

Human decision making in a probabilistic visual task: Testing a model based on expected utility theory.

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Purpose: Researchers in decision making under risk have repeatedly found that Expected Utility Theory (EUT) cannot describe the choices humans actually make [1]. The pattern of failures in their choices suggests that subjects' use of the explicit probability information they are given is markedly distorted [2,3]. In contrast, human performance in rapid motor decisions under risk, where uncertainty is implicit in subjects' motor error, comes close to maximizing expected gain, consistent with EUT [4,5]. Here we studied human decision making in a visual aiming task that is stochastic (subjects can only partially control the outcome) but where probability information is implicit, based on a visual estimate of width. We apply a criterion due to Allais [2] to test whether subjects' choices are consistent with EUT. **Task:** Subjects chose between two possible outcomes by shooting a noisy bullet at one of two possible target zones. The trajectory of the bullet was simulated by a random walk with fixed Gaussian noise. The width of the zone and the location of the shooter determined the probability of hitting the zone. Subjects were presented with pairs of widely-spaced target zones and could choose to shoot at one or the other but not both. The widths of the zones were adjusted so that the subject could win points O_i with probability p_i , $i = 1,2$ by choosing to aim at zone i . Subjects competed for the highest score. **Predictions:** According to EUT, subjects should prefer the zone with the higher expected utility,

$$EU_i = p_i U(O_i), \quad i = 1, 2 \quad (1)$$

where $U(O_i)$ is a function mapping outcomes O_i to subjective utility and their estimates of probability were based on a visual estimate of the width of each target zone. When $EU_1 = EU_2$ subjects will be indifferent between the two options. That is, they are indifferent precisely when

$$p_1/p_2 = U(O_2)/U(O_1) \quad (2)$$

In four conditions, we varied the probability p_2 of incurring outcome O_2 between 0.8, 0.6, 0.4 and 0.2 by varying the width of one of the target areas. Only two outcome values were used ($O_1 = 500$ and $O_2 = 100$) and the ratio in Eq. 2 should be constant if EUT is a valid model of choice in this task. **Analysis:** We used an adaptive staircase procedure to estimate the probability p_1 that corresponded to the point of indifference for choosing between the target zones. **Results:** Five subjects completed the experiment. Subjects' mean probability ratios p_1/p_2 ranged from 0.25 to 0.55 for the range of probabilities tested, but the ratios were typically not constant. They were a convex function of p . For these subjects, EUT cannot account for performance in this visual decision task for any choice of utility function $U(O)$.

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References

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