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The shape of information processing functions

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The shape of information processing functions

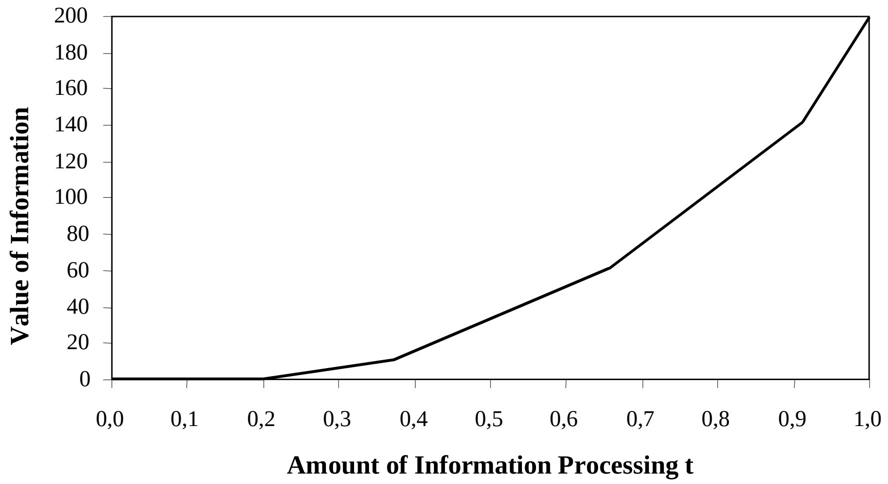
In the context of decision making under risk, additional information can be seen as a resource for the improvement of decision quality. The value of this improved quality is usually measured using Marschak´s concept of the value of information. From this point of view, human information processing can easily be understood as a production process transforming the information processing activity into improved decision quality. The production function of this activity therefore assigns the value of information to each amount of information processing with respect to the decision problem at hand.

According to a well-known result by Radner and Stiglitz (1984), this function has increasing marginal returns near the origin, provided certain conditions are fulfilled. Such conditions are the differentiability of the involved likelihood function, the continuity of utility in the space of alternatives, and especially the information processing being completely uninformative ("zero-information") at the beginning.

The paper discusses the shape of information processing functions with real-valued arguments t, representing the amount of information processing, for decision problems under risk with a finite number of alternatives A_n, states of nature S_s, and information signals I_i. The Radner and Stiglitz-result for such decision problems under analogue conditions is that the beginning of information processing is always of zero value. It is also shown how this shape depends up to the point of perfect information on the componentwise likelihood functions $p_t(I_i|S_s)$ which represent the change in prior probabilities for the states of nature with increasing information processing activity t.

For constant learning speed, i.e. information processing with likelihood functions $p_t(I_i|S_s)$ linear in t, the resulting information processing function is shown to be piecewise linear in t with finitely many indifferentiabilities. At each of these, the function becomes steeper, i.e. the information processing gets more attractive from a prior point of view (see example in figure 1).

Figure 1: Information processing function (constant learning speed)



For increasing learning speed, i.e. information processing with likelihood functions $p_t(I_i|S_s)$ convex in t, the function again has a finite number of in-differentiabilities with growing marginal increases, and is piecewise convex in between. So, for constant or increasing learning speed, the information processing function is nonconcave everywhere.

For the important and often more realistic case of decreasing learning speed, i.e. likelihood functions $p_t(I_i|S_s)$ that are concave in t, the situation is how-ever more complicated: the resulting information processing function is piecewise concave, again having an infinite number of indifferentiabilities at which it gets steeper. Depending on the decision problem and the likeli-hoodfunctions, the sequence of indifferentiabilities can have decreasing or increasing increments (see examples in figure 2).

The proof of these results is comparatively simple, and examples for simple decision problems will be provided.

Figure 2: Information processing functions (decreasing learning speed)