors differentiate a lower league player from a higher league player?

Target Users

The intended users of our visualization are mid-level StarCraft 2 1v1 **multiplayer** gamers who are interested in understanding the skill-based behaviors of higher league players. Another potential user of our visualization include game designers who are interested in understanding whether their game mechanics are achieving the desired outcomes. However, our primary focus will be mid-level gamers.

User Research

We started our project by conducting user research to help us narrow down our scope and better understand our intended users. We created a survey asking the impact of each variable on the performance of gaming. We used a 5-point Likert scale where "1" stands for "does not impact performance at all" and "5" stands for "major impact on performance." The results of this survey helped us define which variables from all the variables in the original dataset are most important and appealing to gamers. We then conducted semi-structured interviews with real mid-level StarCraft II gamers to gather more in-depth insights about how will a real gamer user our visualization and what expectations they have.

Based on our user research, we generated a persona, Michael Saddler. He is a 21-year-old UW student who has been playing StarCraft II for 5 months and has reached league 4, Platinum. However, he is stuck on League 4 and unable go any higher, and he really wants to practice more and get to league 6 (Master), by the end of this year. His major purpose of using our visualization is to understand what skill-based behaviors the league 6 gamers generally have so that he can work towards that direction.

Related Work

This visualization will build off the research done in a cognitive science study that determines some variables involved in complex skill learning.

Figure 1 [1] is intended for cognitive scientists who are interested in skill learning; the data is not presented for gamers. "Actions and attention shifts for a typical StarCraft 2 player over 15 seconds. Each vertical line tic represents a single action. Notice that most aspects of the PAC become faster with an increase in League."

Figure 2 [1] shows time metrics and is helpful in seeing that higher league players are faster. However, the visualization shows changes over 15 seconds and it is not clear how the metrics change over time for a particular league, if at all. This figure shows a histogram of the importance of the 16 variables relating to game metrics for a particular league. The authors made 8 versions of the same figure for each league

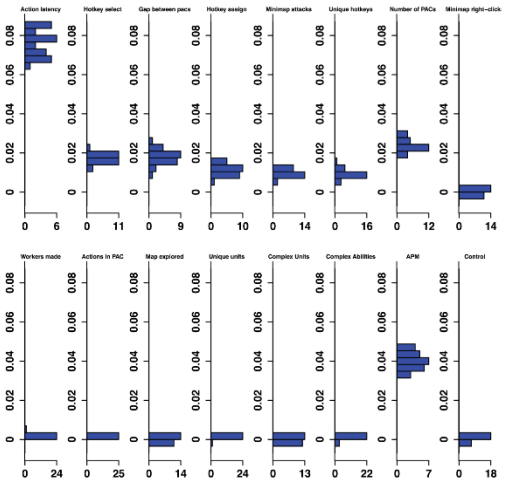


Figure 1

http://skillcraft.ca/ is a project currently underway and is attempting to hopes to be able to find out just what makes experts excel, and establish how someone might be able to learn these same skills on their own.

StarCraft 2 elite players have a specific build order to get consistently closer to winning. A study by He and Li [2] describes a visualization tool for analyzing build orders.

A study by Yang and Roberts [3] uses data from game logs of StarCraft II multi-player games to show clear patterns that players use to increase their score.

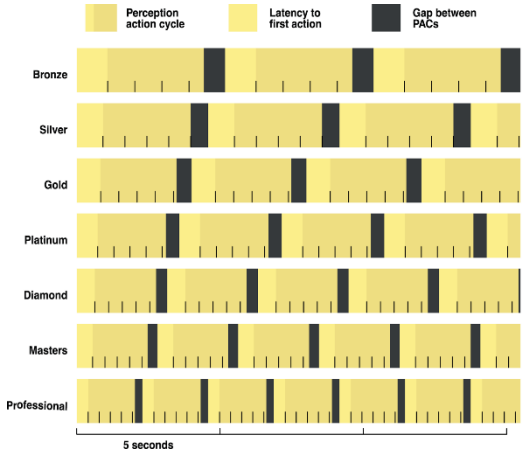


Figure 2

Jewel Loree made a great visualization of Pokémon with interactive filters at the top [4]. The filters are something we wanted to mimic for the leagues within our visualization.

VISUALIZATION DESIGN PROCESS

Understanding the dataset

One challenge for the team was ensuring that we understood the dataset, as three of us have no prior experience with the game. Many of the variables are closely related and had to be differentiated from each other (for instance there are three different variables dealing with hotkeys alone). To deal with this, we first went over the basics of the game itself and what strategies are used. Then we went over each of the variables in the data set to make sure we understand the unique information being conveyed by that variable.

Ensuring variables represent individual gamer data

One concern was whether each row represented data from a single gamer, as opposed to combining metrics from a pair. The latter would not be appropriate for our research question and goals. Since the UCI website and paper were ambiguous about this aspect, we contacted Prof. Mark Blair. He confirmed that each row represented single player data.

Normalizing the dataset

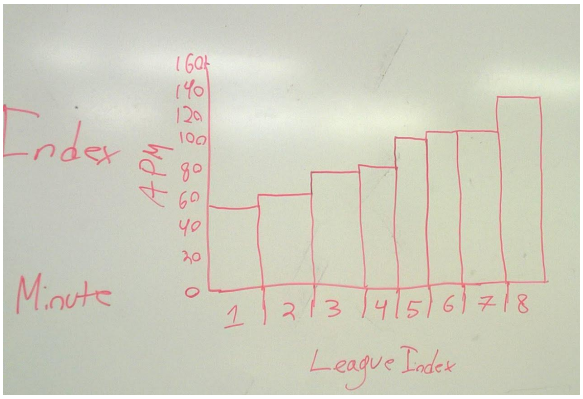
Understanding the dataset uncovered a new complication - variables per unit time were not in typical units of seconds or minutes but in a unit called time-stamp. This resulted in very low values close to zero in our data set. To make the visualization understandable and have a more reasonable axes range, we normalized every variable in time-stamp to seconds (1 second = 88.5 timestamps).

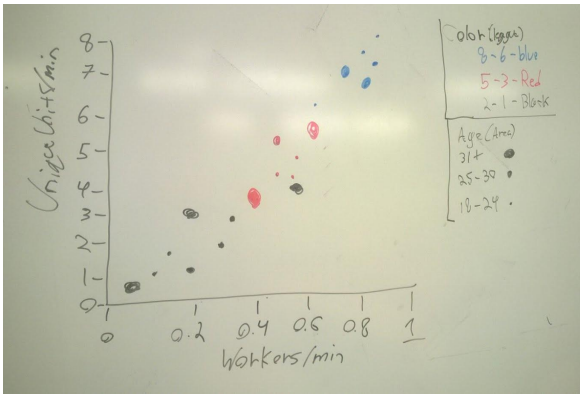
Visualization Design Process: Making Individual views & User flow

Our overall process was divided into two components - making individual views and mapping the overall user flow. We expected each view to be a combination of different variables, and the user flow to be a simple, interesting and efficient way to access and comprehend those different views. The process was not linear; we constantly iterated on both parts and worked on them concurrently. We describe each part below:

Individual Views: Low to high fidelity

(i) Sketches. We started out by taking our variables and mapping them to visual encodings on a white board (Figure 3). We started out with bar graphs for Actions Per Minute (APM) and progressed to a more complex scatter plot that encoded 4 variables with position, color, and size.





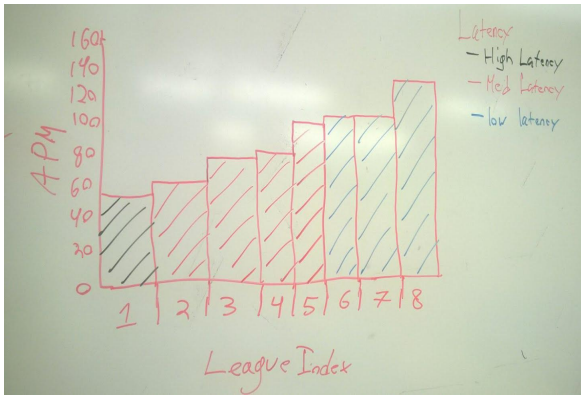
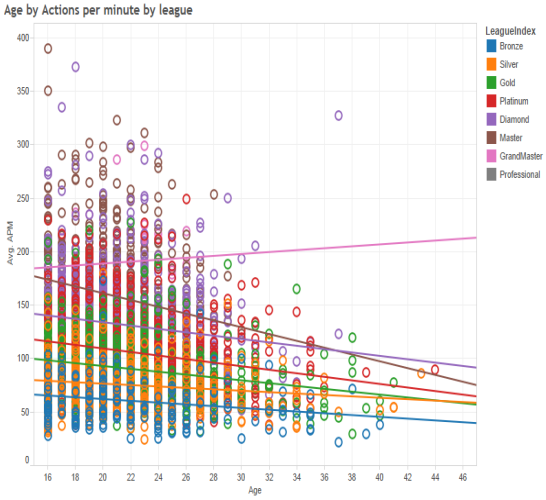


Figure 3: Whiteboard Sketches

(ii) Data Exploration in Tableau. One of the advantages of Tableau is that it allows fast exploration of a big data set (or more accurately, a relatively big data set). We individually explored the data set in Tableau and created multiple views. One immediate observation was that data occlusion might be a problem when we used all data points instead of league averages (Figure 4). We have used larger symbols coupled with brushing and linking to deal with this problem in our final version. An additional observation of interest was that the variable number of PACs was significantly correlated with many gamer metrics. PAC (Perceptual Action Cycles) is considered to represent cognitive processing skills including attention, motor and perception. It was very interesting to see the linear rise in PAC and gamer metrics in this view, and we have built upon it in our final version (Figure 5).



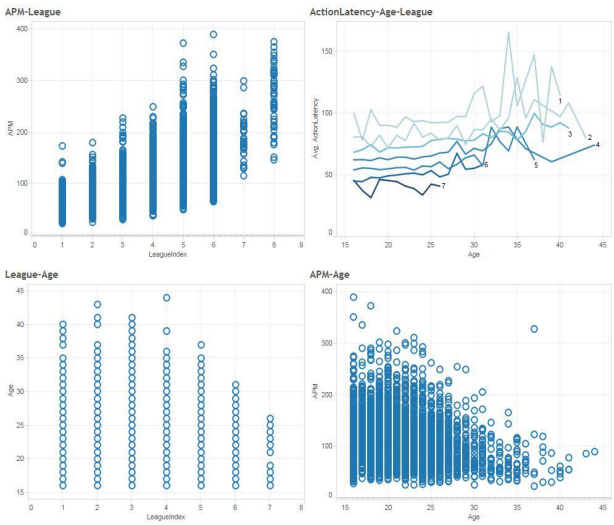


Figure 4: Data Exploration in Tableau

(iii) Adding interactivity:

Our visualization was static until this stage. We explored interactivity and mapped out interactions in a paper prototype. It was immediately clear that the leagues had to be filters and were placed at the top of visualization and consistent in every view (Figure 6). Selecting a league activates highlighting of that league, as well as brushing and linking with every graph in that view. This allows the user to focus on a particular league or compare two leagues. In our final version, the focus and context option through highlighting also made it possible to use and explain complex scatter plots with all data points: as clustering of points from one highlighted league showed the variability within that league, and moving through leagues showed trends in data.

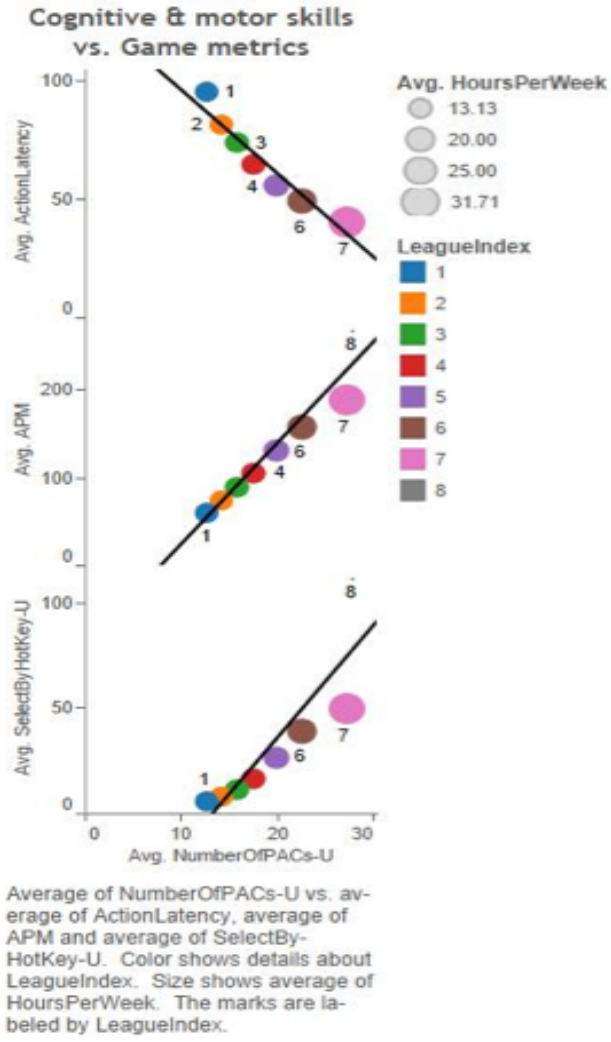


Figure 5: Data Exploration in Tableau

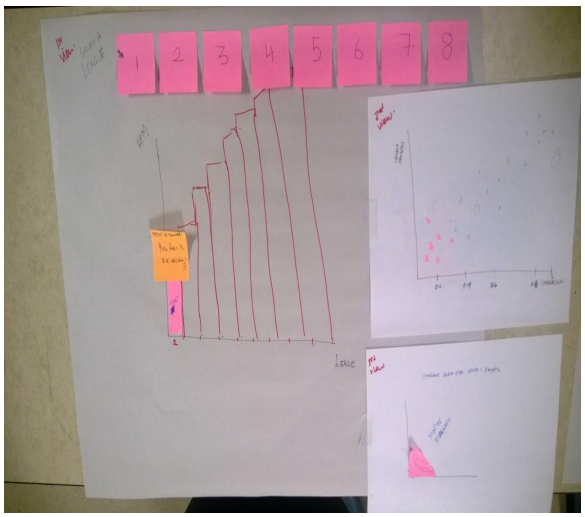


Figure 6: Exploring brushing and linking, and highlighting in a paper prototype

User Flow - A variation of Schneiderman's mantra

(i) Refining the flow - First view: We wanted to provide an overview, and then allow users to drill down. An overview in our case does not mean giving an overview of the entire data set because of the size and the presence of many closely related variables. Instead, we chose variables that would generally define and describe a gamer for the first view. These variables include age, playing times, and APMs. The first view also allows user inputs as described below.

(ii) Refining the flow - allowing user inputs: We wanted to allow gamers to input their own statistics from the game and instantly visualize where he/she stands with respect to other leagues. In our visualization, we were able to incorporate this in the first view where a user can input his APM and time spent playing and instantly see whether he is above or below the range for his league.

(iii) Refining user flow - Drill down process: We wanted to capture as much of the data set as possible with this visualization and hence decided to have multiple views. However, we also wanted to give users the flexibility to choose a particular view - for example a gamer may quickly want to check his PAC stats and he/she should be able to do that without having to explore the entire visualization. Hence, we chose to have other views representative of the data set and gave the user the option to drill down as he/she chose. This process is summarized in the flow chart below (Figure 7).

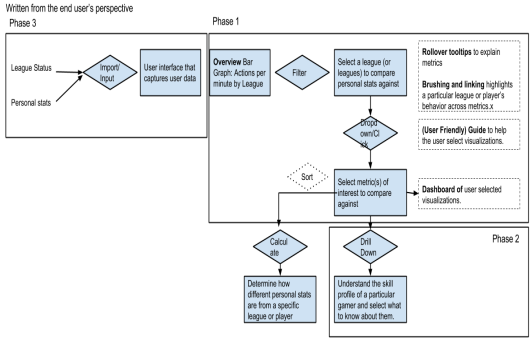


Figure 7

(iv) Final user flow: Our final user flow is shown below (Figure 8). The home page shows general player characteristics (age, APM, hours spent playing per week and in total). It also allows users to input their statistics and immediately see where they stand in their own league and compared to other leagues.

We have 4 other views, which represent variables of interest. Hotkeys view groups together all variables related to hotkeys (Select, assign and unique). Similarly the minimap view shows all variables related to minimaps (minimap attacks and minimap right clicks). Both of these views are self-contained in that they exclusively provide information about that specific variable. But since gamers might want to compare hotkeys (or minimap) with other variables, we created a custom tab. Here, the user can make a custom scatter plot that not only shows relationships but also shows a summary of league data for that variable.

The last view is that of the PAC. PAC is unique because it is not directly derived from the game itself like hotkeys or minimaps, but a variable derived from the gamer actions depending on movement of the camera, that is also indicative of cognition. So the PAC view summarizes PAC variables (number of PACs, gap between PACs) but also relates them to other game metrics. For instance, one graph shows how gap between PACs and player latency reduces drastically and cleanly with league. Each view is explained in detailed below.

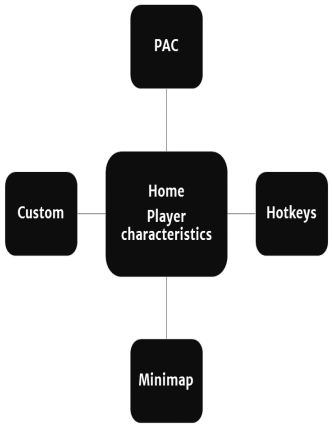


Figure 8

User Testing

The initial plan was to conduct a fairly standard usability test with 5-6 StarCraft II gamers in order to get feedback on our visualization. The usability test asked participants (who were StarCraft II gamers of varying skill levels) to spend time with the visualization and complete the following tasks:

Task 1: Unique task per user (qualitative)

Before showing the visualization, we asked the participant one question they would like answered about a higher league gamer. Then, we evaluated (with a Likert scale) if and how well our visualization was able to answer that question.

Tasks 2 - 4: (qualitative + quantitative)

We set three tasks for participants to complete while they interacted with the visualization:

Easy task: Does a higher league player spend more time in a week playing the game?

Moderate task: Use our visualization to find out if a higher league player is faster than your own league in making an action.

Hard task: Can you name 3 specific attributes that differentiate a higher league player from a player in your own league (or from you)?

We recorded the # of right/wrong answers and the time and steps they took to complete this task (quantitative). We conducted interviews to ask for opinions on how easy the task was, whether the information they found was relevant and helped them answer the question posed in the task.

We also asked all users for a quick opinion on how our visualization looks and whether it fits with the StarCraft/gaming theme. If there were one thing that needs to change, what would it be? Will they recommend this to a friend?

We ran this test on 3 participants and found that participants felt overwhelmed interacting with and answering questions about the visualization in such a short period of time. They all expressed a desire to spend more time playing around with it so that they could provide more in-depth, insightful feedback. Also, a time-constrained user testing format did not fit well with how the visualization was designed: it was designed to facilitate exploration rather than guide the user through a specific story. We decided to alter our test plan and post a link to the visualization on the Reddit StarCraft II forum.

This gave us access to a large community of experienced and passionate SC II gamers (see Table 1). It gave users plenty of time to interact with the visualization, explore the raw data, ask questions and allowed us to respond immediately. This facilitated a rich discussion amongst gamers on the strengths and weaknesses of the visualization and gave us a clear sense of what was confusing and hard to use about the visualization as well as what other information users wanted to see.

Here are just a few of the comments we pulled from the Reddit forum. And as you can see here, we had a lot positive validation on the usefulness of the

visualization and a clear sense of what gamers took away from it.

"Some really cool results here. One of the coolest things to me was 'Workers made per minute' which rises all the way to Masters, then GMs and Professionals actually make less than Diamonds. This 'PAC' stat is also very interesting."

"It looks really cool, and I like how you can create your own graph at the end. I do like how you visualize a lot of things and filter by league."

"The most surprising things to me were the Worker building and minimap clicking had virtually no correlation to league overall despite have a strong correlation until you hit Masters. The actions Per 'PAC' being a negative contributor was also interesting. Seems to imply while you do more actions per screen change, that that's actually a bad thing, maybe you're too focused in one place."

From these comments and the results of our original usability test, we came up with a list of improvements for the next iteration of the visualization.

Iterations

The following improvements were implemented in the current version of the visualization.

1. We removed the linear regression fits on the Custom tab because it was obvious that not all relationships were linear and we did not have time to run proper statistical analysis on the dataset.
2. We provided a way for people to access the raw data since people in the forum requested access to it in order to play around with it.
3. We provided a better explanation of PAC in the visualization. None of the 3 in-person testing participants understood PAC and a few users in the forums asked clarifying questions.
4. We explained why we used medians on the Player Info tab.
5. We used medians instead of each data point in the Custom tab to reduce clutter.

Lastly, we would like to display the behavioral profile of a player if a user clicks on a particular data point (i.e. provide details on demand). We would also like to come with a equation that can predict league progression. In fact, one of our users in the forum already came up with one! These improvements will be included in a subsequent version of the visualization.

Incorporated Feedback	Yet to be Incorporated
Removed linear fits on the Custom tab.	Display the behavioral profile of a player if the user clicks on a particular data point. (Details on Demand)
Provided a way for people to access the raw data since people in the forum seemed excited to play around with it.	Include economic data (how resources are spent, accumulated, etc.)
Provided a better explanation of PAC.	Provide an equation that predicts league progression.
Explained why we used medians on the Player Info tab.	
Used medians instead of each data point in the Custom tab to reduce clutter.	

Table 1: Comparison of usability testing methods

STARCRAFT II VISUALIZATION

After our initial prototypes, user testing, and subsequent iterations, we created our final presentable Tableau visualization, which can be found on sc2skillviz.appspot.com. The visualization contains five dashboards: Player Info, Hotkey, Minimap, PAC, and Custom. Each dashboard was a strategic design decision to orientate StarCraft 2 players towards understanding how this dataset represents change in skill from Bronze to Professional league play. As mentioned before, StarCraft 2 statistics primarily represent win / loss ratio, ladder rankings, league demographics by country, and tactical race preference. As far as we know, we represent the first visualization that engages players with skill-based metrics.

Overarching Design Decisions & Interactivity

Interactive League Badges

The first items our users tended to notice was the league badges prominently displayed at the top of each dashboard (Figure 9). The league filter badges are consistently in the same location across the dashboard, serving three important functions:

highlighting, filtering, and skill progression indication. On hover of the badges, associated league data is highlighted and filtering occurs on a click of a badge. If a user moves their cursor sequentially from bronze to professional league, the badges can mimic motion displaying a progression of skill.

It is important to understand that these badges serve a recognition memory aid for StarCraft 2 players. The cognitive familiarity and visual appeal was well received in our user testing, as opposed to our original use of semantically meaningful color. These badges are represented for each datum of all graphs to provide consistent, quick cognitive recognition of league data. This design was heavily inspired by the "Gotta Viz em' All" Pokémon game visualization, which displays Pokémon element type at the top of the visualization.

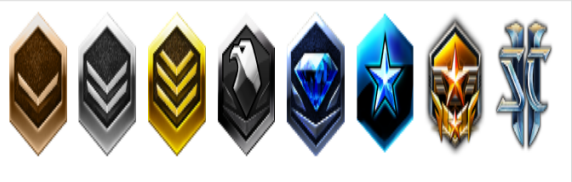


Figure 9: Interactive League Badges

The use of median throughout the visualization

Throughout the visualization we chose to use the median to represent the middle of the dataset as opposed to the mean. This decision stems from how the median is not as heavily affected by outliers as the mean is. To elaborate on our scenario, the sample size collected by league was:

- Bronze: 167
- Silver: 347
- Gold: 553
- Platinum: 811
- Diamond: 806
- Masters: 621
- Professional: 55

Due to the skew in volume for the platinum and diamond leagues, there was a large amount of outliers, which misrepresented the dataset when using the mean. The median, in this scenario, would be the most accurate measure of the middle of the dataset.

Player Info Dashboard

The player info dashboard is the initial view loaded for players to see. This dashboard displays a box & whisker plot of Actions Per Minute (APM), a scatterplot of median league APM by median league hours per week, and a dot plot displaying median league total hours played and age. All StarCraft 2, and even most non-StarCraft 2 gamers, will understand the data dimensions within this dashboard because APM is provided at the end of each match and age, hours per week, and total hours played are simple logistic information. We chose to display this dashboard first to (1) provide StarCraft 2 players with the most familiar data possible, (2) to give StarCraft 2 players an overall sense of the sample of players collected for the dataset, and (3) to allow players to interact and determine where they might fall if their data was collected for this study (Figure 10).

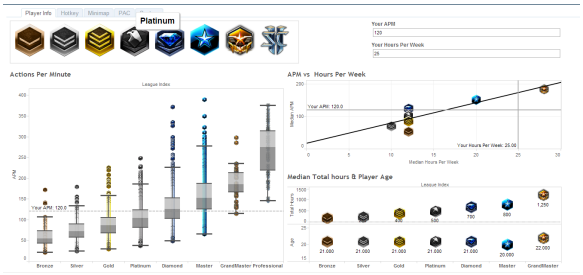


Figure 10: Player Info Dashboard

The APM box & whisker plot represents the most familiar StarCraft 2 skill metric. This metric is provided in a summary at the end of each StarCraft 2 match. Players will be able to understand the difference in the amount of APM that separates players for this dataset. Using the "Your APM" input at the top right, players can adjust a reference line which helps them to understand where they might reside if collected in this sample. While this may seem basic, we chose to provide the most familiar skill based metric due to the novelty of our visualization.

The "APM vs Hours per Week" scatterplot show an interesting finding: the gap between the diamond to master league requires roughly 8 more hours of gameplay per week. There is also an interaction with APM showing a positive linear correlation of hours per week and APM. In this graph, players are able to engage with the familiar metrics of APM and hours per week, and determine where they would reside in this dataset. We designed these interactions for players to become engaged with familiar data, providing an easy to understand initial experience.

The graph in the bottom right of this dashboard was designed to provide players insight on the sample's age and total hours of playtime for each league. Total hours played is an extremely important metric, which helps to determine how many competitive ladder seasons a player might have been involved in. The age was displayed to orientate the players. Overall, this graph was designed to engage StarCraft 2 players with familiar skill based metrics, providing

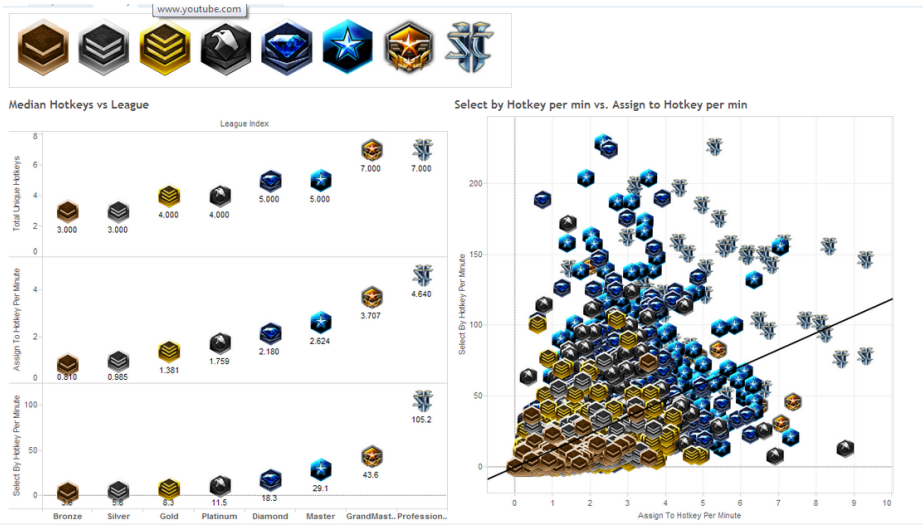


Figure 11: Hotkey Dashboard

an understandable and inviting initial user experience.

Hotkey Dashboard

The hotkey dashboard represents the difference in hotkey usage variables for bronze to professional league play. The variables visualized are total unique hotkeys a player assigns over the battle (possible values range 1-9), hotkey assignments or reassignments per minute, and selection by hotkey per minute. We ordered this dashboard as the second tab from the indicated interest from our survey and the universality of hotkey usage in StarCraft 2 (Figure 11). Utilizing hotkeys are an important part of StarCraft play that are an indication of how dexterous a player has to be with their keyboard to compete at higher levels.

Starting with the graph, "Median Hotkeys vs. League," players will see a general linear trend from bronze to professional league for each graph. This is the first graph in which players are engaging with data not officially collected by Blizzard (developer of StarCraft 2). A difference among skill is immediately noticed: for each graph, each higher tier league always had a greater than or equal to number of unique hotkeys, hotkey assignments, or selection by hotkeys. It seems to be as players rise in league rank, they are able to manage more assigned elements (unique hotkeys), make quicker assignments to those elements (hotkey assignments per minute), and interact with those elements faster (selection by Hotkey per minute). The most pronounced difference is seen in the selection by hotkey per minute from GrandMaster to Professional league play; a 61.6 difference!

The scatterplot demonstrates how assignments to hotkey and selections by hotkeys interact with leagues. The amount of variation increases with each higher level league. This indicates all higher league players have quick hotkey skills, but their individual play style are more pronounced as their rank increases.

Minimap Dashboard

Our minimap dashboard visualizes the variables minimap attacks per minute and minimap right clicks per minute (Figure 12). The minimap is a familiar gaming construct that is seen in most modern real-time strategy games, which provides a zoomed out view of the entire explorable map. In StarCraft 2, players can conduct actions via the minimap to order units without changing the camera view. Combining hotkey usage with minimap coordination can be a powerful tactic to control an army. As seen in other dashboards, as league tier increases, interaction with the minimap increases - indicating that higher league players are more adept at control through the minimap.

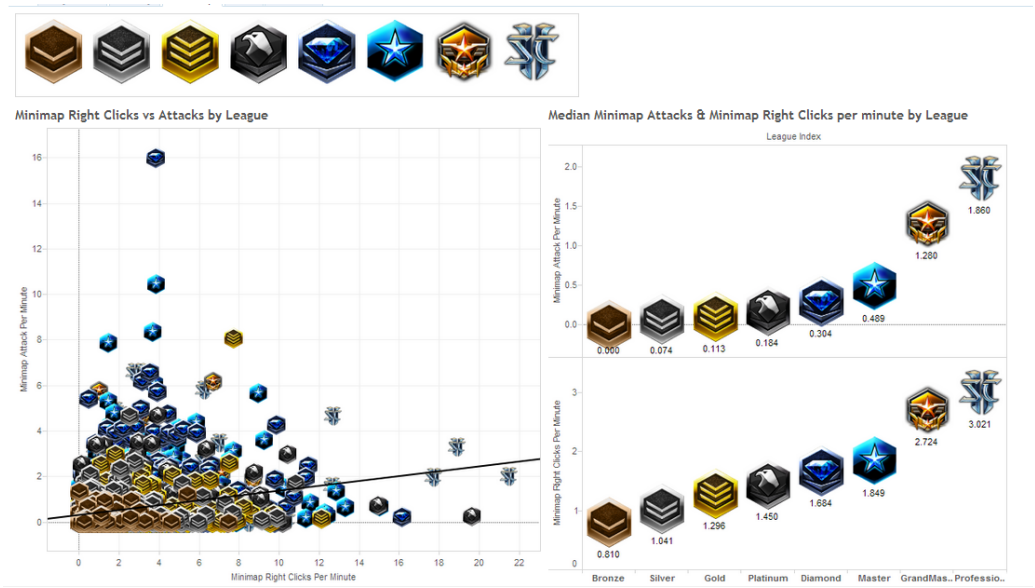


Figure 12: Minimap Dashboard

Mimicking the same format as the hotkey dashboard, the minimap graphs display league medians for minimap right-clicks and attacks, and the variability of the minimap variables via the scatterplot of minimap right-clicks and attacks.

For the league medians, we see a general positive linear correlation of both minimap attacks and right clicks. What's interesting for the minimap attack variable is the difference between the higher tier and lower tier leagues: Grand Masters and Professionals are performing at least 1 minimap attacks per minute while Bronze to Master league players perform less than 1. This may indicate that those who play at higher leagues are able to utilize more inputs of control than lower leagues.

For the right clicks, we see a more standard progression for frequency of right clicks for higher league players. Again we see a dramatic jump after the Master league. Again, this may indicate higher league players are able to utilize more inputs of control than lower leagues.

Our scatterplot shows that variation among minimap interaction by league is, for the most part, clustered closely together. This is a much different result than hotkey interaction where play style became more diverse at higher leagues.

It seems that the minimap interaction is another indicator of that which distinguishes league play. While this the differences between leagues are subtler than the hotkeys, minimap interaction still plays a role into player skill development.

Perception Action Cycles (PAC) Dashboard

A perception action cycle (PAC) is a new point of view that contains at least one action (Thompson et al., 2013). PACs encompass roughly 87% of the participants' game time. This finding echoes research using eye-tracking to record gaze while participants do real world tasks [24]. The PAC variables measured include PACs per minute, amount of actions within a PAC, latency time (ms) between the actions within a PAC, and the time gap (ms) between PACs (Figure 13). This is the most difficult dimension for StarCraft 2 players to understand, but an important indicator of attention and cognitive processing.

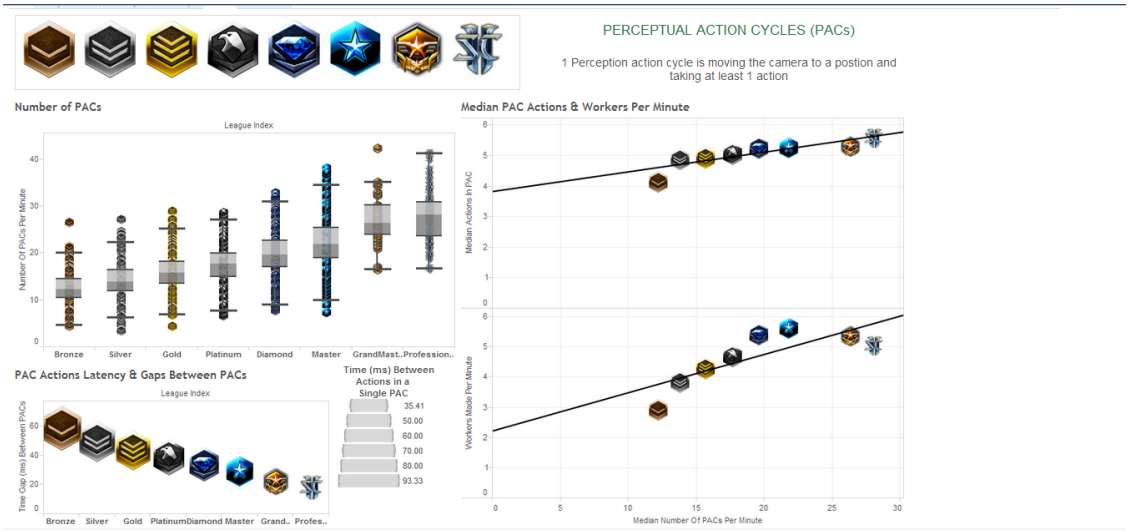


Figure 13: Perception Action Cycle (PAC) Dashboard

To ameliorate the unfamiliarity and difficulty with comprehension, we provided a PAC definition on the dashboard of this tab and more information and examples within our frequently asked questions. Within this dashboard we include a box & whisker plot of number of PACs, a graph showing league median PAC gap and PAC action latency, and median amount of PACs / median workers made per minute by number of PACs.

The box & whisker plot was displayed to show how generally as league tier increases, so does the amount of PACs occurring. This may indicate that players in higher leagues are able to move the camera faster and comprehend in more information within a shorter amount of time than lower league players.

The PAC gap time and action latency time was designed to be presented in order to show how players how as league tier gets higher there is less of a time gap between PACs and less time between actions within a PAC. This indicates how higher league players have a faster comprehension and control as to how to monitor and manage their army.

Median amount of actions within a PAC was displayed to further characterize the dimension of PAC. Workers per minute ties in with PACs from a player having to constantly move the camera back to their base in order to take an action to build a worker. From these graphs, it seems as league tier increases, more actions are taken within a PAC, but the range from Bronze to Professional is 4.159 to 5.587, only a 1.482 difference in the amount of actions taken per minute. For median workers made, there was some very interesting behavior: from bronze to master league there was an increase in workers made per minute, but from grand master to professional there is a decrease in the amount of workers per minute made. This could indicate that at a high level of play, it's inefficient and hindering to make many workers per minute.

Within this dashboard players will be introduced to mostly foreign metrics. We considered this during the design and took care to present the simplest definition possible with associated links for further exploration. It was a challenge to present, but we feel that the PAC variables are an important indicator of what separates a lower league from a higher league StarCraft 2 player.

Custom Dashboard

Our last dashboard was designed to encourage further exploration and engagement by being able to customize a scatterplot. The dashboard provides two drop down bars in the upper right hand corner which serve to change the x and y axis (Figure 14). From our initial iterations, this dashboard has changed to accommodate our findings from our usability studies. For example, we had occlusion problems from showing the entire dataset on the scatterplot. This was ameliorated by displaying only the league medians and not the entire dataset. Another issue was displaying a linear regression line when there would be more appropriate lines. While we attempted to allow for a dropdown to display different regressions, there is no option to do so in Tableau. In this case, we removed the regression line from the dashboard to ameliorate the associated confusion. Lastly, we would like to mention a problem with axis title formatting displayed on this graph. While the y-axis is properly aligned and displayed on the Tableau desktop, Tableau public

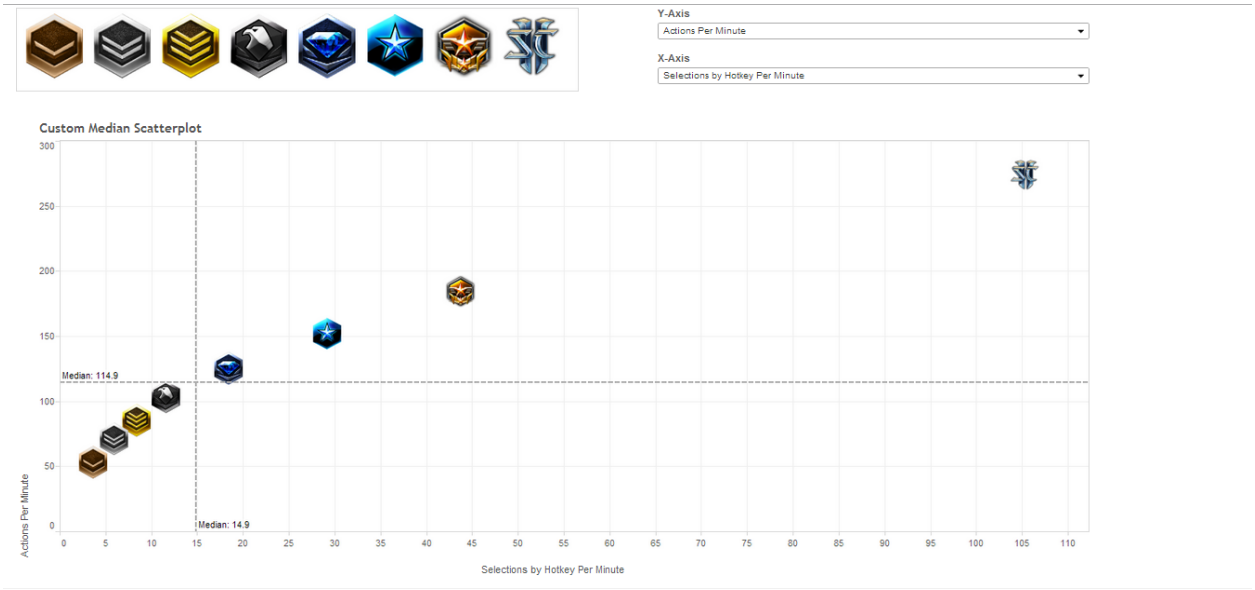


Figure 14: Custom Dashboard

aligns the y-axis along the bottom of the axis. One student spent many futile hours working on a workaround. Overall, we feel this is a great graph to end on, allowing the players to further engage with the dataset in the way they see fit.

DISCUSSION & REFLECTION

As to our knowledge, we are the first attempt to visualize StarCraft 2 skill metrics. As far as we know, there is only one other visualizations which is mostly statistics focused on ranked ladder play (http://www.sc2ranks.com/stats/league). Our positive reception within the StarCraft Reddit community is a good indicator that this visualization is relevant and useful to the players. In light of the community success, there are still many constructs and ideas that we would improve looking back.

After having more confidence within the field of data visualization, we feel our Tableau creation could benefit from a complete redesign using a tool like D3. Our visualization takes about fifteen seconds to load on Tableau Public's servers - this can be a huge deterrent for users who want to explore this dataset. D3 would allow us to script animations, have faster loading times, provide more exploration options, and fix the formatting issues we encountered with Tableau. This is not to undermine our experience with using Tableau - we were still able to create a great visualization in a short amount of time! The larger lesson to take from the actual tool usage is that Tableau is an excellent, higher-level product which can quickly visualize excel data. If there is a need for deeper customization, a tool like D3 should be used in order to fully express a design.

While our team did in depth user research, we lacked experience in the most important part - StarCraft 2. If there was a longer time period to work on the product, our team would have greatly benefited by playing more StarCraft 2. We believe we had an excellent understanding of the game, but an intimate knowledge can really only be achieved by experiencing the game for yourself. Next visualization we strive to have in depth domain knowledge.

One of the best decisions we made was to contact the primary researcher early into our development of the visualization. Mark Blair was instrumental in helping us transform the dataset correctly to display in understandable terms. He was also very supportive of the project from the start, allowing for a transparent display of the data and relevant research for the StarCraft players. This was an excellent decision and we will follow form of contacting dataset curators in future studies.

FUTURE WORK

We would like to continue and display more dimensions properly for the StarCraft players. For example, one variable parsed was total map explored. An initial idea was to display the minimap and color-in the percentage to which the map was explored for each league. Unfortunately, due to time constraints and technical limitations we were unable to implement this.

Another next step would be to provide a pivot table, which characterizes a datum with every dimension, collected, displayed at the bottom of the visualization. With this table players would be able to isolate single datum or compare data and view exactly where individual players differed. Due to screen size and time constraints, we we're unable to design a way to elegantly complete this.

A third step (and important one) is to perform regression analysis with our data set - and calculate what variables contribute and to what extent in defining a player's league. This will enable us to tell a bronze league player exactly what he needs to work on to advance rapidly. In fact, one gamer on the forum calculated this (we cannot verify accuracy):

"League = 1.7APM + 1.8HoursPlayed + 2.5SelectbyHotkey + 6.4UniqueHotkeys - 6.2ActionLatency - 9.9ActionsinPac + 267"

"The actions Per 'PAC' being a negative contributor was also interesting. Seems to imply while you do more actions per screen change, that that's actually a bad thing, maybe you're too focused in one place...Conclusion from this seems to be that your physical mechanics alone determine 50% of your league placement."

A last consideration would be to improve the design of our site and spread the site to more StarCraft communities. As of now, it's kept with no styling in hopes to improve the load times from Tableau Public. In time we wish to style this website with more relevant StarCraft 2 color scheme and font.

ACKNOWLEDGEMENTS

We'd like to thank Mark Blair for his active support in providing clarification and context on the SkillCraft1 Master Table Dataset.

REFERENCES

[1] Thompson JJ, Blair MR, Chen L, Henrey AJ (2013) Video Game Telemetry as a Critical Tool in the Study of Complex Skill Learning. PLoS ONE 8(9): e75129.

[2] He K and Li S (2013). *Starcraft II Build Order Visualizer*. http://vis.berkeley.edu/courses/cs294-10-sp11/wiki/images/3/35/Sc2vis-paper.pdf

[3] Yang P and Roberts D (2013). *Knowledge Discovery for Characterizing Team Success or Failure in (A)RTS Games*. http://www.csc.ncsu.edu/faculty/robertsd/papers/cig2013-roles.pdf

[4] Pokémon visualization with interactive filters:

http://www.jewelloree.com/2013/11/06/pop-viz-gotta-viz-em-all/