Response to “Do the Math” by Joachim I. Krueger

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I appreciated Krueger’s (2020) thoughtful review including his conclusion that “*Innumeracy in the Wild* is a timely and important book.” Writing primarily for researchers, I had three main goals: (1) To explore psychological mechanisms linking innumeracy with poorer judgments and choices; (2) To review its associations with life outcomes (e.g., in health and personal finances); and (3) To examine methods to help people use numbers more effectively.

In the book, I discuss three qualitatively different ways people can be numerically competent – through objective numeracy, numeric confidence, and numerical acuity (which underlies ability to distinguish numerical magnitudes, including in decisions). More research has linked the former two constructs to decision outcomes although, to be fair, such numerical-acuity research is newer. Krueger is also correct that the book little covered dual-process theories which are complex and deserve multiple books. Numeracy findings are generally consistent with dual-process theories including default-interventionist (Stanovich, 2009; Kahneman, 2003), interactionist (Epstein, 1994), and fuzzy-trace (Reyna, 2004) theories. Peters et al. (2019), however, highlighted theory-consistent and theory-inconsistent evidence. For example, greater objective numeracy (presumably a System-2 ability) was linked with worse judgments and greater affect to numbers (presumably a System-1 response), respectively a result and interaction of the two systems not anticipated by default-interventionist theories. Thus, numeracy research can be used to question and potentially improve theory.

Numeracy-and-decision-making studies often control for education, literacy, and/or factors including non-numeric intelligence measures which correlate modestly with numeracy (r=.26-.50; Peters et al., 2006, 2010). Numeracy results sometimes diminish with education controls and I argue it more useful to control for non-numeric intelligence due to education’s causal effects. Chapter 18 reviews existing causal studies in numeracy research; more studies are needed.

Krueger questioned whether numeracy anomalies highlight psychological mechanism. In one example (Chapter 6), anomalies such as the bets effect demonstrate a bias of the highly numerate, but, more importantly, highlight information-processing inclinations that generally underlie their superior decision making (Peters et al., 2019). The more objectively numerate also do simpler calculations than perhaps expected. Unlike Krueger, I would characterize such operations as them adaptively using their numeric capacity to meet goals, in this case accuracy with less effort. Other goals presumably lead to their greater confirmation biases emerging under some circumstances. Additional anomalies point towards potential range limitations of current measures and/or the importance of “diagnosing” both the person (their numeracy) and the situation (its mathematical difficulty). For example, some decisions pose such numeric difficulty that interventions assist only the highly numerate (Chapman & Liu, 2009). Chapter 15-17’s information-presentation techniques put the onus on communicators to recognize innumeracy in their communications and correct them responsibly.

Conclusion

The typical view of STEM education leading to better jobs and improved economy ignores numeracy’s importance to everyday people, the quality of their decisions, and the health, wealth, and other outcomes they experience. Mathematics education should more directly target innumeracy, with

students proceeding to other courses only after they have deep understanding of numeric concepts linked with decisions and life outcomes (e.g., arithmetic, algebra, probabilistic reasoning; Peters et al., 2017; Sinayev & Peters, 2015).

References

Chapman G.B. & Liu, J. (2009). Numeracy, frequency, and Bayesian reasoning. *Judgment and Decision Making, 4*(1), 34–40.

Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. *American Psychologist, 49*, 709–724.

Kahneman, D. (2003). Maps of bounded rationality: Psychology for behavioral economics. *American Economic Review, 93*(5), 1449‑1475.

Krueger, J. (2020). Do the Math: Review of 'Innumeracy in the wild: Misunderstanding and misusing numbers' by Ellen Peters. *The American Journal of Psychology.*

Peters, E., Baker, D. P., Dieckmann, N. F., Leon, J., & Collins, J. (2010). Explaining the effect of education on health: A field study in Ghana. *Psychological Science, 21*(10), 1369–1376.

Peters, E., Fennema, M.G., & Tiede, K.E. (2019). The loss-bet paradox: Actuaries, accountants, and other numerate people rate numerically inferior gambles as superior. *Journal of Behavioral Decision Making*, *32*, 15‑29.

Peters, E., Shoots-Reinhard, B., Tompkins, M.K., Schley, D., Meilleur, L., Sinayev, A., Tusler, M., Wagner, L., & Crocker, J. (2017). Improving numeracy through values affirmation enhances decision and STEM outcomes. *PLoS ONE*, *12*(7): e0180674. https://doi.org/10.1371/

Peters, E., Västfjäll, D., Slovic, P., Mertz, C. K., Mazzocco, K., & Dickert, S. (2006). Numeracy and decision making. *Psychological Science*, *17*(5), 407-413.

Reyna, V. F. (2004). How people make decisions that involve risk: A dual-processes approach. *Current Directions in Psychological Science, 13*(2), 60‑66.

Sinayev, A. & Peters, E. (2015). The impact of cognitive reflection versus calculation in decision making. *Frontiers in Psychology, 6*:532. doi:10.3389/fpsyg.2015.00532.

Stanovich, K. E. (2009). Distinguishing the reflective, algorithmic, and autonomous minds: Is it time for a tri-process theory. In *In two minds: Dual processes and beyond* (pp. 55‑88). New York: Oxford University Press.