How an animal’s behavioural repertoire changes in response to a changing environment: a stochastic model

Ian R. Inglis¹,² & Steve Langton³)

(¹ Animal Welfare Team, Central Science Laboratory, Sand Hutton, York, YO41 1LZ, UK;
³ Hallgarth, Leavening, N. Yorkshire, YO17 9SA, UK)

(Accepted: 3 November 2006)

Summary

We describe a stochastic model that simulates how the behavioural repertoires of animals living in complex and stochastic environments change in response to the changing environment. The model incorporates concepts derived from research in three main areas: (a) cognitive models of the environment, (b) the information-primacy hypothesis, and (c) approach/avoidance behaviours to novel and unfamiliar stimuli. The model animal is in an environment that stochastically changes, and in order to reduce primary needs it must perform behaviours that are appropriate to the changing environmental conditions. Different behaviours from its behavioural repertoire are performed and if the chosen behaviour matches the current environmental conditions the animal is able to reduce its primary needs with a probability that increases with the degree of match. A large mismatch between the performed behaviour and the environment simulates the situation where the behaviour does not meet the current environmental conditions, and hence there is a high degree of uncertainty and little chance of reducing primary needs. In such cases a plausible new behaviour may be created and added to the repertoire, and the unsuccessful behaviour can be deleted. Thus a history of small mismatch values indicates that performance of the behaviour has reliably met the environmental requirements; whilst a history of large mismatch values reflects far greater uncertainty associated with the performance of the behaviour. In the model a high priority to satisfy primary needs favours the selection of behaviours with histories of small mismatch values, and a high priority to reduce uncertainty favours behaviours with histories of high mismatch values. The degree of mismatch interacts with the current cognitive ability of the animal to process the information to create one of two types of negative affect; i.e. either boredom or anxiety. Boredom and anxiety interact with the need state to determine whether reliable or uncertain behaviours are performed. Simulations of low-variability environments
result in a small behavioural repertoire, the repetitive performance of only a few behaviours, and an affective state that is neither markedly anxious nor bored. Whilst simulations of high-variability environments result in a large behavioural repertoire, the performance of many behaviours in different sequences, and an affective state that frequently shifts between high levels of boredom and anxiety. The time it takes after a switch to a novel environment for the behavioural repertoire to include behaviours successful in reducing primary needs in that novel environment is less when coming from a high-variability environment than when coming from a low-variability environment. The outputs of the model are compared to the behaviour of real animals living in environments with differing degrees of change, and the crucial role of uncertainty reduction in the creation of behavioural competence is discussed.

**Keywords:** behavioural repertoire, changing behaviour, environmental change, fuzzy model.

**Introduction**

How do animals living in complex and stochastic environments change their behaviour in response to unfamiliar and novel situations? Here we develop a model of an animal changing its behavioural repertoire in order to reduce primary needs in the face of the uncertainty generated by a stochastic environment. In the model different behaviours are selected over time and if the chosen behaviour matches the current environmental conditions the animal is able to reduce its primary needs. The model does not address the problem of how the animal satisfies different primary needs (i.e., whether it chooses a behaviour that reduces hunger as opposed to one that reduces thirst) but rather how the animal changes its behaviour to satisfy primary needs in general. The model uses simple fuzzy logic systems and its main features are: (a) the development of a repertoire of plausible behavioural responses to environmental change, (b) the continual selection of different behaviours from this repertoire to try to reduce primary needs and/or uncertainty in the changing environment, and (c) the creation of two types of negative affect (i.e., boredom and anxiety) that determine whether new or familiar behaviours are performed. Results from simulations of the model are qualitatively compared to the behaviour shown by animals living in environments with varying levels of change.

**Theoretical basis of the model**

The model incorporates concepts derived from research in three main areas: (a) cognitive models of the environment, (b) the information-primacy