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Unpacking the computations of human spatial search under uncertainty: noisy utility maximization, discounting, and probability warping

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Abstract

Humans navigate daily decision-making by flexibly choosing appropriate approximations of what ought to be done. Which mental algorithms do people use, and when? We use behavioural experiments and modelling to investigate three computational principles known to influence decision making: noisy utility maximization, discounting, and the probability warping principle of Prospect Theory. While these principles have been shown to separately influence human behaviour in simple laboratory tasks, such as bandits and gambles, we evaluate their combined use in the context of a naturalistic spatial search that required sequential decision-making. We found that while aggregate human behaviour can be reasonably well explained by an optimal planner with noisy utility maximization, individual-level behaviour exhibits consistent irregularities, that deviate from expected utility theory. We show that model-based prediction of individual-level behaviours in our experiment is significantly improved by combining the three computational principles, and benefits particularly strongly from probability warping. Furthermore, our results suggest that probability warping may be a common factor of human decision making, that generalizes beyond the gambles explored in Prospect Theory, to natural human behaviours such as spatial search and navigation.