Implications of disregarding objective utilities when selecting a medical test

Jonathan D. Nelson¹, Björn Meder¹, Christine Szalay¹, Vincenzo Crupi^{2,3}, Katya Tentori⁴

¹Center for Adaptive Behavior and Cognition, Max Planck Institute for Human Development, Berlin, Germany, ²Department of Philosophy and Education, University of Turin, Turin, Italy, ³Center for Mathematical Philosophy, Ludwig Maximilian University of Munich, Munich, Germany, ⁴Center for Mind/brain Science and Department of Cognitive Science and Education, University of Trento, Rovereto, Italy

Purpose: Consider the task of selecting a binary medical test to determine whether a patient has a disease. Normatively, this requires considering the base rate of the disease, the true and false positive rate for each test, and the payoffs and costs for correct and incorrect diagnoses. Often, however, these quantities are not precisely known. Furthermore, psychological research shows that it can be difficult for people to appropriately use objective utilities. Are there shortcuts or heuristic strategies that could approximate calculation of tests' objective value (utility)? Can pure information strategies (which disregard the objective utilities) sometimes identify the objectively most useful test?

Methods: We use simulation studies and mathematical proofs to address whether, and the circumstances under which, particular pure information test selection strategies tend to identify the objectively most-useful test. We study both extremely simple heuristic strategies, as well as test selection strategies (such as information gain) that have been proposed in medical decision making literature.

Results: We focus on the likelihood difference heuristic for selecting among binary medical tests. This extremely simple heuristic selects the test with the highest likelihood difference, or difference between true and false positive rate, ignoring all other information. We prove that despite its simplicity, the likelihood difference heuristic identifies the objectively most useful test under certain conditions. This holds if the base rate of the disease equals the threshold probability above which it is best to act as if the patient has the disease. In other circumstances, the likelihood difference heuristic is not in general optimal but identifies the more useful test most of the time. Further analyses show that methods proposed in optimal experimental design literature and in medical decision making literature, such as information gain (mutual information), which was proposed by Benish (1999, 2003), can perform reasonably in some circumstances but are not optimal under any of the circumstances that we studied.

Conclusions: If the objective payoff structure and base rate of a disease are even approximately known, it can be possible to identify a purely informational test selection strategy that does not explicitly calculate utilities, but which nonetheless performs well.