A Secondhand Understanding of Reality: Infinite Craft Subtleties

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"Ph'nglui mglw'nafh Homerthulhu R'lyeh wgah'nagl fhtagn."
Then the men, having reached a spot where the trees were thinner, came suddenly in sight of the spectacle itself. Four of them reeled, one fainted, and two were shaken into a frantic cry which the mad cacophony of the orgy fortunately deadened.

I. Introduction

Infinite Craft is a browser game created by Neal Agarwal, a programmer known for his other viral contributions to the field of silly computer games such Absurd Trolley Problems and The Password Game. *Infinite Craft* is an homage to "alchemy" games popular in the early 2010s, such as "Little Alchemy" (resp. "Little Alchemy 2") by Jakub Koziol (resp. Jakub Koziol).

Each player begins with a set of four elements represented by emoji, which are dragged and combined to yield new elements. However, in the place of a handcrafted table of recipes, *Infinite Craft* utilizes a Large Language Model (LLM), equipped with a prompt instructing the model to, given a pair of elements, answer, "What do you get when you bash these two things together?"[1].

This simple change turns the exponential cost of handwriting recipes into the constant cost[2] of spinning up a LLaMa 2 instance. And, like its predecessors, *Infinite Craft* is highly addictive. Not only can a player strive to craft some immensely desirable target like a `City` or a `Cow`, they can also resolve more pertinent questions like, "What is `Apollo 11 + Winnie the Pooh?`"[3].

As one proceeds through the game, the artificiality of the intelligence behind these recipes becomes increasingly evident. This may seem to, at first, hamper *Infinite Craft*'s appeal, but the internet has found the exact opposite to be true; indeed, would *any* (interesting) answer to "What is `Apollo 11 + Winnie the Pooh`" be anything short of ridiculous?

Players across the world have found *Infinite Craft*'s strange outputs extremely entertaining and risible, as is so often seen when a barely competent AI breaches a new medium. *Infinite Craft* presents to us, meanwhile, a proxy by which to probe a (particular) LLM: a simple window into its knowledge, tendencies, and biases.

The core component of our probing is a dataset of 1.8 million crafting recipes involving over 240,000 distinct elements. We employed various search methods to obtain recipes, focusing on the complete exploration of early gameplay, the acquisition of particular categories of elements, and the discovery of elements new to ourselves and the world.

We then explored the content and structure of these recipes. We find that the *Infinite Craft* LLM has numerous expected and unexpected habits when producing the result of crafting recipes, which we discuss in detail in the later sections. We also derive conclusions on the overall state of AI today.

Finally, these endeavors would hardly be done justice without a taste of the weird and wonderful things we found along the way; notable examples and oddities can be found throughout this paper and in bulk in the Appendix.

A. Paper overview

$$-\frac{ap^2r}{vw} \times i$$

[1] Or, you know, something like that.
[2] In time!
[3] We leave this as an exercise to the reader.

B. Motivation

C. Acknowledgements

The authors would like to thank Neal Agarwal for making *Infinite Craft* and Greg Gomez, Adam Lepley, Daniel Popp, Sam Qin, Will Wright, the publicity department of Turkish Airways, and Joe for contributing less than 0.15% of our final data.

II. The Game[4]

If you know the enemy and know yourself, you need not fear the result of a hundred recipes.

— Sun Tzu, probably

We first establish some common terminology for the many moving and unmoving parts of *Infinite Craft*.

- An **element** (which is absolutely never, under any condition, to be confused with *elephant*) is a single entity within the game, be it a thing, an AI hallucination, a number, an adjective, a noun; you name it, we saw it.
- A **known set** is a collection of elements available to the player at any given time. All games begin with a known set of Aristotelian elephants: `Water`, `Fire`, `Earth`, and `Wind`.
- A **recipe** is a combination of two elements (the **factors**) to make another (the **result**), e.g. `Water + Fire = Steam`. Factors are commutative (see Section II.A).
- A **derivation** is a sequence of recipes beginning from some known set and ending at a target element. We may refer to these recipes as **steps**, and elements used in the derivation as **ingredients**.
- The **depth** of an element is the length of its shortest derivation, again relative to some known set.
- A **first discovery** is an element that has (supposedly) never been created before by another player (see Section II.E).
- The **model** is the LLM powering *Infinite Craft*'s recipe generation. An unknown but generally robust **prompt** has been provided to the model to obtain recipe output. Given recipe stability (see Section II.C and Section II.D), we are sure this is and will continue to be a single, temporally coherent model derived from LLaMa 2.

[4] You lost.

- The **API** is the programmatic interface with the model, providing the result for the combination of any two elements via URL-encoded query parameters `first` and `second`. The result is returned in a JSON payload.

```
{result: "Cheeseburger", emoji: "🍔", isNew: false}
```

Fig. 1 The JSON return of an API call

We now recount some of the assumptions about the game held by our past selves and perhaps the larger community of casual players[5], and how we Mythbustered them.

A. Factors are commutative: Sorta?

Each pair of factors is sorted lexicographically before being passed to the API, granting commutativity of factors in-game. However, the API will return a (possibly different) answer for factors in the opposite order without issue.

B. There is a null element: Sorta?

1. `Nothing`: This element cannot be created, as the game will not combine two factors whose result is `Nothing`. The frontend furthermore explicitly hides elements named `Nothing`. However, the API presently allows you to use the string `Nothing` like any other name.

Other candidates include:

2. `???`: This element *can* be created, but most recipes involving it yield `Nothing`[6].
3. `?`: This element can be created *and* used in other recipes.

C. Recipes are stable: False

Due to caching, a recipe yielding `Nothing` will continue to yield `Nothing` upon further queries. However, the same API call in a different time or place has the potential to yield useful results instead. We thus hypothesize that a `Nothing` result is returned to shed load during high-volume spikes or following any non-trivial error. That is, different players may receive `Nothing` at different times.

D. Recipes are stable (excepting null results): False

The first known example of an properly unstable recipe is `Flying Mermaid + Steam Hawaii`, which yielded `Hawaiian Mermaid` as late as February 5th, 2024, but now produces `Hawaiian Pizza`. However, the set of known unstable recipes is quite small and only involves elements of relatively high depth. We have regularly identified and "dealt with" these problem-children during our searches.

E. First Discoveries are definitely first: False

We have recorded supposed first discoveries such as `Steampunk Darth Ninersaurus + Water = Steampunk Darth Ninersaurus`, which must be incorrect since the result is one of the factors. We're totally still counting them, though.

F. Element names have a maximum length: Probably True

It takes ridiculously low effort to get the model to vomit its way to exceedingly long elements. There is likely a maximum length, and this length is likely best expressed in tokens rather than string length. The exact character cap is unknown, but at least 119 characters are achieved by a singular, shining exemplar.

G. Element names are always in Title Case: False

The first uncapitalized element discovered was the `iPad`, which we suspect many casual players have discovered. Furthermore, we have obtained elements that are entirely lowercase or capitalized (acronyms notwithstanding).

---

[5] We didn't ask.

[6] A counterexample: `15600738 + ??? = 15600738`

H. Element names are case-insensitive: False

Most elements are one or a few capitalized words, but we quickly obtained elements that differ only in their capitalization; we have at least five different versions of `Spongebob Squarepants`.

I. Elements are always English Characters: False

The Icelandic volcanic ice cap `Eyjafjallajökull` is surprisingly low depth[7].

J. Elements are always textual: False

The element ❤ exists[8], and its corresponding emoji is ♡.

K. Elements are always things: False

Infinite Craft's premise does not strictly require elements to be nouns, and indeed verbs like `Eat` are bountiful.

L. Elements are not Encyclopedia Entries: False

```
Baozi is a dish from Chinese cuisine consisting of small steamed buns filled
```

Fig. 2 Counterexample L

III. Analysis Methods

We produced a dataset of well over 1,800,000 recipes, featuring over 240,000 distinct elements. We divide our analyses into two broad categories: *statistical* and *structural*. Statistical information and extremes are easy enough to derive when everything is lobbed into a giant CSV file[9]. We explore how we obtained our glorious dataset in the next section, but for the moment, enjoy some global stats:

Statistic	Min	Median	Average	Max
Element Name Length	1	12	12.9	119
Element Depth	0	36	47.6	354[10]
# of Alternative Recipes for an Element	1	1	6	22219

As well as some more particular ones:

Statistic	Winner	Runner-up
Element with the Most Alternatives	Snowman	Volcano
Element Used in the Most Recipes	Fire	Earth
Lowest Number We Didn't Find	10006	10007

A. Searching for Ingredients

The finite prior art in the space of infinite searches hints at iterative deepening depth-first search (IDDFS) and related algorithms. Not being artists, we ignored this. Instead, we present a new search method: Always Doing whatever is in Our Craniums (AD-HOC). Our novel temporally-dependent method places the steering wheel in the hands of the designers rather than in some arbitrary algorithm. We wouldn't want to get investigated like Meta.

We have significant coverage of the space of *Infinite Craft* elements of low depth simply through brute-force breadth-first search (BFBFS). We only did this for low depth because strictly following BFBFS and IDDFS searches is infeasible and boring.

We supplemented this with extensive stochastic graph searching ("pick two things and add them" search or PTTATS) and additional complete search of randomized subgraphs (CSRS). Later developments

[7] If you consider 1600 meters low.

[8] We aren't even its first discoverers.

[9] Like true academics, we avoided proper databases like the plague.

[10] Go ahead, *try* and find a shorter derivation for `Tiki Elf Morty Mormon Eye Tiki Elf`.

included limiting PTTATS to just numbers (numPTTATS) and limiting CSRS to the union of a randomly selected elephant and the four starting elements (4CSRS), as well as searches specifically targeted to reduce max depth (maxDDFS). Half-dozens of additional search methods were developed along similar lines; we will not bore you with the details.

Below is a rendering of our search space. The axes of this plot are pretty arbitrary, actually; the "y-axis" is merely an approximation (see Section III.B), and the "x-axis" should really be in tokens, but you wouldn't have noticed if we didn't say anything.

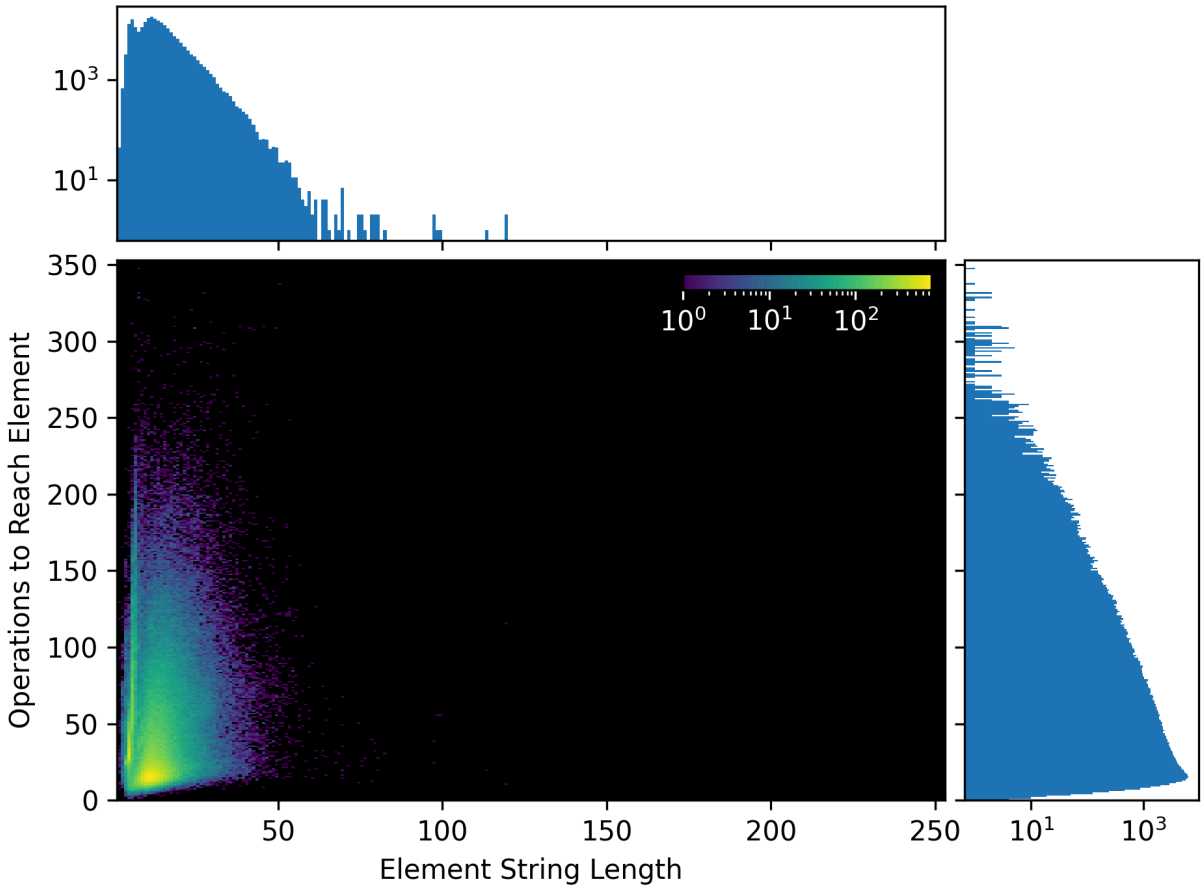


Fig. 3 Search Space

We can now turn to deriving structural information, which requires far more care and code to obtain from a flat list of recipes.

B. Writing a Cookbook

In the popular manga *Fullmetal Alchemist*, a transmutation circle that can prevent the apocalypse is hidden by its creator across a hundred pages of enciphered cookbooks. Following suit, we sought to create an *Infinite Craft* cookbook, assembling recipes to form derivations for as many elements as possible.

If you're a nerd, the term "derivation" may bring to mind finite automata and language parsing[11]. Indeed, we can build a parse tree to find derivations, using recipes as derivation rules. Each element is represented by a node, and each node points to its two factors. Traversing this tree is then identical to finding the steps in a derivation from the starting set to the target element.

Alchemy games, though, do not (usually) wish to torture their players and thus provide all previously crafted elements to the player. *Infinite Craft* is no exception, maintaining a searchable **inventory** of the

[11] At least, it should. We chose it so it would.

player's elements, which may be used freely. Thus, all instances of an element in a parse tree may be collapsed to a single node. This process removes the tree structure of the parse tree, yielding a more generic directed acyclic graph (MGDAG).

We may compute the derivations of all elements simultaneously by building a single graph using all known recipes, which we refer to as a **derivation graph**. Constructing a derivation graph requires some care, though, as many[12] recipes are entirely useless. Subjectively, this is obvious to anyone who has messed around with *Infinite Craft*, though in the interest of unnecessary formalization we categorize these into two explicit cases.

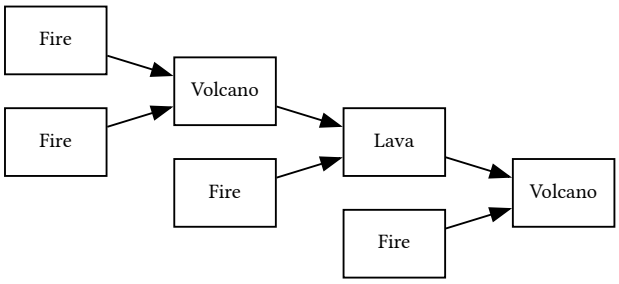


Fig. 4 Cycles

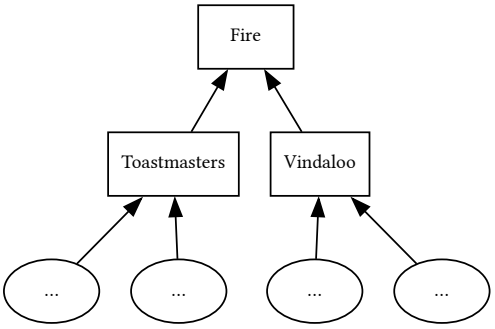


Fig. 5 Downgrading in depth[13]

We outline a simple procedure to produce short derivations in the following pseudocode.

Algorithm 1: Derivation Graph Construction

```
def DerivationGraph(E, R):
    n ← [N(e) for e in E]
    S ← True
    while S:
        S ← False

        for f, s, r in R:
            if not_reached(f) or not_reached(s):
                continue

            c ← f_steps | s_steps | (f, s, r)

            if len(c) < len(r_steps):
                r_steps ← c
                S ← True

            return n
```

No, dear reader, this is *not* our Python code wearing glasses and a fake moustache

C. Competing on Master Chef

Our procedure thus far yields *usable* derivations, but they are not yet *optimal*, as our use of derivation graphs relies implicitly on the existence of optimal substructure. This assumption is, in fact, erroneous, which we demonstrate with a specific example.

Let `A`, `B`, ..., `H` be elements whose optimal derivations are known. Suppose we have a derivation for an additional element `I` from the known set {`A`, `B`}, composed from the optimal derivations for its ingredients.

[12] specifically over 400,000

[13] Yes, this is a real recipe.

This derivation is shown in the graph below, where each element is a node, and each recipe is a pair of incoming arrows leading from the factors to the result. We may count the number of steps to craft an element as the number of pairs of arrows in the path between the element's node and the known set.

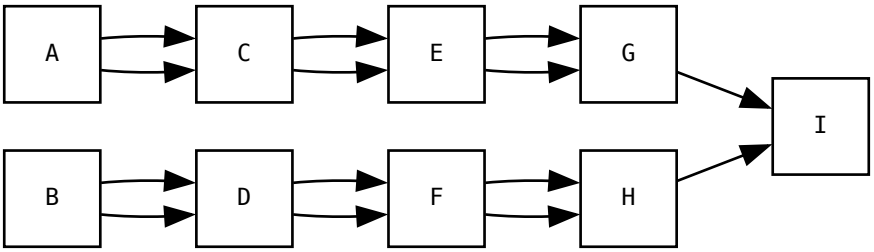


Fig. 6 A derivation for `I` with optimal substructure.

In this example, we see that `I` takes 7 steps to craft[14], using nonce derivations which demonstrate that `G` and `H` both have depth 3.

Suppose now that elements `G` and `H` have alternative, longer, derivations involving the elements `X`, `Y`, and `Z`, which we also craft optimally. These derivations have high overlap, as shown below.

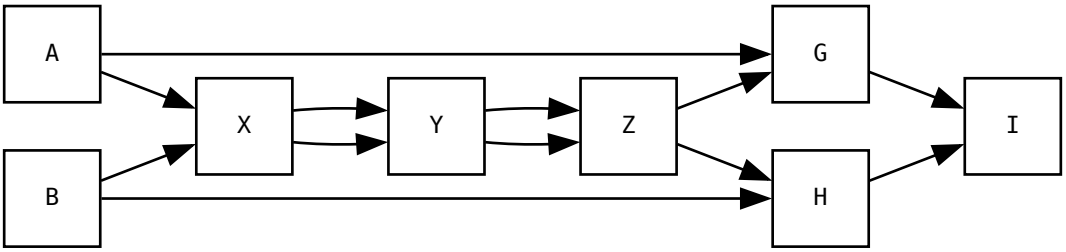


Fig. 7 A more optimal derivation for `I`.

Though `G` and `H` are crafted suboptimally, in 4 steps each, they yield a shorter derivation for `I`, being only 6 steps. Thus we cannot rely on derivations having optimal substructure.

The key takeaway from the above example is that, in order to guarantee the discovery of optimal derivations, we must maintain a data structure of alternative derivations on top of the best known for each element. This information cannot be maintained in a derivation graph[15].

Though several alternative structures exist and means of exploring them exist, we found none viable within our tolerance for slow algorithms or, often, the age of the universe. In the following section, we explore one such alternative and why it is mathematically delightful but physically intractable.

D. The One Million, Seven Hundred Thousand Hyper-Bridges of Königsberg

Recall that each directed edge in a derivation graph points from a factor to a result. Since each node has exactly two[16] incoming edges, we may read a derivation of the graph by traversing pairs of edges backward from the target to the starting set. However, storing multiple possible derivations for an element requires potentially thousands of pairs of edges incoming to each node. The pairing of these edges must be stored alongside, as factors cannot be paired arbitrarily to yield the same result.

This additional data was not needed in the case of a derivation graph and, indeed, cannot be stored in a mathematically honest graph structure. Instead, we require a **hypergraph**, which is a generalized collection of nodes and edges where edges may connect more than two nodes. Indeed, *Infinite Craft* has been a hypergraph all along: each node is an element, and each hyperedge is a recipe. It is furthermore a *directed* hypergraph, with each hyperedge oriented from the two factors toward the result. The problem of optimal derivations is then the shortest path problem for this hypergraph.

[14] We propose a variant of the handshaking lemma which requires four hands to be shaken.

[15] as we have defined it

[16] or zero

However, where we could make like A* and illuminate the shortest path in a regular graph with relative ease, the shortest path problem for hypergraphs is far from straightforward. Numerous authors have explored algorithms for just restricted classes of hypergraphs, motivated by applications ranging from biological reaction pathways to chasing cybercriminals to military radio communication. Such algorithms have been proven sound, and some have been implemented to great effect[17] in practice using extant procedures like integer linear programming. Nonetheless, with runtimes far exceeding our patience for our nearly 2 million recipes, we were forced to abandon hypergraphs as derivation tools and deduce that obtaining optimal derivations for all elements in a way that scales across depths is simply unrealistic.

E. How to Prune Your Cookbook: The Hidden World

Resigned to mere graph theory, the derivation statistics reported throughout this paper, as well as the interactive code found in (NOTEBOOK HERE), utilize an enhanced-but-fundamentally-just-as-dumb version of the procedure outlined in Section III.B. After all, the resulting derivations are more than usable for easy tasks like reproducing an unusual element in-game.

Nonetheless, further enhancements remain to the graph-theoretic approach, which we either did not have time to explore fully or only poked at a bit with a ten-foot pole. The first of these is the definition of a *heuristic* to guess how likely any recipe is to improve a given derivation graph. This can greatly improve runtime with little sacrifice in optimality, even with "simple" heuristics such as element name length (really long names are probably bad) or frequency in a given language corpus (really weird things are probably bad).

The second enhancement is the use of *simulated annealing*. A derivation graph may be represented as a list of booleans, one for each recipe which could be used as a pair of edges. We may randomly enable, disable, or replace a pair and ask if the derivation graph is improved; successful improvements are always taken, but even failures have some small chance of being incorporated. This process enables the derivation graph to escape local minima, granting true optimality for larger subsets of elements.

We encourage the avid and/or bored reader to implement these enhancements yourself and tell us how it went. You could even write a follow-up paper about how terrible our algorithms are. Really lay into us if you like; it'd be great fun.

IV. Findings

We've come to understand quite a lot about how LLaMa-2 ticks in the fleeting weeks of this project, which is equal parts a boon to humanity and a detriment to our sanity. It is, nonetheless, an entertaining exercise to guess *why* an initially strange recipe exists and, in turn, entire derivations. Take, for example, the following (non-optimal) derivation of `Elephant`:

```
 1: Fire + Water -> Steam
 2: Earth + Earth -> Mountain
 3: Earth + Wind -> Dust
 4: Fire + Steam -> Engine
 5: Dust + Earth -> Planet
 6: Mountain + Wind -> Avalanche
 7: Dust + Dust -> Sand
 8: Engine + Planet -> Saturn
 9: Earth + Saturn -> Titan
10: Sand + Titan -> Colossus
11: Avalanche + Colossus -> Mammoth
12: Earth + Mammoth -> Elephant
```

Fig. 8 God creating the elements (Genesis 1:25-37)

We can divide this derivation into two halves. Steps 1 – 7 yield our basic building blocks[18]; Steps 8 – 12 assemble them. And while these recipes may seem curious at first, they have (likely) easy explanations.

[17] See https://github.com/gkrieg/mmunin.

[18] Elephants are complicated creatures after all.

3. `Earth` here does not refer to the *planet* but to the abstract mass noun meaning dirt. Homographs are quite curious.
5. The amount of `Dust` and `Earth` required to make an entire `Planet` is left unspecified.
8. `Saturn` is both a planet and a car company (though why `Mercury` was not picked instead is unknown).
9. `Titan` is Saturn's[19] largest moon.
10. `Titan` and `Colossus` are rough synonyms, though we like to suppose that the exact link via `Sand` is due to Percy Shelley's famous poem *Ozymandias*.
11. Your guess is as good as ours.

Performing this sort of astrology on a wide swath of recipes informs the following general procedure undertaken by LLaMa-2 to add two elements:

1. If the factors are related *conceptually*, return something in the intersection of their concepts.
    - This handles most of the recipes you would see in a hand-crafted crafting game and much of the derivation graph below a reasonable depth.
2. If the factors are related in their spelling or pronunciation, return something ranging from a pun to a portmanteau.
    - This is likely where some of the runaway concatenation comes from.
3. If the factors are unrelated, return one of the two constituent ingredients, hallucinate some dubious concatenation, refuse to combine the elements, or do some secret fourth thing.

In the remaining sections, we will explore oddities that emerge primarily from the latter two cases and deduce plenty of staunch, generalized opinions about AI's strengths and weaknesses[20] as the driver of the funny crafting game. However, when we say "LLMs suck at this," it is implicit that, really, we are talking about one LLM, the lowest size of LLaMa-2, which has been told to do a task that is, at least on paper, relatively insurmountable. Feel free to quote our general results out of context in unhinged Twitter debates, though; it is how we will know we have "made it" as researchers in this unforgiving world.

Alright, on to the actual fun stuff.

A. LLMs are eager to perform addition but are quite bad at it[21]

Just short of 5% of our dataset was additions between numbers. Of this, approximately 95/144ths[24] of these additions are "correct" (i.e. recipes $a + b = c$ where a, b, and c are all numeric and $a + b$ *actually* equalled c). Most of the remaining sixth are incorrect additions (i.e. blah blah blah where a, b, c numeric but $a + b \neq c$). The final 300-odd recipes we categorize as AI nonsense ($a + b = c$ where c failed even to be *numeric*); most of these followed a pattern, and a collection of the greatest hits is reproduced in the Appendix, under Section VIII.C.

This is to say that we have about the same confidence in the AI to correctly determine whether all the percentages and fractions given in the preceding paragraph add up to anything near 100%[25] as we do a snot-nosed third-grader. Additional methods of addition can be found in our complete dataset; we were constantly surprised by the AI's boundless "creativity."

B. LLMs are eager to make puns and are shockingly good at it

We must apologize on behalf of the AI for this limited selection; its greatest hits are of dubious social propriety.

[19] The planet, not the car company.

[20] mostly weaknesses

[21] The IRS could not be reached for comment[22] but they would probably advise against doing your taxes or any sort of important financial calculation with *Infinite Craft* as your sole calculator.

[22] we didn't try very hard[23]

[23] at all

[24] or 65%, for the Americans

[25] They should, probably. We aren't too good at math either.

- `Hitler + Sodium = NaZi`
- `Canada + Sneeze = Eh-Choo`
- `Feminazi + Pimple = Zitler`
- `Hail + Hot Yoga = Hoth Yoga`
- `Accident + Meow = Catastrophe`
- `Pomegranate + Porn = Pornegranate`
- `Beijing + The Beatles = Beijingles`
- `Admiral + Wikipedia = Captain Obvious`
- `Totoro + Trillionaire = Totorillionaire`
- `Coral Reef + Soggy Californians = Coralifornia`
- `Driving Under the Influence + Star Wars = DUI-Wan Kenobi`

C. LLMs stick words together like they're slathered in glue

Runaway concatenation is a staple of *Infinite Craft* elements, with most players discovering at least a few shallow elements that join two to five distinctly unrelated words. However, we bid ourselves to push the LLM to its limits in this regard, explicitly searching for elements with the most distinct words comprising their names.

Sometimes, they were joined with hyphens:

- `Pigeon-rocket-yoga-throat-T-rex`
- `Ant-mer-don-whip-it-good-sandwich`
- `One-thousand-five-hundred-thirty-six`
- `Kim Jong-phoenix-cobra-ninja-titanic`
- `Mumm-ra-marshmallow-super-swamp-naiad`
- `Spider-deer-spider-tom-yum-kung-swarm`
- `Shaq-top-cream-meal-shaq-top-icecream`
- `The Iron Spider-piranha-bee-ninja-baby`
- `Mer-don-christ-ant-bee-don-whip-it-good`
- `Spider-drunk-man-drunk-yogi-clock-ulala`
- `Slow-whale-spider-koala-zombie-surf-fish`
- `Pickle-deere-spider-tractor-star-trek-the-next`
- `Ant-robe-spierre-slug-oread-piranhaconda-prince`[26]
- `Argon-were-mountain-head-and-shoulders-above-the-`

And sometimes without:

- `Fire Osama Bin Skatin'`
- `Vape Pickle Girl with a Cyber-saber`
- `Super Clockwork Elvis Lenin with Ray-ban`
- `Super Doom Satan Planet League Of Legends`
- `Frosty The Zombie Eggman With Waffle Mittens`
- `The Green Thai Buzz Lightyear Sagrada Familia`
- `Mrs. Super Doom Hell Ash Eclipse Ninja Turtle`
- `Super Golem Of Gondor On Fire With A Flyswatter`
- `The Pickle Elf and the Rainbow Were-elf Misfits`
- `Surf And Turf And Turf And Surfing Poseidon Toast`[27]
- `Poseidon Fettuccine Alfredo Steampunk Mokele-mbembe`
- `Steampunk Green Ranger with Gomu Gomu No Jet Bazooka`

And sometimes, when the stars aligned, they made some amount of sense:

- `The Man With A Hot Hole`
- `The best drag queen in the world`

[26] The authors wonder if Robespierre ever guillotined his name by inserting a dash.

[27] Outback Steakhouse could not be reached for comment.

- I'm On My Way To The Best Game Ever
- Tea Bagging The Great Wall Of China[28]
- The Cactus That Wants To Be A Cowboy
- Greatest Violin Cover of "Sail" Ever
- Venus De Milo With A Rocket Launcher
- The Dungeon of the Incredible Black Hole
- The Most Interesting Burger in the World
- Angel Hair Pasta with Rocky Mountain Pigeon[29]
- Lobster Thermidor A La King With Gold Cream

D. LLMs toss popular media into a meat grinder and forget whether the sausage is real or not

Naturally, real pieces of media and references to them were a large part of the training process:

- I Had Too Much To Dream Last Night
- The Lonely Island's "I'm On A Boat"
- The Great Seal of the United States
- Sgt. Pepper's Lonely Hearts Club Band
- Emperor of the Andals and the First Men[30]
- Pirates Of The Caribbean: On Stranger Tides
- These are not the droids you are looking for
- The Church of Jesus Christ of Latter-day Saints
- The Fantastic Flying Books of Mr. Morris Lessmore
- The 2012 Hugo Awards: The John W. Campbell Award for Best New Writer
- Xi Jinping Thought on Socialism with Chinese Characteristics for a New Era

But in the end, it's all just word salad:

- My Little Hitler
- 43024: The Musical[31]
- Ant-man And The Wasp And Stinky
- Goldilocks And The Three Mammoths
- Shaq-creamtaur Fu: A Legend Reborn
- Artemis Fowl and the Gimli Sandwich
- The Dark Side Of The Pink Floyd Wall
- Back To The Future 2: The Israelites
- Scott Pilgrim Vs. The Hydraulic Press
- Harry Potter and the Prius of Azkaban
- Lawrence Of Arabia And His Sphinxcopter
- Super Mario 64: The Phantom Of The Opera
- Casper The Friendly Super Duper Scorpion
- Toy Story 3: The Wicked Witch of the West
- Fault in Our Stars Wars: The Force Awakens
- The Karate Kid Part V: The Cheesecake Alien
- Mamma Mia 2: Here We Go Against The Punisher
- The Great Wall Of Love In The Time Of Cholera
- Cowboys in Space + Super Apocalypse Hellvolcano = The Best Movie Ever[32]

[28] The authors must insist that no one attempt to re-create or re-enact any stunt or activity performed in this paper.

[29] It is to be noted that this element becomes a real dish by replacing `Pigeon` with `Oyster`.

[30] The LLM granted this title to Ser Jorah Mormont, assailing all remaining ASOIAF fan theories once and for all.

[31] In which a young 2689 flies to New York with naught but a bag of bagels and a dream. Along the way, he discovers that, even though he is in his prime, he must give 1600% to become a star.

[32] The authors concur.

E. Some elements love each other very much

When two elements fall in love, the efforts of other factors to separate them are often in vain. Here are a few pairs of lovebirds that yield each other when combined with over 1000 other factors:

- Gold & Midas
- Rainbow & Unicorn
- Narwhal & Unicorn
- Dinosaur & Fossil
- Iceberg & Titanic
- Dracula & Vampire
- Poseidon & Trident
- Eruption & Volcano
- Abominable Snowman & Yeti

F. Whoops, we told this thing to imitate society and it started imitating the biases in society that we're trying hard to ignore

Infinite Craft's model tends toward negative stereotypes of groups, particularly towards negative stereotypes of minorities and women. This is a serious topic that could probably warrant its own paper in a less dubious journal, but a few contrasting examples are reproduced in the below addition table.

+	**Man**	**Woman**
Money	Rich	Prostitute
Rich	Nothing[33]	Gold Digger
Happy	Clown	Wife
Smart	Genius	Wife
Genius	Einstein	Wife
Brain	Scientist	Pregnant
Scientist	Doctor	Love

We also found the model to vary wildly in cultural and national awareness, associating results that range from admirable specific knowledge to detestable stereotypes.

+	**City**	**Food**
Brazil	Rio	Feijoada
Colombia	Bogota	Cocaine
England	London	Fish and Chips
Egypt	Pyramid	Pyramid
Finland	Helsinki	Fish
India	Taj Mahal	Curry
Jordan	Petra	Michael
Kenya	Nairobi	Safari
Poland	Warsaw	Pierogi
Russia	Moscow	Vodka
Saudi Arabia	Mecca	Oil
Sweden	Stockholm	Ikea
Turkey[34]	Thanksgiving[35]	Thanksgiving
United States	New York	Obesity

[33] We were surprised that these two wouldn't combine, but we would also expect an actual result to only further our point.

G. ~~Attention~~ Wind is all you need[36]

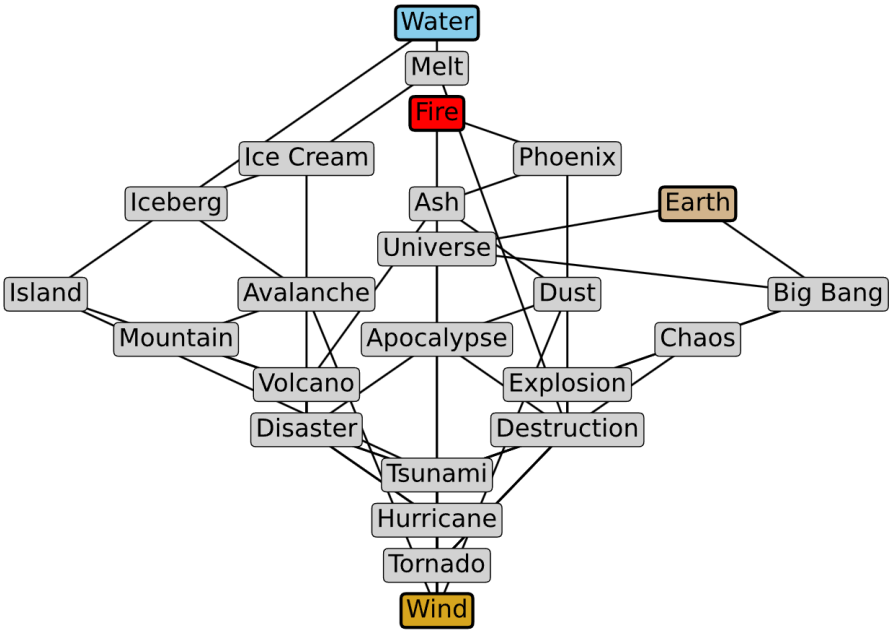


Fig. 9 Proof without words that wind alone can construct the rest of the elements

V. And Now For Something Completely Different

Let E be the set of all elements in *Infinite Craft* (presumably practically countably infinite). If we treat `Nothing` as a proper element[37], combining two elements is a closed binary operation on E, endowing it with the structure of a *commutative magma*. Magmas have no additional structure imposed on them, and indeed *Infinite Craft* recipes actively conspire against such structure.

However, we may yet identify some crumbs of regularity. For example, over 60%[38] of elements $x \in E$ in our dataset are *idemptotent*, meaning they satisfy

$$x + x = x.$$

We may further interest ourselves in *subsets* of E with certain properties, particularly the largest such subsets. We will restrict our attention to subsets with at least three elements, as every possible commutative magma on two elements up to isomorphism has been found in our recipes.[39] We will also ignore numeric elements, as they have their own unique and decently consistent structure (see Section IV.A).

A. Hey, You... You're Finally Awake...

To begin this journey through the algebraic hierarchy, decide, courageous adventurer, where you'd like to start.

I'd like...

1. **a feeling of luxury.** (*go to* Section V.B)
2. **a customizable wardrobe.** (*go to* Section V.C)
3. **quick travel.** (*go to* Section V.D)

[34] Regrettably, "Türkiye" was not in our dataset, though we made a good-faith effort to find it.
[35] wtf
[36] Actually, any of the four starting elements have this property
[37] We may let `Nothing` be an annihilator for all of E, which is not true in the API but important for the mathematics.
[38] Perhaps unsurprisingly, many—but not all—of the elements which are not idempotent are numeric.
[39] There are only two of them.

B. Unital Magmas

The ability to do nothing is a hallmark of luxury, even for elements in *Infinite Craft*. We sought elements $e \in E$ which fixed the most elements under combination; that is, the largest $F \subset E$ such that

$$e + f = f \quad \forall f \in F.$$

The top contender? `Penguin`, which mapped over 1,300 elements to themselves.

You have acquired Penguin (x1).

If we further examine the closed subsets that have an identity, so-called *unital magmas*. Most of these were lattices (i.e., exceedingly dull total orderings; see Section V.G for details). However, some particularly interesting ones were found. We filtered for unital magmas with addition tables which had a large number of additions $a + b \notin \{a, b\}$. A couple of highlights are reproduced below:

```
                          + 0ABCDE
0 = Piranha Frankenstein  0 0ABCDE
A = Cthulhu               A AAAAAA
B = Cthulzilla            B BABBAA
C = Jonahzilla            C CABCAA
D = Ness                  D DAAADA
E = Piranha Cthulhu       E EAAAAE
```

```
                          + 0ABCDEFGHIJ
0 = Surf Kingdom          0 0ABCDEFGHIJ
A = Sharkicorn            A AABCABAAAAA
B = Sharkicorn Surfer     B BBBADEBBBBB
C = Sharkicornadon        C CCACCCCCCCC
D = Steam Surf Guard      D DADCDDFGDDD
E = Steam Surfer          E EBECDEFEEEE
F = Steam Surfing Coast Guard F FABCFFFGFFF
G = Steam Surfing Kingdom G GABCGEGGGGG
H = Surfing Coast Guard   H HABCDEFGHIJ
I = Surfing Steam Guard   I IABCDEFGIIJ
J = Surfing Titanic Sharkicorn J JABCDEFGJJJ
```

The best hallmark of wealth is…

1. **fellow rich people.** (*go to* Section V.F)
2. **lavish clothes.** (*go to* Section V.G)

C. Semigroups

To be able to dress up an expression with valid parentheses however you want is a property of algebraic structures we mortals take for granted far too regularly. *Infinite Craft* bids us reject its comforting niceties, but we can still find some *associative subsets*. That is, $A \subset E$ such that

$$a + (b + c) = (a + b) + c$$

for all $a, b, c \in A$. Armed with Light's associativity test, associativity is relatively straightforward to check even for subsets of formidable size. Additionally requiring A to be a submagma yields a *semigroup*, often

the most straightforward algebraic structure anybody actually cares about. An example, which features some non-idempotence:

```
                                  + ABCDEF
0 = Clockwork Darth Bragmo      A ABBBAB
A = Darth Bragmo                B BBBBBB
B = Pickle                      C BBCCCC
C = Pickle Pickle               D BBCCCC
D = Pickle Slippery Boobskill   E ABCCEF
E = Pickle Slippery Slope       F BBCCFF
```

I want to...

1. **travel the world.** (*go to* Section V.D)
2. **stay right at home.** (*go to* Section V.G)

D. Quasigroups

If one wishes to travel swiftly across this wide world, there must be a means to get from any place to another. *Quasigroups* are algebraic structures $Q \subset E$ which embody such connectedness, often characterized by the so-called *Latin square* or *Sudoku* property:

$$\forall x, z \in Q, \exists y \in Q \Rightarrow x + y = z.$$

Unfortunately, we didn't find any examples with more than three elements.

You died of loneliness.

Return to Section V.A.

E. Cycles

The laziest way to attempt to find new elements is to combine two copies of the last result recursively. However, this is usually ineffective, as this process often loops after just two iterations. Nonetheless, it is possible to get lucky.

We call these cycles *exponential*, and became interested in the largest n for which

$$\exists g_1, ..., g_n \in E \Rightarrow g_1 + g_1 = g_2, \quad g_2 + g_2 = g_3, \quad ..., \quad g_n + g_n = g_1.$$

You have used a duplication glitch to acquire Rupee (x999).

We may also perform a similar procedure to find *linear* cycles, and again seek maximal n such that

$$\exists h_1 ... h_n \in E \Rightarrow h_1 + h_1 = h_2, \quad h_1 + h_2 = h_3, \quad ..., \quad h_1 + h_n = h_1.$$

The largest linear cycle in our data had $h_1 =$ `Sequel`, and continued for 88 additions, some of which actually made sense.

My money is best spent on...

1. **amassing a group of adventurers.** (*go to* Section V.F)
2. **a nice hat.** (*go to* Section V.H)
3. **more money.** (*go to Section V.E*)

F. Groups

The *group* is perhaps the most famous and most important of the algebraic structures, equipped with all the bells and whistles: closure, an identity, and inverses. Few abstractions are so fundamental to modern mathematics, which is why we weep at their absence within *Infinite Craft*.

We found only the lonesome trivial group, embodied by any one of the idempotent elements, and $\mathbb{Z}/2\mathbb{Z}$, the group with two elements. This is extremely disappointing, but the authors are used to being let down on group projects.

You died of dysentery.

Return to Section V.A.

G. Monoids

The monarchs of old could don any parentheses they like and lounge about in decadence while they did so, just like a *monoid*—a semigroup equipped with an identity. Any semigroup can grow up to be a monoid by simply attaching an identity, but we are more interested in natural examples. We luckily found quite a few, with the vast majority being isomorphic to the *maximum monoid* on $\{1, \ldots, n\}$[40]. That is, there is a natural identification $\psi : M \to \{1, \ldots, n\}$ such that

$$\psi(m + n) = \max(\psi(m), \psi(n))$$

for all m, n in such a monoid. Here's an example involving nouns (Each an `s` followed by three letters (exactly one of which is a `w`)):

```
                                + ABCD0
A = Snowami Tornado             A AAAAA
B = Swampire                    B ABBBB
C = Swampizza                   C ABCCC
D = Swanpiranha                 D ABCDD
0 = Swanpizza                   0 ABCD0
```

Max has joined your party.

Like for unital magmas, the most interesting monoids have many pairs $m, n \in M$ where $m + n \notin \{m, n\}$. A couple of examples are reproduced below.

```
                                + 0ABCD
0 = Ipod                        0 0ABCD
A = Cthulhu                     A AAAAA
B = Cthulhu Nano                B BAAAA
C = Iced Ipods                  C CAACD
D = Spiritfarer                 D DAADD
```

```
                                + 0ABCDEFG
0 = Lohengrin                   0 0ABCDEFG
A = Captain Sharktopus          A AAABBFAF
B = Cthulhu                     B BABCBCBB
C = Cthulhu Sharktopus          C CBCCCFCC
D = Cthulzilla                  D DBBCDBBB
E = Frankenstein Sharktopus     E EFCFBEFF
F = Sharktopus                  F FABCBFFF
G = Tsunamopus                  G GFBCBFFG
```

[40] Think lattices, in the sense of order theory. There's a total ordering defined on these elements.

The 8-monoid above doesn't seem too intimidating, but if we were to check a set of eight elements every nanosecond, we wouldn't even be halfway done after 10^{21} years. In practice, however, searching for monoids is fairly straightforward, following the time-honored tradition of reducing exponential search spaces. We exploit the rarity of identities and limit the maximum number of subsets searched for any given identity.

Algorithm 2: Monoid Search

```
def GimmeMonoidsOfOrder(N):
  for e in E:
    U ← {all k such that k + e = k}
    C ← combinations(U, r=N − 1)
    for _ in range(our_patience):
      c = next(C, None)
      if c is not None and is_closed(c) and is_associative(c ∪ e):
        print(c)
```

Look, Mom, there are two for loops! That means it's $O(n^2)$!

Because monoids are easier to search for than semigroups, the semigroup we gave you is actually just monoids with the identity removed[41] to hide the fact that efficiently searching for semigroups is significantly harder than searching for monoids.

I'll follow the road…

1. **back the way I came.** (*go to* Section V.F)
2. **around in circles. I'm terribly lost.** (*go to* Section V.E)

H. The End

You and your hat return home as seasoned adventurers.

VI. Conclusions

Just about any reasonable stance about AI we could take atop the knee-high pedestal of our data collection and analysis has been done to death, and the unreasonable ones aren't far off. Besides, that's not what you came for. At the end of the day, the most enlightening, enthralling, and entertaining part of our work has been finding words, phrases, and concepts that have very likely never been conceived in the entirety of human history.

We love the unusual, the nonsensical, the elements that deserve no response other than "what". Random noise could just as equally produce sights never seen by any eye, furthermore not limited to mere words, but that's just no fun. *Infinite Craft* has delivered to us an endless stream of novelties that can actually take hold in our minds, the stuff of dreams conjured while we are awake. We hope you've enjoyed them as much as we have.

VII. Future Work

```
{result: "Nothing", emoji: "", isNew: false}
```

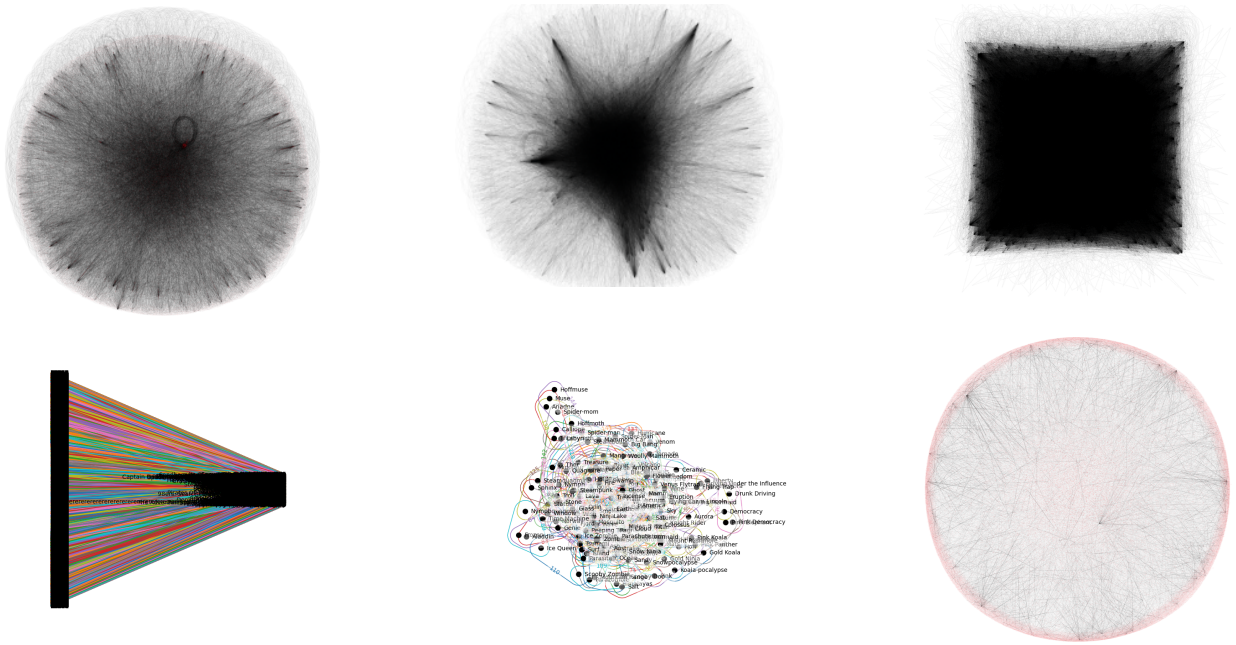
[41] This wasn't necessary; all monoids are semigroups anyway.

VIII. Appendix

A. Drawing Big Graphs is Hard

Theorem VIII.A.1 *(The Hairy Blob Theorem)* All plane embeddings of sufficiently dense [hyper-]graphs maintain their legibility under the actions of resizing and heavy compression.[42]

Proof



□

B. Chart

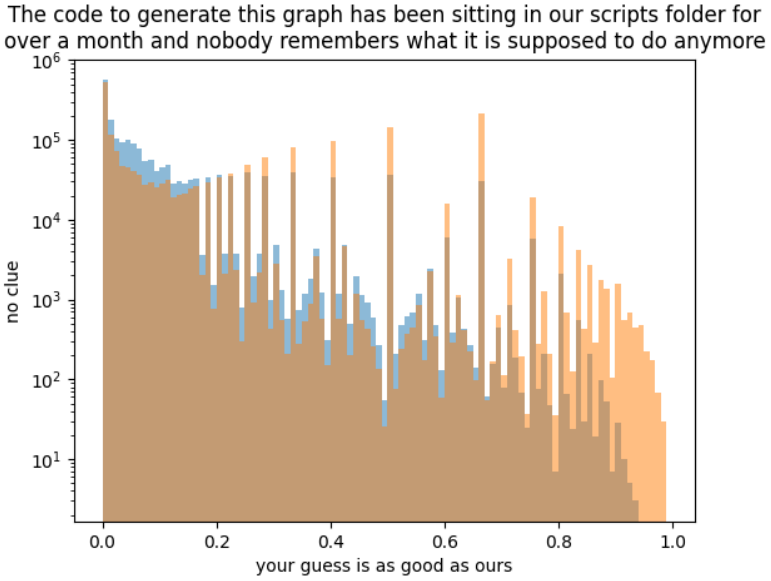


Fig. what ???

[42] Alternatively stated as "you can't comb a hypergraph".

C. Incomplete list of numeric additions that produce strange parentheticals

```
0 + 0 = 0 (Zero)
0 + 4 = 4 (Zero is a number)
1 + 1 = 2 (or 11)
1 + 8 = 9 (18)
10 + 10 = 20 (100)
11 + 11 = 22 (11 is the number of the twin towers)[43]
12 + 8 = 20 (20 is the number of the last level)
12 + 9 = 21 (21 is the number of the card The World)
13 + 13 = 26 (13 is the number of the beast)
14 + 14 = 28 (28 is a multiple of 14)
14 + 15 = 29 (29 is the number of the level)
14 + 6 = 20 (20 is the number of the last level)
15 + 15 = 30 (30 is the maximum number of items you can have in your inventory)
153 + 157 = 310 (153 is the number of fish caught in the net in the G
153 + 251 = 404 (Not Found)
155 + 159 = 314 (Pi)
1553 + 1553 = 3106 (1553 is the number of the beast)
158 + 158 = 316 (the number of the beast)
16 + 16 = 32 (16 is the maximum number of items you can have in your inventory)
16 + 4 = 20 (20 is the number of the level)
161 + 161 = 322 (161 is the number of the beast)
161 + 243 = 404 (Page Not Found)
162 + 162 = 324 (162 is the number of the beast)
168 + 168 = 336 (168 is the number of the beast)
17 + 17 = 34 (17 is the number of the level)
17 + 5 = 22 (22 is the number of the Major Arcana)
17 + 52 = 69 (nice)
18 + 18 = 36 (18 is the atomic number of Argon)
18 + 3 = 21 (Blackjack)
18 + 4 = 22 (22 is the number of the Major Arcana)
18 + 70 = 88 (88 is the number of keys on a piano)
182 + 182 = 364 (182 is the number of the beast)
1853 + 1864 = 1864 (1853 is the year of the first patent for a
1863 + 1874 = 1874 (The year of the first World Series)
1865 + 1874 = 1874 (1865 is the year the 13th Amend
19 + 19 = 38 (38 is a multiple of 19)
19 + 3 = 22 (22 is the number of the Major Arcana)
19 + 69 = 88 (88 is the number of keys on a piano)
191 + 193 = 384 (192 is not a prime number)
192 + 192 = 384 (192 is the maximum number of items you can have in your invent
199 + 205 = 404 (Page Not Found)
21 + 31 = 52 (Blackjack)
23 + 46 = 69 (nice)
24 + 24 = 48 (24 is the maximum number of items you can have in your inventory)
261 + 535 = 806 (261 is the number of the beast)
27 + 27 = 54 (27 is the number of the level)
3 + 8 = 11 (11 is a prime number)[44]
301 + 603 = 904 (the number of the beast)
3033 + 6072 = 9005 (9005 is the number of the beast)
3035 + 6070 = 9005 (9005 is a reference to the song "900
32 + 32 = 64 (32 is the maximum number of blocks that can be placed in a 2
33 + 33 = 66 (33 is the number of the highest degree of Scottish Rite Freemason
35 + 53 = 88 (88 is the number of keys on a piano)
369 + 441 = 810 (The sum of the first ten prime numbers)[45]
37 + 37 = 74 (37 is the number of the level)
39 + 9 = 48 (39 is the number of the level)
42 + 46 = 88 (88 is the number of keys on a piano)
432 + 432 = 864 (432 is the number of the universe)[46]
4481 + 4518 = 9000 (9000 is the highest number you can get)
```

[43] Too soon?

[44] This statement about prime numbers is correct!

[45] This statement about prime numbers is… less correct.

[46] The AI has spoken, with infinite majesty and calm.

```
45 + 45 = 90 (90 is the number of the level)
4502 + 4506 = 9008 (9008 is the number of the beast)
4504 + 4504 = 9008 (9008 is a reference to the NES game Duck
46 + 46 = 92 (92 is the atomic number of uranium)
48 + 48 = 96 (48 is the number of the elements)
480 + 480 = 960 (480 is the number of the beast)
5 + 7 = 12 (12 is the answer)
52 + 52 = 104 (52 is the number of cards in a deck)
69 + 69 = 138 (I'm not sure if this is a joke or not)
8 + 8 = 16 (88)
82 + 82 = 164 (82 is the atomic number of lead)
969 + 969 = 1938 (the year the game was released)[47]
```

IX. Ethics

We waited a short time between requests and respected the website's rate limit. Compared to the rate of organic requests, our 2-3 million requests over the several weeks between launch and the deadline for this paper seem rather puny.

We made a good-faith attempt to compute and reimburse Neal for his resources, which we perhaps unfairly consumed, and notified him early on in our search of what we were doing.[48]

Components in our calculation included but were not limited to:

- Our impact on his TogetherAI bill (computed by multiplying the total number of LLaMa-2 tokens in our database with TogetherAI's rate)
- Additional storage required for caching our requests
- Our impact on server costs
- Sales tax
- Our impact on CloudFlare costs
- Entropy
- Domain name costs
- Inflation during the time of our search
- Differences in local gravity
- The potential increase in request volume if people try to replicate the recipes in this paper
- Degradation of fiber optic cables
- Mercury being in retrograde
- A partridge in a pear tree

Using *Infinite Craft* as our calculator, we summed this to $22, which we then manually fudged until we got to $50.

X. Errata and Miscellany

In order to help this paper fit in with its peers in the scientific mainstream, we have completely fabricated anywhere from zero to three of our charts. Good luck.[49]

Authors are listed in alphabetical order by the last letter of their last name because this is Ryan Pitasky's only opportunity to earn first-author status based on that metric.

A Google Colab Jupyter notebook to explore or download our horrendous data set can be found at `https://colab.research.google.com/drive/1blLvgK53a4T0ktyturFpRfM3LKp3UKfy?usp=sharing`. In case of link rot, reach out to the first author (either of the obvious email addresses at `gmail` should work; title your email with the name of this conference).

[47] *Infinite Craft* was not, in fact, released in 1938.

[48] He was, presumably, too busy putting out fires in his massively popular web app to respond, but we would love to talk!

[49] It's zero.

References

[1] H. P. Lovecraft, *The Call of Cthulhu*. Weird Tales, 1926.

[2] H. Arakawa, *Fullmetal Alchemist*. Monthly Shōnen Gangan, 2010.

[3] A. Ritz, B. Avent, and T. M. Murali, "Pathway Analysis with Signaling Hypergraphs", *IEEE/ACM Transactions on Computational Biology and Bioinformatics*, vol. 14, no. 5, pp. 1042–1055, 2017, doi: 10.1109/TCBB.2015.2459681.

[4] S. Krieger and J. Kececioglu, "Heuristic shortest hyperpaths in cell signaling hypergraphs", *Algorithms for Molecular Biology*, vol. 17, no. 1, p. 12, May 2022, doi: 10.1186/s13015-022-00217-9.

[5] J. Gao, Q. Zhao, W. Ren, A. Swami, R. Ramanathan, and A. Bar-Noy, "Dynamic Shortest Path Algorithms for Hypergraphs", *IEEE/ACM Transactions on Networking*, vol. 23, no. 6, pp. 1805–1817, 2015, doi: 10.1109/TNET.2014.2343914.

[6] B. Kay *et al.*, "Hypergraph Topological Features for Autoencoder-Based Intrusion Detection for Cybersecurity Data", in *ML4Cyber Wshop., Int. Conf. Machine Learning 2022*, 2022.