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## Review of *Innumeracy in the Wild: Misunderstanding and Misusing Numbers* by Ellen Peters

### Abstract

Ellen Peters's new book *Innumeracy in the Wild: Misunderstanding and Misusing Numbers* (Oxford University Press, 2020) is a whirlwind tour of psychological research on numeracy and its interactions with decision-making. The book is packed full of convincing arguments about the impact of numeracy and innumeracy on people's decisions and life outcomes, piles of supporting evidence and relevant references, and detailed expositions of multitudes of research results. Thus, it can serve the motivated reader well as a comprehensive literature review of psychologically oriented research on numeracy and decision-making.

### Keywords

decision-making, innumeracy, numeracy, psychology, quantitative literacy

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### Cover Page Footnote

Gizem Karaali completed her undergraduate studies at Boğaziçi University, Istanbul, Turkey. After receiving her Ph.D. in Mathematics from the University of California Berkeley, she taught at the University of California Santa Barbara for two years. She is currently a professor of mathematics at Pomona College where she enjoys teaching a wide variety of courses and working with many interesting people. Her scholarly interests include humanistic mathematics, pedagogy, and quantitative literacy, as well as social justice implications of mathematics and mathematics education.

Ellen Peters's new book, *Innumeracy in the Wild: Misunderstanding and Misusing Numbers* (Oxford University Press 2020), is a whirlwind tour of research on numeracy and its interactions with decision-making. In nineteen chapters and a little under three hundred pages, Peters makes the arguments that

- (1) numeracy is important,
- (2) its impact on decision-making is almost undeniable,
- (3) we are slowly understanding what goes into making people more (or less) numerate, and
- (4) communicators can help people make better decisions if they are mindful of how numeracy interacts with decision-making.

The book is well researched and is chockful of evidence for the four points above, though some arguments are more complete and convincing than others. (As the author herself points out, there is still need for more research in some of these directions.)

## Content of the Book

Before sharing what I think about the book, let me review its contents in a bit more detail. The book is organized into eight parts. Part I is the introduction and this is where we learn about the three distinct constructs of numerate thinking Peters will be concerned with: objective numeracy, measured by people scoring “high or low on tests of their understanding and use of mathematical concepts” (p. 3); subjective numeracy, which corresponds to people’s “confidence with numbers” (p. 3); and intuitive number sense, “an evolutionarily old sense of how big is a quantity” (p. 4).

Part II focuses on “the objectively innumerate,” those who score badly in math tests and are not good with numeric reasoning as measured by standard tests. The three chapters in this part explain in detail how objective numeracy interacts with people making decisions: we learn in particular that people with lower objective numeracy tend to take shortcuts and are less accurate when using numerical data. Then we are introduced to habits of mind and heuristics and other quick-thinking methods people use to make decisions (in the sense of Daniel Kahneman’s *Thinking: Fast and Slow*).<sup>1</sup> Finally, we read about how emotions and more generally go into the decision-making process and their large influence for those with lower objective numeracy.

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<sup>1</sup> Editor’s footnote: Interested readers are advised that *Numeracy* ran two reviews of Kahneman in its July 2017 issue.

Part III deals with “the habits of the highly numerate.” Again, the focus here is almost exclusively on objective numeracy. In the first three chapters of this part, we learn ways in which objectively numerate people make better decisions involving numbers: they tend to “think harder with numbers,” they have a better understanding of “the feel of numbers,” and they are more sensitive to the numbers provided in decision settings and are more consistent with using them. This part ends with a chapter where we learn that “numerically imperfect reasoning” also occurs among the highly numerate.

Part IV is on how life outcomes may be related to objective numeracy and what directions for further research remain open to explore these types of issues further.

Part V goes deeper into how people come to be numerate in the first place. Chapter 11, the first chapter in this part and perhaps my favorite chapter in the whole book, is about what Peters calls the *approximate number system* (APS), what seems to be a biologically intrinsic capacity to comprehend comparative sizes. Here we learn about how other animals engage with basic senses of magnitude and quantity. We also learn about the distinctions between what seems biologically innate to us as primates and what might be special about humans, especially in the context of a human society using a language with the capacity to distinguish numbers. The next chapter explores how formal education and genetics might or might not interact with numeracy.

Part VI is on how the two ways of numeric reasoning other than objective numeracy can be related to human decision-making. Chapter 13 is about the APS and how it interacts with people making decisions: people who have a better sense of comparative magnitudes tend to make better decisions. Chapter 14 explores subjective numeracy in this context and points towards the importance of knowing what we know and what we don’t.

Part VII is an extended and updated version of an appendix the author and her colleagues contributed to a publication of the National Academies of Science (Peters *et al.* 2014). In the three chapters of this part, we learn how the communication of numeric information can help or hinder people’s decision-making, especially if those involved are not highly numerate. (For example, in Chapter 15, I found it fascinating to learn about how the MPG (miles per gallon), though ubiquitous, can be a misleading measure of fuel efficiency.) Overall, the three chapter titles summarize the message of this part well: “Evidence-based information presentation matters,” “Provide numbers but reduce cognitive effort,” and “Provide evaluative meaning and direct attention.”

Part VIII concludes with an exploration of how one might become more numerate. The last chapter summarizes the contents of the book, going over the main ideas one by one.

## There is a Reason for University Presses

When I was asked to review *Innumeracy in the Wild*, I thought I would be reading a book akin to a revised and updated version of John Allen Paulos's (1989) classic *Innumeracy: Mathematical Illiteracy and Its Consequences*. On my nightstand was another book that I was looking forward to reading once the semester ended: *Calling Bullshit: The Art of Skepticism in a Data-Driven World*, by Carl Bergstrom and Jevin D. West (2020). *Calling Bullshit* is not only or specifically about innumeracy; rather it is about data (il)literacy and how people with a range of motivations can use numbers to influence our decisions. Still the themes overlapped in my mind, and the two books, I thought, would complement each other, amusing and informing me both at the same time.

I was in many ways surprised. First of all, I should have known better to compare a respectable university press book to books published by respectable non-academic publishers. Peters's book is a dense read and would likely be quite a stretch for a general audience, even for readers who might be attracted to the previously mentioned books. Each of its nineteen chapters is accompanied by extensive notes and references; even the introduction runs a list of 37 endnotes and references. In terms of difficulty of reading, *Innumeracy in the Wild* is closer to another book I recently finished reading *Algorithms to Live By: The Computer Science of Human Decisions* by Brian Christian and Thomas L. Griffiths (2016). *Algorithms to Live By* is also about decisions humans make, but its main focus is on how algorithmic thinking can help us make better decisions (as opposed to how numerate thinking can help us make better decisions, as in Peters' book). Like Peters's book, *Algorithms* does not shy away from giving the reader significant amounts of information about research results, but in *Algorithms*, written mainly for a general audience, there is an ongoing narrative that focuses on story and contextualizing which somehow makes the text a lot less overwhelming. Peters on the other hand wrote a book that is a testament to why university presses and other academic presses should exist. This is serious stuff, and you know it. And if you don't, then the long list of references following each chapter is there to prove it to you.

Now you might consider the above to be superficial, but I think this detail about references and endnotes is indeed a reflection of the density and complexity of this text. I am not a terribly slow reader, but this book challenged me significantly, and it took me a lot longer than I had expected to read it from cover to cover. Part of this was due to the fact that the contents of the book were fascinating, at least for someone like me who cares deeply about numeracy and innumeracy and who also views herself as a scholar involved in numeracy-related work. I frequently stopped reading to take notes. There was also a significant amount of information, ideas, and arguments I wanted to ponder upon as I was reading, so reading more slowly

made sense. However, I do think that the density and complexity are intrinsic to the text, both in terms of what the author was trying to do (a lot!) and in terms of how she was doing it (describing a slew of research results one after another in each chapter, providing as much nuance as possible when there might be need for it, just like an honest scientist would). As a result, uncertainties about hypotheses and conjectures are all over the text, and the author is very careful to point out instances when results have not been replicated, when other researchers disagree and so on. All of this looks like good science to me, but it does not work as well for “an exposition for general audiences.”

Furthermore, as the reader can probably conclude from the overview of the contents of this book, there is enough material here for at least three full books. If one is aiming for a general audience, for example, the material here could support a book on how numeracy interacts with decision-making, another on how one can become more numerate, and a third on how to make sure we communicate numeric information better. I can appreciate that the author was ambitious and did not want to dilute her message, and maybe a pair of these three themes could come together productively in one book, but as a whole, I think there is just too much content here for a book addressing a general (and possibly not highly numerate) audience.

Now, the author does state at the beginning that she is writing mainly for an audience of researchers, but she also has some hope that “regular” folks who might be interested in helping their children (or themselves) become more numerate will also pick up a copy of this book and dive in. (On page 3, she writes “I hope [this book] 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.”) Quite often she addresses her reader as a “you” that might not be too sure of their numeracy skills, and she promises that her book will help that kind of reader with some tricks and more general principles to better numeracy and hence better decisions. I found these encouragements and exhortations quite unnecessary, and even distracting. For I believe that anyone willing and able to wade through the piles and piles of research evidence provided in this book must be someone who is already seriously motivated to learn about numeracy, and perhaps not just about numeracy *per se* but about numeracy research.

## **Why *Numeracy* Readers Should Read This Book**

If it sounds like I am being too critical of *Innumeracy in the Wild*, let me rush in and say that I indeed got much out of reading this book and would recommend it strongly. What I am trying to get at above is that this is a book written almost exclusively for folks like us, those who regularly like to read a journal dedicated to the scholarship of numeracy. For us, this book is a valuable collection of relevant and important content: research results about how numeracy interacts with decision

making. Those of us who teach quantitatively rich topics or quantitative literacy/quantitative reasoning (QL/QR) courses in educational institutions and the rest of us who value QL/QR all believe that numeracy is important for better life outcomes, as we believe that numeracy is a tool that can help people make better decisions in all sorts of arenas, including the workplace, health care, and personal finance. Peters in her book provides ample experimental evidence that our belief is justified. I would recommend this book even if you were only interested in justifying your own professional existence as someone who teaches math or QL/QR. There are so many examples, large and small, of how numeracy interacts with decisions people make throughout their lives and so many research results that suggest that numeracy and its impact can be cumulative throughout one's life that any instructor could find something to appeal to a grumpy student or an unconvinced department chair.<sup>2</sup>

Especially for this kind of reader, this book can serve as a compilation of psychologically-oriented research on numeracy and decision-making. As such, it can serve ably as a well-motivated literature review, one that can solidify theoretical foundations. It can also help inspire more discipline-specific work, practice, and scholarship that focuses on education and training of numeracy.

## Numeracy Work in Academic Silos

As I mentioned above, the book has many references and endnotes, each chapter referring the reader to go deeper into the literature related to the themes of the book. However, I have noticed that all the work cited and mentioned here is psychological work focusing on decision making. Even when the topic is math anxiety or formal (mathematics) education, the references do not include work done by math educators. I saw many references to journals such as *Medical Decision Making*, *Journal of Personality and Social Psychology*, and *Journal of Educational Psychology*. But I could find only one reference to a solid math education research journal: reference 54 of Chapter 18 referred to a review article on math anxiety

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<sup>2</sup> Even though Peters is a staunch advocate for numeracy throughout her book, I was taken aback by a comment at the end of Chapter 6. "A focus on measurable economic costs (as opposed to social costs and benefits) could lead to a degradation of resources we greatly value, including education, the environment, healthcare, family and friendships, and happiness. If this difference is greater for the more numerate than the less numerate, the more numerate may suffer individual consequences more. If the more numerate are policy makers, we all may suffer more" (p. 78). I totally understand what Peters is trying to say here: if numerate people value only numbers, then they can make harmful decisions that might affect a lot of people negatively. However, the last sentence on its own is still disturbing in its seeming support for innumerate policymaking. I would have much preferred it if Peters were more careful while making her point. We can strongly advocate for more value-driven education, but we should definitely not recommend less numerate policymakers.

published in the *Journal for Research in Mathematics Education*. I saw no references to *Numeracy*.

All academics are limited by our training, our collaborations, what we read, what we learn, and what we teach. It is absolutely understandable that a researcher whose main training was in psychology and main expertise is decision-making in the context of health care does not engage often with what mathematics education researchers publish in their own journals. However, I was surprised and quite dismayed to find no work mentioned or cited that was not from the silos that the author was familiar with. Then again, this set of references is also quite understandable since even the psychology literature cited on its own made for a really dense book, and the author was indeed able to tell a coherent story with this background. Perhaps a wider cast net would not have made a better book.

However, I was at least mildly worried when Peters used terms like “numeric ability” and “good / bad at math” early on without any discomfort or irony. Though she did end the book with an exhortation that everyone is (or can be) a numerate person, the almost essentialist approach she seemed to promote at the beginning occasionally made me wince. After having engaged with (and personally contributed to) scholarship that agonizes over definitions and nuances of the construct of numeracy through the years, it was also interesting for me to note that Peters dove right into her book by identifying numeracy with basic math skills that can be tested by simple tests. (She did eventually provide some nuance by calling this decidedly math-specific construct “objective numeracy,” allowing some of the remaining aspects of numeracy to be captured by other related terms, such as “subjective numeracy.”)

Also, I have to admit that I was surprised to see a book with the word “innumeracy” in its title not even acknowledge the heritage of the term. If Peters did not want to go into the history of the term as some of us reading and writing for this journal like to do, she could have at least given a hat tip to the first book published in the United States with the same word in its title. I am sure John Allen Paulos does not worry about who cites his work and who does not, but I would have at least expected that an editor would point out that the title of the book would remind at least some readers of his book.

Ultimately, we all live in silos. I did not know of most of the research described in this book. So, I should be careful not to throw stones. Perhaps this book can actually help overcome some of the very same barriers its homogeneity of references reflects. Peters has written a detailed tome that can serve as a comprehensive literature review for those of us who teach quantitatively rich topics or QL/QR courses and think about QL/QR training carefully. Reading this book can help us catch up with all that we might have been missing. After that, perhaps there will be room for more conversations and possibly even collaborations. One can only hope.

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