Entropy of Opponent's Choice Predicts Reaction Time and Outcome Appraisal Time in a 2-Player Strategic Game

Jason J. Jones (jasonj@ucsd.edu)
Department of Psychology, University of California, San Diego
9500 Gilman Drive
La Jolla, CA 92093-0109 USA

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Opponent Entropy and Strategy

In iterative games of strategic choice, the unpredictability of a player can be quantified using the concept of entropy, borrowed from information theory. Given two possible moves, a player who always chooses the same move is analogous to an information source that always outputs the same symbol. There is no uncertainty as to the output and thus zero entropy. Alternatively, a player who chooses his moves at random achieves maximum entropy (1 bit/play in the case of two possible moves each play). Any bias toward choosing one move more often than the other leads to decreasing entropy as depicted in Figure 1a. A rational player should be able to take advantage of any such bias and obtain expected scores in a pattern that is a reflection of the entropy curve (Figure 1b).

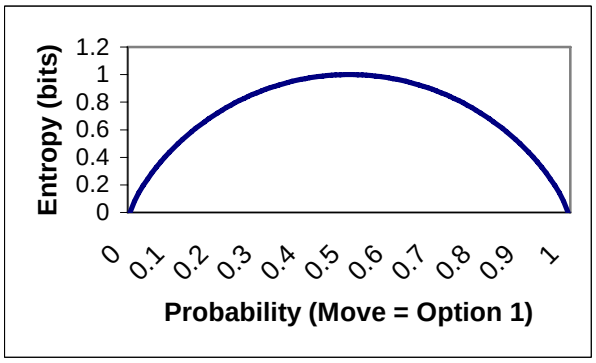

Figure 1a: Opponent entropy as a function of move probability

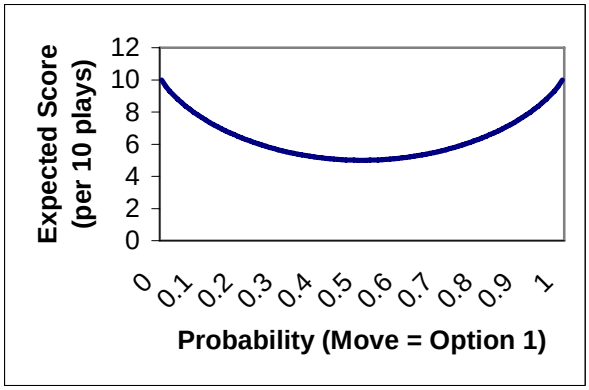

Figure 1b: Expected score as a function of move probability

An experiment was conducted pitting human subjects against computer opponents with various response biases (output entropies) in a paradigm analogous to the game "matching pennies." Subjects obtained scores very close to the predicted pattern. In addition, several other effects were observed:

(1) Subjects learned quickly the response biases of the computer opponents (within the first 10 plays).
(2) However, evidence suggested that subjects frequently forgot the opponent-to-bias mappings they had learned while they played intervening opponents.
(3) Subjects' overall scores were less than optimal because they implemented probability-matching rather than rational-choice response patterns.

Opponent Entropy and Response Times

Strong evidence was also obtained for a relationship between opponent entropy and the time human players spent choosing moves and evaluating outcomes. Figure 2 plots mean "move decision" response times and (separately) mean "outcome appraisal" response times versus opponent entropy. Subjects spent more time choosing moves when facing high-entropy opponents and spent more time evaluating the outcome of plays against high-entropy opponents.

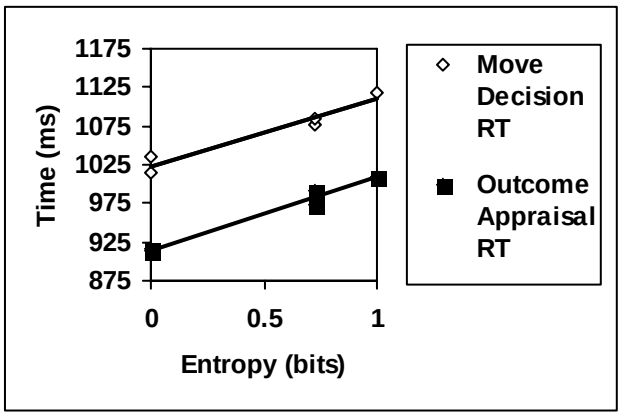

Figure 2: Response times as a function of opponent entropy

References

Pierce, J. R. (1961). *Symbols, Signals and Noise*. New York. Harper & Brothers.