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Reflections on *Innumeracy in the Wild*

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Reflections on *Innumeracy in the Wild*

Abstract

Peters, E. (2020). *Innumeracy in the Wild: Misunderstanding and Misusing Numbers*. (New York, NY: Oxford University Press) 315 pp. ISBN 978-0190861094

This piece briefly introduces and excerpts *Innumeracy in the Wild: Misunderstanding and Misusing Numbers*, written by Ellen Peters and published by Oxford University Press. Through a state-of-art review of the literature, the book explains how numeric ability supports the quality of the decisions people make and the life outcomes they experience. It presents three ways that people can be good or bad with numbers and how each of these numeric competencies matter to decision making.

Keywords

decicion-making, innumeracy, communication

Cover Page Footnote

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The year 2020 has highlighted a variety of numeracy challenges for Americans, including the exponential growth of COVID-19, polls that predict one outcome 90% of the time but (to some people's surprise) predict the opposite outcome 10% of the time, and the numerically quirky Land O'Lakes Half and Half that has 30% more cream than their regular Half and Half (Land O'Lakes 2020).

I wrote *Innumeracy in the Wild* (Peters 2020), not so much to highlight serious and lighthearted numeracy challenges (although I do some of this in the book), but to bring together, in one place, research concerning numeracy and decision making. The book is intended to provide a state-of-the-art review of the literature on numeracy, why and how it matters to decision making and life outcomes, what can be done to improve people's use of numbers, and what research we need moving forward. I hope it will also prove valuable to those who are confused by the innumeracy around them and want to understand it. Having the book come out in the anti-science world of 2020 has been odd. Being anti-science is also anti-math because math is science's older brother and an important language used in the development of science. *Innumeracy in the Wild*, however, focuses on math as a critical language for everyone and every day.

People often laugh about being no good at math as if it's inconsequential outside of STEM careers. It's easy, in fact, to laugh at examples like A&W's 1/3-pound hamburger that failed in the market because most customers thought that McDonald's Quarter Pounder was bigger (Conradt 2016). Even former President Barack Obama joked with Jay Leno about struggling with math above the 7th grade level (Leno 2012).

More numerate people, however, are more likely to make decisions using critical statistics whereas the less numerate rely more on compelling concrete stories, images, and emotions to make their decisions. Although people often believe that they look at the numbers and use them, numbers are often neglected, especially by the less numerate who resort more frequently to superficial heuristic processing of information. Relying on a simple mental shortcut once is efficient and often produces a decision that is good enough. However, when employed again and again, heuristic use seems to be a risk factor that accumulates over time and causes worse outcomes. It seems similar to smoking—smoking one cigarette matters little, but smoking day after day, cigarette after cigarette, takes an average of ten years off of a smoker's life (Jha et al. 2013). People who aren't very good with numbers are more likely to use a variety of common heuristics and to experience worse health, financial, and employment outcomes.

The highly numerate understand numbers better, but they also seem to have developed inclinations and habits with numbers that they bring out of the classroom and into their daily lives. Perhaps not surprisingly, they do more complex number calculations in decisions, but they also pay more attention to numbers, think longer

with them, and do more simple number operations, like number comparisons, than the less numerate, and in ways that seem to influence their decisions.

However, being more numerate is not always helpful. We know, for example, that day traders who stalk the stock market often lose money, presumably because they mistake noise in the market as a signal to buy or sell (Mitchell 2019). In Chapter 6, I look briefly at overuse of numbers by the highly numerate; Chapter 8 also covers some of the imperfect numeric reasoning shown by the highly numerate in problem types that are particularly difficult for everyone (e.g., Bayes' Theorem) and in situations where the highly numerate appear to use their capacity to see what they want to see in the data. It turns out that we humans are flexible in how we use our capacities to meet goals, and the highly numerate have more capacity to attain their goals, whatever they are. In politically contentious domains, motivated processing of information is rife and perhaps especially among more numerate populations who are more able by dint of their numeric prowess to select and reinterpret information.

If you're curious, *Innumeracy in the Wild* also briefly covers the emergence of numeric understanding and how one of its possible causes, the approximate number system, also affects decision making among nonhuman animals as diverse as honeybees and beluga whales. It seems to further affect decision making among human animals independent of people's objective numeracy ability.

Some much newer research on numeric confidence (aka subjective numeracy) suggests that math ability may not be used (or be used as much) among those who lack numeric confidence. A further point made is that being aware of what one knows and doesn't know numerically may propel better health and financial outcomes. The book concludes with how researchers have used what we know about the psychology of numeracy and decision making to improve numeric understanding and use, either through evidence-based presentation of numbers (especially in health domains) or through numeracy education and training.

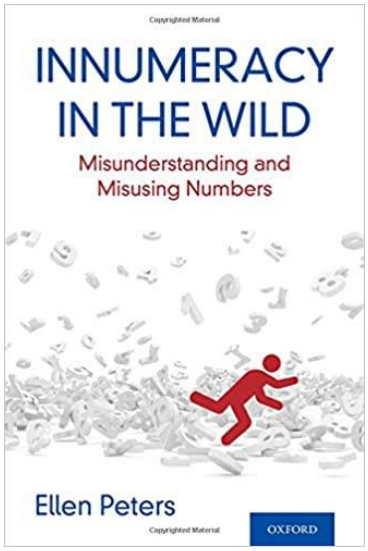
More research is needed, especially to understand causal effects in numeracy research given that most studies are correlational. Such studies can be (and to a limited extent have been) done in math and statistics classrooms. We also need to know more about when and why numeracy matters to decision making and life outcomes versus other non-numeric intelligences. Experimental studies testing numeracy's causal effects will help in this regard.

Numeracy issues deserve attention in the classroom, too. As responsible citizens of the world, we need numeric abilities to understand and react appropriately to the uncertainty and complication of numbers that permeate our daily lives in topics as diverse as science, health, politics, finances, and even sports and hobbies. My hope for this book is that it adequately gives the psychology of numeracy and decision making away (Miller 1969, cited in Bjork 1991) so that we can take another step toward improving human welfare. I hope that it also

encourages and provokes more teaching of this critical subject as its influence appears to extend out of the classroom and into our lives.

Excerpt from *Innumeracy in the Wild*[1]

The Types and Extent of Innumeracy



Available from Oxford University Press

It's been said there are three kinds of people in the world, those who can count and those who can't count. In this book, instead of counting three kinds of people, we will dissect three ways that people can be good or bad with numbers and why each one matters. Thus, this book is intended primarily for academic researchers interested in numeracy and decision making. I think it will also be useful to researchers in related fields. And I hope it will prove valuable to those who are highly numerate and perplexed by the less numerate people around them, as well as to the less numerate who want to do better. We'll look first at brief examples of each of the three numeric competencies and the kinds of everyday situations they support.

First, people can score high or low on tests of their understanding and use of mathematical concepts (called *objective numeracy*). In a 2013 *New York Times* op-ed, Angelina Jolie wrote about her experiences with genetic testing and prophylactic mastectomy. Jolie's doctors had informed her that she had an 87% risk of breast cancer due to her genetics. She took that information and reasoned like a highly numerate person. She thought long and hard about her numeric risks and ultimately chose to have a preventive double mastectomy to reduce her risk (Jolie 2013). Subsequently, Jolie's story and her fears for herself and her children were covered widely by *People Magazine* and other outlets. The less objectively numerate, however, are less sensitive to abstract numeric information. Instead, they use information like stories that are concrete and easier to evaluate. In fact, after Jolie's story went public, the proportion of early-stage breast cancer patients who chose preventive mastectomies rose from about 2% to 17%, with the fastest growth in average-risk women for whom surgery conferred no survival benefit (Pesce et al. 2014; Kummerow et al. 2015). Chapters 2–8 of this book will expand on how

[1] Reprinted with permission from *Innumeracy in the Wild* by Ellen Peters. Copyright © 2020. Published by Oxford University Press. All rights reserved.

individuals lower and higher in objective numeracy understand and use information differently in judgments and decisions.

Second, people can be good or bad with numbers based on their confidence with numbers. Some people believe they are good at understanding and using mathematical concepts (they are high in what we will call *subjective numeracy*); others think they are terrible with numbers (they are low in subjective numeracy). In fact, people often say "I am not a math person." When I asked participants in one study to write about a time they had a hard time with numbers, one person wrote "I am horrible at math. It doesn't come easy for me and never has. I have always got nervous, anxious, and almost panicked when I see numbers" (Peters 2018a). Another person said "I have never gotten along well with numbers, so don't use them too much" (Peters 2018b). To foreshadow Chapter 14, those who are less subjectively numerate do not try as hard with numbers, and their lack of persistence is related to lower comprehension and use of numbers in decisions.

Finally, our third way of being good or bad with numbers is an evolutionarily old sense of how big is a quantity. Using this intuitive number sense, we can discriminate quickly the numeric difference between two numbers (like mortgage rates), and we can make fast numeric estimates (e.g., of the number of coins in a jar). People differ in this intuitive number sense. Those who discriminate more precisely perceive numbers to be further apart and more different than people who are worse at numeric discriminations. This intuitive ability, as we will see in Chapter 13, is found in other species, and it appears to underlie the development of objective numeracy in children. Among human adults, it can compensate for low objective numeracy abilities. We rely on it instead of objective numeracy in some judgments and decisions.

These three ways of being good or bad with numbers are important because numbers permeate our daily lives. They instruct, inform, and give meaning to information about topics ranging from our science and health to politics, finances, and even sports and hobbies. Understanding and using them underlies our extraordinary ability to control the world around us as we choose in the short-term and forecast far out into the future. They are central to decisions that we make whenever we ask how much, how many, how big, how likely, how often, how long, or what time. Overall, our grasp of number is one of humankind's most distinctive and important traits.

These numeric competencies, for example, support personal finance activities like saving and budgeting. They also underlie some aspects of disease management, such as for diabetes and kidney disease. Without good numeric competencies, these everyday activities can be major obstacles for people because of the complex quantitative information involved (Narva et al. 2016). A diabetic patient once wrote "Life with type 1 is manageable, but . . . if I were dropped in the desert, I'd die pretty quickly. In fact, if I want to walk to the shops, or even eat a piece of fruit, I

have to plan, think about what happened since my last injection and what is likely to happen before my next one; I have to carry emergency supplies; I have to do blood tests. I can't even have a drink without having to do maths" (Snow 2017). This patient clearly believed that thinking mathematically matters.

Numbers matter in much more common ways, too, like how to find a restaurant five blocks west and two blocks south, double a brownie recipe, and estimate the gasoline you need to drive from point A to point B. Even shopping environments present challenges that more numerate individuals likely cannot imagine being problematic. Examples include using sales signs, calculating or estimating unit prices to ascertain value, keeping a running total to avoid running short of funds at the grocery story, and applying for credit (Viswanathan et al. 2005). These examples point toward the potentially critical importance of these numeric competencies to the experienced quality of judgments, decisions, and life outcomes.

Definition and Extent of the Three Numeric Competencies

Before we get to the topic of judgment and decision making in the next sections, let's look first at definitions of the three numeric competencies and what we know about the existing extent of innumeracy based on nationally representative US samples. To foreshadow the rest of this chapter, you'll see that a wide and disappointing range of objective numeracy exists, that people claim to be more subjectively numerate than objective numeracy data reveal, and that we know less about how much adults differ in intuitive number sense.

Objective Numeracy. Objective numeracy has been defined variously as the ability to understand and use basic probability and mathematical concepts (Peters et al. 2006) and as "the degree to which individuals can obtain, process, and understand the basic [quantitative] health information and services they need to make appropriate health decisions" (Ratzan and Parker 2000, vi). Medical researchers further described the concept of health numeracy as representing "a constellation of skills necessary to function effectively in the health care environment and act appropriately on health care information" (Berkman et al. 2011, 1). The Organisation for Economic Co-operation and Development (OECD) defined it as "the ability to access, use, interpret and communicate mathematical information and ideas in order to engage in and manage the mathematical demands of a range of situations in adult life" (Desjardins et al. 2013 59).

As suggested earlier, many people have limited skills for dealing with life's numeric information. The OECD estimated that 29% of American adults (about 73 million in 2018) are at or below Level 1 of numeracy; only 9% are at the highest Levels 4 and 5 of numeracy (about 23 million adults) (Desjardins et al. 2013). See Table 1. Those with lowest numeracy are limited to doing simple operations; they

can count, sort, and perform basic arithmetic operations with whole numbers or money. As a result, they likely cannot select the health plan with the lowest cost based on annual premiums and deductibles for a family or calculate the difference in the percent of patients who survive one treatment versus another (Peters et al. 2014). The next 33% of the population can do more complicated math, for example, with percentages, fractions, simple measurement, and estimation; they can also use simple tables and graphs (Desjardins et al. 2013). Only those at the highest numeracy levels (Level 4 or 5) have the quantitative skills necessary to understand and use all of the numeric information integral to management of a complex disease like diabetes (Peters et al. 2014).

Table 1
Proportion (Number) of US Adults at Each Numeracy Level

Numeracy Level	% (number[a]) US adults	Key abilities associated with level[b]
Below Level 1	9% (22,790,483)	Simple processes: counting, sorting, using whole numbers or money. Little or no text or distractors.
Level 1	20% (50,645,519)	Basic one-step or simple processes (counting, sorting, simple arithmetic, simple percents such as 50%). Little text and minimal distractors.
Level 2	33% (83,565,106)	More complicated math with two+ steps, percents and fractions, simple measurement, estimation; simple tables and graphs.
Level 3	26% (65,839,174)	Less explicit and unfamiliar numeric tasks that require several steps, problem solving, interpretation and basic analysis of data and statistics in texts, tables, and graphs.
Level 4/5	9% (22,790,483)	Complex, abstract, unfamiliar contexts. Multiple steps, analysis, statistics and chance, change, formulas.

[a]Based on 2018 estimated adult population from US Census Bureau (2018).
[b]From Desjardins et al.(2013)
Note: Individuals at lower levels do not have the abilities associated with a higher level of numeracy. Approximately 3% of OECD sample is missing data because those individuals were unable to speak or read in the languages used for the assessment.

Demographic differences also are associated with objective numeracy scores. For example, more educated people tend to be more numerate. Even highly educated individuals, though, can be innumerate—think about PhDs in non-numeric fields (Lipkus et al. 2001). Greater numeracy is associated further with being male, younger, having a higher income, and having health insurance prior to the Affordable Care Act (Peters et al. 2014).

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