PNAS LETTER

On multiple sources of value sensitivity

Angelo Pirrone[a,1] and Konstantinos Tsetsos[b,c]

In PNAS, Shevlin et al. (1) find that participants decide faster and more accurately when choosing between high-value as compared to low-value options. According to the authors, these results suggest that high-value options are easier to discriminate, and "cast doubt on the notion that increasing value reduces discriminability" predicted by principles like diminishing value sensitivity (2) and divisive normalization (3).

This article is an important empirical contribution, demonstrating conditions under which increasing value leads to faster and more accurate choices. Previous studies reported only faster decisions for high-value equivalent options, and less accurate decisions for high-value unequal options (4–10). However, we believe that the results of Shevlin et al. (1) cannot rule out representational distortions, such as concave utility functions or divisive normalization.

Value representations that feed into the decision process are thought to be shaped by hard-wired properties of the neural code. Saturating neural responses, divisive normalization, or noisier neural responses for larger inputs could all, independently, lead to faster and less accurate responses. Unlike value representations, decision computations are amenable to cognitive control and top-down adjustments as a function of external (e.g., the reward statistics of the environment) or internal (e.g., motivation levels) factors. Importantly, top-down adjustments could temper or even reverse the influence of value representations on choice. For instance, although representations become less easily discriminated for high-value options, more cognitive resources may be invested in high-stakes decisions. Thus, choosing which luxury car to buy may involve a faster and more accurate deliberation process than choosing which affordable car to buy.

We believe that the experiments presented by Shevlin et al. (1) involved manipulations that could trigger top-down adjustments of decision computations. In these experiments, choices were always made between two low-, medium-, or high-value options, implicitly enabling the classification of each choice trial as belonging to one of these categories. Additionally, most blocks ("cued value") exclusively involved decisions of one value type (low, medium, or high, with the type announced by a cue at the beginning of each block), with a minority of blocks ("mixed") fusing choice trials of all value types. Although the authors base their conclusions on the "mixed" blocks data, carryover effects from the "cued" blocks could be in play, driving the reported results. For example, participants might have paid more attention to the task in "high" blocks, also trying to behave consistently in (the easily identified) "high" trials in mixed blocks. Similarly, because participants responded more slowly in "high" cued blocks, high-value options might be more familiar and easier to discriminate in "mixed" blocks.

These and other hypotheses yet to be proffered cannot be ruled out. A study in which participants are not encouraged to adopt different strategies in trials of different total value could be more diagnostic of the representational distortions that affect value-based decisions. Overall, a result in which large rewards increase engagement and thus discriminability (1) is not incompatible with diminishing value sensitivity at a low level due to concave utility or divisive normalization.

ACKNOWLEDGMENTS. We are grateful to James A. R. Marshall, Fernand Gobet, and Andreagiovanni Reina for discussions. This research was supported by a European Research Council Starting Grant under the European Union's Horizon 2020 research and innovation program (Grant No. 802905, awarded to K.T.).

Author affiliations: [a]Centre for Philosophy of Natural and Social Science, London School of Economics and Political Science, London WC2A 2AE, United Kingdom; [b]School of Psychological Science, University of Bristol, Bristol BS8 1TU, United Kingdom; and [c]Department of Neurophysiology and Pathophysiology, University Medical Center Hamburg-Eppendorf, 20246 Hamburg, Germany

Author contributions: A.P. and K.T. wrote the paper.

The authors declare no competing interest.

[1]To whom correspondence may be addressed. Email: a.pirrone@lse.ac.uk.

Published August 15, 2022.

1. B. R. K. Shevlin, S. M. Smith, J. Hausfeld, I. Krajbich, High-value decisions are fast and accurate, inconsistent with diminishing value sensitivity. *Proc. Natl. Acad. Sci. U.S.A.* **119**, e2101508119 (2022).
2. D. Kahneman, A. Tversky, "Prospect theory: An analysis of decision under risk" in *Handbook of the Fundamentals of Financial Decision Making: Part I*, L. C. MacLean, W. T. Ziemba, Eds. (World Scientific, 2013), pp. 99–127.
3. K. Louie, L. E. Grattan, P. W. Glimcher, Reward value-based gain control: Divisive normalization in parietal cortex. *J. Neurosci.* **31**, 10627–10639 (2011).
4. A. Pirrone, H. Azab, B. Y. Hayden, T. Stafford, J. A. R. Marshall, Evidence for the speed-value trade-off: Human and monkey decision making is magnitude sensitive. *Decision* **5**, 129–142 (2018).
5. A. Pirrone, W. Wen, S. Li, Single-trial dynamics explain magnitude sensitive decision making. *BMC Neurosci.* **19**, 54 (2018).
6. A. Pirrone, A. Reina, T. Stafford, J. A. R. Marshall, F. Gobet, Magnitude-sensitivity: Rethinking decision-making. *Trends Cogn. Sci.* **26**, 66–80 (2022).
7. K. Steverson, H. K. Chung, J. Zimmermann, K. Louie, P. Glimcher, Sensitivity of reaction time to the magnitude of rewards reveals the cost-structure of time. *Sci. Rep.* **9**, 20053 (2019).
8. T. Folke, C. Jacobsen, S. M. Fleming, B. De Martino, Explicit representation of confidence informs future value-based decisions. *Nat. Hum. Behav.* **1**, 0002 (2017).
9. A. R. Teodorescu, R. Moran, M. Usher, Absolutely relative or relatively absolute: Violations of value invariance in human decision making. *Psychon. Bull. Rev.* **23**, 22–38 (2016).
10. R. P. Kirkpatrick, B. M. Turner, P. B. Sederberg, Equal evidence perceptual tasks suggest a key role for interactive competition in decision-making. *Psychol. Rev.* **128**, 1051–1087 (2021).