

Optimal Strategies for Various Match Formats in Hearthstone, and Implications for Competitor and Viewer Preferences

Research Project Proposal

Faculty Mentor

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[[CMU webpage](#), [personal webpage](#)]

Project Web Page

<https://dominic-calkosz.com/HearthNash>

Project Description

Hearthstone is a 1-vs-1 digital card game in which two players, each with their own independently preconstructed decks of 30 cards, aim to destroy the opposing hero before their own hero is destroyed. In a tournament setting, players generally must defeat the opponent in multiple games using different decks. The particular rules and sequencing of this multi-deck, multi-game system constitutes a [match format](#), and can be structured in a variety of ways. John Forbes Nash Jr. showed that in every non-cooperative game, each player has an optimal strategy (the Nash Equilibrium). Note that a certain winrate probability can be determined between every possible deck pairing. Thus, given each player's decks and the corresponding winrates (which are known to both players), an optimal strategy exists at each decision point within the sequence of protections, bans, deck decisions, and probabilistic games that are then played out according to the match format. Using reverse induction, this optimal strategy (presumably a mixed-strategy) can be determined.

This research will be an attempt to formalize and solve several match formats in Hearthstone. Solving this metagame in the general case will mean developing a tool which is applicable to any match format (within some formalized bounds) and any deck winrate data. We predict that a variety of mixed-strategies will emerge as optimal, dependent on the format. The expected payoff of the optimal strategy for each player will also indicate the probability of victory. With these expected payoffs, corresponding to certain match format and winrate states, it will also be possible to measure some qualities of desirability. For example, How many games will be close games as opposed to blowouts? How close will the match as a whole be? How much does player skill affect their overall odds? For each

match format, we intend to do a qualitative analysis across many possible winrate states to determine how desirable it is.

We also see potential to extend this study to the strategies involved in selecting decks for a given format in the first place. If the initial research described above yields a tool for determining expected payoffs, we can immediately use the tool to generate higher level payoff matrices and thus determine the optimal strategy for deck selection under certain metagame conditions. Furthermore, we hope to study the generalizability of this type of match, the corresponding optimal strategies, and the qualities of its possible formats, both in theory and practice. One possible extension is towards games in which any subset of moves has internal interactions, such as selecting a subset of characters to construct a team of 5 in a MOBA (a 5-vs-5 game). Another possible extension is for games which include a draft process that is not simultaneous. This applies to many MOBAs, as well as to physical sports and fantasy sports leagues.

Project Goals

75%

At minimum, we intend to produce a tool for game theoretic analysis of two match formats for Hearthstone, each with respect to multiple possible (if not all) winrate states. We also intend to conduct some analysis using this tool and draw conclusions addressing the question: Are the formats different? And why? The success of this stage can be measured by the correctness, scope, and usability of the tool, as well as the significance of our conclusions.

100%

If all goes as expected, our tool will have a scope of 4 distinct match formats, and we will be able to measure a variety of desirable qualities for each of them. In particular, there are 4 match formats that have been used in official Hearthstone tournaments, and 3 qualities that we have already identified in the project description above. We can then draw deeper conclusions about the quality of each competitive format. The success of this stage can be measured according to how many match format-quality combinations we are able to cover, and how meaningful our qualitative results are.

125%

If things go faster than expected, we plan to expand our study to deck selection strategy *going into* a tournament with a particular match format and meta state. We will also attempt to extend the scope of our tool(s) to similar contexts, and thus generalize our results. This may mean applications to sequenced games with internal interactions, to games with non-simultaneous drafts, or to another similar game type which we have not

considered. We can measure the success of this step using our same measures of success at 75% and 100% but with respect to each new context that we are able to cover.

Milestones

1st Technical Milestone for 15-300

- Complete a more thorough literature review & summary.
- Develop the code to analyze a single n by n game.
- Develop the analysis tool for a single match format.

Bi-weekly Milestones for 15-400

January 27th:

- Develop the analysis tool for a second match format.
 - OR Begin generalizing the tool to function over any formalized match format.
- Design and implement a measurement scheme for one desirable quality.

February 10th:

- Develop the analysis tool for a third match format.
 - OR Finish generalizing the tool to function over any formalized match format.
- Use the first measurement scheme to collect data on one match format.

February 24th:

- Develop the analysis tool for a fourth match format (if applicable).
- Collect desirability data on a second format for the first quality, and use this to draw preliminary results with respect to the first format.
- Design and implement two more measurement schemes for desirable qualities.

March 16th:

- Design and implement a fourth measurement scheme for a desirable quality.
- Collect data for each match format with a corresponding tool, across all measurable qualities.
- Informally draw conclusions based on the results.

March 30th:

- Expand our study into tournament deck selection strategies.
 - Develop a tool which makes use of our previous tools.
 - Draw further conclusions regarding qualitative results of match formats.

April 13th:

- Expand our study into similar games, e.g. MOBA drafting
 - Develop tool(s) which may or may not make use of our previous tools.
 - Draw novel conclusions about different match formats in these other games.

April 27th:

- Write up our research as a publishable paper, including our methods and results
- Write up our research as a concise blogpost
- Format our tool(s) into a convenient interactive web page

Literature Search

I have collected a range of reference sources and arranged them loosely into three categories. The first is academic papers on relevant game theory topics, including extensive-form games, strategic tournaments, backward induction, and multidimensional reasoning. Each of these topics within game theory are applicable to our research to varying degrees, so it will be useful to have them available if and when we need to dive deeper into a certain area. The second category is academic research which directly used Hearthstone, even if it is only tangentially related. These have been insightful, if only to give me a better impression of how recreational video games are utilized and written about in an academic context. The final category consists of unpublished online content, especially from forums such as Reddit. This is particularly useful because I found one post from a user who just about solved the Conquest format optimal strategies (in general) using game theory. This will serve as a helpful reference for getting started on our first stages.

Resources Needed

We expect the computational components of this research (at least in its foreseeable stages) will be simple and undemanding enough that we can simply use JavaScript to achieve them. This will have the benefit of easy interfacing as a web-tool. We do not foresee any other software or hardware requirements.