The Hearthstone Meta For Learning ML and Statistics

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Abstract

We show that Hearthstone: Heroes of Warcraft, a card game created by Blizzard Entertainment, is a potential learning environment for players to empirically practice and learn statistical methods. Hearthstone can be considered as an endogenous game, when considered in the context of being a platform effective in teaching its player-base statistics. We focus on analyzing learning tools widely used by knowledgeable and experienced players in the community. Our contributions also consist of evaluating the effectiveness of learning statistics from Hearthstone. In this paper, we analyze our claims in a cross-disciplinary manner.

1 Introduction

Hearthstone: Heroes of Warcraft is a popular and vastly pervasive card collecting game made by Blizzard Entertainment(Blizzard, 2014). Hearthstone has had a large impact on the competitive gaming industry with esports players being awarded over $18 million in tournament prize money(*Top Player Rankings With Online Results For Hearthstone*, 2019). Competitive games have had an authentic place in history as a method of developing cultural ideas and sharing knowledge(Rieber, 1996). With Hearthstone at the peak of card collecting games with more than 100 million people having played, it's valuable to consider such a game in different contexts(Chalk, 2018). Throughout different works, the learning potential of playing video games has been considered to be quite powerful tools(Gee, 2005; Squire, 2006). As an example of an endogenous game, Hearthstone, in the context of statistics, has empirical learning, a group-oriented community, and players have the agency to make decisions and experiment each turn. It's important to understand how players learn from and use external tools and their knowledge of the Hearthstone meta to improve their chances of winning games. The tools developed and shared by the community add to the complexity of data available about the meta.

1.1 Learning Principles

We find there are core learning mechanisms that make a game fun and applicable learning experiences(Gee, 2005). Many of these principles are present throughout playing Hearthstone. Two of the most widely seen in the game are the concepts of *information just in time* and *cycles of expertise*. We see the concept of *cycles of expertise* playing a big role in teaching players statistics. Players take actions and experience the consequences of their choices throughout the rest of the game. After many iterations of trial and error and recognizing familiar situations, the player eventually learns the best options for many game states. But, there remains a lot of unknown variables in any given state. *What cards does my opponent have in their hand? What's the next card I will draw?* One can use relevant information such as previous cards played to predict the answer to these types of questions. As more actions are taken, more information about the board state becomes readily available, and it becomes easier to predict these unknown variables. This is simply a different application of the concept: Information Just In Time. Similarly, the player learns to readjust and adapt to situations based on the available information about the board state.

1.2 Statistics in Hearthstone

The crux of our argument lies in Hearthstone being an intuitive teaching tool for statistical methods and functions as a learning environment when combined with existing community created tools. We see instances of players computing probabilities to determine the statistically best option. Determining the next card an opponent will play on their turn is a classification task that can be modeled and predicted using Machine Learning (ML) techniques. When done programatically, this has proven to be game-breaking(Bursztein, 2016). Some other examples include using important heuristics (Mana Pool, Minion Stats, and more) in tasks such as: decision making, minion trading scenarios, management of cards, and Arena drafting. Ultimately, Hearthstone is a decision making game about managing resources properly based on the available given knowledge about the current state of the board. This teaches experienced players the intuition behind statistics and ML tasks, both of which are frequently applied in the real world. For experienced players who strive to learn more and improve, there are community provided tools for tracking game replays, updating statistics on the meta, and programs for simulating matches(HearthSim, 2019a, 2019b; *SabberStone*, 2019).

2 Background

Hearthstone is a turn-based competitive multiplayer card game with the goal of reducing the opponent hero's (face) health to 0(Blizzard, 2014). Much of the game relies on Random Number Generation (RNG), such that after learning the basic concepts and the right choices to make in general situations, a player's performance can be significantly improved by working on one thing: statistical analysis. This raises the question: *How does one consistently improve their win rate with the same deck?* In order to improve, players must improve at picking the best options during their turn by getting better at analyzing the many heuristics of the current state of the board and their hand. Thus, it becomes advantageous for players to utilize statistical tools built for deck creation, card play tracking, and card prediction(Bursztein, 2016; HearthPwn, 2019; HearthSim, 2019a).

2.1 Deckbuilding

Using spell, quest, minion, and weapon cards, each with their own unique abilities and strengths, players build decks of 30 cards(Blizzard, 2019). With around 1049 total collectible cards in Standard mode, there are endless possibilities for decks and synergies(*Card set*, 2019). Outside of devising decks, in-game strategies are typically simpler in nature. Interestingly, Standard is full of a small set of tried and tested decks many people copy. This practice is commonly known as *netdecking*(justjimmy, 2014). In Arena mode both players draft their decks by choosing 1 card to add to their deck from sets of 3 cards until they finish drafting their full deck. Because of this, Standard is much more structured with a defined meta, when compared to the randomness of decks in Arena.

2.2 Gameplay

Each card in the game has their own stats and usages. There are many added abilities that have specially programmed mechanics, but these are varying and numerous(*Ability*, 2019). For weapons and minions, there is an attack and a health stat, and there is a mana cost associated with playing any card. These stats and abilities act as very important heuristics for decision making in games as well as deckbuilding. Players start the game with 1 mana, and either 3 cards or 4 cards and a coin, depending on turn order. Each turn, mana refreshes and is incremented by 1 to a capacity of 10 mana, while 1 card is drawn at the end of each turn to a capacity of 10 cards. The game board can hold up to 7 minions on each players' side of the board. After playing a minion, players can control them the next turn to attack an enemy minion or the opponent's face. Players play these cards each turn with goals in mind like controlling the board, aggressively attacking the opponent's face, or using some unique deck-specific strategy.

3 Learning Statistics Intuition

3.1 Gameplay

Several features seen in Hearthstone's gameplay are real world applications of certain statistics fundamentals. We consider mana curves, which are the distribution of the mana costs of cards in a deck. Hearthstone represents this curve as a histogram, implicitly embedding into the game the concept of statistical distributions. In Figure 1, we see some resemblance to a positive skewed normal distribution. The distribution of one's mana curve reflects the type of deck being played along with the optimal strategy to adopt. Positive skewed mana curves result in more low cost cards comprising the deck, so playing aggressively in the early turns is an optimal strategy for this type of deck. Hearthstone uses this graphical depiction of the mana cost distribution to help the player understand the role of mana in this larger level system of gameplay. This notion of *system thinking* is reinforced with the mulligan game mechanic, or card selection(Gee, 2005). By allowing players a chance to randomly redraw cards via rejecting cards, the player has more agency as well. The probability of a player redrawing a specific card can be calculated, and it is typically in the player's favor to reject mana expensive cards as in Figure 2.

In Chow et al. they discuss using a game, 'Deal or No Deal', to teach students expected value in an introductory statistics class(Chow, Woodford, & Maes, 2011). Students would calculate expected value following an activity, and retention rate for students using the game as a learning activity was 36% higher than the students learning from a lecture. In Hearthstone, there are many instances of concepts like expected value or conditional probabilities coming into play. For instance, Nat Pagle is a minion card which has a 50% chance to draw an extra card at the start of the player's turn. One can calculate the expected number of cards drawn by the minion, by using Equation 1 and use this calculated value in deciding whether to play the minion.

This concept isn't limited to card draw ability, players can calculate expected value for the results of playing any card with random effects. Intuitively, understanding the expected value of each card to play allows players to choose the optimal option with the highest expected value per mana cost. With this extra information, players can be better suited to make decisions when compared to others that don't understand this concept. Since teaching concepts like expected value using games has been shown to be successful, one could see that Hearthstone, if used in an educational setting, could be used to teach statistics concepts. However, there exist certain shortcomings to using Hearthstone in this educational-guided manner. The game lacks built-in support for tracking these numbers and calculations. We discuss the usefulness of utilizing community-built statistics and tracking tools in Section 4.1.

3.2 Standard Play

The population distribution of decks played in Standard is non-uniform as a result of the Hearthstone Meta. People share and play decks resulting in specific archetypes of classes becoming more prevalent than others, a result of netdecking(justjimmy, 2014), and this contributes to the formation of the current expansion's meta. Table 1 shows the distribution and winrates of the top decks seen in Standard play(HearthSim, 2019b). This reflects on the distribution of decks seen in actual play and leads to players predicting opponents' deck archetypes and strategies which we will continue to analyze in Section 4.3.

The concept of *cycles of expertise* is put into practice here as players improve their deck prediction skills by analyzing the cards already played by their opponents. As cards are played on each turn, the predictability of an opponent's deck increases, and players begin to implicitly learn this. This idea is very important in the Hearthstone meta, especially when playing ranked Standard games(Nocturne, 2015). The optimal strategy could change drastically depending on what archetype one's opponent is playing. Figure 3 demonstrates a simplified general rule in Hearthstone deck type matchups.

4 Learning Statistical Methods

4.1 Statistical Analysis Tools

As Hearthstone is a competitive game, players will continuously strive to improve their skills and rank. At some point, experience and intuition alone is not enough to continue improving. Members of the Hearthstone community have developed tools to analyze games and provide meaningful statistics. One such tool is HSReplay(HearthSim, 2019b) which has useful card, deck, and meta statistics. Using this information to improve game decisions favors players with this knowledge over others. Hearthstone Deck Tracker(HearthSim, 2019a) is a tool that records games for replaying and storing statistics. In Figure 4, overall and per-class win rates are displayed. Luckily, the Hearthstone community is inclusive and frequently shares this knowledge, making these statistics tools an important part of the Hearthstone community and, therefore, meta. These incentives for players to do supplemental research with statistics about Hearthstone is an effective manner of improving player performance. Utilizing pre-existing knowledge and toolsets is a feature of endogenous games, as well as the group oriented community that supports gameplay(Squire, 2006). We hypothesize that formulating learning statistics methods could be done using problem-based learning, a teaching method where groups of students research topics and solutions when presented with a problem statement(Bland, 2004). Pairing this approach with Hearthstone and the community's statistics tools could greatly aid in teaching a statistics curriculum. Video games have been used as teaching tools in the past, and its success has been reproduced for problem-based learning as well(Annetta, Cook, & Schultz, 2007).

4.2 Arena Mode

Winning consistently in Arena is a difficult task. Players draft cards when making their decks, so predicting decks and building deck synergies are both infeasible. Although, predicting cards is possible to do with card frequency data from HSReplay. Ideally, one would pick good cards that work well with existing cards in their decks, a task which is made easier with card tier lists like HearthArena(HearthArena, 2019). The site provides a heuristic that is useful when considered with other factors like mana curve, abilities, and minion type. Combining this with information about the best cards currently available in Arena like in Table 2, players can learn and make optimal decisions while drafting and in game. The Hearthstone Deck Tracker provides utility for Arena in being able to review which classes result in the best performance for a particular player or playstyle(HearthSim, 2019a). In Figure 5, there is evidence that Warrior is a subpar choice whereas Paladin is an overall strong pick.

4.3 Machine Learning and Hearthstone

Numerous works have explored the idea of automating Hearthstone play and training models which can make predictions based on game states. In Bursztein's work, they gather game states from replay data. They use Markov chains where card co-occurrences are modeled as bigrams. They use this in their card ranking system which models the likelihood of a card being played(Bursztein, 2016). Their attack was quite effective with high accuracies of card prediction on certain turns. Bhatt et al. explore using a genetic algorithm to build new decks and simulate deck matchups as a way to evolve the Hearthstone meta(Bhatt et al., 2018). Many researchers have established Hearthstone as a baseline environment for extending the applicability of existing statstical methods and empirically evaluating these new experiments.

5 Conclusion

In our paper, we evaluate Hearthstone's effectiveness at teaching players statistics by referencing its endogenous learning features. We find that Hearthstone has core learning mechanics that revolve around statistics and has many community developed statistics tools. For a game with a competitive nature, players seek improvement and learn more about how statistics are applied in the game through these many resources. By analyzing Hearthstone's potential as a teaching tool for statistics, we consider using the game as an aid for a course via problem-based learning.

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7 Appendix

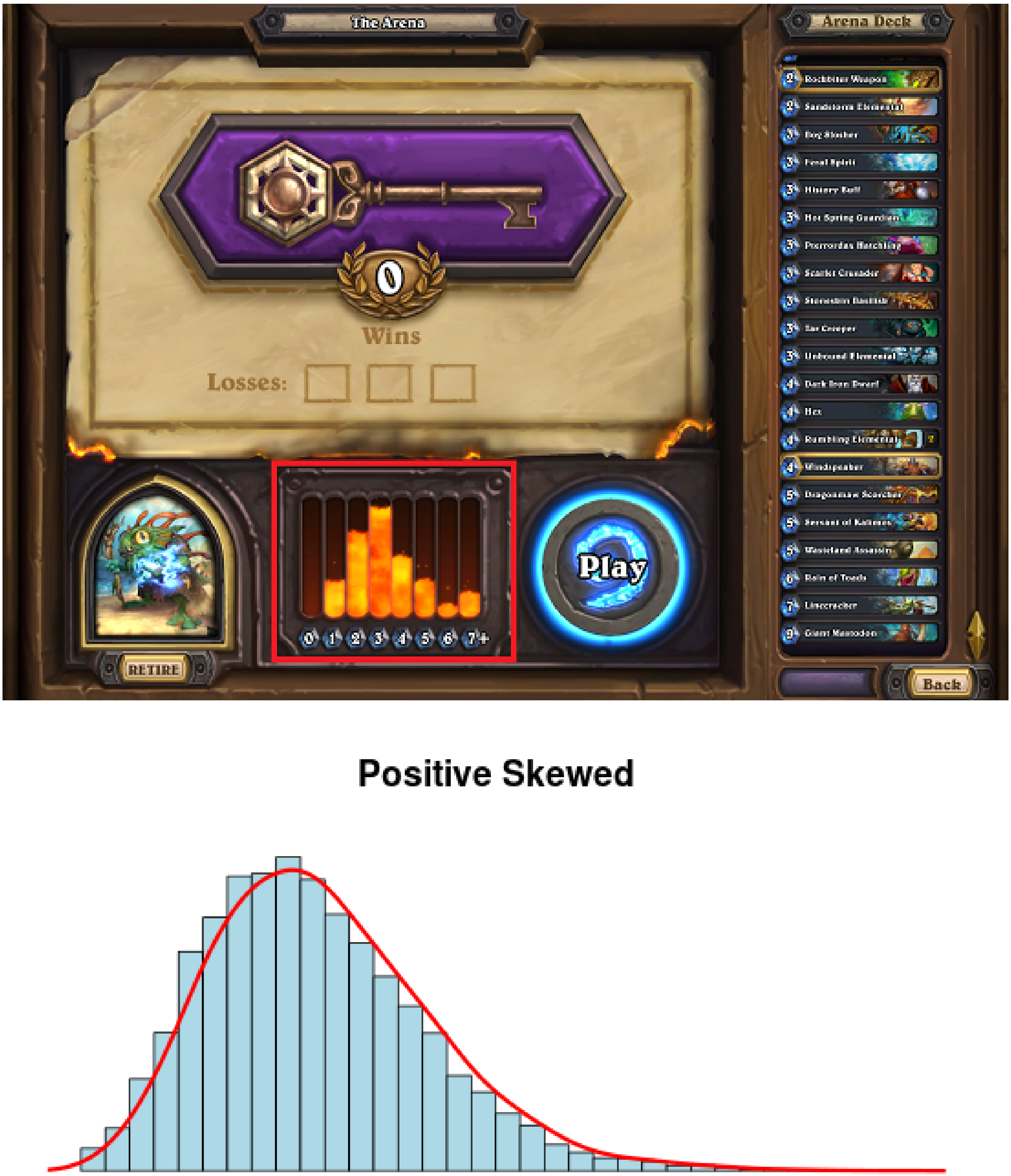

Figure 1. Top: The mana curve outlined in red, seen in an arena drafted deck. Bottom: A positive skewed normal distribution. Note the similarities.

Figure 2. At the start of every game, the player can redraw cards, the red X's represent cards that were chosen to be rejected and will be redrawn.

$$E[x] = \sum P(x) * y \tag{1}$$

where:

$E[x\ ]$ is expected # cards drawn

$P(x)$ is probability card is drawn

y is # turns minion is on the board

Deck Name	**Games Played**	**Winrate**
Quest Shaman	55,000	59.3%
Secret Highlander Paladin	24,000	60.9%
Resurrect Priest	28,000	58.9%
Murloc Shaman	20,000	61.8%
Quest Shaman	17,000	59.0%

Table 1

Data of top 5 most popular deck archetypes; Data found on HSReplay at the time of the latest patch. Quest shaman appears twice because of different card combinations.

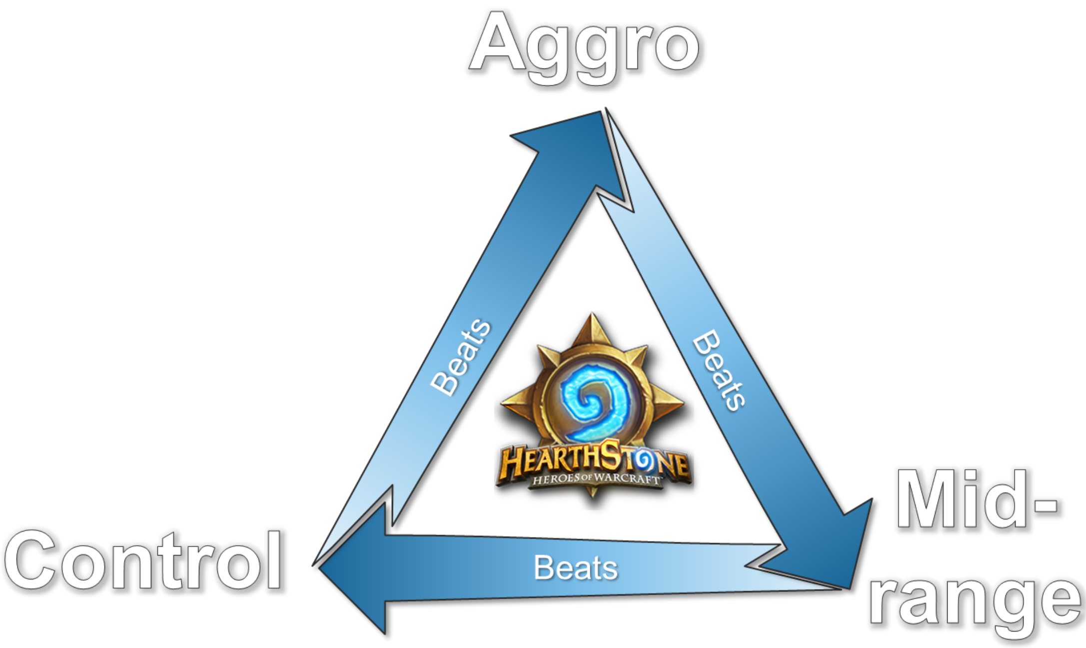

Figure 3. A diagram depicting archetype matchup outcomes. A player's strategy can change because of a matchup.

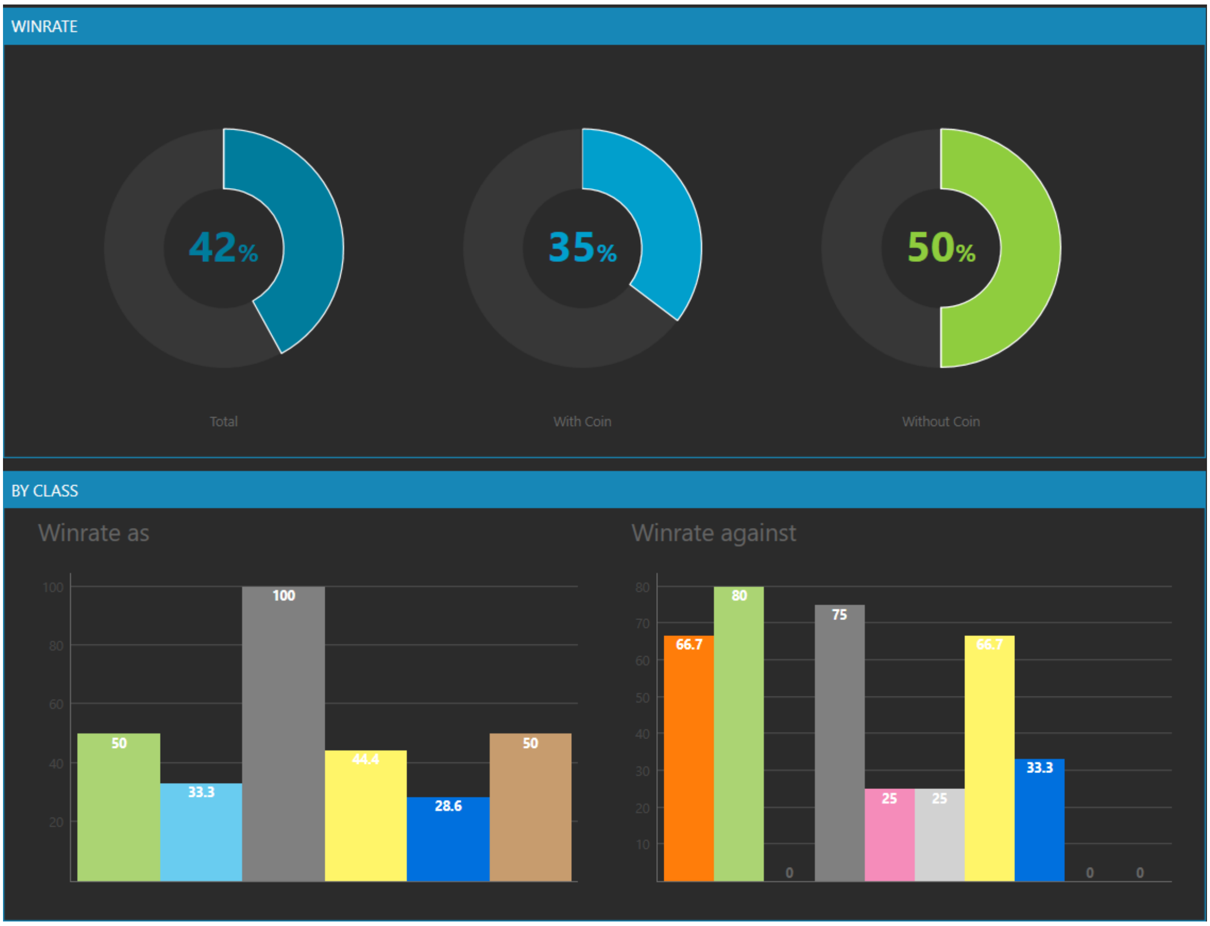

Figure 4. Top: Overall win rates for starting hand situations.

Bottom: Win rates per class and against classes.

Card Name	**In % of Decks**	**Deck WR**	**Played WR**
Sunkeeper Tarim	0.6%	65.3%	64.8%
Envenom Weapon	1.2%	64.2%	61.7%
Muster for Battle	3.0%	63.9%	62.9%
Vinecleaver	3.9%	63.4%	66.9%
Eadric the Pure	0.4%	63.4%	56.6%

Table 2

Data of top 5 deck win rates of cards; All except Envenom Weapon are Paladin specific cards. WR is win rate. Paladin is also widely considered the best class to play in Arena currently.

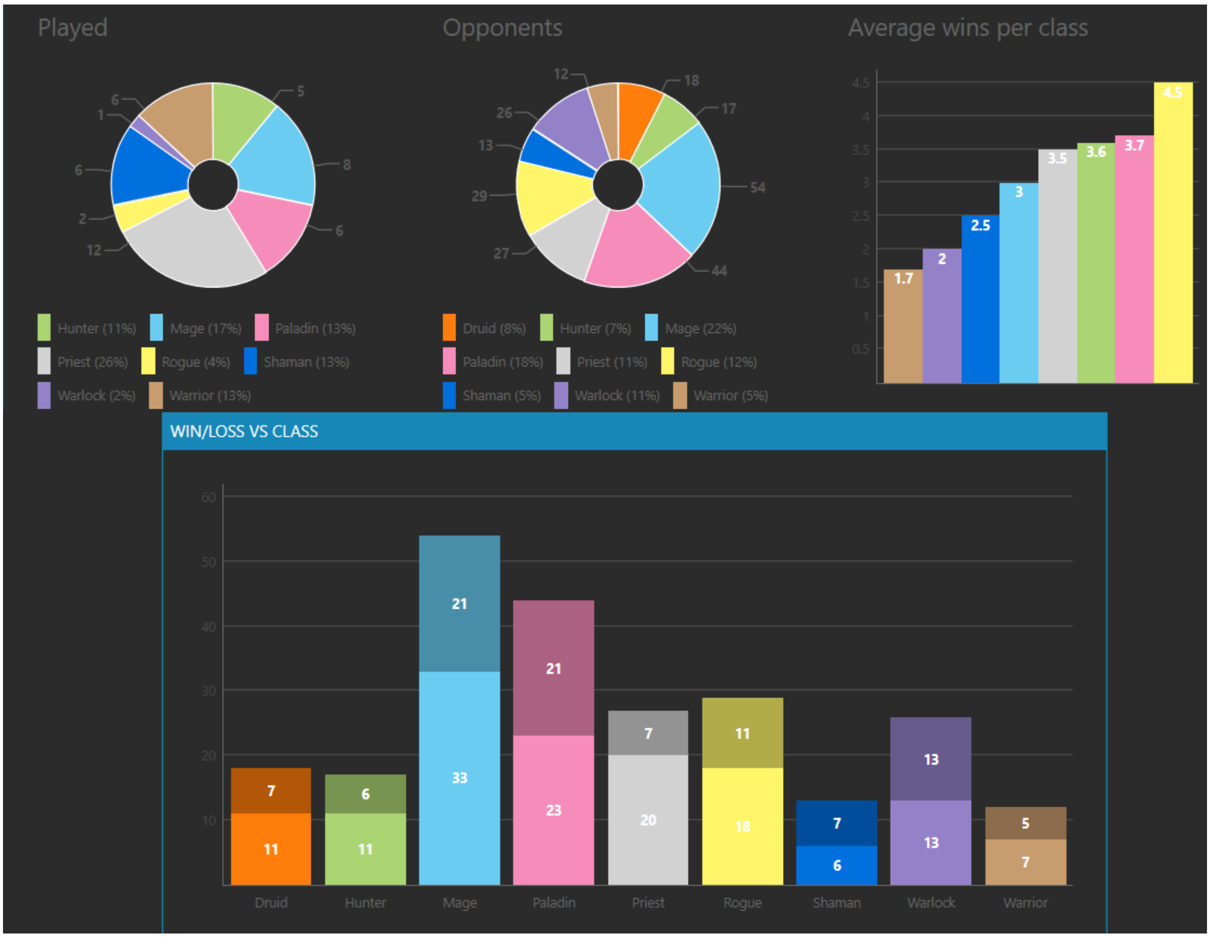

Figure 5. The following shows graphics of a player's arena matches in Hearthstone Deck Tracker. Rogue has the highest average win rate, and the player's highest win rate is against the Priest class.

Orange:Druid, Green:Hunter, LightBlue:Mage, Pink:Paladin, Gray:Priest, Yellow:Rogue, DarkBlue:Shaman, Purple:Warlock, Brown:Warrior