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An information primacy model of exploratory and foraging behaviour

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We describe a stochastic model of an animal exploring and foraging within an uncertain environment. Behaviour is determined not by an optimizing algorithm but by fuzzy systems using linguistic rules derived from the information primacy hypothesis which stresses the importance of continual information gathering under conditions of uncertainty. In the model, the animal's hunger increases steadily over time and is reduced by visiting locations that may contain varying amounts of food. Uncertainty arises from three sources: (1) location novelty or ambiguity, that is, the animal is uncertain whether it has visited the same location before; (2) variation in the amounts of food in a given location; and (3) the recency of information concerning these two aspects of a given location. In complex and changing environments fresh information is likely to be more accurate than old information and consequently our model gives most weight to recently gathered information. All sources of uncertainty are reduced by visiting locations and gathering fresh information. The model is successful in simulating results from experiments investigating such phenomena as: spontaneous alternation; patrolling; the effects of hunger on the variability of learnt responses; latent learning; contrafreeloading; and behaviour following changes in food availability.

Uncertainty is unavoidable in complex and changing environments. As Kahneman & Tversky (1982, page 144) have argued 'At all levels of biological complexity there is uncertainty about the significance of signs or stimuli and about the possible consequences of action'. It is, therefore, not surprising that one of the most often criticized constraints of the classical models of optimal foraging, for example the marginal value theorem, is the unrealistic assumption that the animal has complete information about its environment. While these optimal foraging models have regarded animals primarily as momentary maximizers, more recent research, both empirical and theoretical, has focused on the need for animals to counter fluctuations in food abundance. There are a number of ways in which an animal might do this, for example by storing fat on its body (McNamara & Houston 1990), by foraging in groups (e.g. Ekman & Hake 1988), or by hoarding food for later consumption (McNamara et al. 1990). An additional possibility is that animals respond to fluctuations in food supply by gathering information that can be used at a later time when conditions change and the presently preferred patch disappears or is reduced in profitability. To obtain such information the animal has to start exploring before the preferred patch has been fully exploited, that is, it has to be actively looking for a change, as opposed to reacting to one (Berlyne 1960). The proximate mechanism for this behaviour might, in motivational terms, be the 'information primacy hypothesis' (Woodworth 1958; Inglis 1983, 2000) which proposes that a major determinant of behaviour is a need to reduce environmental uncertainties. We describe a stochastic model of behaviour based upon the premises of this hypothesis. The model is used to simulate a range of experimental paradigms that investigate exploratory and foraging behaviour to assess the general applicability of the information primacy hypothesis in explaining animal decision making concerned with satisfying primary needs in conditions of environmental uncertainty.

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THEORETICAL BASIS OF THE MODEL

The ability to adapt to unfamiliar and novel situations is a fundamental requirement for animals living in complex

