# Part I: Handedness

## Chapter 1: Whom to believe?

While language and anonymous societies give us humans our superpowers, they can also limit our thinking. Those limitations can be hard to see, because social discourse— “the conversation,” as many people have taken to calling it— defines the building blocks of thought itself.

First, by identifying with abstract, discrete symbols like “Palestinian” or “Israeli,” “straight,” or “gay,” we can impose arbitrary thresholds or cutoffs on properties that usually come in many shades of “yes and.” We may struggle to notice when people don’t fall neatly into our categories. The result can be uncomfortable for those in the middle, artificially collapsing a continuous and multidimensional human landscape into opposing camps: tribalism. The consequences can be severe, even deadly, especially when those camps are very unequal in size or privilege.

When I started to think about how to run online surveys about identity in 2016, I puzzled over this— how to survey both the human landscape and the tribal encampments on it. Ultimately the surveys would have to use language to ask questions and get answers. Yet getting “underneath” the problems of language by *using* language seemed a bit like lifting yourself up by your own bootstraps.

The instinct of a researcher, when faced with a complex, thorny problem, is to look for simplifications that allow the essence of the problem to be explored systematically. Early on, I hit on two such simplifications. One was to begin with handedness before tackling more complex identities. The other was to stick to yes/no questions.

Why handedness? I knew that I wanted to figure out how to ask and reason about identity categories like race and sexuality, which involve majorities and minorities, biological elements and cultural ones, behaviors and visible markers. But race and sexuality are complicated and politically fraught. There are debates raging today about the definitions of words and identities in these domains, the harms that language can or can’t cause, who has the right to use words that may offend, and even about grammar (the capitalization of races, the use of the singular “they”). Before wading into such landmine-strewn territory, I felt that I needed what physicists call a “toy problem” with lower stakes.

Handedness seemed like the perfect solution. Something in human neurophysiology makes a majority of us right-handed, but some of us are left-handed. Handedness strongly influences everyday behavior, such as which hand you write with, and how you hold tools. It’s also an identity— something people say that they “are.” With a survey on handedness, I could begin to explore how identity works in a simplified setting— one that seemed less likely to land me in hot water during the learning process. There’s no talk radio about deporting left-handed people, no grave offense taken for guessing someone’s handedness incorrectly, no epic debate over terminology, no moral panic about whether left-handed couples should be allowed to have children together— or adopt, lest their left-handedness rub off on an innocent child.

My sense, on running the first handedness surveys, was that the experiment had pretty much worked as planned. There was no blowback. Dozens of respondents wrote some variation on “I liked this survey, thanks!”[[1]](#footnote-22) Some were also bemused. “What are you testing for? I’m curious!”[[2]](#footnote-23)

Part of what made the survey fun and quick to take was its format. It consisted almost entirely of short yes/no questions, with no assumptions made and no definitions given. Finding out what someone’s handedness is and which hand they write with required asking not one or two, but four yes/no questions:

Are you left-handed?

Are you right-handed?

Do you write with your left hand?

Do you write with your right hand?

(In practice, these would turn up in random order.) At first glance, this rather simpleminded approach might seem like a head-scratcher if the goal is to get at nuances. As one respondent put it, “A very binary test for nonbinary concepts.”[[3]](#footnote-24) Answering seemingly unnecessary questions could be annoying for some people, too— in the words of a man from Morrison, Illinois, “This could really be condensed into a short set of multiple choice questions.” Yes, and no.

Normally, all four yes/no questions would be presumed to follow from a single, two-choice question: “Are you (a) left-handed, or (b) right-handed?” This would give us a single “bit” of information for every person. (“Bit” is short for “binary digit,” meaning a zero or a one, or equivalently an (a) or (b).) Since each yes/no question also gives us a single bit of information, using the “yes/no method” with the four questions above produces *four* bits per respondent instead of one, which works out to 16 different possibilities (2x2x2x2) instead of just two. The man from Morrison might argue that all of these extra possibilities are redundant, because if someone answers “yes” to being left-handed, they will also answer “no” to being right-handed, “yes” to writing with their left hand, and “no” to writing with their right hand. Isn’t that what being left-handed *means*?

In real life, we make assumptions like these all the time. They are, however, just that— assumptions. Put another way, they’re testable hypotheses. We just have to ask thousands of people the same four questions. Then, we can see how well our assumptions match the data. Here’s the breakdown of actual answers to the first two questions (2x2=4 possibilities), from a total of 5,590 respondents:

\*\*Not left-handed\*\* \*\*Left-handed\*\*

**Not right-handed** 1.14% 11.93% **Right-handed** 85.89% 1.04%

Unsurprisingly, a large majority of people— about 86%— answer “yes” to right-handed, and “no” to left-handed. A minority, just under 12%, answer “yes” to left-handed, and “no” to right-handed. This accounts for about 97.8% of the population, which tells us that the assumption that a person is either left- or right-handed, but not both or neither, is generally correct. However, it doesn’t cover everyone. About 1 in 46 people answer either “yes” to both or “no” to both.

These people belong to an “excluded middle.” By answering as they have, they’ve opted out of our usual multiple-choice, either/or assumption about left- and right-handedness. One in 46 is not such a small number, either. If our sample is representative of the US, this works out to about 7.2 million Americans. That’s more than the combined population of LA and Chicago.

The fact that we can see this excluded middle in our statistics shows us that yes/no questions are not as binary as they seem. Or rather, each individual question *is* binary, and forces each respondent to “round up or down” with every answer. However, when we look at the aggregated answers of multiple yes/no questions over many subjects, we can make out the excluded middle in the *pattern* of yeses and nos. This is a bit like the old printing and graphics technique known as “halftoning” or “dithering,” which allows a black and white printer or screen to render images in shades of gray— even if each pixel can only be black or white. We’ll shortly explore how we can produce a nuanced “halftoned” image of the human landscape using only the unpromising ingredients of binary (and redundant-seeming) yes/no questions.

Before we do that, though, you may be wondering: what if these 1 in 46 people are wrong— misguided, delusional about their handedness, or just sloppy at answering the questions? This last, at a minimum, is definitely a fair concern. I automatically paid everyone who completed the survey, even if they clicked at random, because I didn’t want to get into a petty dispute with a Mechanical Turk worker over a dollar and change. The way I figured it, I was paying for their time, and hoping that by paying fairly they’d reciprocate by answering carefully and honestly.

As a social experiment, this was interesting in its own right. The results were, on the whole, affirming. The great majority of respondents took obvious care with their work— pride, even— clarifying any apparent contradictions in their answers using the free response section, or sometimes even by sending me explanations by email. As you’ve seen, they didn’t hesitate to let me know if they felt I might have overlooked something in the survey design (this feedback was often valuable), or when they worried they might have taken the same survey twice (this tended to happen with I revised and reran an updated version).[[4]](#footnote-25) In an era that sometimes seems characterized by abusive behavior online, it was reassuring to see that decency, reciprocity, and a work ethic seemed very much the norm.

A cynic might argue that this is a function of the power dynamic between Amazon and its gig workers on Mechanical Turk— that they’re kept on a short leash, subject to a harsh reputation economy. I’m not a romantic about either people or corporations, but I think this view does both a disservice. Reputation probably does matter, online just as in real life, and the anonymity of burner accounts almost certainly does undermine social accountability on the internet, but my experiences with Mechanical Turk have left me with an impression that most people, regardless of their tribal affiliations or beliefs, are wired for decent social behavior by default.

Nonetheless, I did set some “traps” in the surveys, to filter out respondents who weren’t answering carefully. The details are in the *Appendix for data nerds*. Suffice it to say: there’s good reason to believe that for the 90% or so of survey respondents who made it through the filter, the excluded middle is unlikely to be the result of random clicking. They meant to answer as they did. So what does it mean to be neither exclusively left-handed nor exclusively right-handed?

As noted, people whose yes/no answers in the main body of the survey aren’t self-explanatory often elaborate on them in free response field at the end of the survey. I left the wording of this final question deliberately vague, along the lines of “Is there anything else you’d like to add?,” to encourage this. This open-endedness helps compensate for the rigidity of the yes/no questions. The tradeoff is that while those yes/no questions are perfect for analyzing statistically by computer, free text narratives aren’t easily quantifiable. They do tell stories that give us insight, though, like this one from a 62 year old woman living in a small town in rural Washington:

Due to an industrial accident ten years ago, I lost half of my right hand, so [some] of these questions were hard to answer because I’ve had to “adapt” by learning how to use my left hand for things like writing, etc. I wouldn’t necessarily call myself [ambidextrous], though, because if that hadn’t happened, I would still be strictly right-handed.

Injuries leading to outcomes like these are in fact not so uncommon. A recent paper in a medical journal[[5]](#footnote-26) estimated that “One in 190 Americans is currently living with the loss of a limb.” Many respondents described far more commonplace injuries affecting handedness: “I badly burnt my left hand as a kid and was forced to [learn] to write with my right hand”[[6]](#footnote-27); “When I was young I was becoming ambidextrous, but due to an injury my right hand became dominant”[[7]](#footnote-28); “I was forced to switch when I got [juvenile rheumatoid] arthritis at 13”[[8]](#footnote-29); or even “I can write reasonably well with my right hand because I broke my left wrist for a while”[[9]](#footnote-30).

Although some hand or arm problems are congenital, most injuries happen at some moment in a person’s life, and affect things from that time forward. This makes it interesting to look beyond overall percentages, and start to break down people’s responses by age using graphs like the one below.

We’ll be using age breakdowns like these a lot, so a word of explanation is in order. The graphs are generated by dividing responses into age brackets or “bins,” which are shown as shaded regions alternating between light gray and light yellow. Here, the bins are ages 18-21, 21-25, 25-30, 30-40, 40-50, and 50-80.[[10]](#footnote-31) For each quantity described in the legend, straight solid lines connect values from the center of one bin to the next showing how these quantities vary with age (hence the left edge of the graph is at the midpoint of the first bin, 19.5, and the right edge is at the midpoint of the last, 65). The black “Strictly right-handed” line shows the percentage of people who both answered “yes” to “Are you right-handed?” and “no” to “Are you left-handed?”; the gold “Strictly left-handed” line is the converse. Putting multiple quantities on the same graph this way can be useful for understanding patterns in the data.

You’ll also notice shaded regions around the lines. Here, they look small, though in many later graphs they won’t be. These are important. They’re what data scientists call “error bars.” They represent the 90% confidence interval, meaning that if we assume every bin contains a random sampling from a much larger candidate population, then 90% of random samples of the same size would produce a percentage within this range.[[11]](#footnote-32) We can’t say for certain that the *real* percentage of the candidate population falls within this (or any) range, because we can only sample a tiny fraction of, say, all of the 18-21 year olds in the United States, and it’s impossible to guarantee that our sample isn’t biased— though I have taken pains to make it as unbiased as possible, using so-called “stratified sampling” methods as described in the *Appendix for data nerds*. Still, the error bars are useful in showing us how seriously to take the estimate. When they’re tight around the solid lines, as they are here, it means those numbers are pretty statistically reliable.

So what patterns do we see? There’s more afoot here than all-in, age-blind tables of numbers like the one we started with can reveal. For one thing, we can see that a very large proportion of the youngest adults, probably well over 90%, characterize themselves as strictly right-handed, and only a small proportion (a bit over 5%) say they’re left-handed. However, this rapidly shifts to only about 80% strictly right-handed by the mid-20s, and from there, the number of strictly left- *or* right-handed people declines slowly but steadily with age.

Big meta-analyses of the scientific literature suggest that about 10% of people are left-handed on average, and that left-handedness is about 23% more common in men (so, closer to about 9% of women and 11% of men).[[12]](#footnote-33) It’s generally been theorized that this is due to some inherent sex-linked difference in brain development. There may be such a factor, but zooming in on the strictly left-handed curve and breaking it down by sex, we see something interesting.

On the whole, our survey data are consistent with the big studies— showing 9.6% of women strictly left-handed and 11.7% of men.[[13]](#footnote-34) However, that difference may only be significant before middle age; by 45, men and women seem pretty much alike, with both under 10% and falling. What’s going on here?

Looking at strict *right*-handedness adds some further color.

Here, it’s *young* men and women who are all but indistinguishable; but as they age, fewer and fewer men report being strictly right-handed. By age 65, only about 75% are, as compared to about 83% of women. Those 90% confidence intervals show us that this effect is probably quite significant.

It has been well-established that, on average, men are more accident prone than women. They use (and misuse) more power tools, fall off more roofs, lose more limbs, and are even (somewhat bafflingly) struck by lightning more often![[14]](#footnote-35) As a cohort, young men are, it will surprise nobody to learn, especially unwise in their life choices. This is likely due to a complex stew of biological, cultural, and behavioral factors.

The apparent result is that regardless of initial handedness, with every passing year, men have on average a greater likelihood of needing to *change* their handedness due to injury. Even if women and men started off with equal (and very low) probabilities of left-handedness at birth, this would not only result in an excess of left-handed men by age 18 due to disproportionate childhood injuries, but would also result in more sharply declining numbers of both strictly left- *and* strictly right-handed men over time— especially since injury of the dominant hand is more common, as it’s in harm’s way more often. And this is exactly what we see.

The evidence mounts when we look at the “excluded middle.” With declines in both strict left- and strict right-handedness, it follows that an increasing number of people are answering the handedness questions ambiguously. This is true; that curve is in fact very similar to the rate at which people answer “yes” to “Are you ambidextrous?,” and consists largely of the same population (though “ambidextrous” seems to be a somewhat stronger statement, as it’s used a tad less often, at every age).

When people say they’re ambidextrous, it’s often accompanied by an account of injury, as in “I have severe deficiencies with my right arm I’ve had 9 surgeries so I became ambidextrous”[[15]](#footnote-36) or “ambidextrous in some things due to having a severely broken right hand wrist, in a cast/pins for 6 months”[[16]](#footnote-37). So, that likely accounts for the increasing numbers with age.

None of this means that there’s no innate biological component to handedness. We do have good evidence for at least *some* heritability of handedness (from studies on twins), and there may well be inherently sex-linked differences too.[[17]](#footnote-38) Eventually, our understanding of neuroscience and genetics might let us actually point to a sex-linked developmental mechanism. However, I’d say that given the variations by age and sex we see in the survey data, the burden of proof would be back on the medical community to demonstrate such an effect— and show that the different overall averages can’t be accounted for simply by different rates of injury (which, granted, may itself be partly sex-linked, just not in the obvious way). This is a good illustration of the old saying “correlation is not causation.”

And so, we’ve arrived at this book’s first— but not last— minor run-in with medical authority.

We have much to thank the medical community for. Many of us would die far younger than we do were it not for everyday miracles like antibiotics, perinatal care, insulin, even modern dentistry. (In the last chapter of this book, we’ll return to the key role these innovations have played in the larger human story.) As I write this chapter, I’m eagerly awaiting my COVID vaccine, an extraordinary achievement that will change everybody’s life for the better in 2021. However, as with any in-group, the medical community has its preconceptions and biases. Medical history is certainly rife with long-held assumptions that turned out to be wrong, and with at least the usual share of expert overconfidence in those assumptions. We entrust doctors with our bodies and our lives, and maybe that’s why we invest them with a kind of intellectual and even moral authority that we don’t tend to extend to other kinds of researchers and knowledge specialists.

That’s the authority I unwittingly reached for when, in wondering what ambidexterity “really means,” I consulted medical sources— I think many people would do the same to resolve a dinner table dispute as to the “official” definition. I was puzzled because so many people were claiming to be ambidextrous. Indeed, according to much of the medical literature, ambidexterity or mixed-handedness is a fairly rare condition “afflicting” about 1% of infants and “associated with atypical cerebral laterality” resulting in “a greater likelihood of having language, scholastic, and mental health problems” later in life.[[18]](#footnote-39)

This kind of finding is in a similar spirit to a great deal of older research ascribing such woes to left-handed people. As an influential 1977 paper on measuring handedness by psychologists Curtis Hardyck (of UC Berkeley) and Lewis Petrinovich (of UC Riverside) put it,[[19]](#footnote-40)

“Reaction to the problems of explanation posed by the left-handed has followed two courses. Perhaps the most common approach has been to assume that left-handedness is a signal that something is wrong—that the left-handed represent an aberrancy or abnormality and can thus be excluded from consideration in theories of normal cerebral functioning. Certainly the search for deficit associated with left-handedness has been both extensive and unceasing. […] A second approach has been to disregard the left-handed […]”

Despite a lack of evidence that left-handed people have “something wrong,” this attitude filters into people’s lives in a variety of ways. A 24 year old survey respondent from Wewahitchka, Florida, for instance, wrote,

“I was left handed at birth but the doctor encouraged my parents to train me right handed due to me being on the spectrum, the doctor said I would have enough problems without adding left handedness to them.”

Speaking from the majority’s point of view, a 42 year old from Each China, Michigan wrote, “I seem to be right handed dominant. I think I have less emotional problems than left handed people.”

To check for myself, I did include questions on the survey about depression, bipolar disorder, alcoholism, and a number of other conditions that have been at one time or another associated with left-handedness. The results are underwhelming, with the exception of cerebral palsy, one case where the link with left-handedness has long been well established.[[20]](#footnote-41) Left-handed people are also slightly overrepresented among the bipolar population, though the effect is modest.

More fundamentally, though, the survey doesn’t bear out the idea that either left-handedness or ambidexterity are “aberrant or abnormal” traits. Ambidexterity in childhood may indeed be rare, perhaps as low as 1% or even less, based on the youngest people we can observe (unfortunately we can’t survey people under 18). But as we’ve seen, by middle age it also rises, and to well above 10%— even more common than strict left-handedness. That’s a pretty big excluded middle. This seems incompatible with the idea that ambidexterity is a rare medical condition you’re either born with or not. So whom should we believe, the doctors or the survey respondents?

1. A man from Charlotte, North Carolina. [↑](#footnote-ref-22)
2. A woman from Odessa, Florida. [↑](#footnote-ref-23)
3. This respondent was, in fact, a non-binary 23 year old from Chicago. [↑](#footnote-ref-24)
4. After some initial experimentation to get survey designs right, I used a Mechanical Turk feature called “qualifications” to make sure that nobody could take a survey twice (unless they went to the trouble of creating a fake second account, which is against Mechanical Turk’s policies). [↑](#footnote-ref-25)
5. Ziegler-Graham et al., “Estimating the Prevalence of Limb Loss in the United States: 2005 to 2050,” 2008. [↑](#footnote-ref-26)
6. A 36 year old man from Henderson, Kentucky. [↑](#footnote-ref-27)
7. A 35 year old man from Springville, Utah. [↑](#footnote-ref-28)
8. A 67 year old woman from Kearney, Nebraska. [↑](#footnote-ref-29)
9. A 34 year old woman from Bellevue, Nebraska. [↑](#footnote-ref-30)
10. These bins or intervals are “half-open” and would be written in mathematical notation as [18,21), [21,25) and so on, meaning that someone aged exactly 21 would fall in the [21,25) bin, not the [18,21) bin. Questions about birth month (“Were you born in January or February?”), together with age in years, allow the ages of respondents to be calculated to within two months. Bin sizes are chosen to ensure that each contains enough samples for the error bar to be reasonably small, while still capturing significant changes by age, as described in the Appendix. [↑](#footnote-ref-31)
11. I’ve chosen a generous 90% confidence interval rather than the more common 68% confidence interval (one “standard deviation”) in order to both emphasize uncertainty where it exists and, where the regions are tight, make clear how many of the effects we’ll see are so large that they’re highly unlikely to be statistical artifacts. [↑](#footnote-ref-32)
12. Papadatou-Pastou et al., “Sex Differences in Left-Handedness: A Meta-Analysis of 144 Studies,” 2008. [↑](#footnote-ref-33)
13. Later on we’ll delve into the non-binariness of sex and gender. For purposes of the analysis here, “women” is a shorthand for those who answer “yes” to “Do you identify as female?” and “no” to “Do you identify as male?,” and vice versa for “men.” There are a number of other possible definitions based on the survey questions, but none of them would materially affect these results. [↑](#footnote-ref-34)
14. [[Citations for all of these.]] On lightning see Jensenius, “A Detailed Analysis of Lightning Deaths in the United States from 2006 through 2019,” 2020; Williams, “Men vs. Women: Which Gender Is More Likely to Be Fatally Struck by Lightning?,” 2018, https://www.accuweather.com/en/weather-news/men-vs-women-which-gender-is-more-likely-to-be-fatally-struck-by-lightning/351789. [↑](#footnote-ref-35)
15. A woman from Elkton, Maryland. [↑](#footnote-ref-36)
16. A woman from Kansas City, Kansas. [↑](#footnote-ref-37)
17. Porac, *Laterality: Exploring the Enigma of Left-Handedness*, 2016. [↑](#footnote-ref-38)
18. Rodriguez et al., “Mixed-Handedness Is Linked to Mental Health Problems in Children and Adolescents,” 2010. [↑](#footnote-ref-39)
19. Hardyck and Petrinovich, “Left-Handedness,” 1977. [↑](#footnote-ref-40)
20. Only 14 people surveyed have cerebral palsy, but 4 of those are left-handed, which at about 29% is much higher than the expected rate of left-handedness. This is consistent with the medical literature. [↑](#footnote-ref-41)