Ertai's Study of Lesser Wizards
Version 1

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Contents

1 Introduction

This study is meant to complement sources of Magic the Gathering (MTG) Competitive Elder Dragon Highlander (cEDH) such as Lerker's list of staples and building blocks[1]. I do not attempt any analysis (although obvious conclusions will be pointed out) rather, the aim is to identify and quantify the Archetypes and cards found in cEDH decks.

1.1 Objective

I've been playing EDH for 2 years and moved into the competitive realm recently because I like winning. Problem is, I'm an awful pilot, horrible judge of board state and pending moves and miserably inept at identifying combos. I've managed to scrape together a "high-powered" deck[2] which could be better with a better pilot. While waiting for experience to improve my faults, I thought that a survey on cEDH decks might provide me with an insight and an edge. Failing that, enumerating the cards seen in cEDH decks could help me identify cards that I need or need to play around.

[1] https://www.reddit.com/r/CompetitiveEDH/comments/8h49o3/lerkers_updated_list_of_staples_and_building/dygxjvd/
[2] https://tappedout.net/mtg-decks/pennies-from-phyrexia-primer/

1.2 Data

I used Python[3] to scrape cEDH decks from TappedOut[4] and compile them into data structures using Cockatrice's[5] card database. The decks were selected using AverageDragon's conglomerate[6] of primary decks. In total, 42 decks are used in this study. The decks are current as of 07-Aug-18 and a brief description of each can be found in Appendix A.

1.3 Contact

If there are decks that should be present, decks that should be removed or additional statistics/-metrics desired, post on my TappedOut wall at https://tappedout.net/mtg-decks/ertais-study-of-lesser-wizards/. I can also be contacted via email at TemporalInept@mail.com.

1.4 Remainder of Paper

The remainder of this paper, covers Decks in Section 2, Cards in Section 3, Archetypes in Section 4 and concludes in Section 5. Four appendices provide a short description of each surveyed deck (Appendix A), additional graphics (Appendix B), initial attempts to categorizes the decks (Appendix C) and links to the raw data (Appendix D).

2 Holistic: Decks

This section provides a brief synopsis of the cEDH decks used in the survey. Additional details about the decks can be found in Appendix A and links to the raw data can be found in Appendix D.

2.1 Average CMC and Card Types

The average CMC and card count is shown in Table 1 and a comparison of all decks is listed in Table 2. Table 2 breaks down the decks by Color, average CMC and the counts of card types.

CMC	Basic	Non-Basic	Artifact	Creature	Enchantment	Instant	Planeswalker	Sorcery
1.94	8.0	22	13.9	17.6	6.1	22.5	0.2	11.3

Table 1: Average Card Count and CMC

A quick overview of the high and low counts for CMC and card types shows a varied deviation from the norm.

- CMC
  - High Selvala Brostorm at 2.46
  - Low Sidisi Ad Naus Fishbowl at 1.4

[3] https://www.python.org
[4] https://tappedout.net
[5] https://cockatrice.github.io/
[6] https://docs.google.com/spreadsheets/d/e/2PACX-1vQqiznwO4FqlwXXFdWZfWj_Qflxqy8TfPF8RFwl6mtJVYaUuAvqmHNSK1Az2EluIDO8SYnhKiQkZVt_/pubhtml

- Total Lands
  - High Gitrog Dredge with 36
  - Low Paradox Scepter Storm with 27
- Basic Lands
  - High High Tide Jace with 27
  - Low SBT Grave Combos, Lightning Druid, Yidris Melt Banana, Breakfast Hulk and Najeela Tempo with 0
- Non-basic Lands
  - High Gitrog Dredge with 32
  - Low High Tide Jace with 5
- Artifacts
  - High Paradox Arcum with 45
  - Low Najeela Tempo, Tazri Hulk and Razakats with 5
- Creatures
  - High Paradox Sisay, Midrange Yisan, Blood Pod, Edric Turns with 34
  - Low Teferi Chain Veil with 3
- Enchantments
  - High Blood Pod with 12
  - Low Sidis Ad Naus Fishbowl with 2
- Instants
  - High Rashmi Control with 37
  - Low Midrange Yisan with 6
- Planeswalkers
  - High Teferi Chain Veil with 3
  - Low Multiple with 0
- Sorceries
  - High Jeleva Storm with 22
  - Low Midrange Yisan with 3

Obvious conclusions can be drawn. In short, most cEDH decks appear to utilize mana rocks over lands, and rely less on Planeswalkers and Enchantments and more on Instants and Sorceries. Additionally, while decks like Gitrog Dredge and Paradox Arcum (which utilize a specific card type for their game plan), cEDH decks do not appear to follow a deterministic 'recipe' in determining card type counts.

			Lands		Spells					
Deck	Color	CMC	B.	N-B	Art.	Cre.	Enc.	Ins.	Pla.	Sor.
Baral Control	U	2.19	25	6	17	5	4	33	1	9
Blood Pod	WBRG	2.28	6	27	10	34	12	8	0	5
Breakfast Hulk	WUBG	1.69	0	29	6	21	4	28	0	12
Buried Alive Razaketh Sidisi	B	1.72	21	11	29	13	3	13	0	16
Doomsday Yidris	UBRG	1.88	2	26	17	7	4	28	0	16
Doomsday Zur	WUB	1.82	9	19	16	5	4	33	0	14
Edric Turns	UG	1.99	11	20	7	34	5	15	0	11
Food Chain Prossh	BRG	1.83	4	24	10	33	7	16	0	9
Food Chain Tazri	WUBRG	1.68	1	27	6	23	5	27	0	11
Gitrog Dredge	BG	1.91	4	32	9	20	8	18	0	10
Godo Helm	R	2.10	18	14	37	10	3	14	0	8
Grixis Consultation	UBR	1.74	3	27	16	4	3	32	0	15
Grixis Twin	UBR	2.18	2	30	11	9	5	24	1	18
HE-MAN	WUBG	1.71	4	24	16	7	9	28	0	12
High Tide Jace	U	2.40	27	5	15	4	3	31	0	15
Honorbru Meren	BG	2.18	8	24	9	33	11	7	0	10
Hulkweaver	WUBG	2.00	4	26	6	31	11	18	0	7
I Can't Believe It's Not Varolz!	WUBG	1.66	4	25	6	26	7	24	0	8
Jeleva Storm	UBR	2.04	8	20	15	4	4	26	1	22
Kess Storm	UBR	1.88	9	19	16	5	3	29	1	18
Lightning Druid	UBRG	1.61	0	28	6	20	7	28	0	11
Midrange Yisan	G	2.33	21	13	15	34	11	6	0	3
Mimeo Reanimator Hulk	UBG	2.24	4	26	7	24	6	25	0	11
Momir Hackball	UG	1.55	9	20	6	31	5	23	0	6
Najeela Tempo	WUBRG	1.66	0	30	5	18	9	32	0	6
Nooze Reanimator	UBRG	2.03	3	27	9	21	9	19	0	14
Paradox Arcum	U	1.93	14	15	45	22	3	18	0	4
Paradox Scepter Storm	UBRG	1.67	2	25	16	8	5	29	0	15
Paradox Sisay	WG	2.13	5	25	20	34	7	10	0	5
Rashmi Control	UG	2.41	14	16	10	5	5	37	0	13
Razakats	WUBG	2.01	3	27	5	26	7	19	0	14
SBT Grave Combos	UBG	1.83	0	28	6	28	7	24	0	8
Scepter Control	UBG	1.90	8	24	11	9	9	27	0	12
Scepter Thrasios	WUBG	1.62	2	26	10	15	5	32	0	10
Seasons Pastigur	UBG	2.22	3	28	12	12	10	22	0	14
Selvala Brostorm	G	2.46	24	7	11	27	7	15	1	12
Shimmer Zur	WUB	1.80	9	20	23	5	3	30	0	11
Sidisi Ad Naus Fishbowl	B	1.40	21	11	41	9	2	8	0	13
T&T Hulkball	WBRG	1.90	3	28	8	28	7	20	0	6
Tazri Hulk	WUBG	1.97	1	28	5	25	8	24	0	10
Teferi Chain Veil	U	2.35	22	9	20	3	6	26	3	11
Yidris Melt Banana	UBRG	1.64	0	28	20	8	5	18	0	21

Table 2: Side by Side Deck Comparison

One of the arguments against cEDH is a perceived lack of variety in the decks. From Table 2, there appears to be variety in terms of colors and card types.

However, let us briefly consider cards. As of the release of C18, there are 18170 legal Commander cards with 17535 legal non-Land cards. Of the 42 cEDH decks surveyed, there are 654 unique non-Land cards which means that only 3.7% of the possible cards in the multiverse are used in cEDH. It may be that cEDH decks are "inbred"[7] or it could be that the subset of "good" cards in the multiverse is small. We will return to this topic in Sections 2.4 and 3.

Going back to Table 1, cEDH decks have a relatively low CMC. Figure 1 shows a histogram of card CMCs found in cEDH decks. 75% of all cEDH cards are less than 3 CMC with CMC 1 composing 38%.

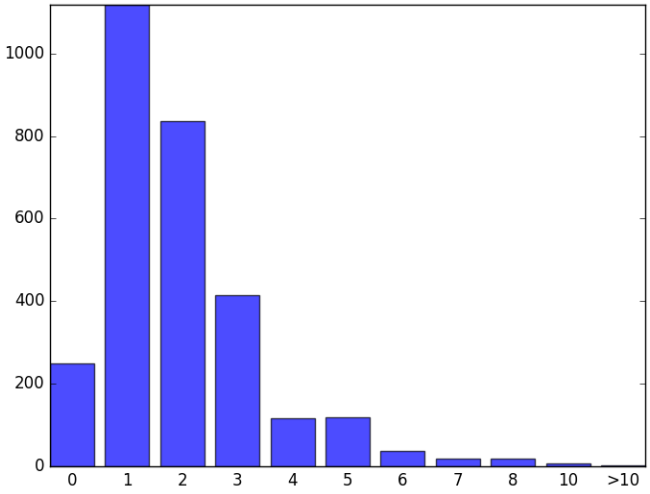


Figure 1: CMC counts

cEDH decks will generally only play cards with CMC 5 or greater if that card(s) will win the game on the spot or if there is a way to tease the card into play.

2.2 Commanders

Table 3 shows the list of Commanders with the pair Thrasios, Triton Hero and Tymna the Weaver making up the most common Commander (draw power and infinite mana outlet). Individually, Thrasios is the most common Commander showing up in 10 decks with Tymna showing up in 9 decks. In a pod of four, chances are Thrasios will be in the command zone.

2.3 Color

There are 32 possible deck colors in EDH (counting colorless). Roughly half of those, 15, are seen in cEDH decks. Figure 2 shows a pie chart of the deck colors found in cEDH. Four color decks top

[7] Without comparison to casual EDH decks it is impossible to say with a high level certainty

Commander(s)	Count
Thrasios, Triton Hero, Tymna the Weaver	7
Thrasios, Triton Hero, Vial Smasher the Fierce	3
Kess, Dissident Mage	3
Yidris, Maelstrom Wielder	2
Tana, the Bloodsower, Tymna the Weaver	2
Tasigur, the Golden Fang	2
Zur the Enchanter	2
Sidisi, Undead Vizier	2
Captain Sisay	1
The Mimeoplasm	1
The Gitrog Monster	1
Najeela, the Blade-Blossom	1
Arcum Dagsson	1
Jace, Vryn's Prodigy	1
General Tazri	1
Godo, Bandit Warlord	1
Rashmi, Eternities Crafter	1
Momir Vig, Simic Visionary	1
Selvala, Heart of the Wilds	1
Edric, Spymaster of Trest	1
Yisan, the Wanderer Bard	1
Baral, Chief of Compliance	1
Meren of Clan Nel Toth	1
Sidisi, Brood Tyrant	1
Prossh, Skyraider of Kher	1
Teferi, Temporal Archmage	1
Jeleva, Nephalia's Scourge	1

Table 3: Commanders

the chart with WUBG at 7 and UBRG at 5. Of no surprise, is U which can be found in 31 of the 42 decks. But, is not necessarily an auto-include given the 11 decks which do not utilize it.

Going back to the concept of limited variety in cEDH, berryjon of Tappedout stated in a recent article[8]:

"Did you know that you can divide all decks into two groups, and one will be manifestly better than the other? And that can be defined as such: Is your Commander UBG? Then you are playing a top-tier deck. Is your Commander RW? Thank you for playing."

The numbers do not support that argument. There are only 4 decks playing a Sultai (UBG) commander and in total, only 18 decks playing Sultai colors. 55% of the decks lack one of the Sultai colors. Furthermore, the two most predominant deck identity colors, UBRG and WUBG supplement Sultai with R or W.

[8] http://tappedout.net/mtg-articles/2018/aug/23/pattern-recognition-80/

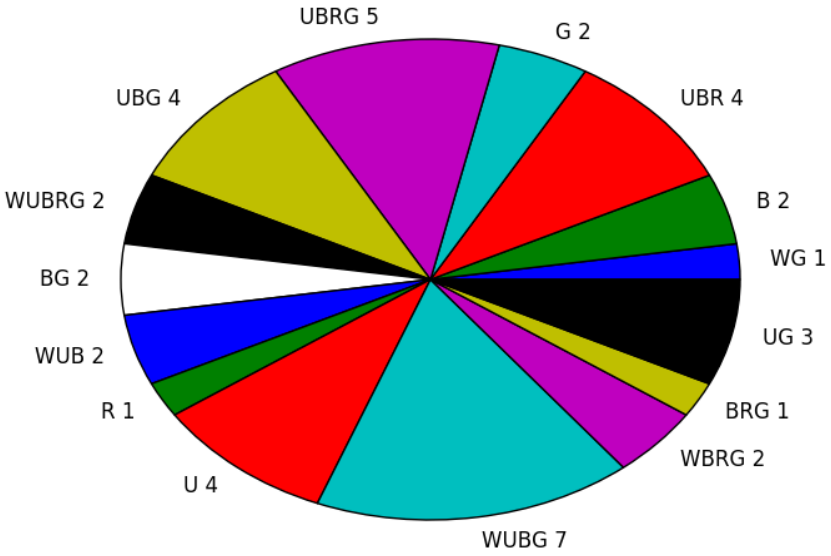
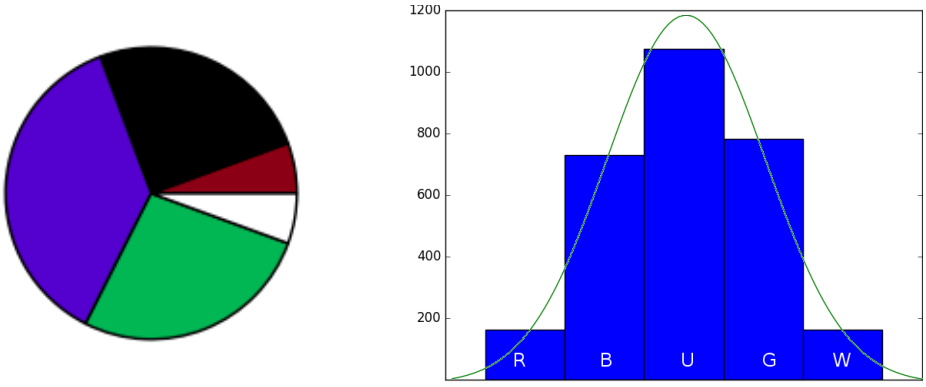


Figure 2: Deck Colors



(a) Mana Symbol Pie

(b) Mana Symbol Distribution

Figure 3: Mana Symbols

In cEDH, U is important, and Figure 3.a shows the importance with 36.9% of all mana symbols being U. What was not obvious until I looked at the mana symbol pie chart, is that colored mana symbols in cEDH are normally distributed. Figure 3.b plots the mana symbols on a normal distribution. Viewing the mana symbols this way does provide support for berryjon's argument.

Another way of looking at decks and color identity is shown in Figure 4. Where 14 decks have either R and/or W, 29 have G and 31 and U and/or B.

2.4 Similarity

Figure 85 in Appendix B.1 shows a heatmap comparing the similarity of cEDH decks to each other based on cards in common. Shimmer Zur and Doomsday Zur had the most number of common non-Land cards with 62. Godo Helm and Selvala Brostorm were the most dissimilar having only 3 cards in common. To calculate the heatmap, the number of similar non-Land cards across each deck was counted and then normalized so that each value lay between 0 (dissimilar) and 1 (similar).

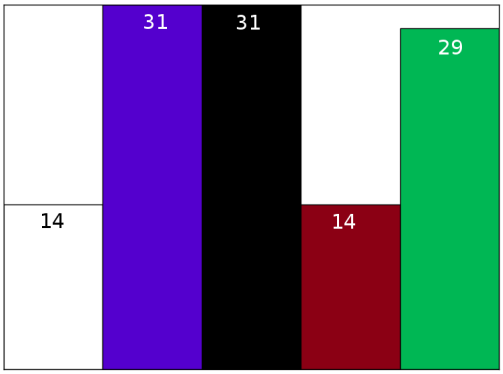


Figure 4: Decks and Color Count

Due to the number of decks compared, the resulting heatmap is difficult to read but, if cEDH decks had little variance, we would expect to see a heatmap with a majority of dark red and black where in fact, much of the heatmap is orange or yellow. Without further analysis it appears that there is a subset of cards that most decks share but, each deck plays "unique" cards as well.

3 Individual: Cards

Not surprisingly, the top ten cards in cEDH decks (Sol Ring, Mana Crypt, Mox Diamond, Chrome Mox, Mystic Remora, Vampiric Tutor, Demonic Tutor, Imperial Seal, Brainstorm, Carpet of Flowers) generate mana or card advantage. The raw data, in Appendix D, provides readers with the ability to sort and process to their individual needs.

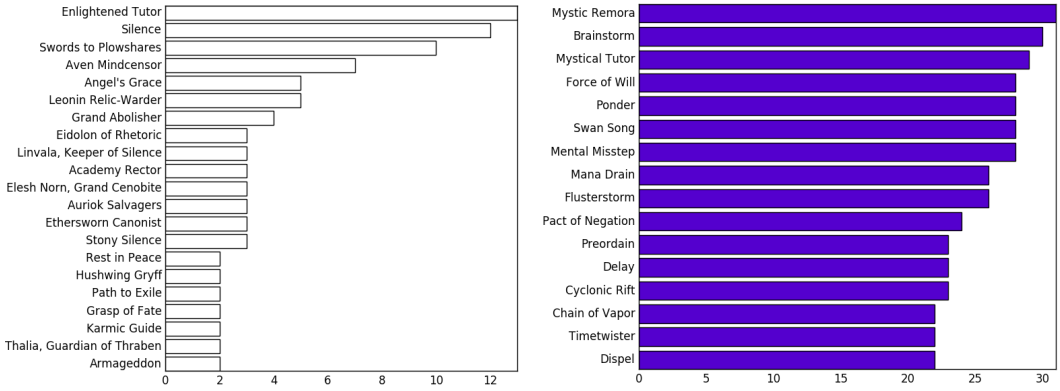
3.1 cEDH Staples

Figures 5 through 7 show the top 15 cards[9] in each color and colorless and provide a quantitative overview of Lerker's Conglomerate. Each color has a focus:

- W, Figure 5.a, is primarily hate and removal
- U, Figure 5.b, is primarily card advantage and counter spells
- B, Figure 6.a, is primarily rituals, tutors and win-cons
- R, Figure 6.b, combines some hate pieces, combo pieces, R card advantage and destroy/damage.
- G, Figure 7.a, is primarily mana boosts with some combo pieces
- C, Figure 7.b, is mostly mana rocks with a few combo paces

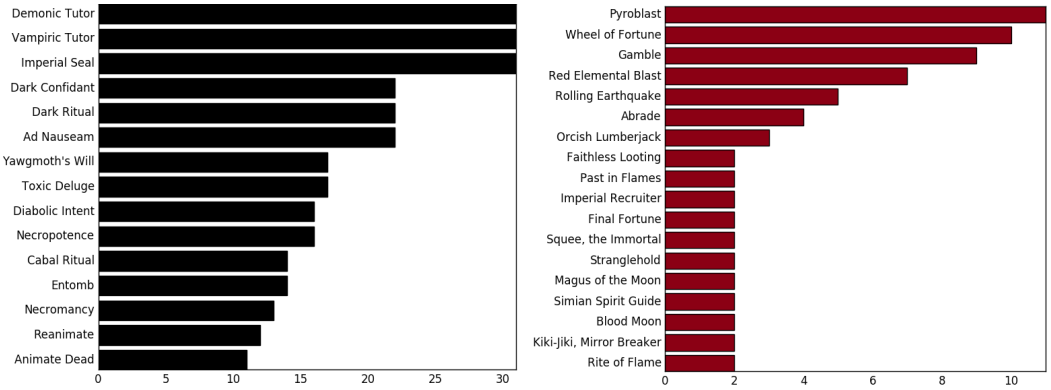
The only cards that appear in every deck are Sol Ring and Mana Crypt. While there appears to be some diversity in R and W there are staples in the remaining colors. Every deck running U plays Mystic Remora. Every deck running B plays Demonic Tutor, Vampiric Tutor and Imperial Seal

[9] In Appendix D, the provided links are not limited to the top 15 in each color.



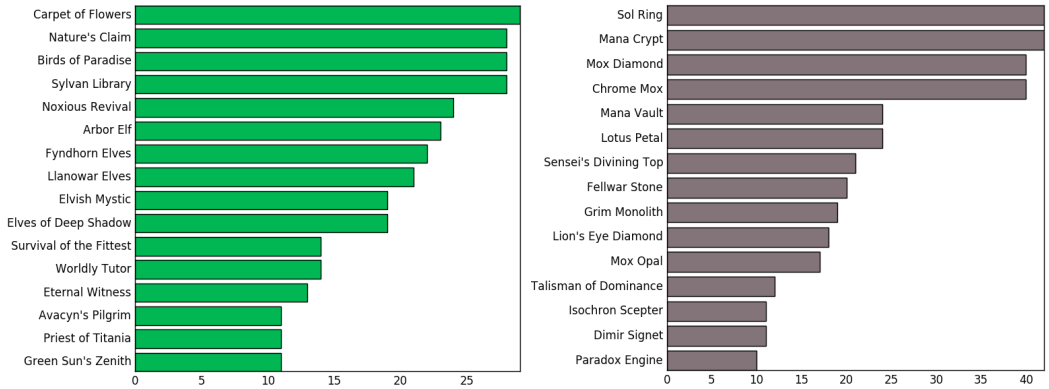
(a) W (b) U

Figure 5: W and U Top 15



(a) B (b) R

Figure 6: B and R Top 15



(a) G (b) C

Figure 7: G and C Top 15

and every deck running G plays Carpet of Flowers.

There are also staples that while not appearing in every deck appear in the majority such as

Brainstorm, Mystical Tutor, Force of will, Ponder, Swan Song and Mental Misstep in U and Nature's Claim, Birds of Paradise and Sylvan Library in G.

3.2 Gold Cards

There are surprisingly few (at least to me) gold cards in the surveyed cEDH decks. Enumerating the guilds or dual color card combinations, Azorius (WU)[10] and Boros (WR) have no cards. Orzhov (WB) and Simic (UB) have the Commanders, Tymna the Weaver and Thrasios, Triton Hero respectively.

In Golgari (BG), there are 22 instances of Deathrite Shaman, 20 of Abrupt Decay, 7 of Life // Death and 2 each of Grim Flayer and Squandered Resources.

In Dimir (UB), there are 18 Lim-Dul's Vault and 13 Notion Thiefs.

In Rakdos (BR), there are 9 copies of Fire Covenant and 3 copies of Vial Smasher the Fierce (Commanders).

In Gruul (RG), there are 3 Manamorphose and two each of Vexing Shusher, Guttural Response and Tana, the Bloodsower.

In Selesnya (WG), there are 6 instances of Eldamri's Call.

In Izzet (UR), there are 3 copies of Dack Fayden.

3.3 Multiple Mana

For the purpose of this survey, multiple mana cards are considered any card with more than 1 of the same colored mana symbol in the casting cost. There are a number of multiple mana cards in the cEDH decks. In fact, 121 of the 654 unique cards (or 18.5%) are multiple mana and 16 of those are triple mana cards. I had assumed that there would be a few considering the use of Ad Nauseum, Counterspell, Mana Drain and Necropotence but did not believe there would be this many.

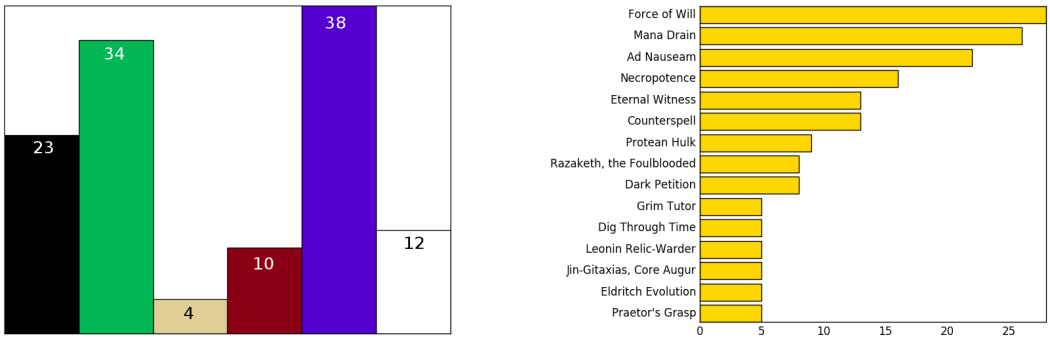
Figure 8.a plots the unique multiple mana cards by color. Multiple mana cards do not reflect the same color distribution as we found in Figure 3 but is similar. The two secondary colors R and W have 10 and 12 instances respectively and the three primary colors U, B and G have the most instances. However, unlike the distributions seen earlier, G has much more than B, nearly as many as U does. The 4 gold card are hybrid: 2 Gruul, 1 Dimir and 1 Rakdos.

Figure 8.b plots the top 15 multiple mana cards by count. There are 65 singleton in total and 33 with 3 or more copies.

3.4 Card Types

This section surveys the cards types found in cEDH decks. No attempt has been made to assign and separate by primary types i.e. "is an Artifact Creature an artifact or a creature?" and as such, multiple cards will be counted twice.

[10] No GAAIV or Taigam lists were surveyed



(a) By Color (b) Top 15

Figure 8: Multiple Mana Cards

3.4.1 Artifacts

Artifacts as we have already seen play a vital role in cEDH but not just for mana rocks. There are 126 unique artifacts found in the surveyed decks. Recall Figure 7.b which identified the top 15 Artifacts. Of those, 12 are mana rocks, 2 are combo pieces, and 1 is card advantage/filtering[11].

Plotting the CMCs of the artifacts, Figure 9 shows that the highest CMC for artifacts is 7[12].

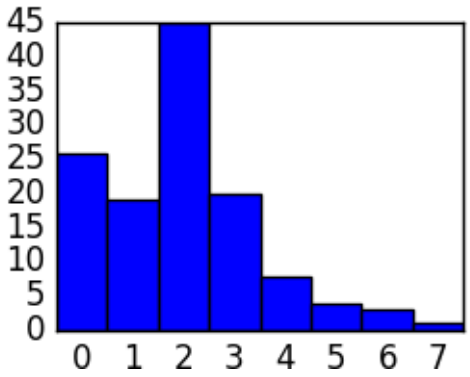


Figure 9: Artifact CMCs

Here we see a difference in the CMCs of cards in general and the CMCs of Artifacts. Recall Figure 1 where 75% of cards have a CMC of 3 or less and CMC 1 comprises the largest portion. For artifacts, 87% have a CMC of 3 or less and CMC 2 is most prevalent at 35%.

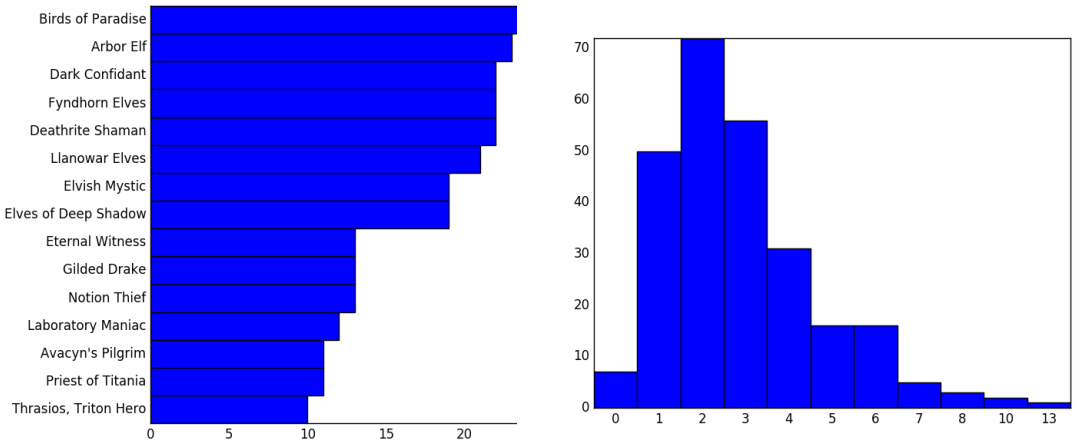
3.4.2 Creatures

There are 259 unique (counting commanders) creatures used by cEDH decks. Figure 10 shows the top 15 creatures and creatures counts by CMC. In creatures, we see a larger number with CMCs of 4 or greater than we did for artifacts. However, the majority (71%) of creatures are still 3 or less (Figure 10.b). There are a larger number of cards with CMC 5 or greater. These are either

[11] Of course, Lion's Eye Diamond is also a combo piece and in some decks Lotus Petal and Sensei's Divining Top are also combo pieces

[12] Spine of Ish Sah in Paradox Arcum which is generally teased into play

teasable, combo pieces or so devastating to opponents' board state that they are basically win-cons.



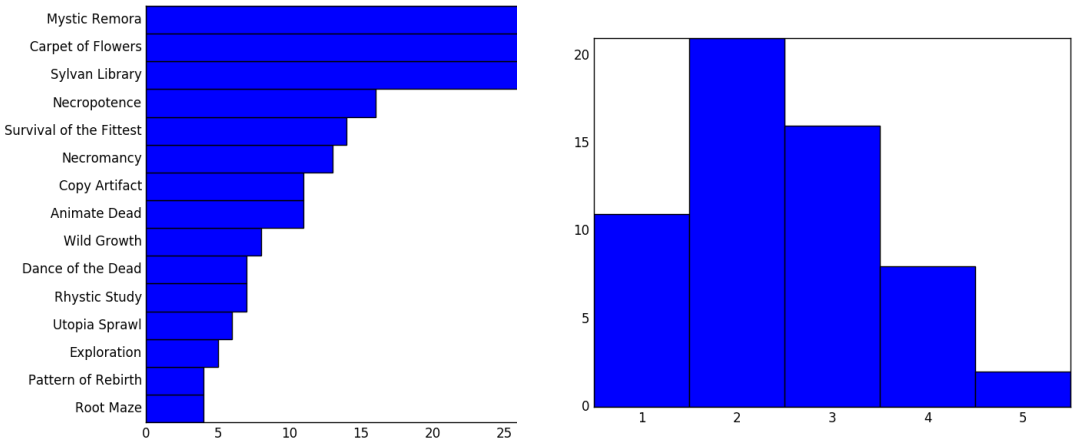
(a) By Card (b) By CMC

Figure 10: Creatures

Figure 10.a shows a similar trend for creatures as we have already seen for artifacts. Namely, mana producers, card advantage and combo pieces are prevalent. Of course, mana dorks are the realm of G (with a few non-G exceptions). We also see control (Gilded Drake) and recursion (Eternal Witness) make an appearance.

3.4.3 Enchantments

Enchantments (Figure 11) play a minor role (in terms of card count), there are only 58 unique enchantments and the average enchantment count per deck is 6 (Table 1). Again, there is a trend for lower CMC cards with enchantments having a markedly lower number of instances over CMC 4.



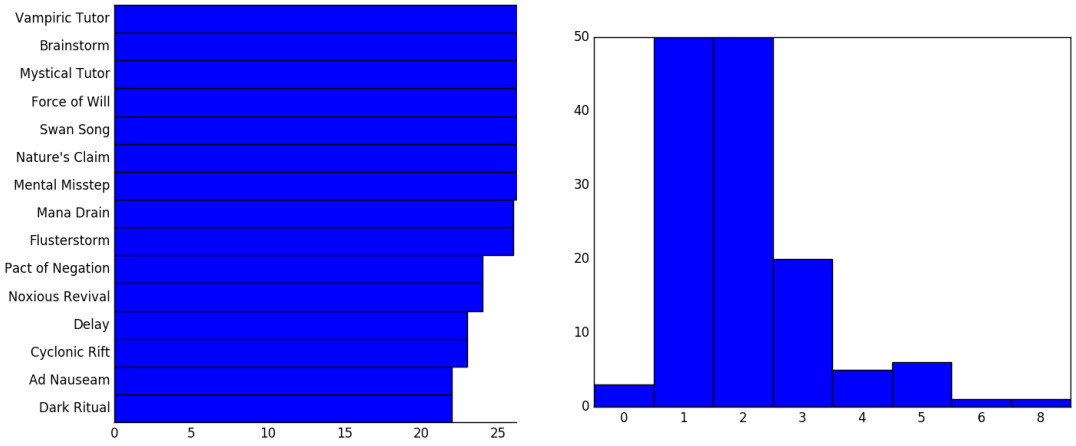
(a) By Card (b) By CMC

Figure 11: Enchantments

With enchantments, we continue to see the same trend of card advantage, fast mana and combo pieces in the top 15.

3.4.4 Instants

There are 136 unique instants in cEDH decks. With instants, we see a break in the norm. Figure 12.b shows that while the majority are 3 CMC or less, instants are primarily CMC 1 or 2 with 74% of all instants having a CMC of 1 or 2.



(a) By Card (b) By CMC

Figure 12: Instants

For instants, Figure 12, the top 15 also differ from what has been previously seen with 10 of the top 15 related to control.

3.4.5 Lands: Non-basic

Looking at the top 15 non-basic lands, Figure 13, we see primarily fetch lands and a few that can tap for more than one color. In total, there are 110 unique non-basic lands, 37 of which only appear in a single deck.

It is not until Ancient Tomb, the 14th most played non-basic land, that non-fetch and non-multi mana lands show up. Following that, we have Gaea's Cradle at 23rd with 16 instances and Cavern of Souls at 24th with 15 instances.

There are 34 non-basic lands that serve a purpose other than/in addition to tapping for mana, 2 with cycling and 9 that can add more than one mana (not including filter lands etc). Note that these are not necessarily distinct i.e. Phyrexian Tower which acts as a mana producer and/or sac outlet.

One surprise was the lack of Strip Mines which appears in only five decks. Is it that mass land destruction is not a dominant meta or opponent's lands like Gaea's Cradle or The Tabernacle at Pendrell Vale are not threatening enough to spend a land on?

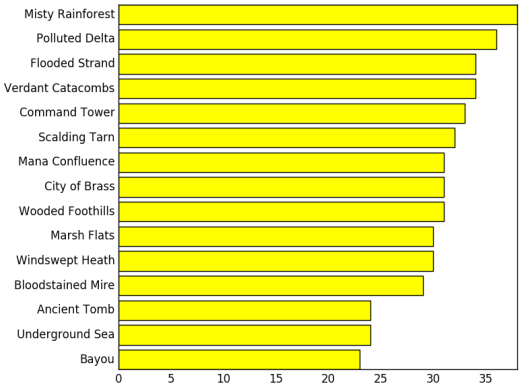


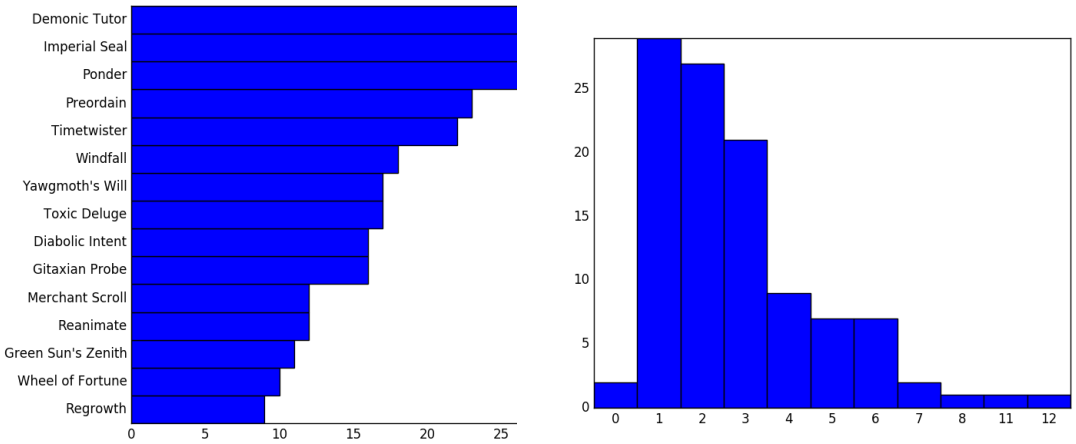
Figure 13: Lands Top 15

3.4.6 Planeswalkers

As seen before, Planeswalkers are not prevalent in cEDH and there are only 5 unique planeswalkers, one of which is a commander. Dack Fayden appears in 3 decks, Ugin, the Spirit Dragon in two and Teferi, Temporal Archmage, Tezzeret the Seeker and Garruk, Primal Hunter each appear in deck.

3.4.7 Sorceries

There are 107 unique sorceries in cEDH. Again, as shown in Figure 14.b, we see a large portion of cards with CMC 3 or less, but like creatures, there is a trend of higher CMC cards sorceries.



(a) By Card

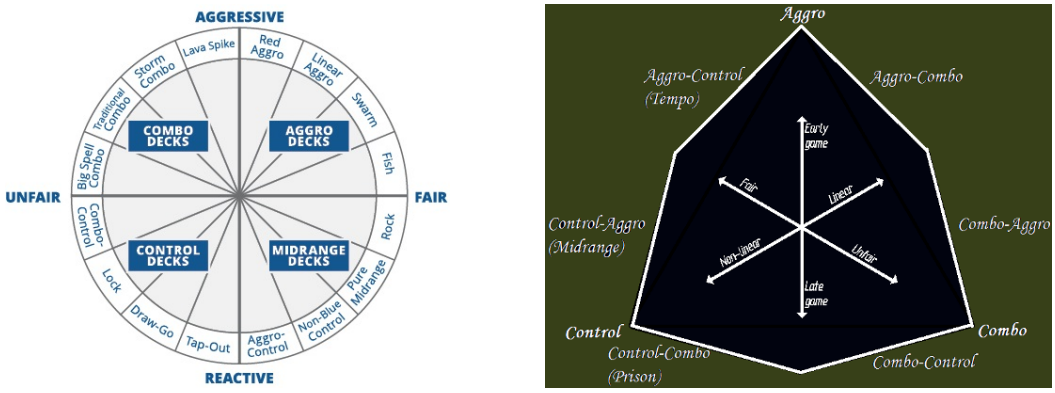
(b) By CMC

Figure 14: Sorceries

Sorceries also concentrate on card advantage (tutors and draws) and combo pieces, Figure 14.a.

4 Visualizing, Comparing and Categorizing cEDH

There are any number of Archetypes prevalent in MTG. Depending on the source, there are generally considered either four primary archetypes as defined by Patrick Chapin[13] or three primary archetypes as defined by Brandon Bobal[14], Figure 15. The primary Archetypes can be combined or divided to form any number of sub-archetypes. While there may be some disagreement over the number of Archetypes and their primacy i.e is Midrange a primary Archetype or sub-Archetype, there will be no arguments to the statement that cEDH decks fall under a limited number of Archetypes.



(a) Chapin's Archetypes
Copyright ©Star City Games

(b) Bobal's Archetypes
Copyright ©TechRaptor

Figure 15: MTG Deck Archetypes

All readers will agree that the majority of cEDH decks do not fall under a singleton Archetype i.e. Control and that cEDH decks fall under only a limited number of Archetypes. Most, if not all, cEDH decks use a combination of combo, control, and stax, and utilize some combination of ramp and card advantage.

As a relative newbie to the world of MTG and having no experience with non-EDH decks and play, I found myself constantly switching between deck descriptions and Archetype definitions until I hypothesized that perhaps cEDH decks do not have Archetypes in the academic sense, as agreed upon by the MTG community. There may be some initial hesitance by readers but I think that upon further review all cEDH pilots will agree that the traditional concept of Archetype and the traditional definitions of Archetypes fail to adequately define a cEDH deck.

Traditional Archetypes fail to capture the essence of cEDH decks and are "faulty" for several reasons. They are subjective and fail to quantifiablely define a deck, and therefore are an unsuitable method to compare decks. They are too constraining, unnecessarily pigeon-holing decks. Looking at Bobal's Archetypes in Figure 15.b, a Combo deck is by definition "Unfair", "Late Game" and "Linear". In some cases, such as a Sidisi ANT deck, that is true but cEDH decks have evolved to the point where they cannot be easily placed on a chart that defines the deck and its style of play.

[13] http://www.starcitygames.com/article/26620_Next-Level-Deckbuilding-Sneak-Peek–The-Sixteen-Archetypes-Of-Magic.html

[14] https://techraptor.net/content/magic-gathering-archetype-primer-pt-1

For example, consider Najeela Tempo, a self-claimed Tempo deck. The definition of Tempo, according to Bobal is:

"...a semi-linear, early-game orientated archetype that focuses on playing strong, early-game threats and controlling the flow of gameplay with efficient disruption spells. ... Tempo employs primarily aggressive strategies, utilizing disruption only when absolutely needed to protect their board state."

While this definition of Tempo loosely applies to Najeela Tempo, it is not accurate. Najeela Tempo is far from semi-linear and it packs enough non-linear cards to do more than merely protect the board state. Applied to the chart in Figure 15 .b, the deck would be considered "Fair" but, the deck in fact employs multiple elements of unfairness to win. And, rather than using multiple cheap threat cards to kill an opponent(s) over multiple turns, Najeela Tempo's main aim is it use one threat card (Najeela) combined with a combo to kill all opponents in one turn. More importantly, for me at least, is that by using the traditional understanding of Tempo and the resources available to us like Chapin's and Bobal's charts, we cannot truly understand how the deck compares or differs from others. That is, how similar (or different) is Najeela Tempo to Edric Turns or Godo Helm? And, how different (or similar) is it from Tazri Food Chain or Paradox Sisay.

Several initial attempts failed to elicit a better understanding, categorization and comparison of current cEDH Archetypes (Appendix C covers those attempts for interested readers).

This section is an experimental attempt to visually compare and organize the surveyed cEDH decks based on our concept of Methods and Modes (defined in Section 4.1) of the cards in those decks.

Our aim is to:

1. Eschew traditional holistic views of Archetypes,
2. avoid subjectiveness as much as possible and identity parameters/features of decks that can be used to quantify and therefore compare them,
3. define a system that removes traditional arbitrary boundaries, and
4. define a "living" system that can accommodate new decks without rewriting rules, definitions or mechanisms.

4.1 Card Categorization and Data Manipulation

Rather than pigeon-holing a deck to a pre-defined Archetype based on a holistic view of the deck or subjective views of the deck author and others, we define a deck based on the categorization of the individual cards in the deck.

Before showing the results, definitions used in this paper and an explanation of how the data was derived are required. There may be some disagreement to the categorization of the cards but keep in mind that constraints were needed in order to simplify the programmatic correlation and manipulation of the data. A link to the data can be found in Appendix D.

We consider a primary category, Method and a secondary category Mode, defined below.

Definition 4.1. Method: the purpose or effect of a card that when combined with 0 or more cards provides the means of winning.

Definition 4.2. Mode: the manner of a card that enables a winning state to be achieved faster than opponents.

Readers will note that Method and Archetype are synonymous. To avoid confusion, we will use the following conventions in the remainder of this paper. Archetype will refer to the commonly held understanding of a deck's "type" whereas Method will refer to a card. The terms Combo, Stax and Control will be capitalized when referring to the Archetype of a deck and lower-case when referring to the Method of a card.

4.1.1 Method

Method can be divided into three categories 1) combo, 2) control and 3) stax.

Definition 4.3. combo a set of 1 or more cards that interact together to provide an effect.

Definition 4.4. control a card that provides a one-time effect hindering an opponent from executing their game plan.

Definition 4.5. stax a card that forces a state that hinders all players or all opponents.

Control cards are counter-spells/abilities, removals, bounces and protection. In general they are one-time effects and apply to one player[15]. Stax cards have a permanent (in general) effect on the game state and apply to either all players or all opponents[16]. Combo pieces are self-explanatory but only include key pieces. For example, Ornithopter can be used by Sidisi ANT to up the storm count for the combo piece Tendrils of Agony (or Aetherflux Reservoir) but it is not vital to the combo. It can be replaced by any other 0-CMC card included or not included in the deck.

4.1.2 Mode

Mode can be divided into three categories 1) famp, 2) card advantage and 3) enable.

Definition 4.6. ramp a non-land card that provides mana.

Definition 4.7. card advantage (CA) a card that replaces itself or another card with an additional card(s).

Definition 4.8. enable a card that assists in advancing the objective of winning but is not vital to winning.

For ramp, we considered rituals, dorks and rocks as well as cards like Helm of Awakening which lowers the casting cost of cards. CA includes tutors, draws, loots, filters and recursion. Enable cards while easy to identify, are harder to define. Enable cards assist in winning or initiating a combo but are not necessary to win or execute a combo. Going back to the Sidisi ANT example from earlier, Ornithopter is an enable card. It provides a means of upping the Storm count but is interchangeable with any other 0-cmc card and the deck can still win without playing it.

[15]Cyclonic Rift can be used to bounce all opponents non-land permanents but is still considered a control piece as it is only temporary - players can recast the bounced cards

[16]Grand Abolisher is considered control as it only affects opponents during your turn.

4.1.3 M2 Index

A card can have any number of Methods and/or more Modes. For example, Blind Obedience is categorized as both a stax piece (all opponents artifacts and creatures come into play tapped) and a combo piece (using extort with infinite spells kills opponents), Aura of Silence is categorized as both a stax piece (all opponents must pay additional mana to cast artifacts and enchantments) and a control piece (destroy an artifact or enchantment) and Remand[17] is categorized as a control piece with mode card advantage. A card could have all or none and each card's categorization is based on its effect and perceived use in the decks it was found in.

To compare the cEDH decks to one another, we used the categorization of individual cards to derive indexes. Each Method (control, stax, combo) and Mode (ramp, CA, enable) has an index. The indexes are ratios, derived from the number of cards in the deck categorized as a Method or Mode divided by the number of non-land cards[18]. In other words, a deck's Combo Index is the ratio of combo cards to non-land cards, its Control Index is the ratio of control cards to non-land cards and so forth. Keep in mind that a card may be counted under more than one (or none) Method and Mode. The formulas are listed in equations 1 through 6 below. For lack of a better term, we will refer to the indexes as a whole as the M2 Index of a deck in the remainder of this paper.

$$ComboIndex = \frac{\sum_{i=1}^{100} is\_combo(Card_i)}{nl} \tag{1}$$

$$ControlIndex = \frac{\sum_{i=1}^{100} is\_control(Card_i)}{nl} \tag{2}$$

$$StaxIndex = \frac{\sum_{i=1}^{100} is\_stax(Card_i)}{nl} \tag{3}$$

$$RampIndex = \frac{\sum_{i=1}^{100} is\_ramp(Card_i)}{nl} \tag{4}$$

$$CAIndex = \frac{\sum_{i=1}^{100} is\_ca(Card_i)}{nl} \tag{5}$$

$$EnableIndex = \frac{\sum_{i=1}^{100} is\_value\_only(Card_i)}{nl} \tag{6}$$

where nl $= 100 - \sum_{i=1}^{100} is\_land(Card_i)$.
Appendix D contains a link to the full M2 dataset and short sample of the data.

4.2 M2 Index Visualization and Processing

To start, we define the M2 Index of a deck as a point (Equation 7) in 6-dimensional space.

$$M2Index_i = (Control_i, Stax_i, Combo_i, Ramp_i, CA_i, Enable_i) \tag{7}$$

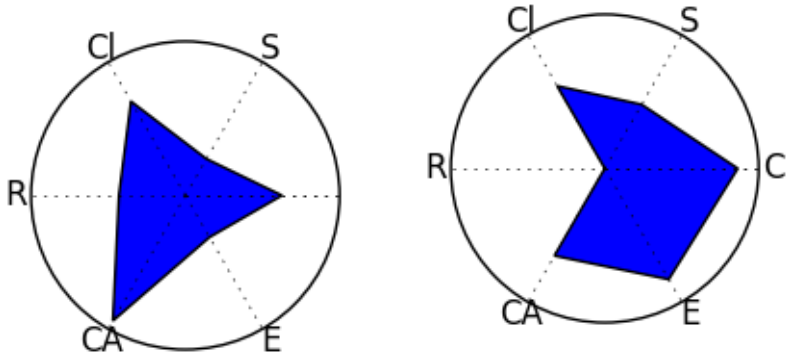
[17] In some decks Remand could also be a combo piece by bouncing the caster's spell and upping the storm count.
[18] At present, we are not considering lands although there are some lands that could be categorized under Method or Mode in the deck

where i is the i^{th} deck. As points, the decks can be compared using distance, area etc. However, while humans can conceptualize 2-dimensional and 3-dimensional space, visualization at greater dimensions becomes impossible. To rectify this, we use a spider chart[19]. As an example, consider my Ertai, the Corrupted deck, Pennies from Phyrexia (PfP). Table 4 shows the unprocessed and normalized (we discuss normalization shortly) values for the deck's M2 Index.

	Combo	Stax	Control	Ramp	CA	Enable
Unprocessed	0.22	0.10	0.25	0.15	0.33	0.11
Normalized	0.60	0.34	0.43	0.00	0.46	0.58

Table 4: Pennies from Phyrexia M2 Index

Figure 16 shows the spider charts for PfP. Each index: combo (C), stax (S), control (Cl), ramp (R), card advantage (CA) and enable (E) is represented as an angle and a magnitude (the distance from center). Spider charts allow us to visually identify features of a deck. Looking at Figure 16.a we can see that PfP relies on combo and control with some stax and utilizes a lot of CA with equal parts ramp and enable.



(a) Unprocessed (b) Normalized

Figure 16: M2 Index spider chart for Pennies from Phyrexia

The average indexes for the surveyed decks are shown in Table 5 and the high and low indexes are shown in Table 6. From Table 5 it should be obvious that stax is tertiary to combo and control and enable is tertiary to ramp and CA.

Combo	Stax	Control	Ramp	CA	Enable
0.18	0.04	0.25	0.27	0.39	0.03

Table 5: Average M2 Indexes

4.2.1 Normalization

Before processing the data, the M2 Indexes of all the surveyed decks were normalized[20]. The purpose of normalization is to "scale" the M2 Index. The formula used for data normalization in this survey

[19] https://en.wikipedia.org/wiki/Radar_chart
[20] https://en.wikipedia.org/wiki/Normalization_(statistics)

	High		Low	
	Deck	Index	Deck	Index
Combo	Buried Alive Razaketh Sidisi	0.35	Edric Turns	0.01
Stax	Paradox Sisay	0.29	High Tide Jace	0.00
Control	Edric Turns	0.43	Sidisi Ad Naus Fishbowl	0.10
Ramp	Sidisi Ad Naus Fishbowl	0.49	Najeela Tempo	0.01
CA	Grixis Twin	0.54	Godo Helm	0.15
Enable	Selvala Brostorm	0.19	Baral Control	0.00

Table 6: High and Low M2 Index

is min-max normalization, listed in Equation 8. The minimum and maximum values for each index are listed again in Table 7[21]

$$i' = \frac{i - min_i}{max_i - min_i} \tag{8}$$

where i is the current index. Note, that we conduct feature-wise normalization vice vector-wise normalization.

	Max	Min
Combo	0.3529	0.0145
Stax	0.2857	0.0
Control	0.4348	0.1029
Ramp	0.4853	0.1571
CA	0.5441	0.1471
Enable	0.1884	0.0

Table 7: Normalization: Min and Max

Without going too in depth, normalization is important for the comparisons we do in the next section. The M2 Indexes of each deck do not correspond "equally" to each other because the decks have different land counts and a card may have multiple Methods or Modes and therefore be counted multiple time across the M2 Indexes. In other words, a 0.49 Combo Index for one deck does not equal a 0.49 Combo Index in another deck. Looking at Figure 16, PfP's normalized M2 Index, Figure 16.b, appears to represent an entirely different deck from PfP's unprocessed M2 Index in Figure 16.a. Taking a closer look, we can say that while PfP's Ramp Index is high relative to PfP's other Indexes, it is negligible relative to the Ramp Indexes of cEDH decks as a whole. Likewise, the Enable Index of PfP appears small but relative to cEDH decks, it is quite high and, after normalization it is easy to see that PfP has too many enable cards to be competitive.

Therefore, one must be careful when comparing the unnormalized M2 Index spider charts in Appendix A. The spider charts are useful for making comparisons between the different indexes of a single deck (as we did earlier with PfP) and identifying what that deck primarily uses to win but can lead us to wrong conclusions if used to compare two decks. To illustrate, comparing Baral Control's spider chart in Figure 43.d with PfP's, Figure 16.a, the conclusion could be drawn that both decks

[21]For those readers who wish to plot their decks against the cEDH decks, use the minimum and maximum values in Table 7 and Equation 8. After the normalization, set any value(s) less than 0 to 0 and any values greater than 1 to 1.

use the same amount of control and CA but PfP uses more combo, ramp and enable. However, by overlaying the two normalized M2 Indexes, Figure 17, we see that Baral Control utilizes more control than PfP and PfP uses more combo, stax, CA and enable. Additionally, both decks use minimum ramp.

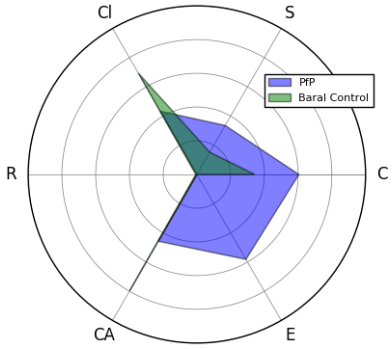


Figure 17: Normalized M2 Index for PfP and Barak Control

Keep normalization in mind when viewing the results in the next section. A Combo Index of 1 on the plots does not mean the deck has 100% combo pieces, rather that it has the highest Combo Index among the surveyed decks. Likewise a 0 does not mean the deck has no combo pieces, rather that it has the lowest Combo Index among the decks.

With normalization, the M2 Indexes are represented as the 6-dimensional point defined in Equation 9. Table 14 in Appendix B.2, lists each deck with its corresponding normalized M2 Index.

$$Deck_i = (C_i, S_i, Cl_i, R_i, CA_i, V_i) \tag{9}$$

where
$C_i = \frac{ComboIndex_i - min_{Combo}}{max_{Combo} - min_{Combo}}$
$S_i = \frac{StaxIndex_i - min_{Stax}}{max_{Stax} - min_{Stax}}$,
$Cl_i = \frac{ControlIndex_i - min_{Control}}{max_{Control} - min_{Control}}$
$R_i = \frac{RampIndex_i - min_{Ramp}}{max_{Ramp} - min_{Ramp}}$
$CA_i = \frac{CAIndex_i - min_{CA}}{max_{CA} - min_{CA}}$
$E_i = \frac{EnableIndex_i - min_{Enable}}{max_{Enable} - min_{Enable}}$

4.3 Self-organizing Maps and the M2 Index

In this section, we use a Self-organizing Map (SOM)[22] to categorize and compare the cEDH decks using the Python implementation of Somoclu[23].

A SOM is an artificial neural network using unsupervised (or competitive) learning to perform data reduction and data clustering. A SOM can be conceptualized as a set of neurons arranged to form a topology. SOMs are generally 1-dimensional such as a line or 2-dimensional i.e. a grid (See Figure

[22] https://en.wikipedia.org/wiki/Self-organizing_map
[23] somoclu.readthedocs.io/en/stable/

18). Each neuron has a static location and a variable weight (a vector having the same dimension as the data). The SOM is initialized with the neurons having random weights. The SOM is then presented data from the training set. For each presentation, the best matching unit (BMU) is rewarded by having its weight vector updated to become more like the current data. The BMU is chosen using the Euclidean distance[24] between the neuron's weight and the presented data. Neighbors of the BMU are also updated to become more like the current data albeit on a lesser scale. Over time, the number of neighbors that are updated and the amount each weight vector is updated decreases so that the SOM will eventually stabilize.

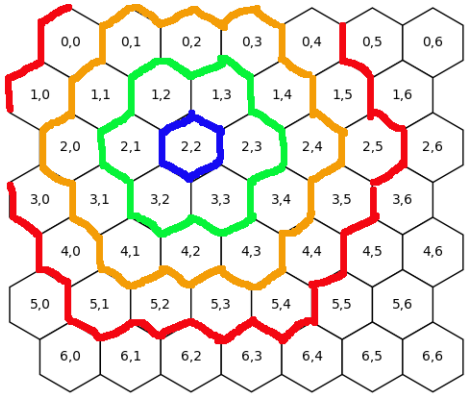


Figure 18: Neighbors in a 7x7 Hexagonal Grid Topology: Blue = BMU, Green = radius of 1, Orange = radius of 2 and Red = radius of 3

Through training, the neurons update their weights in such a manner that they form prototypes of the data. By maintaining their topological location, the neurons also form clusters of like prototypes. Because SOMs approximate the data presented to them, choosing the appropriate size i.e. number of neurons is important. If there are too many, individual neurons will begin to form representations of individual data and the resulting SOM will not be able to generalize to new data. If there are too few, the neurons will not separate the data with enough granularity. The problem is further excaberated when the training set is small as it is in this survey.

There is no set rule for determining the correct number of neurons. A general rule of thumb is the formula $5\sqrt{n}$ where n is the number of training samples. With 42 training samples, our SOM would need approximately 32 neurons. After several test runs, we found that with 30 or more neurons, the resulting SOM began representing individual decks as their own prototypes and with less than 20 neurons, the SOM failed to make reasonable delineation between certain decks.

4.4 Results

In this survey, we implemented a $5x4$ hexagonal grid topology. Each neuron is identified by its 2-dimensional location and corresponding weight, a 6-dimensional point, which relates directly to the M2 Index. An example neuron is shown in Figure 19.

The results after training are shown in Figure 20. Each neuron is shown as a hexagon containing a spider chart of the prototype M2 Index the neuron represents. The neurons are colored based

[24] https://en.wikipedia.org/wiki/Euclidean_distance

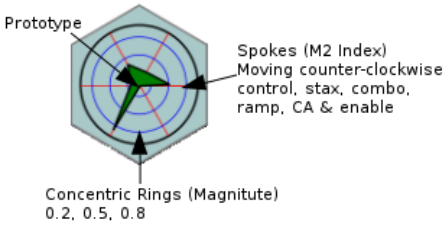


Figure 19: A Neuron

on the number of decks that they are the BMU for, ranging from black = 0 decks to white = 4 decks. We can identify each neuron by it's it location, a tuple $t = (row, column)$. Numbering the neurons left to right, top to bottom starting from 0 so that the first neuron in the upper left portion of the SOM is $(0, 0)$ and the last neuron in the bottom right of the SOM is $(4, 3)$ (see Figure 18).

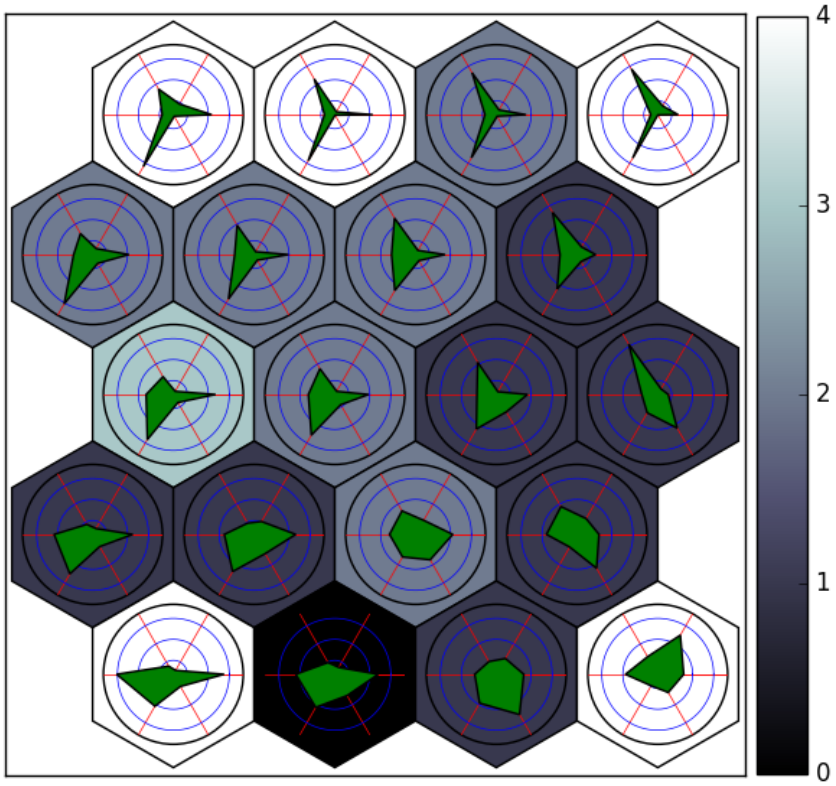
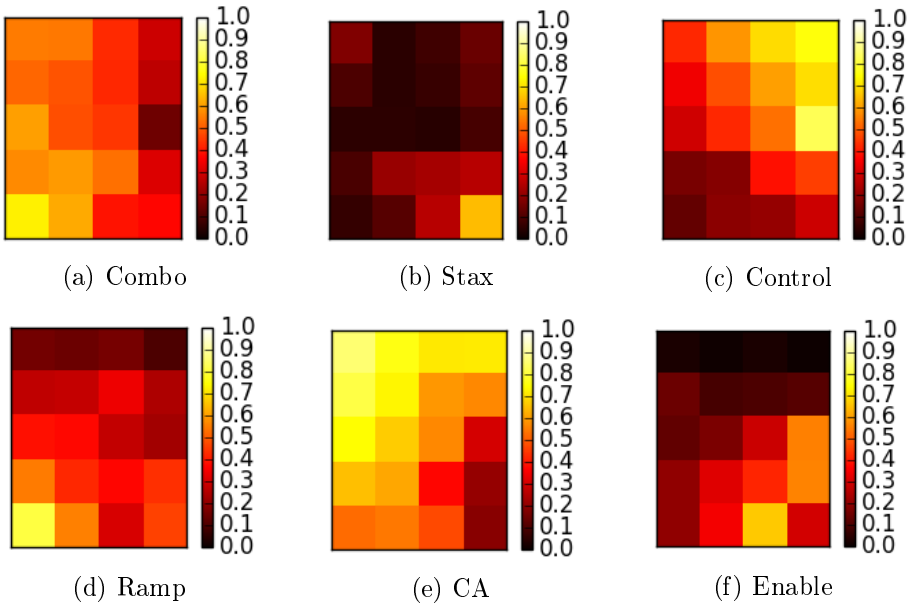


Figure 20: 5x4 SOM trained on 42 cEDH decks

Visually, it appears that control and CA are prominent features. Figure 21 shows heatmaps of the magnitudes of the six features for each neuron. Each prototype has some form of combo and control although the former is more prevalent in the lower left and the latter is more prevalent in the upper right. The use of stax is more limited with prototypes in the lower right making the most use of it. CA is the most prevalent Mode with decks in the upper left relying heavily on it. Ramp also sees a lot of use with all prototypes exclusive the top row using 0.3 or more. And enable plays a part as well with prototypes in the lower right making more use of it than the other prototypes.



(a) Combo (b) Stax (c) Control

(d) Ramp (e) CA (f) Enable

Figure 21: Feature heatmaps

Now, is there a way to use the SOM to identify Archetypes? There are several courses of action. The easiest is to take each neuron as representing a prototype or archetype of cEDH decks. Thus, we would have 20 distinct archetypes. This approach fails to take into account the similarity of many of the prototypes. It is obvious that there are some clusters present and if we can cluster like prototypes we can use those clusters to identify Archetypes.

Programmatically, there are tools such as the U-matrix[25] or k-means[26] clustering. Both of these use distance to determine cluster membership. However, given the small number of neurons in the SOM, the U-matrix is not suitable and it easy enough to manually identify the clusters.

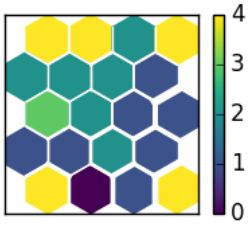
We derive some visual aids using the distance between neurons to assist us along with the feature heatmaps of Figure 21. Figure 22 shows two visual tools to assist in identifying clusters in the SOM. Figure 22.a, is a heatmap of the SOM (using a different color map). White edges, whose widths correspond to the distance between the weights of adjacent neurons, have been added. Figure 22.b shows a combined heatmap where each square represents a heatmap of the distance matrix for that neuron compared to all other neurons in the SOM. Lighter colors denote "nearness" and darker colors denote greater distances.

From Figure 22.a we make the following observations:

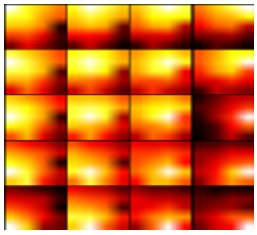
(a) the neurons in the top three rows, with the exclusion of neuron $(2, 3)$, are similar and form a cluster

(b) the first two neurons in each of the bottom two rows, $(3, 0)$, $(3, 1)$, $(4, 0)$ and $(4, 1)$, form another cluster

[25] https://en.wikipedia.org/wiki/U-matrix
[26] https://en.wikipedia.org/wiki/K-means_clustering



(a) Heatmap (number of associated decks) with edges



(b) Distance matrix heatmap

Figure 22: Visual tools for manual clustering

(c) Neurons $(2,3)$, $(3,2)$, $(3,3)$, $(4,2)$ and $(4,3)$ are not near each other or other neurons in the SOM forming their own clusters

Figure 22.b provides additional support for these observations. Using the above observations as an initial setup of the clusters, we manually compared the individual prototypes, and made the following additional observations.

1. ramp, while prevalent in rows 2 and 3, is minor in row 1.
2. neurons $(3,2)$, $(3,3)$, $(4,2)$ while not near each other, do not use one of the three Methods to exclusion of another.

With these observations, we derived Figure 23.

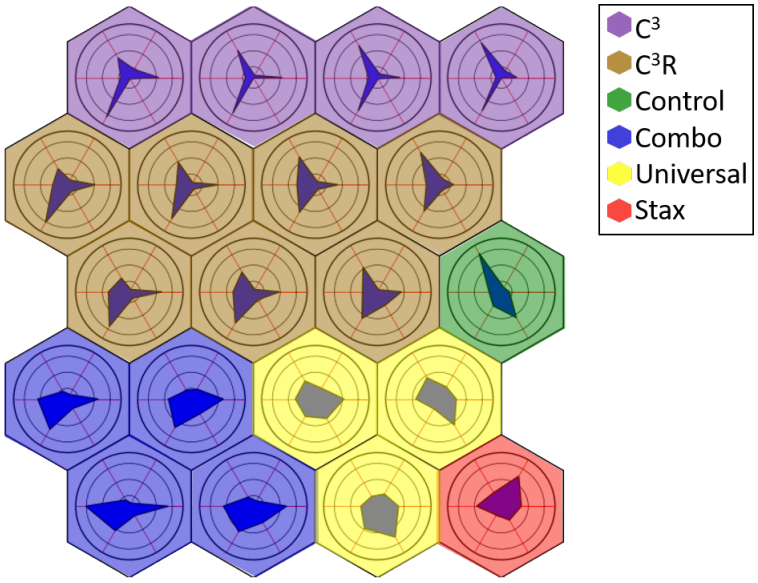


Figure 23: Manual clustering of the SOM

Based on Figure 23, we have identified four primary clusters, (1) combo, control and CA (C^3), (2) combo, control, CA and ramp (C^3R), (3) Combo and (4) Universal. There are also two singleton prototypes (1) Control and (2) Stax (although Stax has elements of combo and control).

We can now consider that each of these clusters represent an Archetype, and the prototype of each neuron (in the cluster) represents a sub-Archetype. The next sections will discuss each of these clusters separately.

4.4.1 C^3 Archetype

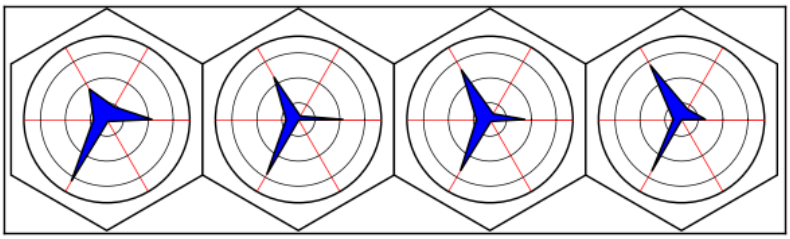


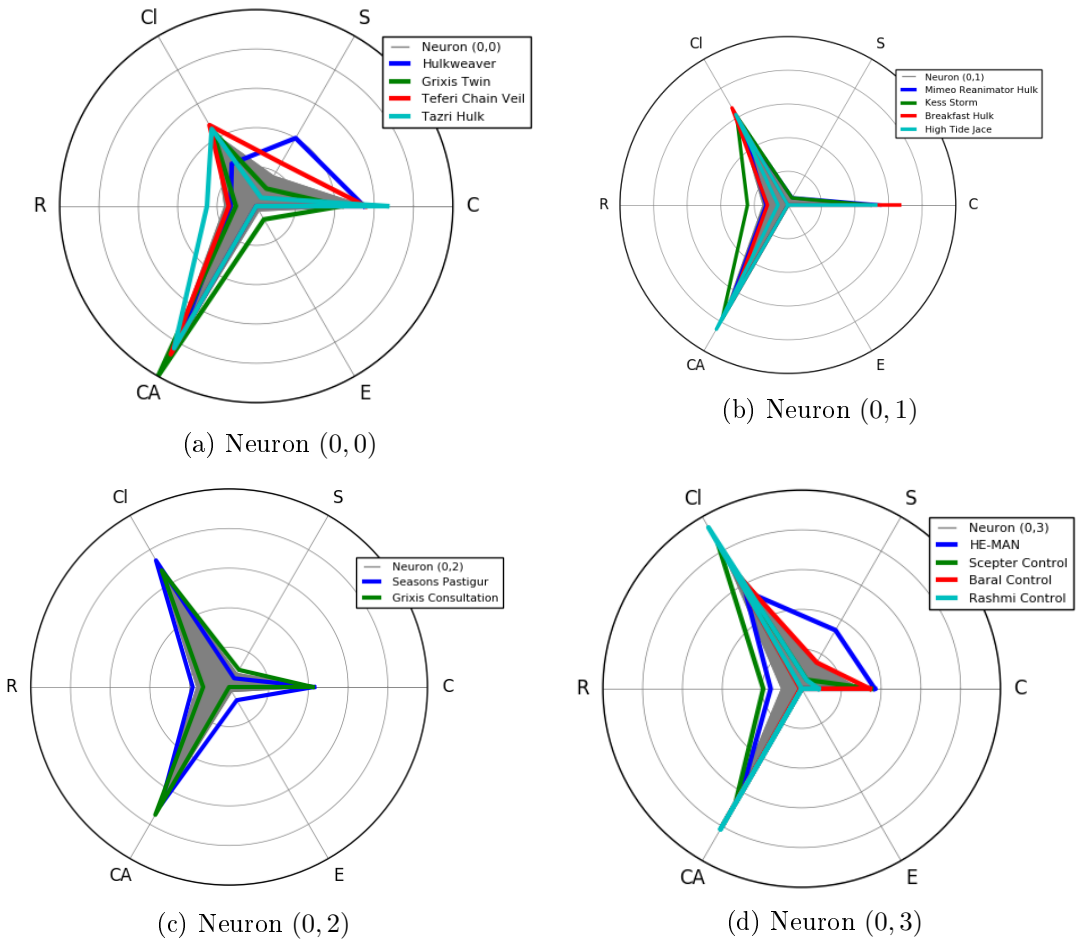
Figure 24: C^3 Archetype: Combo, Control and CA

The C^3 Archetype, Figure 24, uses both combo and control to varying degrees, and is characterized by reliance on CA to push the decks to a win faster than opponents. From left to right, as control increases, combo decreases. Decks in this archetype may have some stax and ramp elements but these are secondary[27]. The prototypes of this archetype with their associated decks can be found in Figure 25.

It is the largest Archetype in terms of the number of decks associated with it at 14:

1. Hulkweaver (Section A.17),
2. Grixis Twin (Section A.13),
3. Teferi Chain Veil (Section A.41),
4. Tazri Hulk (Section A.40),
5. Mimeo Reanimator Hulk (Section A.23),
6. Kess Storm (Section A.20),
7. Breakfast Hulk (Section A.3),
8. High Tide Jace (Section A.15),
9. Seasons Pastigur (Section A.35),
10. Grixis Consultation (Section A.12),
11. HE-MAN (Section A.14),
12. Scepter Control (Section A.33),
13. Baral Control (Section A.1) and
14. Rashmi Control (Section A.30).

[27] Teferi Chain Veil and HE-MAN use Stax in a more dominant role



(a) Neuron $(0, 0)$

(b) Neuron $(0, 1)$

(c) Neuron $(0, 2)$

(d) Neuron $(0, 3)$

Figure 25: C^3 Archetype with associated decks

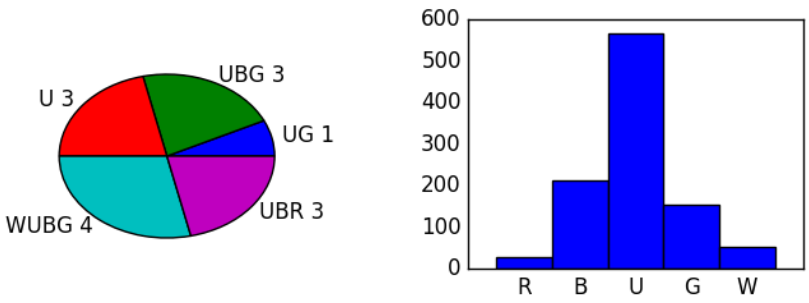
The major commonalities are deck color identities, Figure 26.a and card color identities, Figure 26.b. Every deck in this archetype uses U with seven having UBG in their identity. There are also four having UBR. The primary Commanders seen are the pair Thrasios, Triton Hero & Tymna the Weaver and Kess, Dissident Mage. Unlike cEDH decks as a whole, the distribution of mana symbols in the C^3 Archetype are not normally distributed. Whereas cEDH decks are running 37% U, decks in the C^3 Archetype run 56% U.

Comparing the C^3 Archetype deck averages to cEDH deck averages from Table 1 gives us Table 8. The notable difference here is the use of creatures and instants. The C^3 Archetype uses approxi-

	CMC	Basic	Non-Basic	Artifact	Creature	Enchantment	Instant	PWalker	Sorcery
C^3	2.06	9.0	21.2	12.0	11.7	6.1	27.4	0.4	12.6
cEDH	1.94	8.0	22	13.9	17.6	6.1	22.5	0.2	11.3
Delta	+0.12	+1.0	-0.8	-1.9	-5.9	–	+4.9	+0.2	+1.3

Table 8: C^3 Average Card Count and CMC

mately 6 less creatures on average, and 5 more instants on average than other cEDH decks.



(a) Deck Colors (b) Mana Symbol Distribution

Figure 26: C^3 Deck colors and Mana Colors

These decks use time tested strategies/combos to win:

1. Timetwister loops is present in 11 of the 14 decks,
2. Dramatic Scepter is found in 6 decks (Copy Artifact is present in those decks as well),
3. Reanimator is a strategy used by 4 of the decks,
4. Laboratory Maniac is used in 4 decks,
5. Flash Hulk is used in 4 decks,
6. Storm is found in 4 decks,
7. Seasons Past loops is used by 2 decks,
8. Miscellaneous combos include multiple turns, Hermit Druid, Beast Within/Reality Shift and Teferi Chain Veil.

The majority of these decks are graveyard dependent, gain massive card advantage and rely on heavy interaction with opponents to maintain their board state.

4.4.2 C^3R Archetype

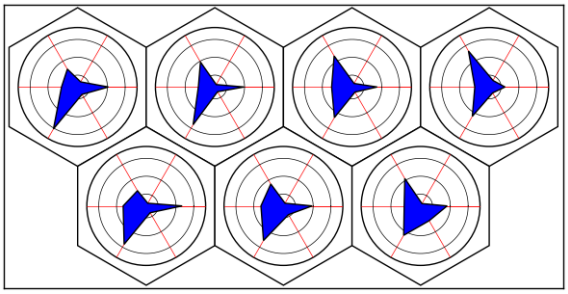
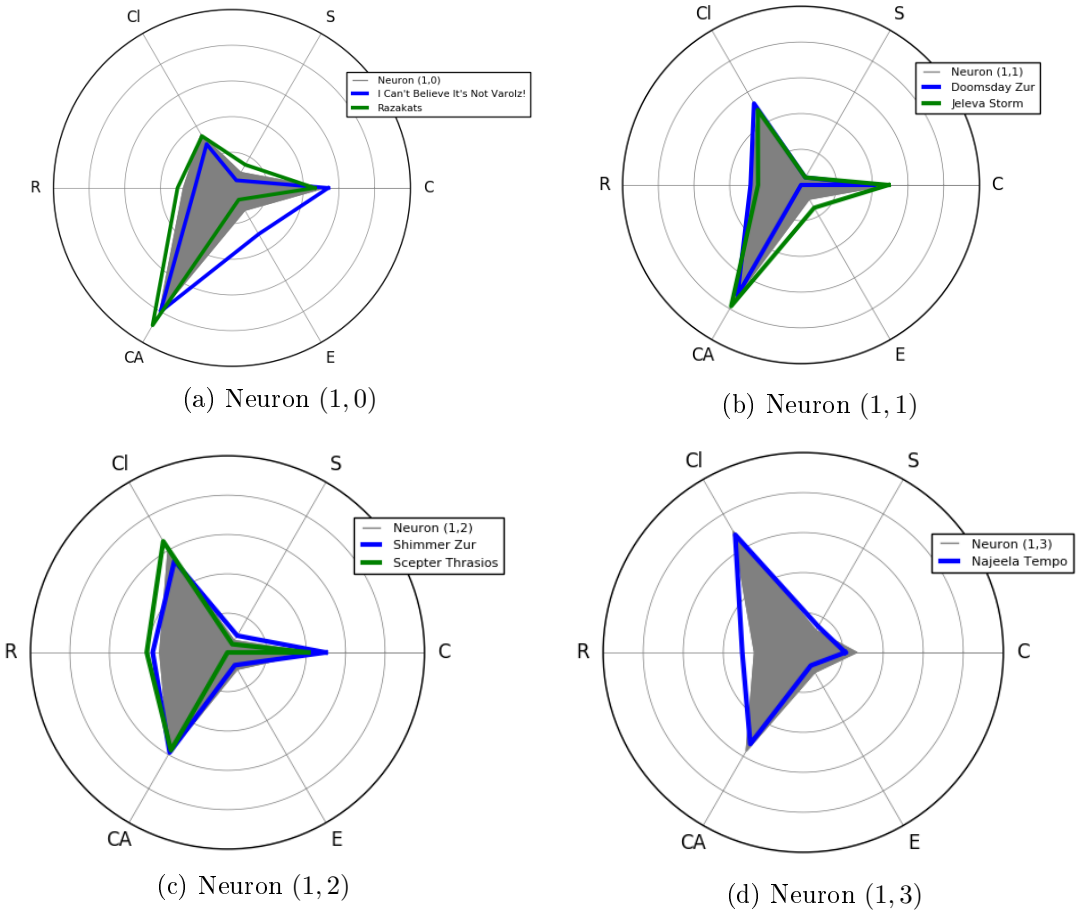


Figure 27: C^{3}R Archetype: Combo, Control, CA and Ramp

The C^{3}R Archetype, Figure 27, is very similar to C^3 except that the use of combo and control is generally less and the use of ramp is higher.



(a) Neuron $(1, 0)$

(b) Neuron $(1, 1)$

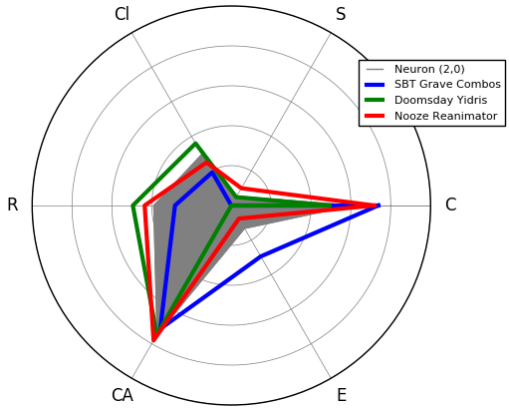
(c) Neuron $(1, 2)$

(d) Neuron $(1, 3)$

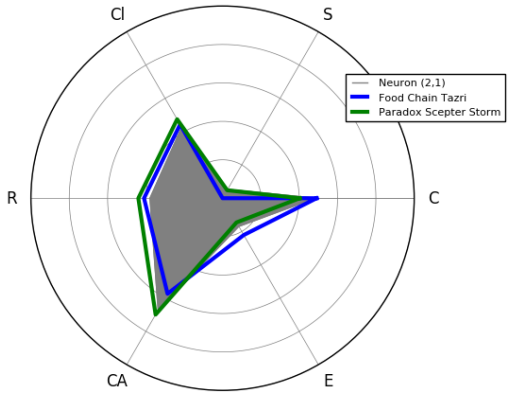
Figure 28: C^3R archetype row 1 with associated decks

The C^3R Archetype, Figure 28 and Figure 29, is the largest in terms of the number of prototypes and second largest in terms of associated decks with 13. The associated decks are:

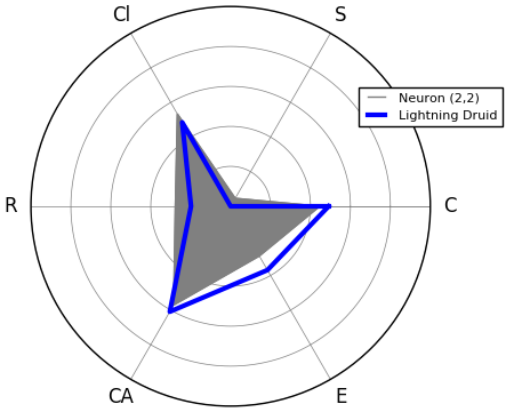
1. I Can't Believe It's Not Varolz! (Section A.18),
2. Razakats (Section A.31),
3. Doomsday Zur (Section A.6),
4. Jeleva Storm (Section A.19),
5. Shimmer Zur (Section A.37),
6. Scepter Thrasios (Section A.34),
7. Najeela Tempo (Section A.25),
8. SBT Grave Combos (Section A.32),
9. Doomsday Yidris (Section A.5),
10. Nooze Reanimator (Section A.26),



(a) Neuron $(2, 0)$



(b) Neuron $(2, 1)$



(c) Neuron $(2, 2)$

Figure 29: C^3R archetype row 2 with associated decks

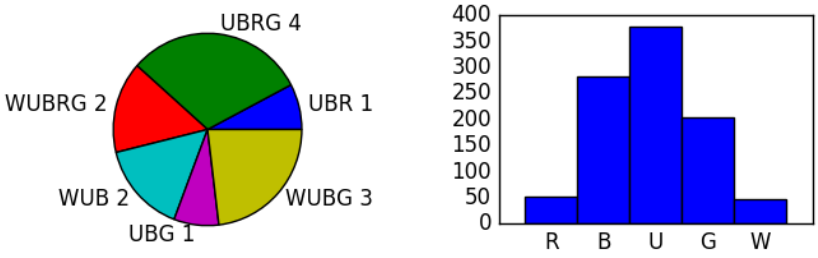
11. Food Chain Tazri (Section A.9),
12. Paradox Scepter Storm (Section A.28) and
13. Lightning Druid (Section A.21).

Like the C^3 Archetype, all decks in the C^{3}R make use of U. Here, however we see a wider distribution of deck color identities, Figure 30.a, and Commanders. There are 6 decks with UBG in their identity, 5 with UBR and 2 Esper (WUB) decks. The Commander pair Thrasios, Triton Hero & Tymna the Weaver, make 3 appearances and the pair Thrasios, Triton Hero & Vial Smasher the Fierce show up 3 times. The C^{3}R Archetype is closer to the cEDH average in terms of its use of U, running 39% U and relying on B and G more than C^{3}R, Figure 30.b.

The average CMC of C^{3}R decks is lower than C^3 decks (by 0.27) and cEDH decks (by 0.15). Referring to Table 9, the number of basic lands drops dramatically to an average of 3.3 and Artifacts are less prevalent than the cEDH average. C^{3}R, while still under the average, makes more use of Creatures than C^3 and also relies on more Instants than the average cEDH.

C^{3}R uses many of the same strategies/combos as C^3:

1. Timetwister loops can be found 9 decks,



(a) Deck Colors (b) Mana Symbol Distribution

Figure 30: C^{3}R Deck colors and Mana Colors

	CMC	Basic	Non-Basic	Artifact	Creature	Enchantment	Instant	PWalker	Sorcery
C^{3}R	1.79	3.3	25.2	10.8	15.8	5.8	27.0	0.1	12.3
cEDH	1.94	8.0	22	13.9	17.6	6.1	22.5	0.2	11.3
Delta	-0.15	-4.7	+3.2	-3.1	-1.8	-0.3	+4.5	+0.2	+1.0

Table 9: C^{3}R Average Card Count and CMC

2. Laboratory Maniac is found in 8 decks,
3. Dramatic Scepter is present in 4 decks,
4. Aetherflux Reservoir 3 decks, and
5. Flash Hulk is in 3 decks.

The following, while present in C^3, are dominant in C^{3}R:

1. Recursion via Yawgmoth's Will: present in 8 decks,
2. Windfall/Notion Thief are in 8 decks,
3. Necropotence is in 8 decks and
4. Doomsday is in 4 decks.

C^{3}R is a graveyard dependent, interactive Archetype. C^{3}R decks want to gain card advantage, but the manner in which they do so differs from C^3.

4.4.3 Control Archetype

The Control archetype, Figure 31, has one prototype and one associated deck, Edric Turns A.7). Because the Control Archetype only has one deck, we will forgo the graphics on deck color identity and card color identity but will point out that Edric Turns is running 62.8% U. The average CMC and card type distribution is shown in Table 10.

While Edric Turns is "classified" as a Control deck, it is important to note that a majority of the control cards are related to taking extra turns. In comparison, to C^3 and C^{3}R, Edric Turns has far fewer interactive cards as it relies on low CMC creatures to generate card advantage.

Edric Turns is self-classified as a Tempo deck and its strategy relies on multiple turns generating combat damage.

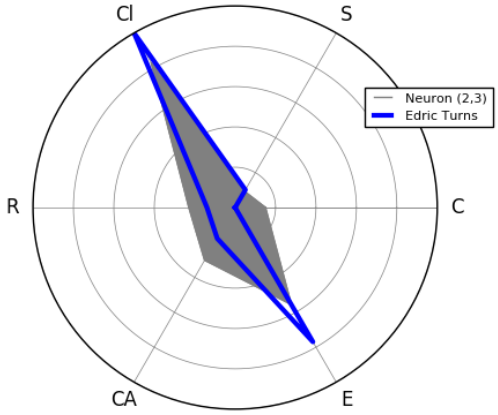


Figure 31: Control archetype with associated decks

	CMC	Basic	Non-Basic	Artifact	Creature	Enchantment	Instant	PWalker	Sorcery
Control	1.99	11.0	20.0	7.0	34.0	5.0	15.0	0.0	11.0
cEDH	1.94	8.0	22	13.9	17.6	6.1	22.5	0.2	11.3
Delta	-0.5	+3.0	-2.0	-6.9	+16.4	-1.1	-7.5	-0.2	-0.3

Table 10: Control Average Card Count and CMC

4.4.4 Combo Archetype

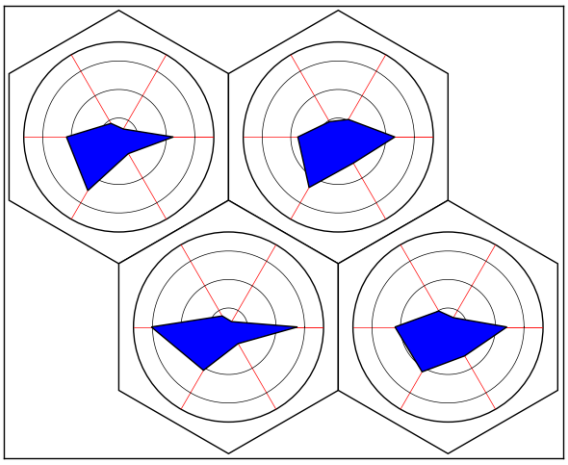
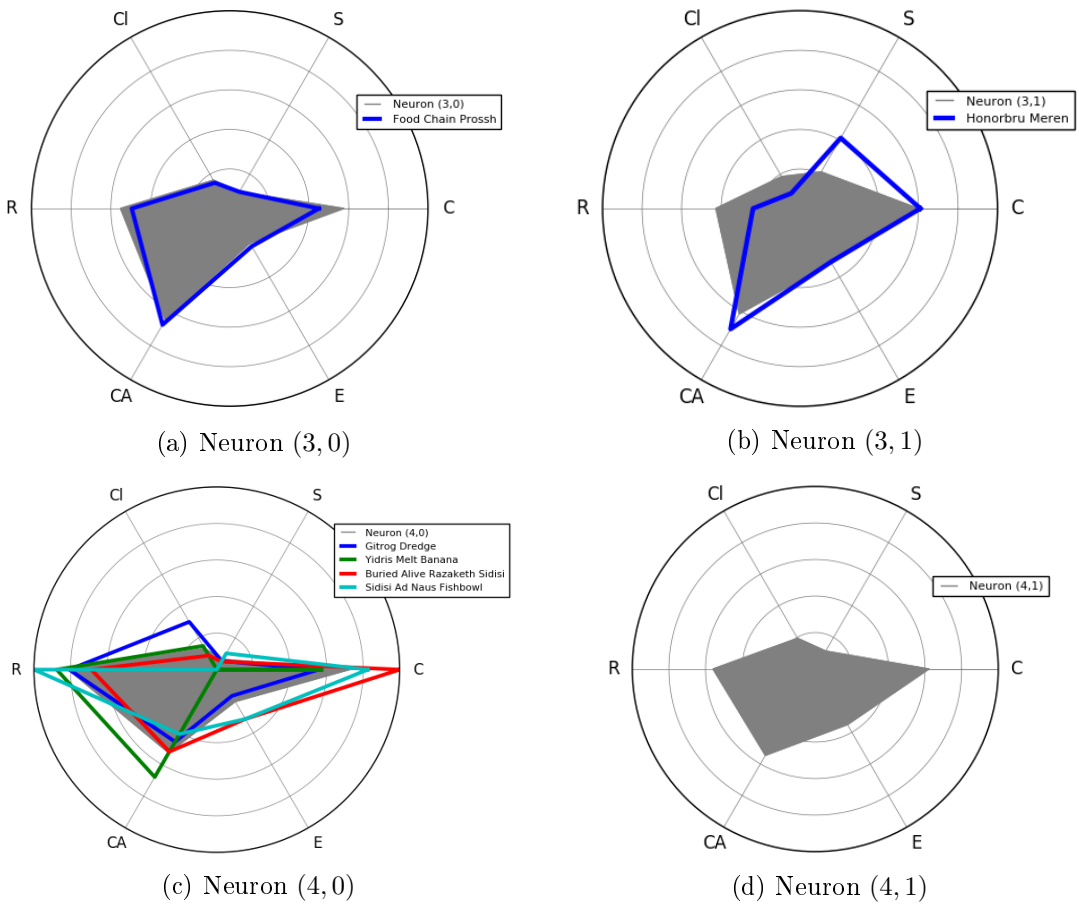


Figure 32: Combo Archetype

The Combo Archetype, Figure 32, uses very few elements of control and stax relying primarily on combo to win. Like C^3R it uses elements of ramp but, has limited CA pieces. Unlike C^3R and C^3 it generally uses more enable pieces. Combo decks, as we will see shortly, break away from the norm in terms of deck color and Commanders, eschewing the trademark Commanders.

There are four prototypes or sub-archetypes (one of which has no associated decks), Figure 33, and only six decks fall under the Combo Archetype:

1. Food Chain Prossh (Section A.8),



(a) Neuron $(3, 0)$

(b) Neuron $(3, 1)$

(c) Neuron $(4, 0)$

(d) Neuron $(4, 1)$

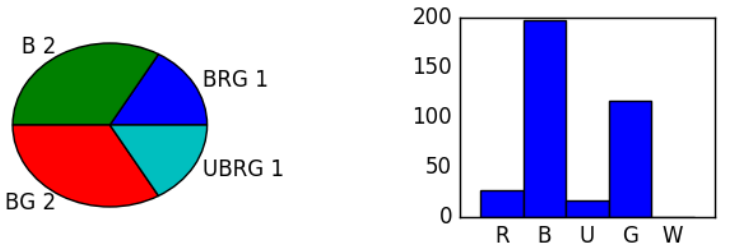
Figure 33: Combo Archetype with associated decks

2. Honorbru Meren (Section A.16),
3. Gitrog Dredge (Section A.10),
4. Yidris Melt Banana (Section A.42),
5. Buried Alive Rasaketh Sidisi (Section A.4) and
6. Sidisi Ad Naus Fishbowl (Section A.38).

First seen Commanders are Sidisi, Undead Vizier, Prossh, Skyraider of Kher, The Gitrog Monster and Meren of Clan Nel Toth. Commanders in the Combo Archetype play a more central role to both the deck and the deck strategy than previously seen.

In Figure 34.a, we see that the Combo Archetype is the first to break away from U, with only one deck, Yidris Melt Banana running it. Figure 34.b further highlights the lack of U, only .5% of cards are U. In Combo, B reigns supreme accounting for 55% of the card colors and G comes in second with 33%. U and R see little play and W is non-existent.

As we can see in Table 11, the Combo Archetype differs from the average cEDH deck in other ways. There is more emphasis on permanents with a slight increase in the number of creatures and nearly



(a) Deck Colors (b) Mana Symbol Distribution

Figure 34: Combo Deck colors and Mana Colors

six more artifacts than the cEDH average. Another noticeable difference is instants, with Combo decks running nine less instants. This implies that Combo decks rely less on interaction and more on proactive permanents to achieve their results.

	CMC	Basic	Non-Basic	Artifact	Creature	Enchantment	Instant	PWalker	Sorcery
Combo	1.78	9.7	21.7	19.7	19.3	6.0	13.3	0.0	13.2
cEDH	1.94	8.0	22.0	13.9	17.6	6.1	22.5	0.2	11.3
Delta	-0.2	+1.7	-0.3	+5.8	+1.7	-0.1	-9.2	-0.2	+2.0

Table 11: Combo Average Card Count and CMC

Lines to winning include some of the previous strategies and some new ones:

1. Protean Hulk (sans Flash) and sac outlets in 1 deck,
2. Dramatic Scepter and Paradox Engine in 3 decks,
3. Food Chain in 1 deck,
4. Timetwister in 1 deck,
5. Ad Nauseum/Necropotence in 5 decks, and
6. Storm via Aetherflux Reservoir in 3 decks.

and new ones:

1. Blood Artist/Zulaport Cutthroat in 1 deck,
2. Discard/Dredge and Cleanup combo,
3. Walking Ballista in 2 decks,
4. Razaketh tutor chains in 2 decks,
5. Cascade in 1 deck,
6. 0-CMC spells and rituals in 2 decks.

In the Combo Archetype, we begin to see hacks and alternate methods of achieving a win. For example, whereas previous decks would rely on an infinite mechanism to win via Aetherflux Reservoir, the Combo decks also employs the use 0-CMC spells, rituals and recursion to increase the spell count. And of course, the notorious Gitrog Cleanup Step[28].

4.4.5 Universal Archetype

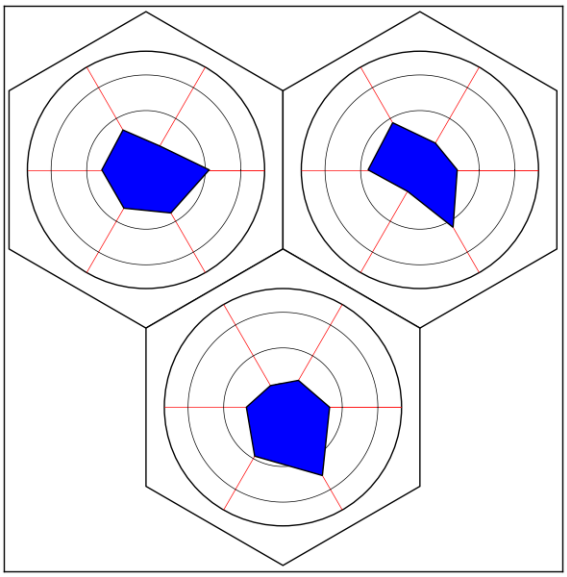


Figure 35: Universal archetype

The Universal Archetype, Figure 35 is exemplified by the near equal use of Methods: combo, stax and control as well as the near equal use of Modes: ramp, CA and enable.

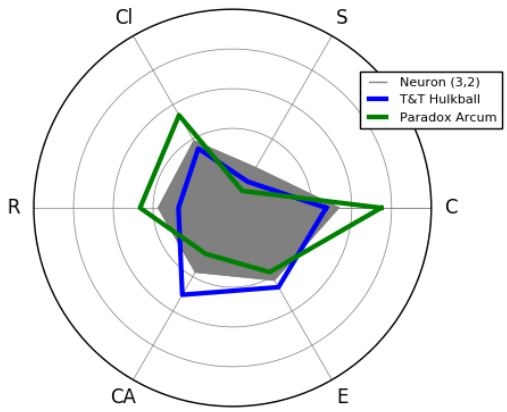
Decks in the Universal Archetype, Figure 36, are

1. T&T Hulkball (Section A.39),
2. Paradox Arcum (Section A.27),
3. Momir Hackball (Section A.24) and
4. Selvala Brostorm (Section A.36).

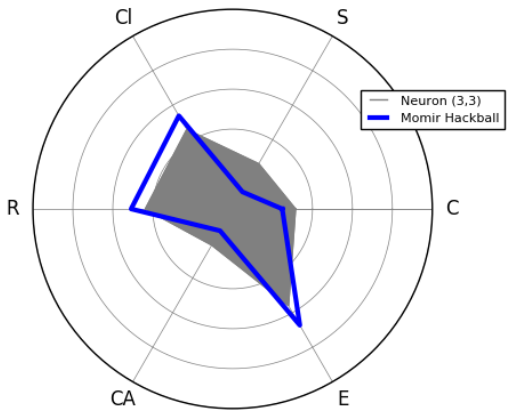
The Universal Archetype returns to the use of U with one mono Blue deck and one UG deck, Figure 37.a. However, U is still not the dominant color with G making up 56% of the card colors in the Archetype, Figure 37.b. Commanders include the common pair Tana, the Bloodsower and Tymna the Weaver and the singletons Momir Vig, Simic Visionary, Arcum Dagsson and Selvala, Heart of the Wilds.

Again, we see an increase in the number of Artifacts and Creatures from the average and a decrease (although sleight) in the number of instants, Table 12.

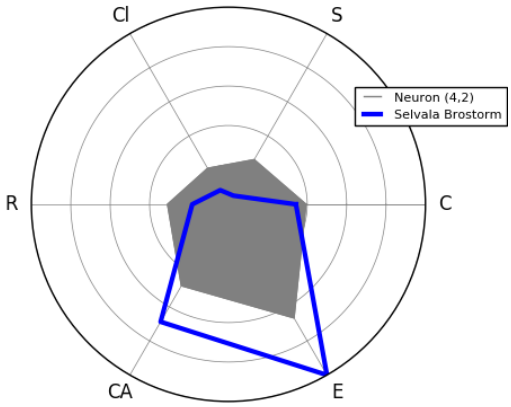
[28] https://blogs.magicjudges.org/rulestips/2016/04/the-gitrog-monster-and-the-cleanup-step-a-better-love-story-than-twilight/



(a) Neuron $(3, 2)$

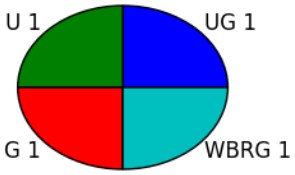


(b) Neuron $(3, 3)$

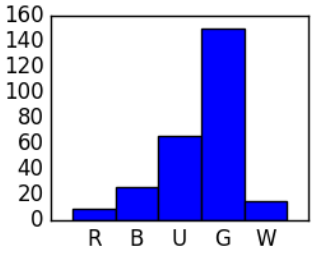


(c) Neuron $(4, 2)$

Figure 36: Universal archetype with associated decks



(a) Deck Colors



(b) Mana Symbol Distribution

Figure 37: Universal Deck colors and Mana Colors

	CMC	Basic	Non-Basic	Artifact	Creature	Enchantment	Instant	PWalker	Sorcery
Universal	1.96	12.5	17.5	17.5	27.0	5.5	19.0	0.3	7.0
cEDH	1.94	8.0	22	13.9	17.6	6.1	22.5	0.2	11.3
Delta	–	+4.5	+4.0	+3.6	+9.4	-0.6	-3.5	+0.1	-4.3

Table 12: Universal Average Card Count and CMC

Decks in the Universal Archetype make more use of enable cards than the other Archetypes and rather than Commanders providing an outlet for infinite, the Commanders tend to generate the infinite. In other words, the Commanders in these decks are more vital to the deck strategy than other cEDH decks.

Deck strategies include:

1. Protean Hulk (sans Flash) and sac outlets in 1 deck,
2. Walking Ballista in 1 deck,
3. Artifact sac and recursion in 1 deck
4. Deck Draw in 2 decks,
5. Mill and Kill in 1 deck, and
6. Bounce/recast lines into kill loops in 1 deck.

4.4.6 Stax Archetype

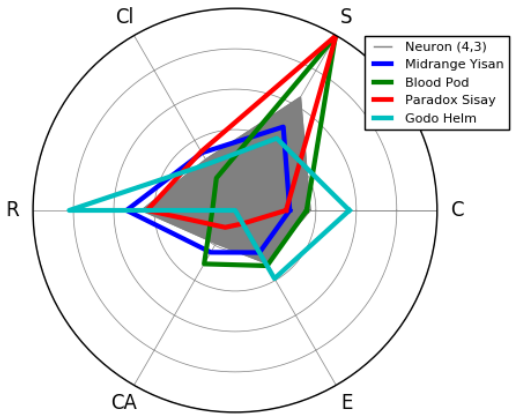


Figure 38: Stax archetype with associated decks

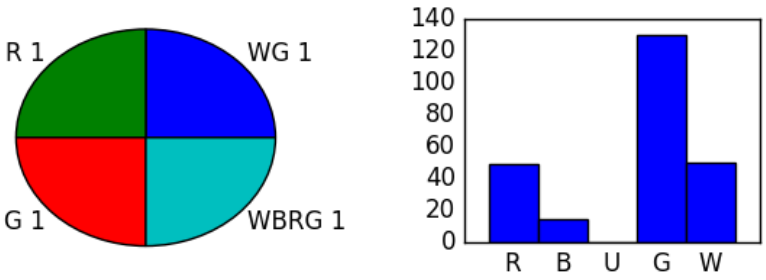
The Stax archetype, Figure 38, is similar to the Universal archetype. However, it relies more on stax than combo or control and its uses of the different Modes are not equal. Four decks are associated with this archetype:

1. Midrange Yisan (Section A.22),
2. Blood Pod (Section A.2),
3. Paradox Sisay (Section A.29) and
4. Godo Helm (Section A.11).

The Stax Archetype is the most disparate both in comparison of the associated decks to the prototype and in comparison of the associated decks to one another. Two decks, Blood Pod and Paradox Sisay are very "Staxy" whereas the other two, Midrange Yisan and Godo Helm, use stax not as a central theme but as a means of control. Rather than Stax it may be better to call this the

anti-Archetype.

No decks in the Stax Archetype utilize U, Figure 39.a and we see our second Mono Green, first Mono Red and first WG deck. Again, G is the dominant color, Figure 39.b, W and R make up the next most used and B makes up a relatively small portion. Like the previous two Archetypes, Commanders are generally central to the deck strategy.



(a) Deck Colors (b) Mana Symbol Distribution

Figure 39: Stax Deck colors and Mana Colors

Surprisingly, decks in the Stax Archetype have a high CMC at 2.21, Table 13. The number of Artifacts and Creatures are much higher than the average and there is a slight increase in the number of Enchantments. We also see a dramatic decrease in both the number of Instants and Sorceries.

	CMC	Basic	Non-Basic	Artifact	Creature	Enchantment	Instant	PWalker	Sorcery
Stax	2.21	12.5	19.8	20.5	28.0	8.3	9.5	0.0	5.3
cEDH	1.94	8.0	22	13.9	17.6	6.1	22.5	0.2	11.3
Delta	+0.3	+4.5	-2.2	+6.6	+10.4	+2.2	-13.0	-0.2	-6.0

Table 13: Stax Average Card Count and CMC

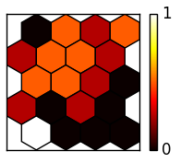
The strategies include:

1. Deck draw and kill loop,
2. Kiki-Jiki/Bell Ringer combo lines,
3. Paradox Engine and Death by Mill, and
4. Godo and Helm of the Host.

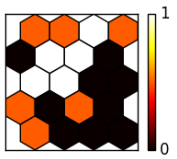
4.4.7 Combos and Winning

Perhaps the biggest difference between casual EDH and cEDH is ultimately the "combo" - the card or set of cards that instantly wins the game. A random selection of 15 card(s) from well known winning combos and/or virtual game-winning plays and plotting their presence is shown Figure 40.

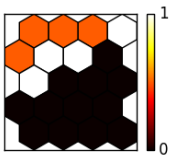
We'll leave it up to readers to draw any conclusions.



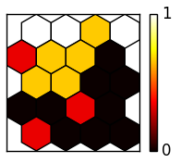
(a) Ad Nauseam



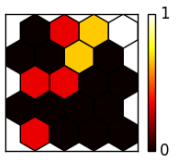
(b) Necropotence



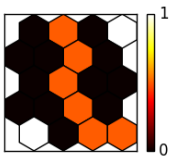
(c) Windfall/Notion Thief



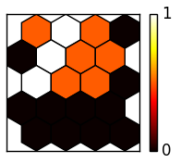
(d) Timetwister



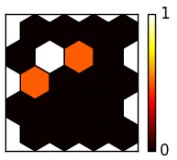
(e) Dramatic Scepter



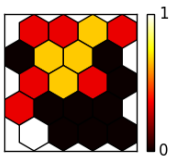
(f) Paradox Engine



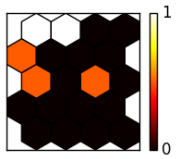
(g) Labman



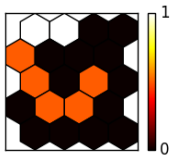
(h) Doomsday



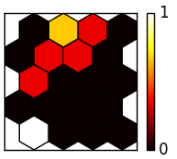
(i) Yawgmoth's Will



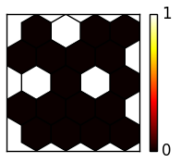
(j) Flash Hulk



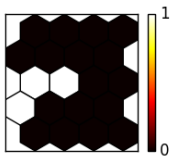
(k) Hulk sans Flash



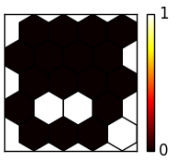
(l) Aetherflux Reservoir



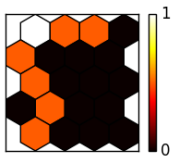
(m) Hermit Druid



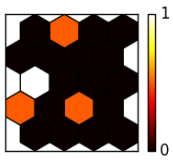
(n) Food Chain



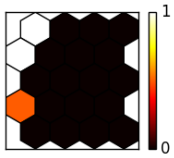
(o) Birthing Pod



(p) Razaketh



(q) Walking Ballista



(r) Blood Artist/Zulaport Cutthroat

Figure 40: Combos and Win-Cons

4.5 Additional Remarks

Recall from the introduction to Section 4 that our aim in using a SOM was fourfold: (1) abstain from using traditional Archetypes to define/categorize decks, (2) avoid subjectiveness, (3) avoid

traditional boundaries and (4) provide for expansion and growth. I believe that the SOM was largely successful. The largest failure was in terms of subjectiveness. Even though we ignored subjective holistic views of the decks themselves, each card was manually tagged and therefore subject to the opinion of one individual. To alleviate this, a consensus by the community should be obtained.

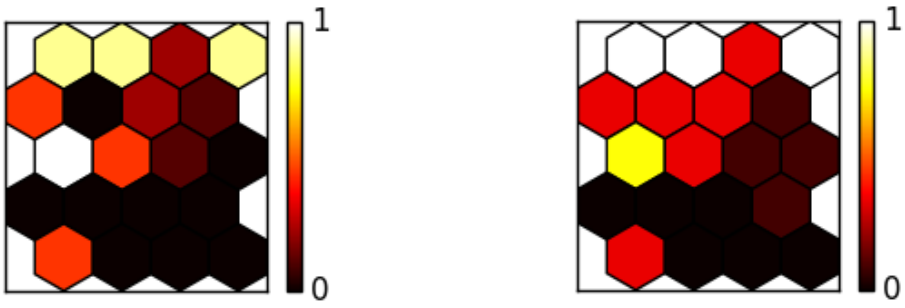
Proving the validity or correctness of a SOM is hard. I for one am not satisfied with the Stax Archetype as the four decks associated to neuron $(4, 3)$ show major variations from each other. This could be due to the fact that many decks exhibited a similar C^3-like nature that there were not enough neurons left over for non-dominant type decks. It could also be a result of the features identified for the M2 Index. Are there too few or too many? Are they the right ones to use?

A benefit of using a SOM is that there is no preconceived notion of "truth", "correctness" or "importance" that is, the SOM is self-taught, relying on the data it is presented. Part of the reason that my initial attempts (Appendix C) failed was my assumptions. For example, I assumed that the three primary "components" of a cEDH deck were control, combo and stax. As such, an unreadable and unhelpful cluster of decks formed along the control/combo axis with much of the stax dimension left unused. The SOM, without any arbitrary constraints, determined that combo, control and CA are primary as can be seen in Figure 20 .

One of the interesting features or byproducts of SOMs are its emergent properties. Emergence[29] is the manifestation of a property or properties in a system that its individual parts do not have, arising from the interactions of its parts. Two of the emergent properties, Color Identity and Interaction Ratio, are discussed in the following sections. These properties may not prove the credibility of the SOM but they do help validate it.

4.5.1 Color Identity

An interesting emergent property is that the dominant colors and dominant Commanders in cEDH show a heavy presence in the the top three rows of the SOM whereas the bottom two rows are primarily populated by the lesser color identities and niche Commanders. This delineation has occurred despite the fact that neither color or Commander(s) are present in the data.



(a) Weighted BUGx (b) Weighted UBx and UGx

Figure 41: Dominant color identities with U

Figure 41 shows weighted[30] heatmaps for the dominant cEDH colors, U, B and G: Figure 41.a is

[29] https://en.wikipedia.org/wiki/Emergence

[30] After calculating the number of decks in a neuron containing the specified colors, the neuron is weighted by a

a heatmap of BUGx decks and Figure 41.b is a heatmap of decks that contain U and at least one other dominant color i.e. decks that are either UBx or UGx. With the exception of Yidris Melt Banana in neuron $(4, 0)$, all BUGx decks are associated to neurons in the top three rows.

We could treat the "placement" of Yidris Melt Banana as an anomaly and an error on the part of the SOM. However, on further review, we conclude that Yidris Melt Banana is located correctly. Yidris Melt Banana's M2 Index is closely aligned to its neuron prototype and the other decks in the same neuron and adjacent neurons, see Figures 33 and 22.b. Its Interaction Ratio (discussed in the next section) like that of its siblings is low. Finally, its mana color distribution is similar to its sibling decks. Yidris Melt Banana has 39% B versus 25% U and its use of U is not for control but combo and CA.

4.5.2 Interaction Ratio

Another emergent property of the SOM is the interaction ratio. The interaction ratio is an experimental concept still under review. As such, it cannot be considered entirely accurate but is still another useful method of comparing decks. The interaction ratio (IR) is defined in equation 10 and can be summarized as the ratio of control cards that are instants to cards (non-land) that are either non-control or non-instants.

$$IR = \frac{\sum_{i=1}^{100} is\_control(Card_i) \wedge is\_instant(Card_i)}{\sum_{i=1}^{100} \neg(is\_land(Card_i) \wedge (\neg is\_control(Card_i) \vee \neg is\_instant(Card_i))} \tag{10}$$

where $\neg$ = logical not,
$\wedge$ = logical and,
$\vee$ = logical or.

The interaction ratio is an attempt to measure the linearity and interaction of a deck[31]. A high interaction ratio implies that a deck can respond at instant speed to an opponent's game play whereas a low interaction ratio implies that a deck cannot respond to an opponent's play and can only change the board state during the pilot's turn[32].

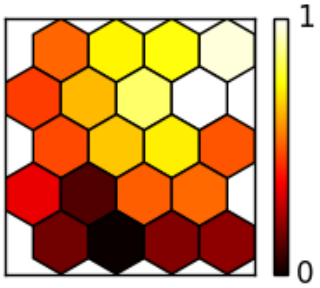


Figure 42: Interaction ratio heatmap

Figure 42 shows a heatmap of the average interaction ratio (normalized) for the SOM. While not as clearly delineated as the color identity, the SOM has placed highly interactive decks in the top

factor based on the number of decks associated to that neuron. This is done so that a neuron with only one deck can be compared relatively to a neuron with four decks.

[31] Rashmi Control has the highest interaction ratio at 0.52 and Sidisi Ad Naus Fishbowl has the lowest at 0.015

[32] Keep in mind we are not considering activated abilities of permanents in play

right with lesser interactive decks fanning out circularly. Note that Yidris Melt Banana, which has an interaction ratio of 0.09, does appear to be in the correct place.

5 Conclusion

This survey has evolved throughout its production. Initially, my only intent was to write several scripts that could load and parse cEDH decks and provide a quick deck summary or a side-by-side comparison of multiple decks in order to avoid tabbing back and forth between multiple TappedOut deck descriptions. That was not enough however. Just saying that this deck is Mid-Range and this other deck is Combo was useless for me. I needed a way (that didn't involve a spreadsheet or table or labels) to take all the decks, put them in the same "space" and see how they related to each other as well as where my deck would fall. Finally, the cEDH community is friendly and transparent, always willing to share information and acquired knowledge so, after the data was compiled, the idea of a paper summarizing the findings was born.

The usefulness of this paper (and associated data) will depend on the reader. For my part, it has aided in identifying weaknesses and/or shortcomings in my deck but most importantly, it has aided in identifying shortcomings in my deck-building thought processes. I have found that the biggest difference between casual and competitive Commander decks is the end-game. My first decks were always built around a combo or two that would be awesome after the game has grinded on for hours. The first versions of my Ertai, the Corrupted deck were built the same way. Ertai would be nearly unstoppable once I equipped Thornbite Staff, Lightning Greaves and Vanishing and had Lullmage Mentor and Teysa, Orzhov Scion in play with Nether Traitor, Reassembling Skeleton et al in the graveyard. And then, the coup de grâce, cast Replenish and put all my lock enchantments on the field. Nevermind, that first I had to find all of Ertai's pieces but also had to put all my enchantments in the graveyard somehow. And, that is the difference. Casual decks are built around the idea that eventually, the game will reach a state where all your resources are magically available and voilà - end game. Competitive decks are built to make the end game happen as early as possible.

Competitive deck builders will most likely not find the same level of enlightenment in this survey as I did but hopefully will still receive some benefit.

5.1 Way Ahead

There are several updates, modifications and areas of the survey to be addressed in future versions that are discussed below.

Old Data: The survey is out of date. Since the data was acquired in August 2018, multiple new sets have been released with a new one coming in January 25. The survey was written piecemeal and as time allowed and new scripts were written when needed to facilitate new ideas. With the paper's framework and scripts in place, a new version with updated data, decks and deck lists will not take as long to compile.

Decks/Cards Sections: Section 3, while meeting the initial intent of quantifying the cards used by cEDH decks, falls short and is basically a "whos who" of cEDH cards based on type, color etc. More useful to readers would be additional sub-sections breaking down what the cards do i.e. Hate

cards (and what type of hate), counter-spells etc[33]. Since I had not thought of using a SOM and/or an M2 Index, manual tagging of cards was not started until the sections on cards and decks was complete. Now that the hard part, manually categorizing the cards, is done only minor changes and updates would be necessary.

Descriptions of decks can be more in-depth by including details from above. the Interaction Ratio should be explored further as well.

Mana Production: The quantity and type of mana a deck can produce should be explored.

Modification to SOM Data: This entails several concepts. (1) Is the M2 Index sufficient or are there other features that could be added i.e. CMC? (2) The size of the dataset is small. Ideally, a SOM would have a training and a testing dataset but with only 42 samples there are just not enough decks. (3) Quality of training data is covered below.

Card Method/Mode Consensus: As we already discussed, the categorization of cards was done manually and is therefore subjective. Additionally, the cards were categorized based on my experiences and knowledge. To decrease both the subjectiveness and possible mis-categorization, a consensus by the cEDH community would be beneficial. More details on this process is described in Appendix D.

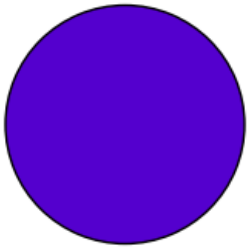
[33]I had originally planned on parsing the oracle text of each card and programmatically tagging each card but the ambiguity of some card texts and similarity of keywords i.e. "counter" target spell vs put a +1/+1 "counter" made simple keyword searches impossible.

Appendix A Decks

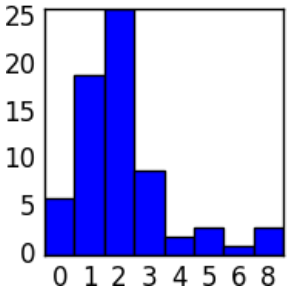
This section lists each deck with some statistics. Four graphics are provided: the mana color pie, CMC histogram, card type histogram and M2 Index.

A.1 Baral Control: http://tappedout.net/mtg-decks/baral-draw-go-2

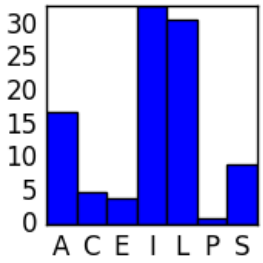
Author: asm (http://tappedout.net/users/asm)
Commander(s): Baral, Chief of Compliance
Color: U (U: 62 100.0%)
CMC: 2.19



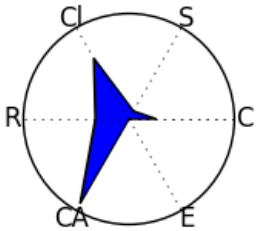
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



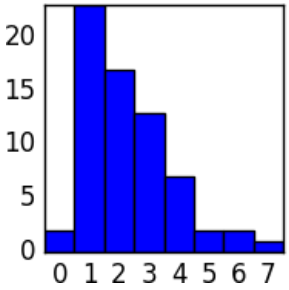
(d) M2 Index Spider Chart

Figure 43: Baral Control

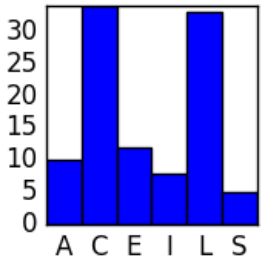
A.2 Blood Pod: http://tappedout.net/mtg-decks/tana-and-tymna-blood-pod-primer

Author: LabManiac_Luke (http://tappedout.net/users/LabManiac_Luke)
Commander(s): Tana, the Bloodsower, Tymna the Weaver
Color: WBRG (W: 23 29.5% B: 15 19.2% R: 12 15.4% G: 28 35.9%)
CMC: 2.28

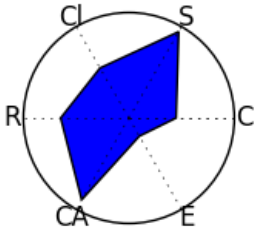
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

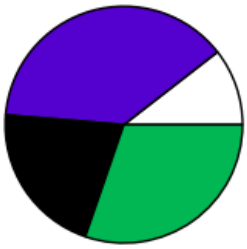


(d) M2 Index Spider Chart

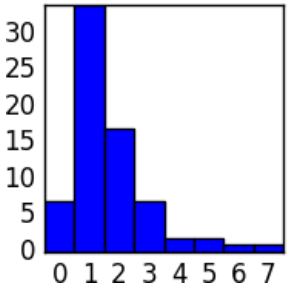
Figure 44: Blood Pod

A.3 Breakfast Hulk: http://tappedout.net/mtg-decks/breakfast-hulk

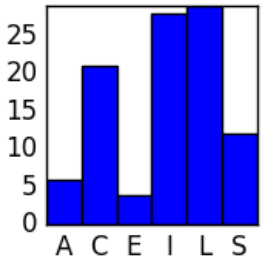
Author: LabManiac_Sigi (http://tappedout.net/users/LabManiac_Sigi)
Commander(s): Thrasios, Triton Hero, Tymna the Weaver
Color: WUBG (W: 8 10.5% U: 29 38.2% B: 16 21.1% G: 23 30.3%)
CMC: 1.69



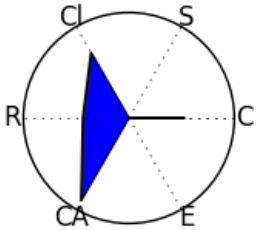
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



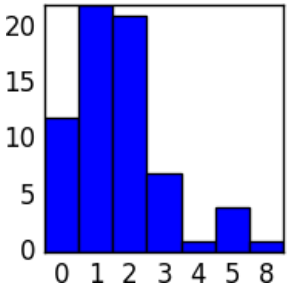
(d) M2 Index Spider Chart

Figure 45: Breakfast Hulk

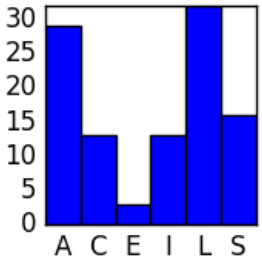
A.4 Buried Alive Razaketh Sidisi: http://tappedout.net/mtg-decks/buried-alive-sidisi

Author: marsthesoos (http://tappedout.net/users/marsthesoos)
Commander(s): Sidisi, Undead Vizier
Color: B (B: 45 100.0%)
CMC: 1.72

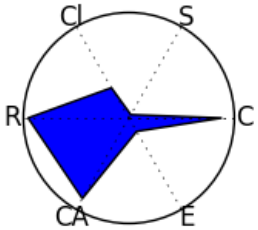
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



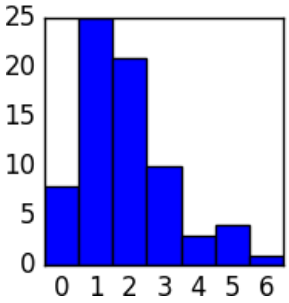
(d) M2 Index Spider Chart

Figure 46: Buried Alive Razaketh Sidisi

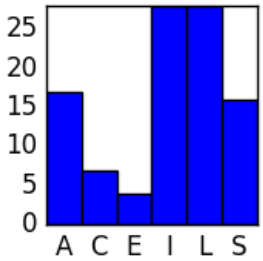
A.5 Doomsday Yidris: http://tappedout.net/mtg-decks/yidris-stormdoomsday-20

Author: LabManiac_Sigi (http://tappedout.net/users/LabManiac_Sigi)
Commander(s): Yidris, Maelstrom Wielder
Color: UBRG (U: 32 44.4% B: 24 33.3% R: 6 8.3% G: 10 13.9%)
CMC: 1.88

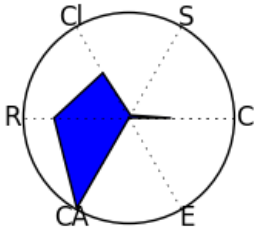
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

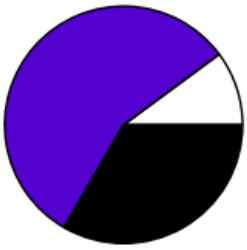


(d) M2 Index Spider Chart

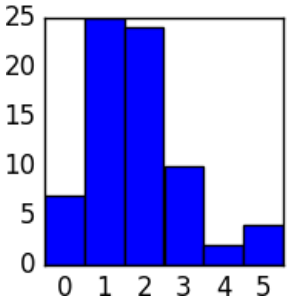
Figure 47: Doomsday Yidris

A.6 Doomsday Zur: http://tappedout.net/mtg-decks/12-05-17-AKL-zur-doomsday

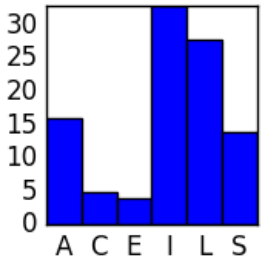
Author: AlwaysSleepy (http://tappedout.net/users/AlwaysSleepy)
Commander(s): Zur the Enchanter
Color: WUB (W: 7 10.1% U: 39 56.5% B: 23 33.3%)
CMC: 1.82



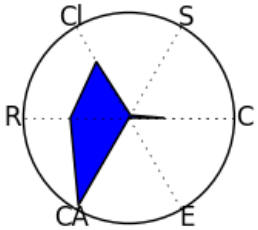
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

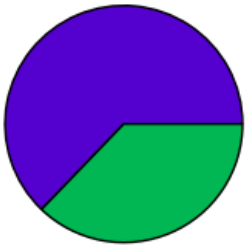


(d) M2 Index Spider Chart

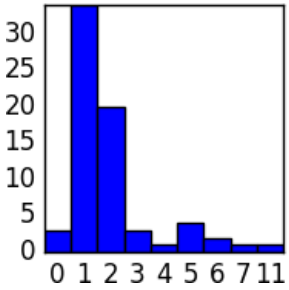
Figure 48: Doomsday Zur

A.7 Edric Turns: http://tappedout.net/mtg-decks/15-01-17-edric

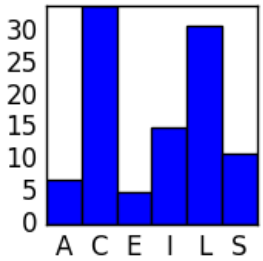
Author: LabManiac_Simon (http://tappedout.net/users/LabManiac_Simon)
Commander(s): Edric, Spymaster of Trest
Color: UG (U: 49 62.8% G: 29 37.2%)
CMC: 1.99



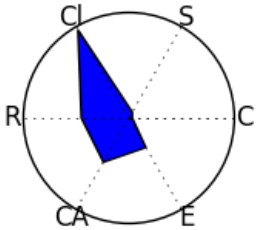
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



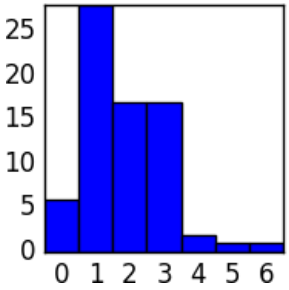
(d) M2 Index Spider Chart

Figure 49: Edric Turns

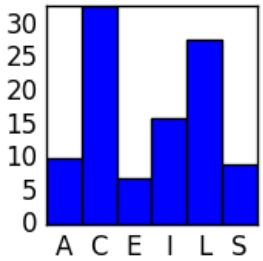
A.8 Food Chain Prossh: http://tappedout.net/mtg-decks/19-07-16-food-chain-prossh

Author: angelforge (http://tappedout.net/users/angelforge)
Commander(s): Prossh, Skyraider of Kher
Color: BRG (B: 26 32.5% R: 19 23.8% G: 35 43.8%)
CMC: 1.83

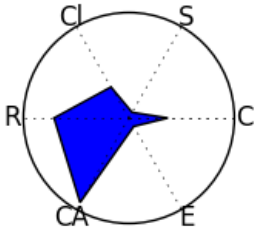
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



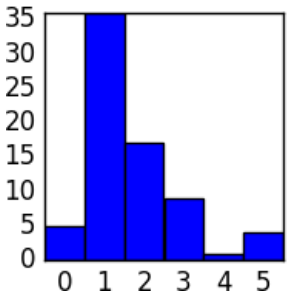
(d) M2 Index Spider Chart

Figure 50: Food Chain Prossh

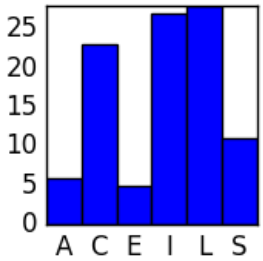
A.9 Food Chain Tazri: http://tappedout.net/mtg-decks/food-chain-tazri

Author: ShaperSavant (http://tappedout.net/users/ShaperSavant)
Commander(s): General Tazri
Color: WUBRG (W: 4 5.3% U: 27 36.0% B: 21 28.0% R: 3 4.0% G: 20 26.7%)
CMC: 1.68

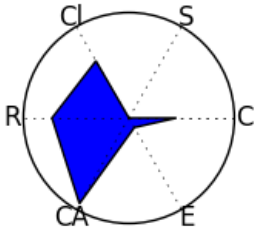
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



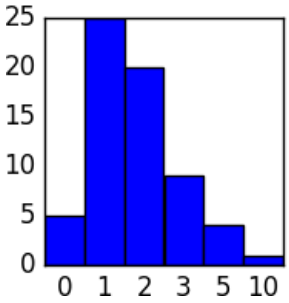
(d) M2 Index Spider Chart

Figure 51: Food Chain Tazri

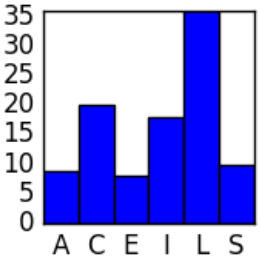
A.10 Gitrog Dredge: http://tappedout.net/mtg-decks/gitrog-land-combo

Author: Leptys (http://tappedout.net/users/Leptys)
Commander(s): The Gitrog Monster
Color: BG (B: 29 45.3% G: 35 54.7%)
CMC: 1.91

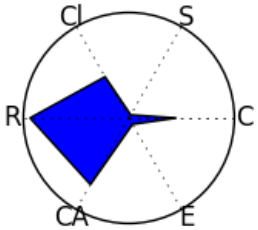
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

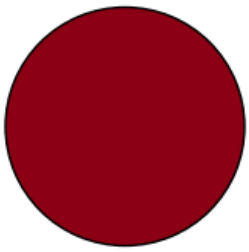


(d) M2 Index Spider Chart

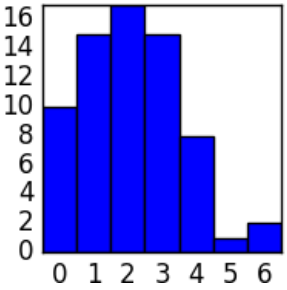
Figure 52: Gitrog Dredge

A.11 Godo Helm: http://tappedout.net/mtg-decks/waiting-for-godo-cedh-primer

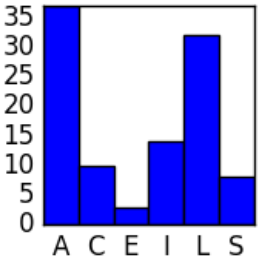
Author: gtoast99 (http://tappedout.net/users/gtoast99)
Commander(s): Godo, Bandit Warlord
Color: R (R: 37 100.0%)
CMC: 2.10



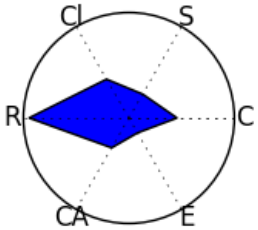
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

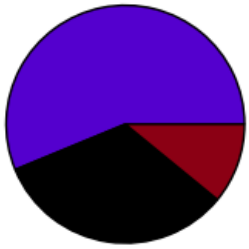


(d) M2 Index Spider Chart

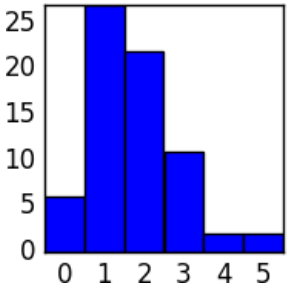
Figure 53: Godo Helm

A.12 Grixis Consultation: http://tappedout.net/mtg-decks/grixis-consultation

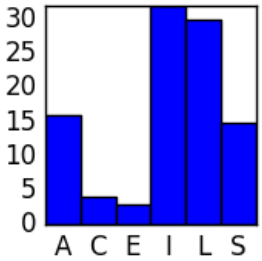
Author: Nakhla (http://tappedout.net/users/Nakhla)
Commander(s): Kess, Dissident Mage
Color: UBR (U: 36 56.2% B: 21 32.8% R: 7 10.9%)
CMC: 1.74



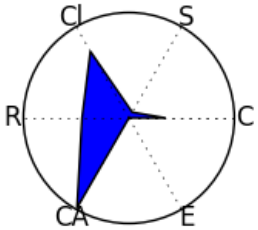
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



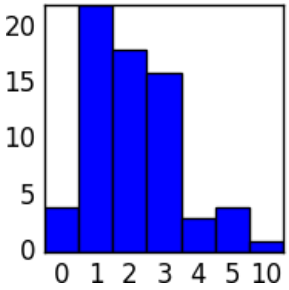
(d) M2 Index Spider Chart

Figure 54: Grixis Consultation

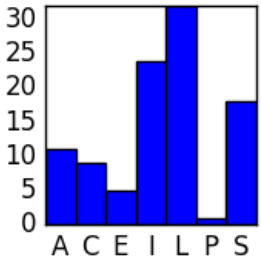
A.13 Grixis Twin: http://tappedout.net/mtg-decks/17-09-16-grixis-twin

Author: infiniteimoc (http://tappedout.net/users/infiniteimoc)
Commander(s): Kess, Dissident Mage
Color: UBR (U: 32 43.2% B: 28 37.8% R: 14 18.9%)
CMC: 2.18

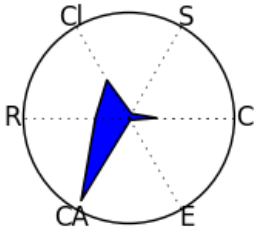
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



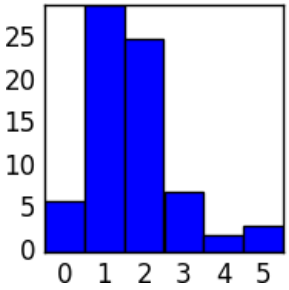
(d) M2 Index Spider Chart

Figure 55: Grixis Twin

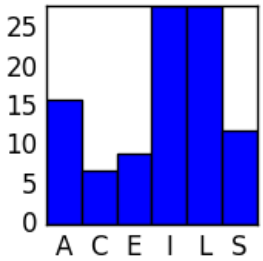
A.14 HE-MAN: http://tappedout.net/mtg-decks/the-holy-trinity-of-hate-99-casual-copy

Author: LabManiac_Luke (http://tappedout.net/users/LabManiac_Luke)
Commander(s): Thrasios, Triton Hero, Tymna the Weaver
Color: WUBG (W: 10 15.2% U: 36 54.5% B: 10 15.2% G: 10 15.2%)
CMC: 1.71

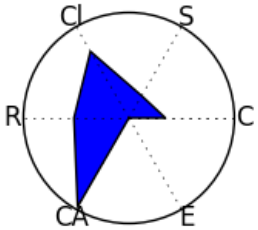
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

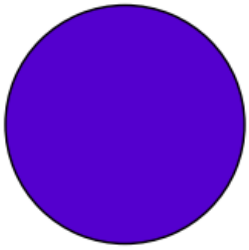


(d) M2 Index Spider Chart

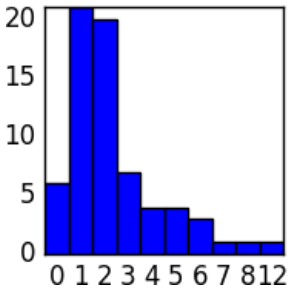
Figure 56: HE-MAN

A.15 High Tide Jace: http://tappedout.net/mtg-decks/03-04-16-high-tide

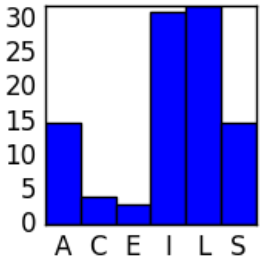
Author: ShaperSavant (http://tappedout.net/users/ShaperSavant)
Commander(s): Jace, Vryn's Prodigy
Color: U (U: 71 100.0%)
CMC: 2.40



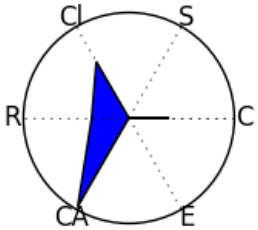
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



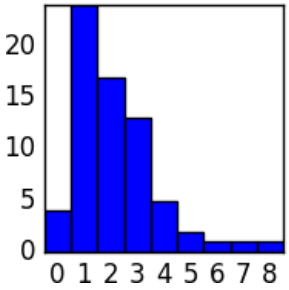
(d) M2 Index Spider Chart

Figure 57: High Tide Jace

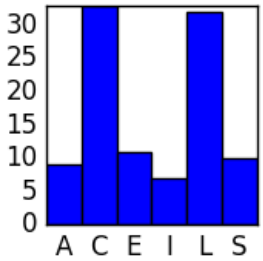
A.16 Honorbru Meren: http://tappedout.net/mtg-decks/honorbru-meren-finite-hulk

Author: roguelikedev (http://tappedout.net/users/roguelikedev)
Commander(s): Meren of Clan Nel Toth
Color: BG (B: 43 56.6% G: 33 43.4%)
CMC: 2.18

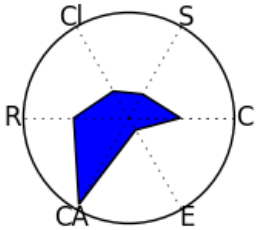
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



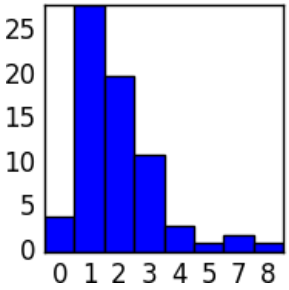
(d) M2 Index Spider Chart

Figure 58: Honorbru Meren

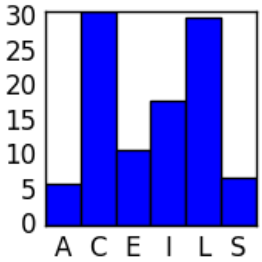
A.17 Hulkweaver: http://tappedout.net/mtg-decks/protean-weaver

Author: trestian (http://tappedout.net/users/trestian)
Commander(s): Thrasios, Triton Hero, Tymna the Weaver
Color: WUBG (W: 24 28.2% U: 15 17.6% B: 21 24.7% G: 25 29.4%)
CMC: 2.00

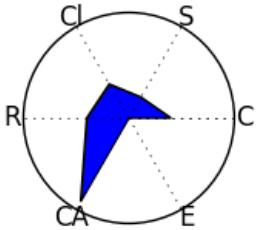
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

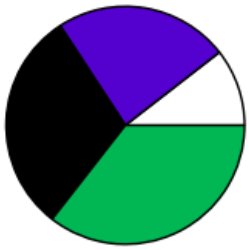


(d) M2 Index Spider Chart

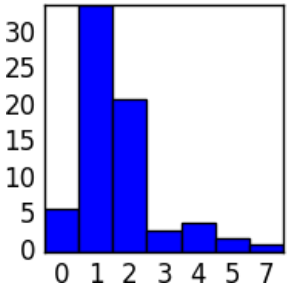
Figure 59: Hulkweaver

A.18 I Can't Believe It's Not Varolz!: http://tappedout.net/mtg-decks/definitely-not-varolz

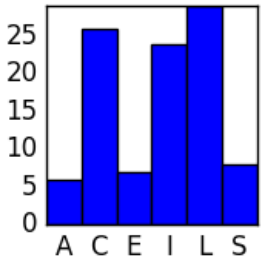
Author: sickrobot (http://tappedout.net/users/sickrobot)
Commander(s): Thrasios, Triton Hero, Tymna the Weaver
Color: WUBG (W: 8 10.5% U: 18 23.7% B: 23 30.3% G: 27 35.5%)
CMC: 1.66



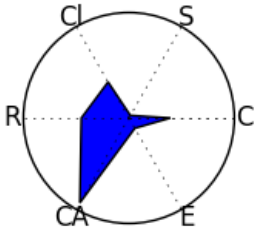
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



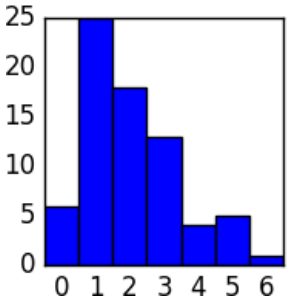
(d) M2 Index Spider Chart

Figure 60: I Can't Believe It's Not Varolz!

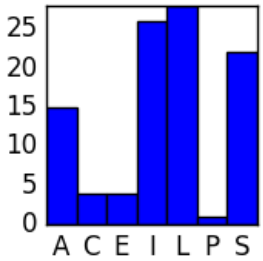
A.19 Jeleva Storm: http://tappedout.net/mtg-decks/jeleva-slim

Author: reversemermaid (http://tappedout.net/users/reversemermaid)
Commander(s): Jeleva, Nephalia's Scourge
Color: UBR (U: 41 55.4% B: 22 29.7% R: 11 14.9%)
CMC: 2.04

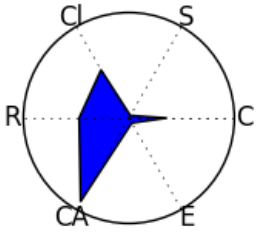
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

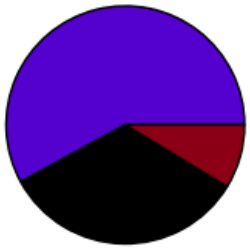


(d) M2 Index Spider Chart

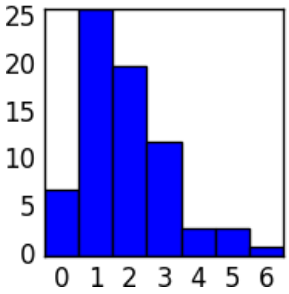
Figure 61: Jeleva Storm

A.20 Kess Storm: http://tappedout.net/mtg-decks/grixis-flux-1

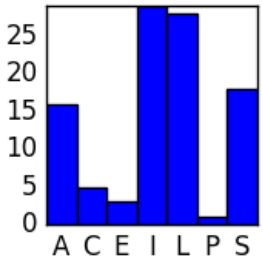
Author: Wedge-cEDH (http://tappedout.net/users/Wedge-cEDH)
Commander(s): Kess, Dissident Mage
Color: UBR (U: 40 58.0% B: 23 33.3% R: 6 8.7%)
CMC: 1.88



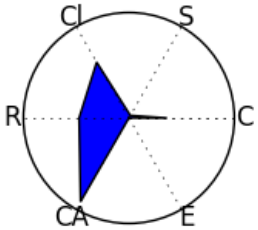
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



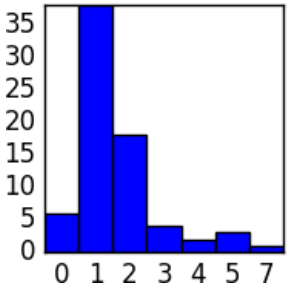
(d) M2 Index Spider Chart

Figure 62: Kess Storm

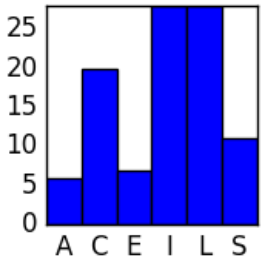
A.21 Lightning Druid: http://tappedout.net/mtg-decks/lightning-druid

Author: AverageDragon (http://tappedout.net/users/AverageDragon)
Commander(s): Thrasios, Triton Hero, Vial Smasher the Fierce
Color: UBRG (U: 26 35.1% B: 16 21.6% R: 10 13.5% G: 22 29.7%)
CMC: 1.61

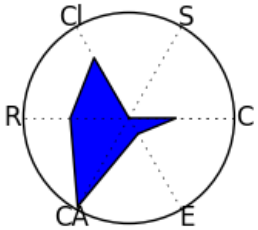
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

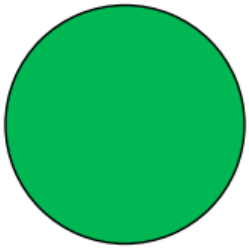


(d) M2 Index Spider Chart

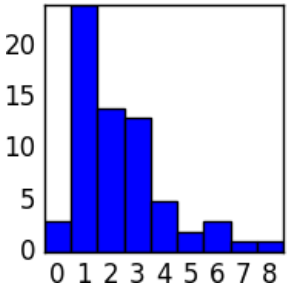
Figure 63: Lightning Druid

A.22 Midrange Yisan: http://tappedout.net/mtg-decks/wanderers-song

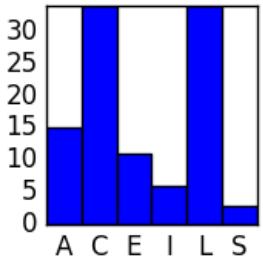
Author: ShaperSavant (http://tappedout.net/users/ShaperSavant)
Commander(s): Yisan, the Wanderer Bard
Color: G (G: 64 100.0%)
CMC: 2.33



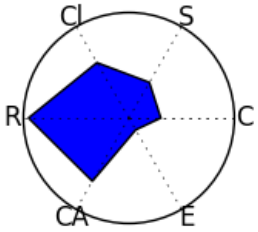
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

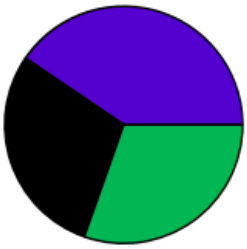


(d) M2 Index Spider Chart

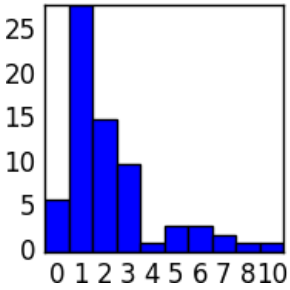
Figure 64: Midrange Yisan

A.23 Mimeo Reanimator Hulk: http://tappedout.net/mtg-decks/19-09-16-the-mimeoplasm-edh

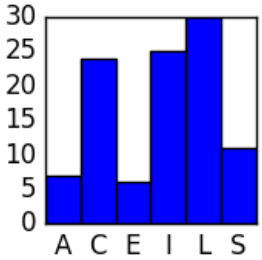
Author: monkeryz (http://tappedout.net/users/monkeryz)
Commander(s): The Mimeoplasm
Color: UBG (U: 32 40.5% B: 23 29.1% G: 24 30.4%)
CMC: 2.24



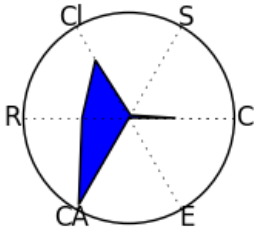
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

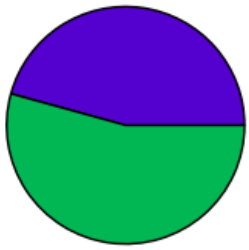


(d) M2 Index Spider Chart

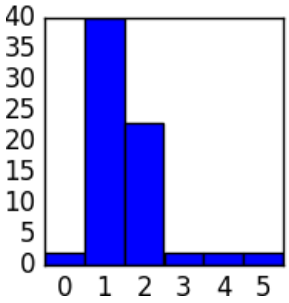
Figure 65: Mimeo Reanimator Hulk

A.24 Momir Hackball: http://tappedout.net/mtg-decks/hackball-momir-vig-primer-wip

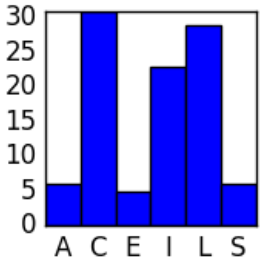
Author: AverageDragon (http://tappedout.net/users/AverageDragon)
Commander(s): Momir Vig, Simic Visionary
Color: UG (U: 32 45.7% G: 38 54.3%)
CMC: 1.55



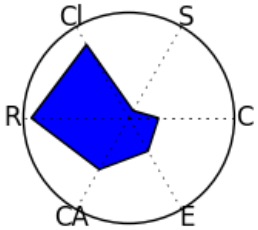
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



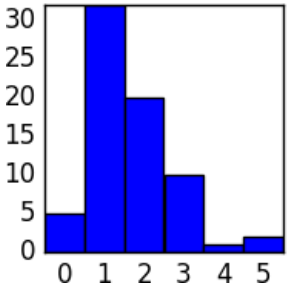
(d) M2 Index Spider Chart

Figure 66: Momir Hackball

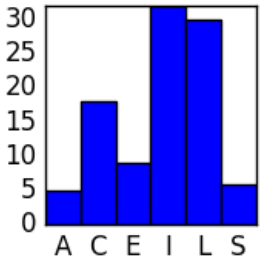
A.25 Najeela Tempo: http://tappedout.net/mtg-decks/najeela-tempo

Author: tw0handt0uch (http://tappedout.net/users/tw0handt0uch)
Commander(s): Najeela, the Blade-Blossom
Color: WUBRG (W: 9 11.2% U: 24 30.0% B: 18 22.5% R: 4 5.0% G: 25 31.2%)
CMC: 1.66

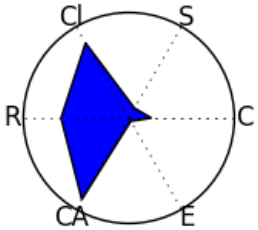
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



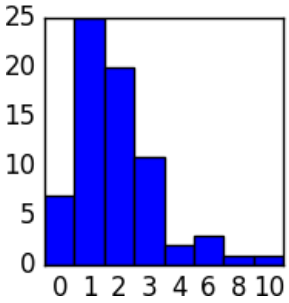
(d) M2 Index Spider Chart

Figure 67: Najeela Tempo

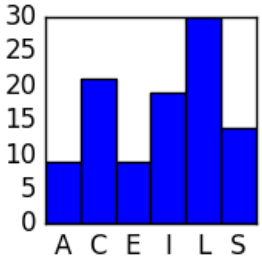
A.26 Nooze Reanimator: http://tappedout.net/mtg-decks/4c-necrotic-ooze-brewsday-112216

Author: infiniteimoc (http://tappedout.net/users/infiniteimoc)
Commander(s): Thrasios, Triton Hero, Vial Smasher the Fierce
Color: UBRG (U: 24 30.4% B: 25 31.6% R: 8 10.1% G: 22 27.8%)
CMC: 2.03

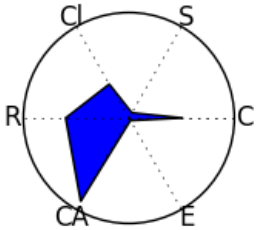
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

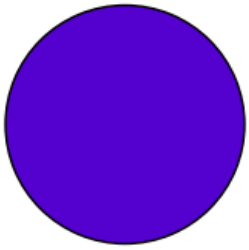


(d) M2 Index Spider Chart

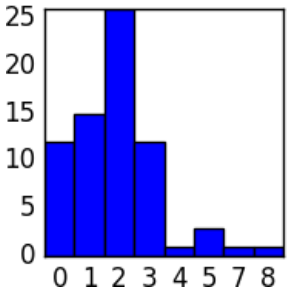
Figure 68: Nooze Reanimator

A.27 Paradox Arcum: http://tappedout.net/mtg-decks/03-02-17-paradox-arcum

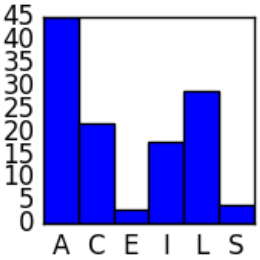
Author: LabManiac_Sigi (http://tappedout.net/users/LabManiac_Sigi)
Commander(s): Arcum Dagsson
Color: U (U: 34 100.0%)
CMC: 1.93



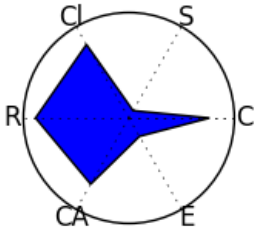
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



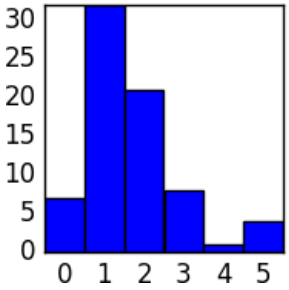
(d) M2 Index Spider Chart

Figure 69: Paradox Arcum

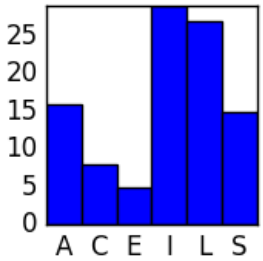
A.28 Paradox Scepter Storm: http://tappedout.net/mtg-decks/thrasios-eggs-prototype-copy

Author: Lilbrudder (http://tappedout.net/users/Lilbrudder)
Commander(s): Thrasios, Triton Hero, Vial Smasher the Fierce
Color: UBRG (U: 26 36.6% B: 23 32.4% R: 9 12.7% G: 13 18.3%)
CMC: 1.67

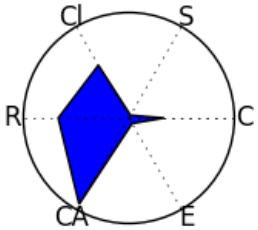
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

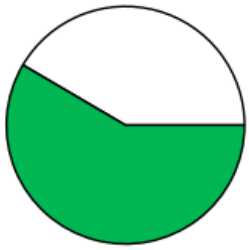


(d) M2 Index Spider Chart

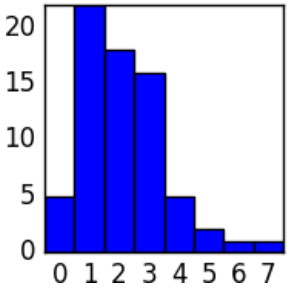
Figure 70: Paradox Scepter Storm

A.29 Paradox Sisay: http://tappedout.net/mtg-decks/sisay-staxcombo

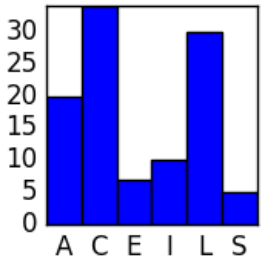
Author: biopouvoir (http://tappedout.net/users/biopouvoir)
Commander(s): Captain Sisay
Color: WG (W: 27 41.5% G: 38 58.5%)
CMC: 2.13



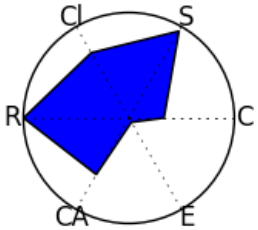
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

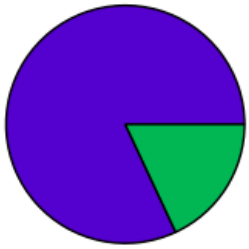


(d) M2 Index Spider Chart

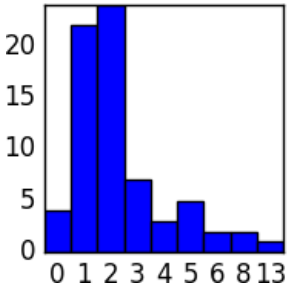
Figure 71: Paradox Sisay

A.30 Rashmi Control: http://tappedout.net/mtg-decks/06-12-17-rashmi-turns-copy

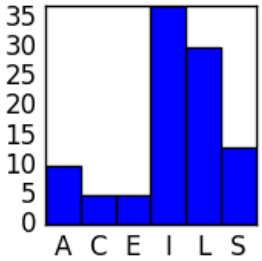
Author: asm (http://tappedout.net/users/asm)
Commander(s): Rashmi, Eternities Crafter
Color: UG (U: 59 81.9% G: 13 18.1%)
CMC: 2.41



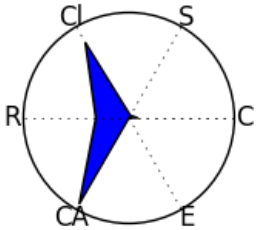
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

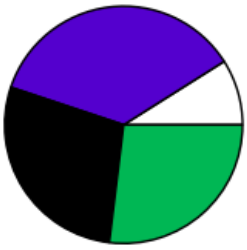


(d) M2 Index Spider Chart

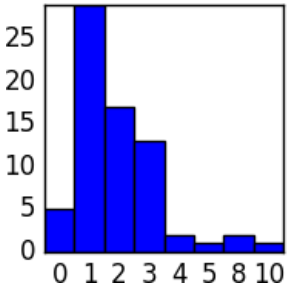
Figure 72: Rashmi Control

A.31 Razakats: http://tappedout.net/mtg-decks/razakats

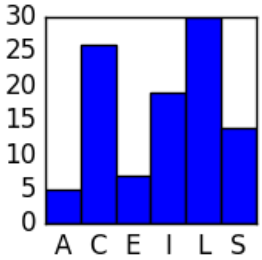
Author: ShaperSavant (http://tappedout.net/users/ShaperSavant)
Commander(s): Thrasios, Triton Hero, Tymna the Weaver
Color: WUBG (W: 7 9.0% U: 28 35.9% B: 22 28.2% G: 21 26.9%)
CMC: 2.01



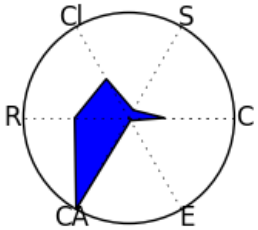
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

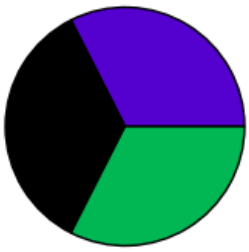


(d) M2 Index Spider Chart

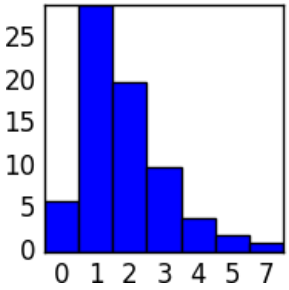
Figure 73: Razakats

A.32 SBT Grave Combos: http://tappedout.net/mtg-decks/a-heart-three-sizes-too-small-turn-1-win-copy

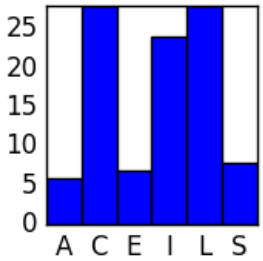
Author: Lilbrudder (http://tappedout.net/users/Lilbrudder)
Commander(s): Sidisi, Brood Tyrant
Color: UBG (U: 25 32.5% B: 27 35.1% G: 25 32.5%)
CMC: 1.83



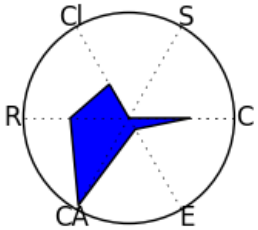
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

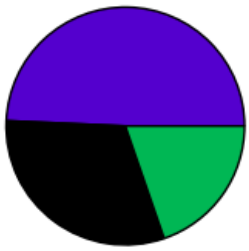


(d) M2 Index Spider Chart

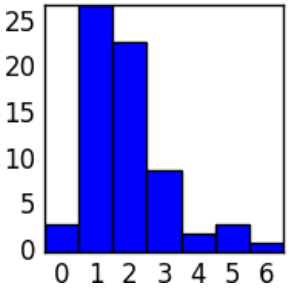
Figure 74: SBT Grave Combos

A.33 Scepter Control: http://tappedout.net/mtg-decks/20-04-17-scepter-control

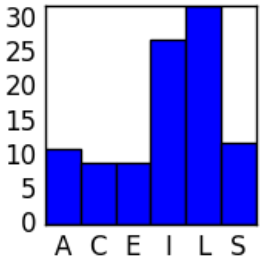
Author: ShaperSavant (http://tappedout.net/users/ShaperSavant)
Commander(s): Tasigur, the Golden Fang
Color: UBG (U: 35 49.3% B: 22 31.0% G: 14 19.7%)
CMC: 1.90



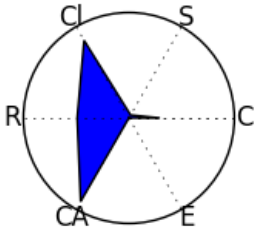
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

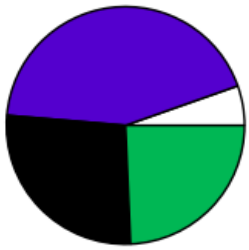


(d) M2 Index Spider Chart

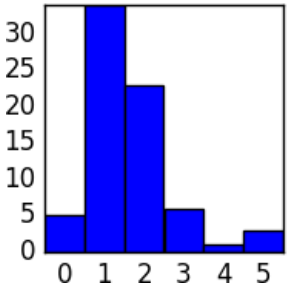
Figure 75: Scepter Control

A.34 Scepter Thrasios: http://tappedout.net/mtg-decks/paradox-scepter-thrasios-1

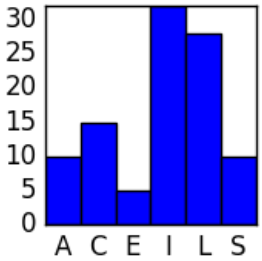
Author: AlwaysSleepy (http://tappedout.net/users/AlwaysSleepy)
Commander(s): Thrasios, Triton Hero, Tymna the Weaver
Color: WUBG (W: 4 5.4% U: 32 43.2% B: 20 27.0% G: 18 24.3%)
CMC: 1.62



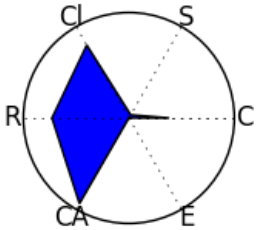
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



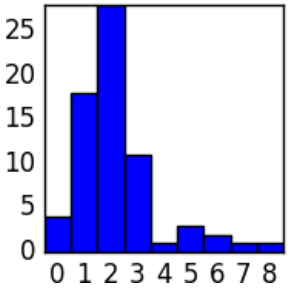
(d) M2 Index Spider Chart

Figure 76: Scepter Thrasios

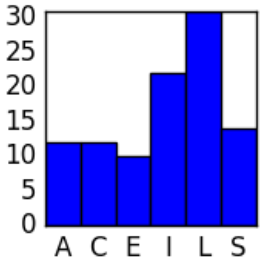
A.35 Seasons Pastigur: http://tappedout.net/mtg-decks/tasigur-seasons-past-season-pastigur

Author: LabManiac_Cameron (http://tappedout.net/users/LabManiac_Cameron)
Commander(s): Tasigur, the Golden Fang
Color: UBG (U: 33 41.8% B: 24 30.4% G: 22 27.8%)
CMC: 2.22

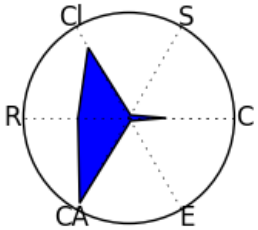
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

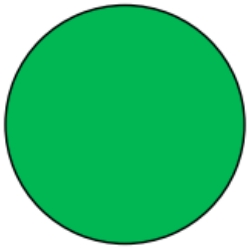


(d) M2 Index Spider Chart

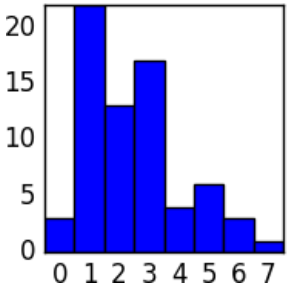
Figure 77: Seasons Pastigur

A.36 Selvala Brostorm: http://tappedout.net/mtg-decks/selvala-brostorm

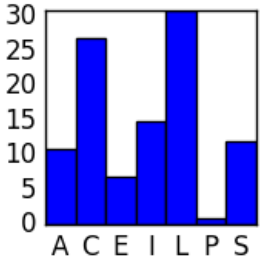
Author: asm (http://tappedout.net/users/asm)
Commander(s): Selvala, Heart of the Wilds
Color: G (G: 78 100.0%)
CMC: 2.46



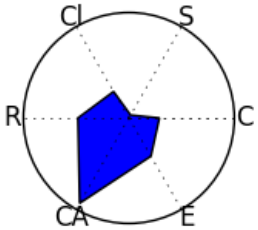
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

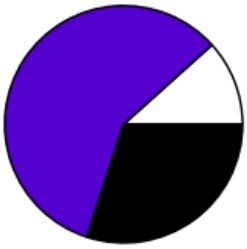


(d) M2 Index Spider Chart

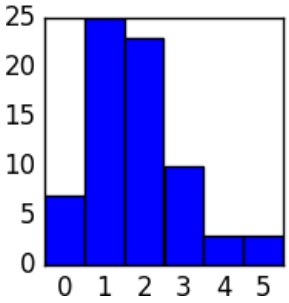
Figure 78: Selvala Brostorm

A.37 Shimmer Zur: http://tappedout.net/mtg-decks/ad-nauseam-doomsday-zur-2

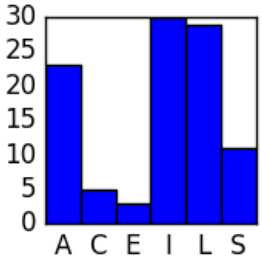
Author: Bolsheviktory (http://tappedout.net/users/Bolsheviktory)
Commander(s): Zur the Enchanter
Color: WUB (W: 7 11.7% U: 35 58.3% B: 18 30.0%)
CMC: 1.80



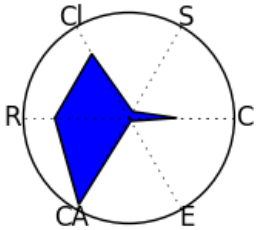
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



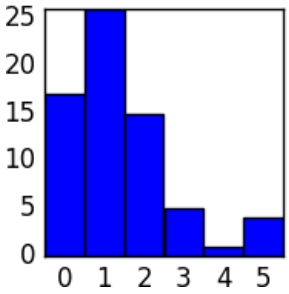
(d) M2 Index Spider Chart

Figure 79: Shimmer Zur

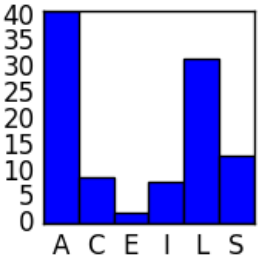
A.38 Sidisi Ad Naus Fishbowl: http://tappedout.net/mtg-decks/sidisis-reign-of-filth

Author: Nakhla (http://tappedout.net/users/Nakhla)
Commander(s): Sidisi, Undead Vizier
Color: B (B: 30 100.0%)
CMC: 1.40

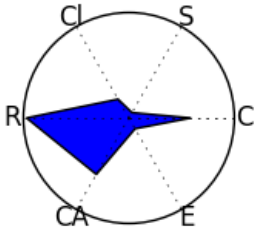
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



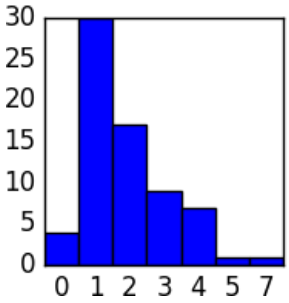
(d) M2 Index Spider Chart

Figure 80: Sidisi Ad Naus Fishbowl

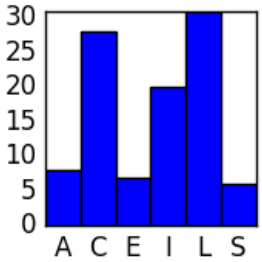
A.39 T&T Hulkball: http://tappedout.net/mtg-decks/tymna-tana_the-burlap-sack_threaten-copy-1

Author: tw0handt0uch (http://tappedout.net/users/tw0handt0uch)
Commander(s): Tana, the Bloodsower, Tymna the Weaver
Color: WBRG (W: 15 17.9% B: 26 31.0% R: 9 10.7% G: 34 40.5%)
CMC: 1.90

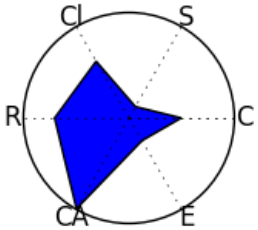
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



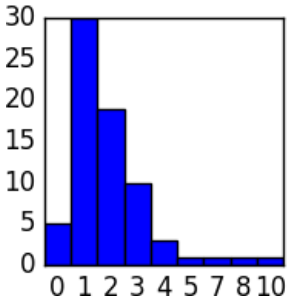
(d) M2 Index Spider Chart

Figure 81: T&T Hulkball

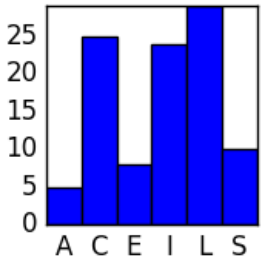
A.40 Tazri Hulk: http://tappedout.net/mtg-decks/relic-seeker-raza-hulk

Author: ShaperSavant (http://tappedout.net/users/ShaperSavant)
Commander(s): Thrasios, Triton Hero, Tymna the Weaver
Color: WUBG (W: 9 11.4% U: 25 31.6% B: 22 27.8% G: 23 29.1%)
CMC: 1.97

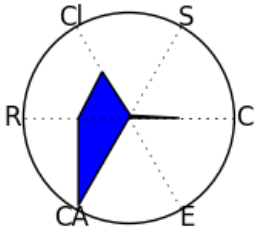
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram

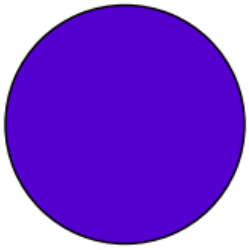


(d) M2 Index Spider Chart

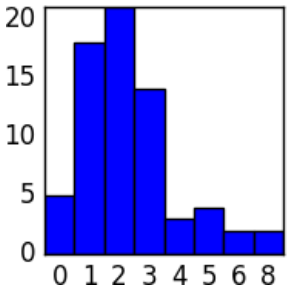
Figure 82: Tazri Hulk

A.41 Teferi Chain Veil: http://tappedout.net/mtg-decks/chain-veil-teferi

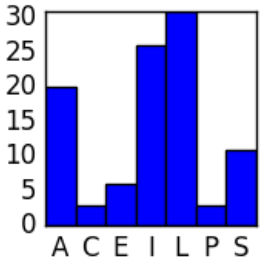
Author: LabManiac_Sigi (http://tappedout.net/users/LabManiac_Sigi)
Commander(s): Teferi, Temporal Archmage
Color: U (U: 61 100.0%)
CMC: 2.35



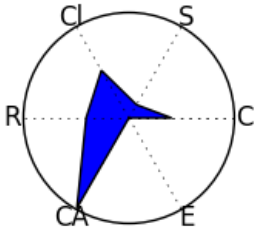
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



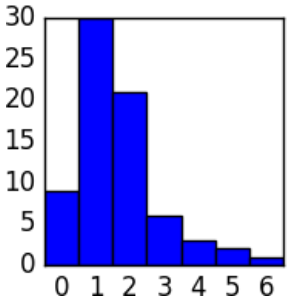
(d) M2 Index Spider Chart

Figure 83: Teferi Chain Veil

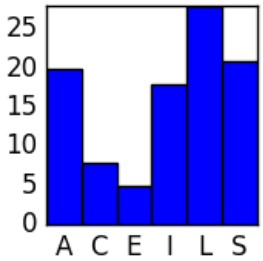
A.42 Yidris Melt Banana: http://tappedout.net/mtg-decks/melt-banana

Author: JimWolfie (http://tappedout.net/users/JimWolfie)
Commander(s): Yidris, Maelstrom Wielder
Color: UBRG (U: 17 26.6% B: 25 39.1% R: 8 12.5% G: 14 21.9%)
CMC: 1.64

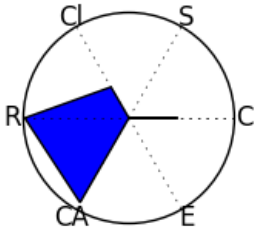
(a) Mana Pie



(b) CMC Histogram



(c) Card Type Histogram



(d) M2 Index Spider Chart

Figure 84: Yidris Melt Banana

Appendix B Additional Charts and Graphics

B.1 Similarity by Cards

Figure 85 shows a heatmap of the similarity of the cEDH decks to each other in terms of the number of cards they have in common.

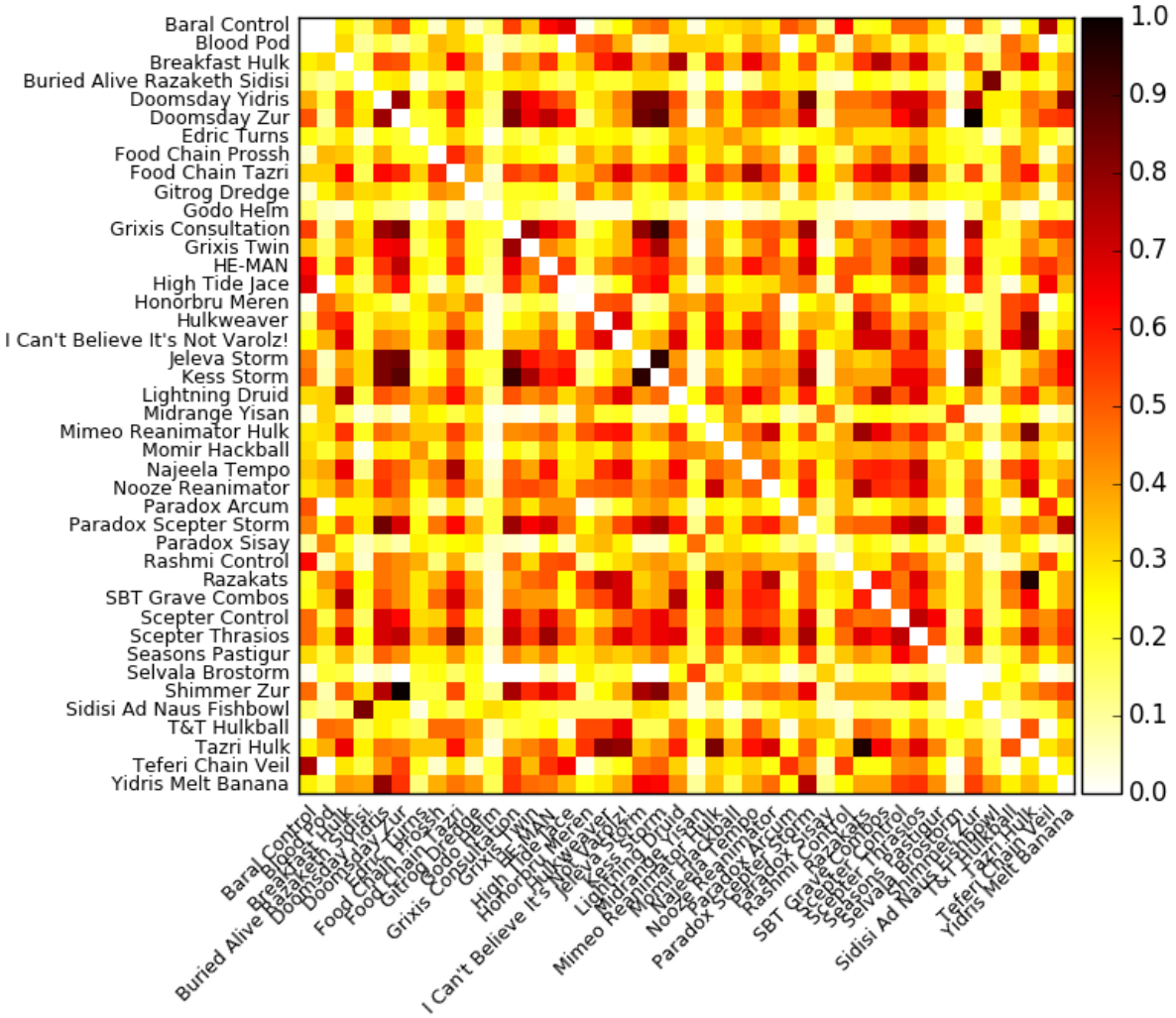


Figure 85: Similarity Heatmap

B.2 Normalized M2 Indexes

Table 14 lists the normalized M2 Indexes for the surveyed cEDH decks.

#	Deck	Combo	Stax	Control	Ramp	CA	Enable
1	Baral Control	0.34	0.15	0.69	0.01	0.80	0.00
2	Blood Pod	0.35	0.99	0.18	0.11	0.31	0.32
3	Breakfast Hulk	0.66	0.00	0.67	0.12	0.66	0.00
4	Buried Alive Razaketh Sidisi	1.00	0.05	0.09	0.69	0.52	0.31
5	Doomsday Yidris	0.49	0.05	0.36	0.49	0.75	0.00
6	Doomsday Zur	0.41	0.05	0.53	0.28	0.71	0.00
7	Edric Turns	0.00	0.10	1.00	0.14	0.18	0.77
8	Food Chain Prossh	0.45	0.10	0.15	0.49	0.68	0.22
9	Food Chain Tazri	0.49	0.00	0.44	0.41	0.57	0.22
10	Gitrog Dredge	0.56	0.05	0.30	0.81	0.46	0.17
11	Godo Helm	0.57	0.41	0.27	0.82	0.00	0.39
12	Grixis Consultation	0.42	0.10	0.68	0.13	0.74	0.00
13	Grixis Twin	0.44	0.10	0.44	0.10	1.00	0.08
14	HE-MAN	0.37	0.34	0.57	0.16	0.61	0.00
15	High Tide Jace	0.52	0.00	0.62	0.06	0.85	0.00
16	Honorbru Meren	0.61	0.41	0.09	0.24	0.70	0.31
17	Hulkweaver	0.55	0.40	0.25	0.13	0.78	0.00
18	I Can't Believe It's Not Varolz!	0.54	0.05	0.28	0.21	0.80	0.30
19	Jeleva Storm	0.49	0.05	0.49	0.24	0.78	0.15
20	Kess Storm	0.49	0.05	0.61	0.24	0.78	0.00
21	Lightning Druid	0.49	0.00	0.49	0.20	0.61	0.37
22	Midrange Yisan	0.27	0.48	0.33	0.54	0.24	0.24
23	Mimeo Reanimator Hulk	0.55	0.05	0.55	0.13	0.71	0.00
24	Momir Hackball	0.25	0.10	0.54	0.51	0.13	0.67
25	Najeela Tempo	0.21	0.15	0.68	0.30	0.53	0.08
26	Nooze Reanimator	0.72	0.10	0.25	0.44	0.78	0.08
27	Paradox Arcum	0.75	0.10	0.54	0.47	0.27	0.37
28	Paradox Scepter Storm	0.40	0.05	0.47	0.44	0.70	0.15
29	Paradox Sisay	0.25	1.00	0.34	0.44	0.10	0.08
30	Rashmi Control	0.08	0.05	0.94	0.00	0.82	0.00
31	Razakats	0.46	0.15	0.34	0.30	0.89	0.08
32	SBT Grave Combos	0.74	0.00	0.19	0.28	0.71	0.29
33	Scepter Control	0.35	0.05	0.84	0.19	0.67	0.00
34	Scepter Thrasios	0.41	0.05	0.65	0.41	0.57	0.00
35	Seasons Pastigur	0.43	0.05	0.74	0.18	0.69	0.08
36	Selvala Brostorm	0.34	0.05	0.08	0.18	0.69	1.00
37	Shimmer Zur	0.50	0.10	0.54	0.38	0.59	0.07
38	Sidisi Ad Naus Fishbowl	0.83	0.10	0.00	1.00	0.41	0.31
39	T&T Hulkball	0.47	0.15	0.34	0.27	0.51	0.46
40	Tazri Hulk	0.66	0.05	0.45	0.25	0.84	0.00
41	Teferi Chain Veil	0.56	0.25	0.48	0.14	0.87	0.00
42	Yidris Melt Banana	0.57	0.00	0.15	0.88	0.68	0.00

Table 14: Normalized M2 Index

Appendix C Other Deck Comparisons

This section outlines our initial attempts to visualize cEDH decks with the aim of categorization and comparison. Due to the large number of data points, each deck is numbered. The numbering

scheme is shown in Table 15.

1 Baral Control	2 Blood Pod	3 Breakfast Hulk
4 Buried Alive Razaketh Sidisi	5 Doomsday Yidris	6 Doomsday Zur
7 Edric Turns	8 Food Chain Prossh	9 Food Chain Tazri
10 Gitrog Dredge	11 Godo Helm	12 Grixis Consultation
13 Grixis Twin	14 HE-MAN	15 High Tide Jace
16 Honorbru Meren	17 Hulkweaver	18 I Can't Believe It's Not Varolz!
19 Jeleva Storm	20 Kess Storm	21 Lightning Druid
22 Midrange Yisan	23 Mimeo Reanimator Hulk	24 Momir Hackball
25 Najeela Tempo	26 Nooze Reanimator	27 Paradox Arcum
28 Paradox Scepter Storm	29 Paradox Sisay	30 Rashmi Control
31 Razakats	32 SBT Grave Combos	33 Scepter Control
34 Scepter Thrasios	35 Seasons Pastigur	36 Selvala Brostorm
37 Shimmer Zur	38 Sidisi Ad Naus Fishbowl	39 T&T Hulkball
40 Tazri Hulk	41 Teferi Chain Veil	42 Yidris Melt Banana

Table 15: Deck Numbering

C.1 5 Feature Visualization

At first, excluding Enable, we defined each deck as a 5-dimensional point:

$$Deck_i = (x_i, y_i, z_i, r_i, c_i) \tag{11}$$

where i is the current deck, x is the (normalized) Combo Index, y is the (normalized) Stax Index, z is the (normalized) Control Index, r is the (normalized) Ramp Index, c is the (normalized) CA Index. Then, the 5-d points were mapped to 3-dimensional space (x, y, z) where the x-axis is Combo, the y-axis is Stax and the z-axis is Control. Adding the Ramp Index as a variation of the marker size and the CA Index as a variation of the marker color "teases" out further information about the decks as shown in Figure 86.

Unfortunately, even with only 42 decks, the number of decks "near" each other and the number of factors plotted makes the visualization difficult/impossible to read. The decks Buried Alive Razaketh Sidisi, #4 and Sidis Ad Naus Fishbowl, #38 could be defined as Combo decks. Decks Edric Turns, #7 and Rashmi Control, #30 could be defined as Control decks and decks Blood Pod, #2 and Paradox Sisay, #29 are clearly Stax decks. Aside from these 6 decks though, the other 36 decks cannot be easily tagged as a specific Archetype. Furthermore, there appears to be an epicenter, where a large number of decks cluster. This point, $(0.5, 0.05, 0.4)$, shows the current trend of cEDH decks. Decks are being constructed with equal parts Combo and Control with some Stax elements. In other words, a large number of the surveyed decks are interactive and win by comboing. The decks ramp and CA indexes differ but, although difficult to see, most decks[34] ranged from "Green" to "Purple" (high CA Index) and varied in terms of ramping.

[34]Godo Helm being mono-red had the least CA.

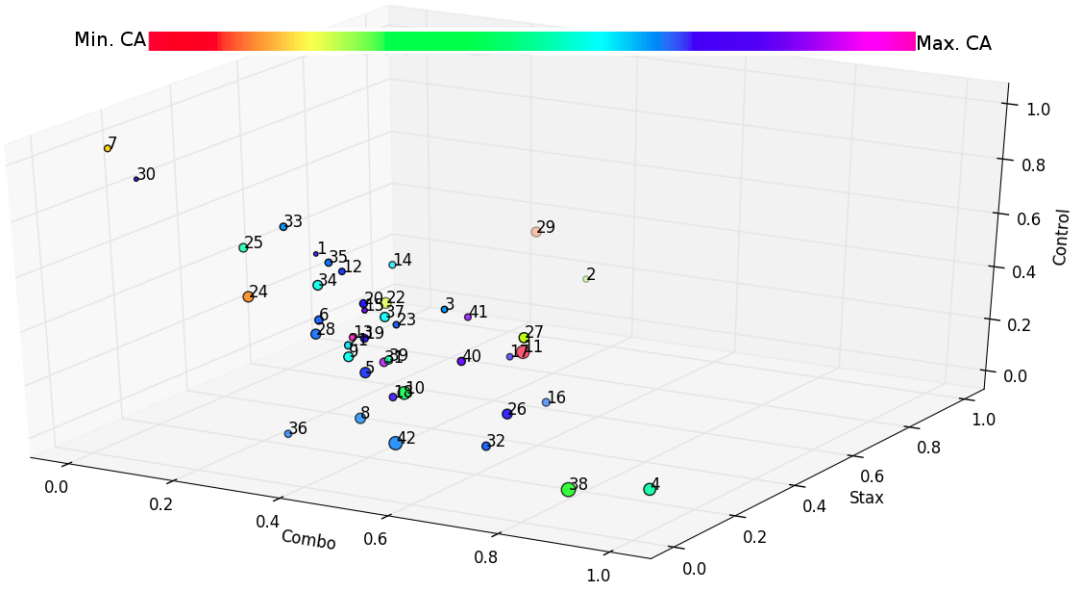


Figure 86: 5-Feature Visualization

C.2 3 Factor Visualization

Due to the issues of visualization arising from the number of decks and their tendency to cluster, we decided to look only at thre features in this section. Removing ramp and CA, each deck is defined as a 3-dimensional point

$$Deck_i = (x_i, y_i, z_i) \tag{12}$$

where, as in the previous section, the x-axis is Combo, the y-axis is Stax and the z-axis is Control. This change still did nothing to make the visualization easy to read and therefore k-means clustering was used in an attempt to (a) make visualization easier on the eye and to (b) identify a set of clusters that decks "gravitate" towards. After clustering, it might then be possible to identify new Archetypes based on the center point of these clusters.

Figure 87 show the results. By minimizing clutter through clustering, Figure 87 is easier to read albeit at the expense of losing two factors (Ramp and CA). As before, the outliers at what could be called "pure" Combo (#4, #38), "pure" Control (#7, #20) and "pure" Stax (#2, #29) remain. There are also seven singleton decks: Selvala Brostorm, Food Chain Prossh, Yidris Melt Banana, SBT Grave Combos, Nooze Reanimator, Honorbru Meren and Midrange Yisan.

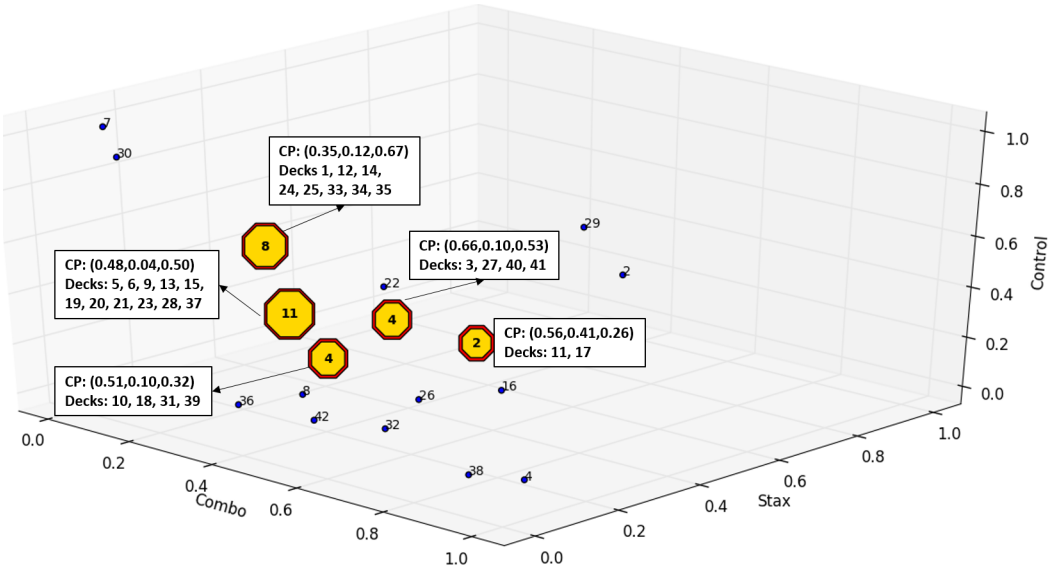


Figure 87: 3-Dimensional Archtype

Appendix D Data

Links to the raw data is listed below.

Section 2 Holistic: Decks

(1) **sbs**: is the Side by Side Deck comparison used in Table 1 and Table 2 and can be downloaded at `https://docs.google.com/spreadsheets/d/1dR27duzYbcefQ-XcV_Sx4x8Ya1Wb5ntZ1Y1iOn78iyc/edit?usp=sharing`

(2) **similarity-nonland**: is the Similarity matrix used to derive Figure 85. The spreadsheet contains the number of cards that each deck has in common with the other decks. It can be downloaded at `https://docs.google.com/spreadsheets/d/1-HhPjWCRNOw4CZ-jIjhfSWbvgCvgJ1VrXGyRlBBivJM/edit?usp=sharing`

Section 3 Individual: Decks

(1) **cardhist**: is a spreadsheet of each card (excluding basic Lands) along with the number of times it appears in a deck and the decks it appears in. It can be downloaded at `https://docs.google.com/spreadsheets/d/1-wwm4LcKbX6QNSzyaEyX4cxQGnxSgt96iiW43-bF_5w/edit?usp=sharing`

(2) **cardhist-bycolor**: contains six tabs, one for each color and one for colorless (Note: that these do not contain mult-colored cards). This spreadsheet was used to compile the top 15 in Figures 5 through 7 in Section 3.1. It can be downloaded at `https://docs.google.com/spreadsheets/d/1jEfNyN8-o1UMNzP1OQwuckArTj-cr8xa_GYW6xzyT9Y/edit?usp=sharing`

(3) **cardhist-bycolor-gold**: contains gold cards used in Section 3.2. It can be downloaded at `https://docs.google.com/spreadsheets/d/1R1ZWYBp96YpHDKsRmskB5PFbVH-qMMWoVpI3YD5I6k4/`

edit?usp=sharing

(4) **cardhist-multmana**: contains all multiple mana cards and was used in Section 3.2 to compile Figure 8. Includes the card name, card count, and casting cost. It can be downloaded at https://docs.google.com/spreadsheets/d/1fWf3IPk5xyMHknIQ45VsHbZemdEHzC90d3y5dokFX5Q/edit?usp=sharing

(5) **cardhist-bytype**: contains tabs for each card type. The spreadsheet was used in Section 3.4 to compile Figures 9 through 14. It can be downloaded at https://docs.google.com/spreadsheets/d/1mTk17NTu3PtqXRF5Pmxcxd_Lm9Qay_6AUbfzq8sFAc8/edit?usp=sharing

(6) **pairings**: is the result of a failed attempt to identify synergies amongst cards by enumerating the cards (and count) that appeared in decks with each other card. For example, given the card Isochron Scepter, we would expect to see a lot of Dramatic Reversals. Unfortunately the staples made such an endeavor fruitless (for now). This data file is included for interested readers. It can be downloaded at https://docs.google.com/spreadsheets/d/1p7rFkKnn8Ccz1cwt7V6QLjnukYif2f8LUvJ7ZqodyU0/edit?usp=sharing

Section 4 Visualizing, Comparing and Categorizing cEDH

(1) **m2**: contains the M2 Indexes and can be downloaded at https://docs.google.com/spreadsheets/d/1ZvD_Co_rTybIASzbFbaLUGrfcUIbrxG4_hnIrkG0ygQ/edit?usp=sharing. The M2 Index data requires additional attention.

Table 16 shows a sample set of the M2 Index data. Some cards like Blind Obedience have multiple Methods, some cards like Karmic Guide have a Method(s) and a Mode(s) and some cards like Phyrexian Soulgorger currently have no annotations.

Card	Method	Mode	Value
Karmic Guide	Combo	CA	Recursion,Put-Into-Play
Hope of Ghirapur	Control		
Frantic Search		CA	Draw,Pays-For-Self
Body Snatcher			Put-Into-Play
Songs of the Damned		Ramp	Ritual
Cursed Totem	Stax		Abilities-Hate
Phyrexian Soulgorger			
Blind Obedience	Stax,Combo		Life-Gain,Life-Loss

Table 16: Sample M2 Index Data

Astute readers will notice two things: (1) the additional column Value was not mentioned in Section 4.1 and (2) Mode enable is not present in the data. The Value column plays two roles that address these "concerns". Value is used to define what the card does and/or provide additional details as to the cards "sub-type". For example, Cursed Totem is categorized as stax with the value "Abilities-Hate" (.i.e. what it does) and Songs of the Damned is categorized as ramp with the value "Ritual" (its sub-type). Value is also used to determine if a card is an enable card. We make the assumption here that cards will not be present in a cEDH deck for no reason and therefore, if a card does not

have a Method or Mode it must be an enable card i.e. Body Snatcher and Phyrexian Soulgorger[35].

To calculate the M2 Index for a deck, each non-land card was queried against the M2 data and a running total of methods and modes was updated as necessary. A deck containing the eight cards in Table 16 would have the following counts: 2x combo, 2x stax, 1x control, 1x ramp, 2x CA, and 2x enable. Once all the cards in the deck are queried, the counts are divided by the total number of non-lands cards in order to derive the indexes or M2 Index for the deck.

In the concluding remarks, we identified two improvements: (1) further breaking down what cards do and (2) getting a consensus on the card's categorization.

In order to realize #1, two things must occur. First, a standardized set of annotations for the Value column needs to be derived. This will facilitate the programmatic parsing and processing of cards, providing the capability to separate cards not only by Method but by sub-method i.e divide stax cards into GY hate, cost increaser, untap-hate etc. Second, the M2 data needs to be redone, re-tagging cards as necessary, following the standard annotations and filling in blanks such as the Value for Hope of Ghirapur and Phyrexian Soulgorger in Table 16. This process will occur after the release Ravnica Allegiance and subsequent re-parsing of cEDH decks.

For #2, the help of the cEDH community is needed to gain agreement from cEDH experts on the card categorizations.

[35]Ideally, all cards will have, at a minimum, a Value. At present though, it was not necessary for the SOM