Smallest Big Number: Findings and Analysis

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A brief note

When I sent this survey out, I didn't make it explicit that I would be publicly sharing the quotes that you submitted. That was a mistake on my part. If you recognize a quote from yourself below and you would like it removed, please reach out directly to me (handamalaika at gmail dot com) and I'll take care of that!

Background

A friend posed this question to a group chat I'm in:

> *Extremely weird question: what is the smallest number that you think qualifies, in the abstract, as a "big" number?*
>
> *Like, I think we all agree that single-digit numbers are small. But what's the threshold at which numbers become "big"?*

People immediately began weighing in, but I thought the question was one that warranted hundreds of responses, not just a couple, so I put together a Google Form.

Methodology

Survey

The survey was conducted in a Google Form which recorded people's responses. Emails were also recorded, to ensure people would not answer multiple times. People were allowed to edit their responses. (Only one respondent did.)

We want to know what number you think is the cut-off point for "big"
There is no context. Please do not answer "it depends." This is not a trick question!

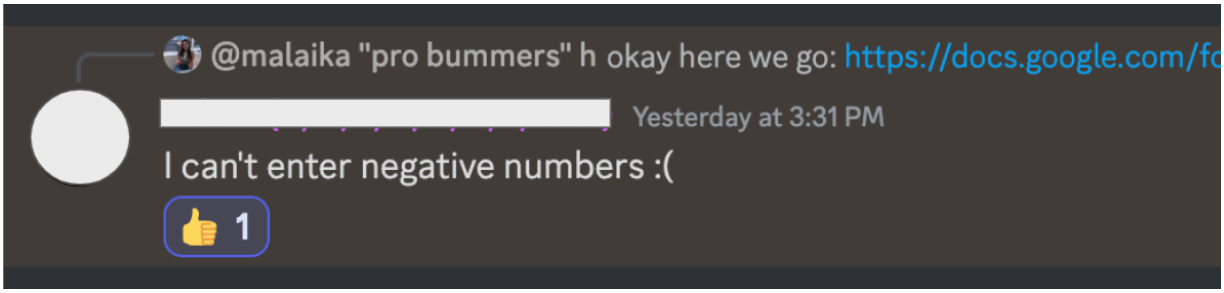
What is the smallest number that you think qualifies, in the abstract, as a "big" number? *

250

You can explain your reasoning if you like. Totally optional!

Your answer

The question contained response validation, which meant that the input had to be numerical; something like “one zillion” would not be accepted. It also could not be negative. In case you are wondering, in a survey of **big** numbers, I did indeed have someone reach out to me asking why they couldn’t input a negative value.



Survey population

I did not gather any metadata about the survey responders.

I sent the survey out to my friends and relatives, posted it on various social media, and encouraged others to share it. There was no effort made to ensure any type of representative population.

Results

I closed the survey after I had 200 total responses. (Three of those 200 were entered by me manually from people who indicated they were unable to use the form.) Of the respondents, 126 people provided some rationale for their answer.

Troll Responses

Of the results, I identified four Troll Responses. My classification does not have to do with the magnitude of the number (as you'll see, other responses that I counted as valid pitched very big or very small numbers) but more to do with the rationale, which I felt didn't embrace the earnest spirit of the question.

Troll's number	**Troll's rationale**	**Why I consider this to be a Troll Response**
118	It's the lowest number that contains the letters of HUGE when spelled out as ONE (HU)NDRED EI(G)HT(E)EN.	This person is being silly and making a cute joke
1	In my opinion every numbers meaning is derived by context and its impossible to think of a big number without some context as to what makes it big. I chose the context of "number of lives you've saved". 1 is a large number of lives to have saved. 1 is also a large number compared to 0.00001. Every numbers bigness or smallness comes from the other numbers that are part of the context	I don't actually mind that they responded 1 (several other people did), and I also don't mind that they picked a context (most other people did!) but the phrasing of their rationale reads like they are purposely trying to be contrary
0	A circle technically has infinite sides and 0 sides simultaneously. In that way, 0 is also infinity.	I believe they were trying to submit an image of a circle, and chose to represent that using the number 0. Because of this, I should not do math using "0," I should be using "circle" but that's not really possible.
1E+79	~10^80 baryons in our light cone. 10% of that seems like a large quantity	I rolled my eyes while reading this, tbqh, I'm sorry but there is no way this person actually thinks numbers smaller than this are small

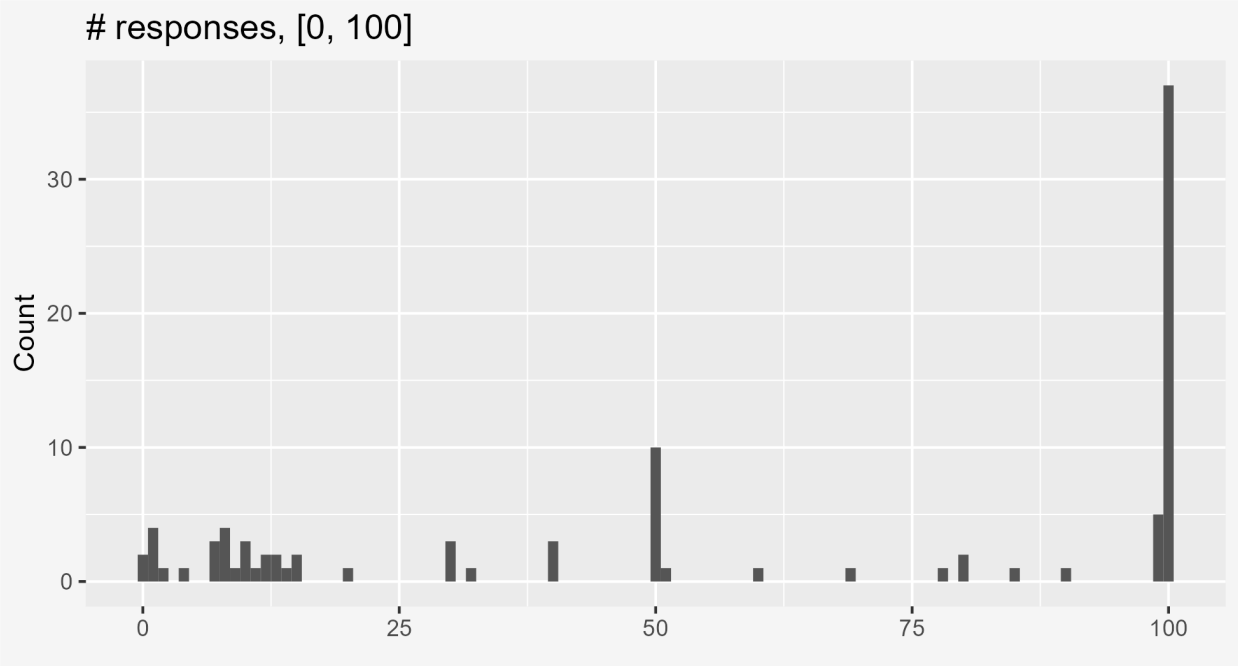
The Troll Responses will typically be excluded from the numerical summaries, but included in the qualitative summaries. I'll indicate each case.

Summary statistics

The mean of a dataset is easily influenced by outliers. With the Troll Responses, it's 5 x 10^{76}. Excluding all four of the Troll Responses, it's 10,240,353,719.63 (around 10 billion).

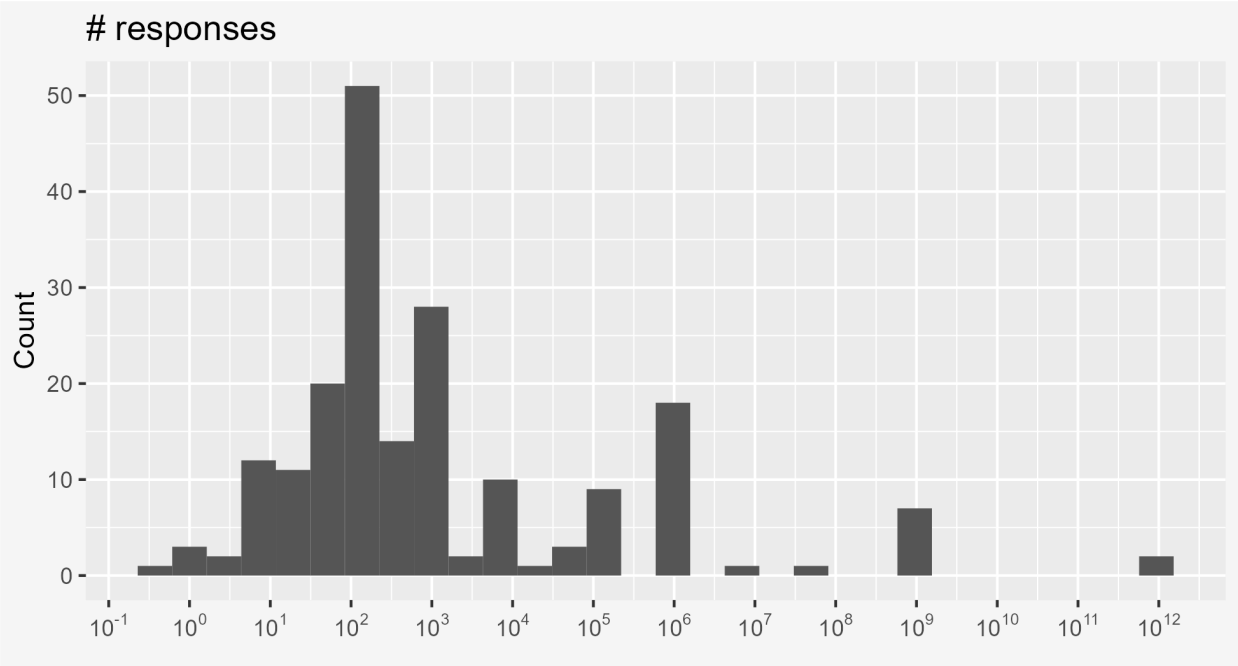
The median of a dataset is resistant to outliers, meaning even if the dataset includes a comically huge number, the median won't be shifted by much. With the Troll Responses it's 138. Excluding all four of the Troll Responses, it's 173.

There were a lot of repeated results! First let's take a look at all of the responses that were between 0 and 100, inclusive. Nearly half (95 of 200) of the responses fell into this category, and that includes two of the Troll Responses. Over a third (37 of 95) of these responses were 100. There was also a sizable contingent of 50s and 99s.



Now let's take a look at all the results, although I'm excluding the Troll Responses here. This graph uses a logarithmic scale on the X axis so that we can visualize everything at once. This means that the numbers one hundred, one thousand, and ten thousand (etc) will all be equally far apart on the graph, even though the numeric gap between one hundred and one thousand (900) is much smaller than the gap between one thousand and ten thousand (9,000) (and etc).

As you can see, there are large clusters around one hundred (10^2), one thousand (10^3), and one million (10^6). Things drop off a little until we hit one billion (10^9). The highest non-Troll Response was one trillion (10^{12}).



Some people (like me!!) don't like a logarithmic scale since the visualization can feel a little misleading, so I'll also include a table which itemizes numbers that got four or more responses. This table will include the Troll Responses (namely, the 1).

Response	**Number of submissions**
1	4
8	4
50	10
99	5
100	37
500	5
1,000	26
10,000	9
100,000	7
1,000,000 (one million)	18
1,000,000,000 (one billion)	7

Rationales used by lots of people

Of the 200 responses, 126 (63%) contained some sort of rationale. I took a look at some of the explanations that cropped up again and again. I included the Troll Responses throughout the rest of this section, because they did include some type of reasoning, even if it was Troll Reasoning.

The numbers below have some double counting. For example, consider a response like this:

> *50 of anything is a lot! doing something 50 times, keeping track of 50 things. it feels like a big number!*

This person touches on the idea of “visualizing items,” as well as “vibes,” so the response would be counted in each of those categories.

Vibes

Listen, when I ask a couple hundred people to answer a question with absolutely zero context, I expect that a lot of answers are going to be vibes-based. And I was right! Forty-two of the 126 responses that included a rationale (one third) mentioned “feeling” that something was big.

Notable quotes:

- *no reason just vibes*
- *i dont really know man*
- *Vibes*
- *It's a classic big one*
- *Feels right*
- *i dunno its pretty big*
- *idk idk*
- *there will be no explanation there will only be 8*
- *10 still has single digit vibes*
- *50 FEELS right to me. 50 somehow feels bigger than 51 even.*
- *I don’t really know, honestly. Like, 90 is not by any means a *small number,* but 100 feels like a real event.*
- *300 feels like something that would start to have emergent properties of "bigness."*

Visualization

The second most popular rationale involved visualizing a number of items.Thirty-five responses (28%) cited this in their explanation. For this category, I also included responses that talked about “comprehending” a number that size or “wrapping their mind around it,” even if they weren’t specifically discussing the act of picturing or holding something.

Notable quotes:

- *I answered it by thinking about what number is something abstract enough that I have hard time imagining its scale*

- *100-200ish things are certainly "a lot"*
- *I think 10k is a point where it seems really hard to grasp what that looks like*
- *visializing a million is hard and most people underestimate it a lot*
- *I can imagine 100, 1000 but a million is huge. I think understanding the number breaks down around this range.*
- *1 billion is where things get truly impossible to conceptualize*
- *how many people would immediately come up with or know on hand a trillion or know what big number after trillion. At that point it's incomprehensible*

People often mentioned specific small items that they visualized:

- *when I play card games having 8 cards in my hand at once is the first round that feels like "a lot of cards"*
- *80 pennies will look like ~80 pennies*
- *100 oranges is a lot, but 100 grains of sand... not so much*
- *100 toothpicks is a lot but not an excess*
- *Are there 300 jelly beans in the jar, or 800? Fuck if I know.*
- *in my hypothetical abstract im guessing how many jellybeans are in an imaginary jar and it's a big jar*
- *Devouring 1,000 M&Ms isn't too daunting, but I would cower from 10,000. That's like Chestnut level of M&Ms.*
- *there are few items that humans interact with regularly for which 500 isn't a lot. [...] grains of rice? a lot.*
- *A million of _anything_ bigger than a grain of rice is a lot of something. That makes it big.*
- *I tried to imagine at what point ppl would be unable to accurately visualize X marbles in their mind.*
- *big = the quantity of grapes I could carry before dropping one (mouth not included, only arms)*

References to mathematical / scientific concepts

Hello, sampling bias! I sent this survey to a lot of my coworkers (I'm an engineer), as well as an email list that includes many people with jobs in polling and research. Twenty-five people (20%) gave an answer which referenced a mathematical or scientific concept; three of the Troll Responses fit into this category.

Notable quotes:

- *quartic polynomials? wtf man*
- *the human brain can remember 7+-2 things*
- *I vaguely remember something from stats class about 30 being a cutoff for something*
- *32 is closer log-scale to 100 than 10. It's also overflow for an int5.*
- *the "long hundred" just feels right*
- *dunbar's number*
- *Kinda did median in me head and got to that number. It feels big but not too big.*
- *Any numbers smaller than this can be encoded in a 16 but representation*
- *I was thinking the earliest numbers that people start representing using scientific notation*

- *for example in statistical physics a billion is basically infinity*

Several people referenced 100% meaning “all,” although a subset of those actually chose 1 as their answer, rather than 100:

- *It's at the "high end" of various conceptual ranges, e.g. 100% means "everything"*
- *I chose 100 because it's the easiest number to link to a percentage (100%)*
- *As in all, 100%, a complete and perfect whole thing.... The thing we round up to so frequently in our imperfect choices. Beautiful in it's potential scope... One universe down to one cell. Something something Bob Marley, U2* 😎
- *Probabilities 0-1, 1 is the max. 100% is a Big Number.*
- *1 is a whole of a pie (1/1, not a fraction)*

Given the audience, I was not surprised at how many people mentioned conducting surveys in their explanation:

- *I'm thinking about how a sample size of 30 is often the minimum requirement to answer questions about the population using the central limit theorem*
- *In qual studies, an n of > 50 would still be big.*
- *I'm a sociologist, so I think my instinct was to think about large-n samples in sociological research and the lowest sample size that I'd consider legitimate in survey data.*
- *I'm a survey researcher, so that to me (based on most power analyses I've done) is a sample size that screams 'ok now we're cooking with gas'*

Digits

Twenty-three of the respondents (18%) focused on the number of digits a number had. There didn’t seem to be broad agreement on how many digits is big, though. The following chart summarizes the number of digits that were in people’s final responses, regardless of what the text of their rationale mentioned.

5 of these responses had...	2 digits
4 of these responses had...	3 digits
5	4
3	5
2	7
1	10

Notable quotes:

- *Look at mr fancy pants over here being able to afford more than one digit*
- *This is the point where it gets into double digits*
- *usually I think people would put any number that is at least two digits*
- *3 digits, much big*

- *also the move from 2 digits to 3 digits*
- *i think 1,000 is the smallest big number because it's the first to reach 4 digits!*
- *5 digits feels big - like 9,999 feels significantly smaller than 10,000 so that must mean that 5 digits feels like the "big" threshold.*
- *Based entirely on gut, I think when you cross over to 5 digits, that's when people go whoa!*
- *It seems that things feel really big once you hit 5 figures.*
- *7 digits!*

Three people who selected 1,000 cited its comma:

- *it gets a comma (i.e. 1,000)*
- *I think that the second you have to start using a comma, that's when it becomes a big number.*
- *if people write it with a comma, that means it's definitely not small*

Money

The last explanation with a big chunk of respondents was money. Twenty-one people (17%) mentioned money in their response. Anyone who mentioned a currency used USD. (Unsurprising, given where I live and work.)

Notable quotes:

- *thinking in terms of what i could consider a meaningful amount of money*
- *I think my reasoning is purely based on USD*
- *It's the minimum amount of money that if I found it I would try to return it.*
- *40 bucks is a lot to drop on something*
- *a thing that is 100$ can still be cheap*
- *1,000 monetarily seems like a good amount but not "big"*
- *1 million anything seems like a lot (e.g., $1 million)*
- *for money, a million dollars is maybe enough to last a life time but probably not. a billion dollars is effectively infinite money for a lifetime.*

Two people mentioned rent specifically:

- *It's my rent and everytime I pay I feel like I just lost a big amount of money. In* **[REDACTED]** *I payed* **[REDACTED]** *for a much bigger place with a lot more things.*
- *Strangely enough, I am thinking about this largely in terms of rent.* **[REDACTED]***/month seems like a lot, but* **[REDACTED]** *is excessive*

Rationales used by a few people

People (or Dalmatians)

Ten people mentioned the idea of a gathering, party, large group, or crowd in their response. (One of these was specifically Dalmatians.)

Notable quotes:

- *At a "standard" "large" dinner table, you can squeeze in 4 down each side and 2 on each end for a total of 10 people. 11 people requires a second table.*
- *The first thing that came to mind was food, in which case having a dozen guests for dinner, or a dozen servings of a dish, or something similar, is quite a lot!*
- *30 to 40 is the biggest vibe jump to me. Feels like the amount that would be too many people.*
- *A crowd for 50-60 people will seem like that to me. [...] But going higher, my brain is generally just guessing.*
- *I still think that a party or something with 60-70 people is pretty big*
- *the whole point of the movie 300 is that 300 is an *impressive* number, but it's still a small number. 600 is twice as much -- if king leonidas had had 600 greasy guys with him, the average filmgoer would have been completely unimpressed by his big army*
- *If 10,000 people show up to something, that's a lot.*

Counting

Counting has a similar vibe to visualization, but I separated it out because it felt more specific. When counting appeared in these rationales, it often had a relationship to time.

Notable quotes:

- *Anything higher than 6 and you have you make sure you've counted it right. You don't just know it instantly.*
- *I can't count to it without needing to eat or sleep*
- *I could count to 100 pretty easily, and doing that twice seems pretty manageable. 300 is where it gets pretty tedious, so I think 400 is the lowest big number because I would not want to count to 400.*
- *I can imagine counting to 500. Beyond that, nah.*
- *It is relatively straightforward to count to 100 for example, but that might take some patience from many people. I suspect that almost no one can patiently wait while counting to one thousand.*
- *Because it's a number that I can't easily conceive in terms of counting, like my brain clocks out and I cent conceive of how big it is*

Time

Time was also mentioned outside of the concept of counting.

Notable quotes:

- *I was born* **[REDACTED]** *8th and it takes a whole week after* **[REDACTED]** *1st to get to my birthday lol.*
- *I just noticed it's my age + 1, hmm.*
- *40 years old seems very far away for me (not that it's old)*
- *I think there are many contexts where 100 is a lot, [...] 100 hours, etc.*
- *I'm thinking of age. I'm not a numbers person, and since I'm on the other side of 50, [my mother] made it past 90, 100 seemed like a big (attainable) age*

- *Ancient cultures often used the number 1000 to represent "forever", as it was a longer time horizon than anyone could conceive of. Seems big!*

Childhood

Throughout responses, people differentiated between numbers that a child (including their younger self) would consider large and numbers that an adult would consider large.

While analyzing the rationales, I noticed that people who gave similar contexts would generally settle on wildly different numbers. Two people might do their reasoning based on money, but one landed on $500 while another landed on $1,000,000,000. Initially I had planned on comparing the averages between categories-- would people who all did their reasoning based on visualization align on a number different from those who did their reasoning based on time? But the results were incredibly boring! Throughout each category there were huge amounts of variation, and the summary stats and graphs looked pretty much the same for each one.

The one exception is this category. Every single person who mentioned kids agreed that 100 is a big number for kids!

Notable quotes:

- *100 day in school*
- *100 is the canonical first number that children understand to be "a big number in the abstract"*
- *when I was a little kid 100 was the smallest big number to me*
- *remember when you were a kid and counting was like, an activity? and making it to 100 was kind of the holy grail?*
- *I work with kids, and the little ones are always shocked when I can count to 100. 99 is fine, but 100 seems unfathomable to them.*

Answers I liked that didn't fit a category

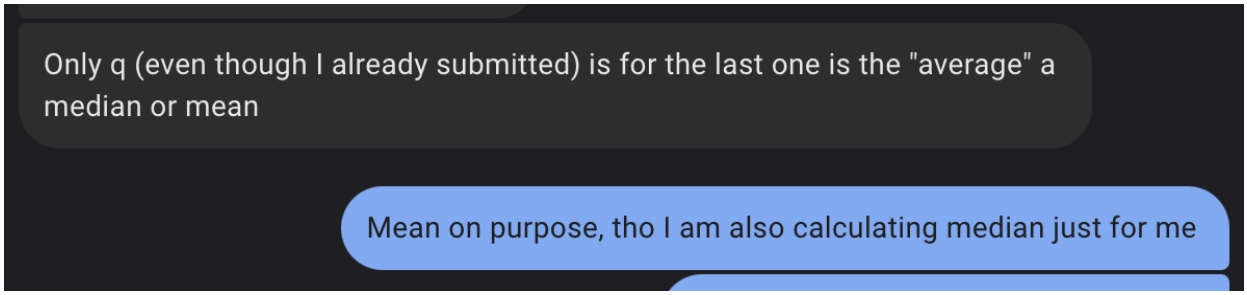
These didn't feel relevant enough to the categories above that they should be highlighted, but I'm highlighting them here because I like them:

- *more than the number of dalmatians*
- *Dr. Evil thought it was a lot! Even though it's not a lot of money these days (or then).*
- *in terms of every day use it seems like a resonable number*
- *I incremented by 10x: 1, 10, 100, 1000 and when I get to 1000 it feels "big".*
- *I have nothing smart to say, but I did think about this a lot, and it's a VERY fun question!!!!*

Bonus results: Guess the Average

I offered people the opportunity to guess what the average of the results were. This was kind of a trick question-- most of the respondents didn't realize how easily an average will be skewed by a single giant response.

It probably would have been fairer to have people guess the median, but I wanted to embrace the chaos of outliers:



One respondent actually spelled out exactly the issue with calculating the average:

> *my guess below is not literal - I think someone will have put a really truly enormous number which will swing the entire arithmetic mean*

Their guess was 10^{24}, which, when including the Troll Responses, *still* undercounts the average (5×10^{76}), though their answer was the closest simply by virtue of being the largest. Results are summarized in the following table. As fun proof of how outlier-resistant the median is, note that the same person guessed the correct median whether we included or excluded the Troll Responses!

		Closest guess
Mean, incl Troll Responses	5×10^{76}	10^{24}
Mean, excl Troll responses	~10 billion (10^{10})	500 million (5×10^{8})
Median, incl Troll Responses	138	151.3
Median, excl Troll Responses	173	151.3

Appendix

I did some of this analysis in Google Sheets (mostly labeling the rationale categories), and the rest of it in R. I won't post it because the data is not anonymized, but if you're interested in taking a look, feel free to reach out.