Numeracy
Advancing Education in Quantitative Literacy

Volume 14 | Issue 2 Article 11

2021

The Cost of Mathematical Illiteracy: Review of *Innumeracy in the Wild* by Ellen Peters (2020)

Anne Kelly
Dakota Wesleyan University, ankelly@dwu.edu

Recommended Citation

Kelly, Anne. "The Cost of Mathematical Illiteracy: Review of *Innumeracy in the Wild* by Ellen Peters (2020)." *Numeracy* 14, Iss. 2 (2021): Article 11. DOI: https://doi.org/10.5038/1936-4660.14.2.1396

The Cost of Mathematical Illiteracy: Review of *Innumeracy in the Wild* by Ellen Peters (2020)

Abstract

In *Innumeracy in the Wild* (Oxford University Press, 2020), Ellen Peters, a researcher in decision science, persuasively argues that numeracy skills, numeric confidence, and our intuitive sense for numbers impact our lifelong outcomes in health and wellbeing. Peters draws from research and real-world examples to show how daily life for innumerate people is different from that of numerate people and makes practical recommendations on improving how we communicate numerical information.

Keywords

cognition, decision-making, numeracy, persuasion

Cover Page Footnote

Anne Kelly is a professor of behavioral sciences and chair of the psychology department at Dakota Wesleyan University. Her research focuses on the causes, treatment, and prevention of suicide, the psychological mechanisms underlying suicide ideation, and the cognitive and social factors that influence detection of suicide risk in others.

In her 2020 book, *Innumeracy in the Wild*, Ellen Peters, a researcher in decision science, makes a convincing case that numeracy greatly contributes to effective decision-making. Numbers and mathematics pervade lives, so a practical facility in math is essential to making informed decisions. Peters uses a combination of thorough research and real-world examples to persuasively argue that numeracy skills, numeric confidence, and our intuitive sense for numbers affect our financial, social, and professional outcomes and even our health and well-being. We use math every day to cook, measure medicine doses, balance a checkbook, shop for the best price, evaluate medical treatments, and interpret politically-charged numerical information. The questions which stood out to this reviewer, an experimental psychologist with a background in cognition, were: 1) what is daily life like for innumerate people, and how is it different from that of numerate people; 2) is mathematical decision-making different from other types; and 3) is innumeracy changeable, or can we help people use numbers to make better decisions?

Peters defines the ability to access, use and understand numerical concepts as objective numeracy. Two other numerical competencies also affect overall numeracy, but objective numeracy, which is arguably the more fundamental of the three, will be the focus of this review. According to Peters, a significant number of adults lack the basic skills for working with and using mathematical information. Their skills are limited to simple operations, such as counting, sorting, a basic understanding of math with two or more steps, percentages and fractions, and simple tables and graphs. For them, trying to figure out the math to calculate mortgage payments, choose the right health insurance plan, balance a budget, make the best health decisions, and manage complex diseases like diabetes is hard. Diabetes is especially burdensome among certain groups, including poorly educated adults and those in lower socioeconomic classes. These groups are already less likely to receive timely and adequate healthcare, but innumeracy amplifies the negative consequences of diabetes within these populations.

Because "math is hard," individuals with lower objective numeracy avoid numerical information and lean toward personal stories and anecdotal evidence. Their decisions are influenced by emotions and mood. They seek out and remember more easily information that supports their existing beliefs. They are also more vulnerable than individuals with high objective numeracy to framing effects, which occur when two or more options are worded, or "framed," differently, but the outcome is the same. This may remind readers of what Nobel Prize-winning psychologist Daniel Kahneman identified as the first of two decision-making systems in *Thinking Fast and Slow* (2011). System 1 thinking is associated with intuition and operates quickly, is governed by heuristics (or mental shortcuts that we use to think and act quickly), and leads to systematic errors in judgment, but it saves energy and reduces decision fatigue. System 2 attempts objectivity; however, it is slower and requires selective and sustained attention. This results in higher

cognitive load and ultimately ego depletion when mental resources are used up and mental activity is low. When the demands of handling complex numerical information exceed mathematical ability, ego depletion results, making us more likely to default to System 1 thinking, which is experience-based and more biased. This occurs more quickly in individuals with low objective numeracy skills and places the innumerate at greater risk of making poor decisions. That individuals will ignore *numerical* information is Peters' point, and what sets apart *Innumeracy in the Wild* from the several similar popular books on thinking and decision-making published in the time since Kahneman's. Peters walks us through several errors in judgment which relate to numeracy, specifically the representativeness, availability, and affect heuristics.

The representativeness heuristic is used when making judgments about the probability of an outcome or event based on its similarity with a stereotype or an existing prototype. It allows us to identify causal connections between events automatically and easily, but sometimes erroneously. Among the many examples Peters uses to illustrate this mental shortcut is Kahneman and Tversky's (1972) well-known vignette, the hospital problem. In this thought experiment, a town is served by two hospitals: one large and one small, in which are born daily about 45 and about 15 babies, respectively. Participants are asked which of these hospitals would, over the course of a one-year period, record days in which more than 60% of the babies born were boys. Most answered, incorrectly, that sex percentages of babies born from the hospitals would be about the same. Those familiar with the "law of large numbers" would know that, because small samples contain greater variability, the smaller hospital would have a greater number of days deviating from the perfect 50% toward which the larger hospital would, necessarily, always more closely approach. Most participants, however, having considered the hospitals' similarities, inaccurately predicted similar daily returns of birth sex.

Peters then explains the increased vulnerability of innumerate people to the availability heuristic, another mental shortcut, this one arising from examples of a particular problem or event which come quickly to mind. Vivid and easily imaginable stories can activate schema which lend weight to the information conveyed (such as remembered details assumed to be necessarily significant), thus influencing decision-making. In one experiment involving a fictitious court case, the presentation of vivid and detailed descriptions of a defendant increased the likelihood that the defendant would be seen as guilty. Another example I might offer to readers of this review is many people's tendency to overestimate, based on their television viewing, the numbers of doctors and lawyers in the general population. Again, this is particularly true of people low in numeracy.

Current emotions can also play a large part in our deliberation and decision-making, and, when they do, this mental shortcut is known as the affect heuristic. Broadly, it is quicker and less burdensome to trust feelings than it is to sort, weigh,

and prioritize complex information; there is far less cognitive load to carry. Positive feelings amplify benefits as we weigh them against risks; negative feelings the opposite. More specifically, Peters distinguishes between three types of affect that influence decision-making and are important to studies of objective numeracy: integral feelings about outcomes, integral feelings about quantitative information in a judgment, and what she calls incidental affect. The first two of these types of feelings, the integral, concern themselves with how we represent an object being considered and are built into how we react to it. Examples of the first of these, integral feelings about outcomes, Peters says, are feelings about "possible end results of a choice such as a side effect from a prescription drug." Examples of the second type, integral feelings about quantitative information in a judgment, are the feelings, good or bad, which we experience when informed of a numerical probability. Finally, the third type of affect, incidental affect, is that of mood states mistakenly attributed to particular unrelated stimuli. Less numerate people rely more often than do the numerate on both incidental affect and integral affect to non-numeric outcomes (Peters' example here is cancer fears). Emotions also influence our tendencies to take risks.

The framing of information prompts emotional responses which, in turn, affect our decisions by coloring how we perceive risk. An especially effective frame is that of gain-or-loss, which relies on our greater sensitivity, and thus aversion, to loss. Peters shares an example in which subjects are asked about their willingness to choose saving 200 lives if it means losing 400. Presented positively—in terms of survivors—use of hypothetical Treatment A "Saves 200 lives"; presented negatively, "400 people will die" with its use. Treatment B, presented positively, brings "A 33% chance of saving all 600 people, 66% possibility of saving no one," whereas that same treatment framed negatively gives "A 33% chance that no people will die, 66% probability that all 600 will die." When participants were presented with a choice between the two treatments presented positively, they chose Treatment A 72% of the time, but when presented with negatively-framed treatments, they chose Treatment A only 22% of the time. Gain-or-loss framing is seen to be an effective motivator because people are more willing to choose riskier courses of action if their available alternatives have been presented negatively; more conservative courses of action are preferred when available alternatives are presented positively. As with our other examples, innumeracy amplifies the effects of framing, and these errors are compounded the more we turn away from numerical information. Peters also notes in this section that people with low objective numeracy distrust numbers.

It is often said that "people lie with statistics," which I find troubling as it has made people distrust statistics rather than liars, who can just as easily lie with words or pictures. Rather, students should be given the skills and confidence to evaluate the information they are given, skills which Peters shows are often lacking in the

general population. Through an unnecessary learned aversion to statistics and numbers, people remain bereft of the skills which could help them thrive (or even cope). This psychologist noted similarities here with others' research on what is called the peripheral route to persuasion, in which focus is on surface-level characteristics rather than the content of the argument (the central route). Details both superficial and visceral already have an advantage in influencing our decisions, so when we eschew meaningful numerical data outright, these will carry the day. Systems 1 and 2—each of which has its place—are already in tension with one another, so choosing to avoid System 2 by favoring anecdotes, personal stories, and emotions severely handicaps us. Cultivation of System 2 habits of thought, however, gives us greater facility with them and decreases the cognitive load we must carry when this manner of thought is required of us.

People with greater ease at handling numbers, that is, those high in objective numeracy, tend to select data most directly relevant to the topic under consideration. They use reason-based strategies informed by numerical data and are better at untangling fact from feeling. Highly numerate people do take longer to make decisions, but they encode the facts which inform these in more meaningful ways for later recall and as integrated component parts of ever-growing and, frankly, better systems of knowledge, in which the habits and memories of consistent reason continue to inform and improve intuitive and automatic judgments. Whatever natural disposition they may have for numerical intelligence, their habitual practice and use of it have made for an ability to sustain thought in this manner without the sharp increase in cognitive load seen in their innumerate peers. To what extent, then, are numerical intelligence and mathematical decision-making facets of general intelligence and decision-making? Are there parts of it which lie beyond what we can say about the general?

Peters says that numerical intelligence is a part of general intelligence (e.g., learning, reasoning, problem solving, and integration of cognitive functions) but still retains its own special functions and contributions. To this end, she cites several studies, one of which shows that inferior-parietal lesions destroy numerical knowledge while leaving other knowledge intact; another, that older bookkeepers and accountants have maintained numerical memory comparable to that of young adults despite declines elsewhere. According to Peters, "numeracy's effects on decision tasks also tend to be independent of general intelligence." This may seem obvious, but beyond general smarts (such as ease with words and abstract reasoning), the more numerate make better numeracy-related decisions. The significance of such a statement may be unclear until Peters cites evidence showing that numeracy correlates with better health and financial outcomes, even after controlling for variables associated with non-numeric intelligence.

So what are the causes of numeracy, and to what extent can it be acquired? Genetics may influence numerical competencies, and socioeconomic backgrounds

may then amplify initial aptitude differences in the opportunities for development which they provide. Access to wealth can mean increasing educational opportunities and outcomes for children. Rich people can invest in high-quality education that develops students' ability to use and understand numbers and to persevere when solving problems. Students receive positive feedback and make appropriate changes. Accordingly, Peters says that education is tied closely to numeracy skills. Poverty may mask genetic differences by limiting the educational opportunities children need to develop their potential numeric intelligence. However, while being good at math usually relates to better outcomes, objective numeracy does not always guarantee it. Numeric confidence also plays a role.

People who are high in objective numeracy skills and feel confident in their ability to use numbers, what Peters calls "subjective numeracy," have the best outcomes. Alternatively, people with low objective numeracy may be high in subjective numeracy. A mismatch between objective numeracy and numerical confidence can lead to bad decisions. People who are low in subjective numeracy experience more anxiety, which increases cognitive load, the strain of which often makes one revert to biases and heuristics. Numeric confidence relates to approach or avoidance and persistence in the face of obstacles.

Whether people are low in objective numeracy, lacking subjective numeracy, or even high in both, they are still prone to some degree of error when handling complex mathematical information, by its very nature. That being said, those high in both objective numeracy skills and the confidence to approach numerical information and persist in complex numerical tasks have the best outcomes. Incongruous confidence levels, in both directions, interestingly, bring poor results. As one might expect, the biggest mistakes are made by people lacking in objective numeracy yet nevertheless full of confidence, but results are also poor among those high in objective numeracy yet low in subjective numeracy. These individuals experience more anxiety which increases cognitive load, the strain of which often makes them revert to biases and heuristics. All of this has a direct bearing on quality of life. By failing to effectively engage with numerical information, we limit our own ability to achieve better health, financial, and social outcomes.

A significant chunk of the book concerns itself with practical recommendations on improving how we can present numerical information for more effective use by those who will receive it. These recommendations are directed toward not just educators, but anyone who communicates numerical information: physicians, governmental entities, even mechanics. First, to communicate effectively, one should know what his or her communication seeks to accomplish and then communicate that clearly. Having demonstrated the effects of cognitive effort and its load, Peters naturally urges using methods demonstrated to reduce cognitive effort and increase attention to important numeric information. Such methods include highlighting the meaning of only the most important information and

ordering the information so the most important occurs either first or last, providing comparison, providing fewer options and less information (favoring the most relevant), and providing appropriate and effective visuals. These techniques will help people whose judgment may be clouded by incorrect facts correct their inappropriate interpretations, help people avoid being surprised by unexpected events and their consequences, focus attention, and help people perceive the usefulness of numeric information. Peters also makes a strong case for improving mathematical education in schools, which is associated with higher wages and better financial outcomes.

Although Peters' book competes with a number of popular books on general decision-making with conclusions applicable to numeracy, Peters' focus on numeracy was timely and welcome and made it stand apart from other works. Peters persuasively argues the importance of numbers in our lives. They instruct, inform, and give fuller meaning to information about myriad topics including science, health, finances, politics, sports, and hobbies. Although Peters states that the book is aimed at a general audience, its presentation calls for more of an expert audience. Each chapter is followed by several dense pages of references; how these various studies reached the findings they did may have been better explained. Regardless, the book is a culmination of an impressive amount of research into the important understanding of numbers, how different abilities affect decision-making, and need to better present information. She shows us that innumeracy is not inevitable. We are born with an intuitive sense of numbers. The opportunities we are provided and how we communicate can increase our use and understanding of numerical information, strengthening the decisions we make, and improving life outcomes.

References

Kahneman, Daniel, and Amos Tversky. 1972. "Subjective Probability: A Judgment of Representativeness." *Cognitive Psychology* 3: 430-454. https://doi.org/10.1016/0010-0285(72)90016-3

Kahneman, Daniel. 2011. *Thinking, Fast and Slow.* New York, NY: Farrar, Straus, and Giroux.