Modelling Biases and Biasing Models: The Role of 'Hidden Preferences' in the Artificial Co-evolution of Symmetrical Signals*

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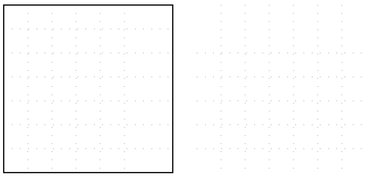
Abstract

Recently, within the biology literature, there has been considerable interest in exploring the evolutionary function of animal displays through computer simulations of evolutionary processes (Arak & Enquist, 1993, 1995a; Enquist & Arak, 1993, 1994; Johnstone, 1994; Hurd, Wachtmeister, & Enquist, 1995; Krakauer & Johnstone, 1995). Whilst we applaud biologists' adoption of the simulation techniques pioneered within the artificial sciences (see, for example, Meyer & Wilson, 1991; Meyer, Roitblat, & Wilson, 1993; Cliff, Husbands, Meyer, & Wilson, 1994, for collections of such research), and feel that *bi-directional* cross-fertilisation between natural and artificial sciences has a bright future, we suggest that the application of such techniques to

to explain it (e.g. Stewart & Golubitsky, 1993). Within the discipline of evolutionary biology, recent speculation concerning the possible role of animal symmetry as an honest indicator of viability has prompted an explosion of



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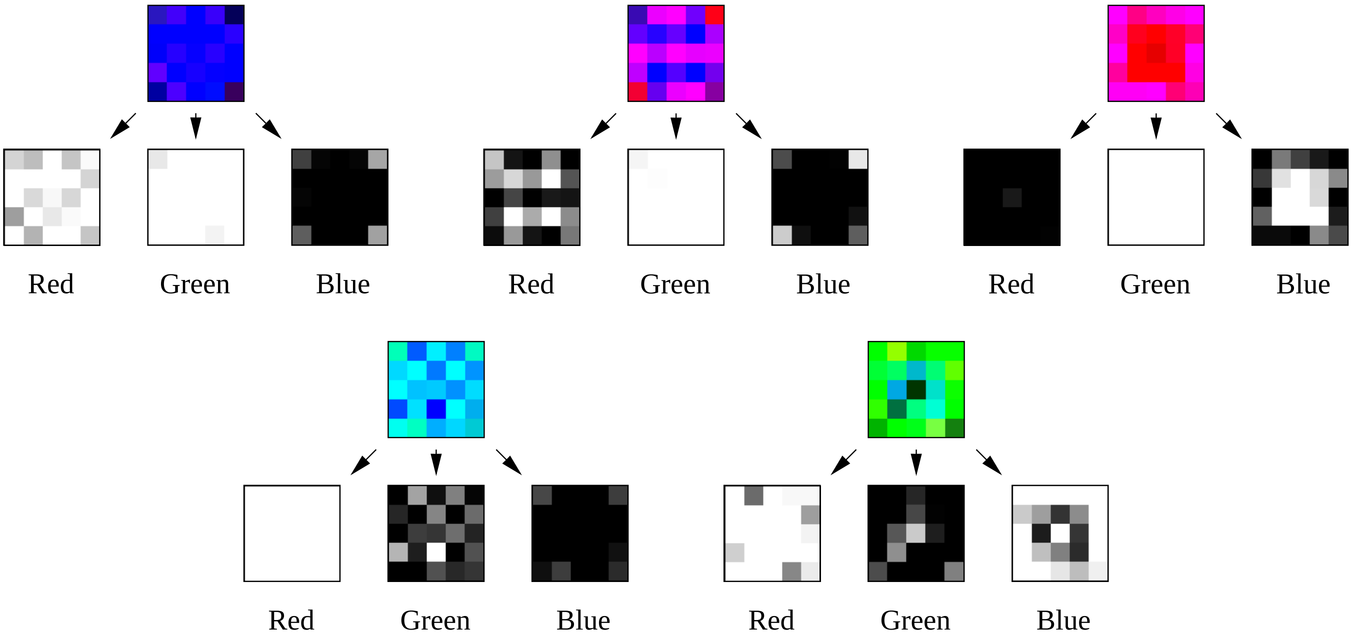
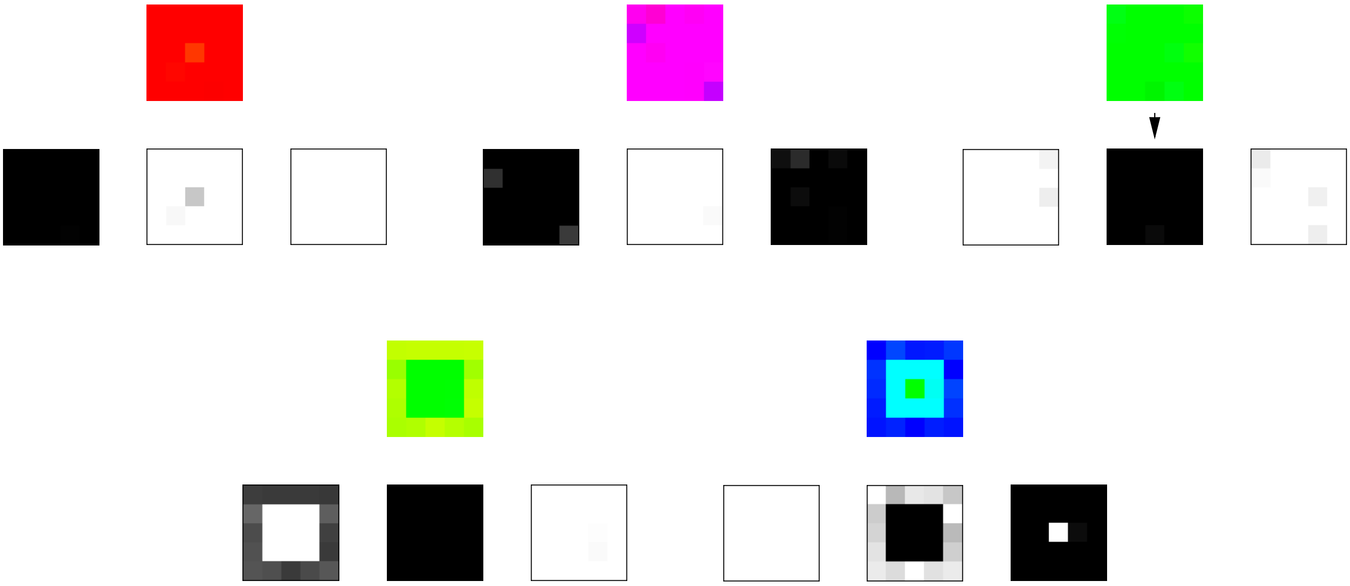
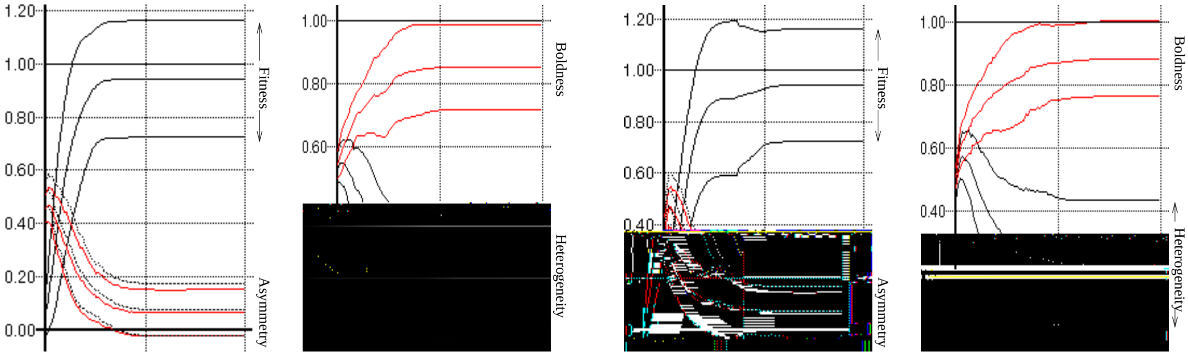


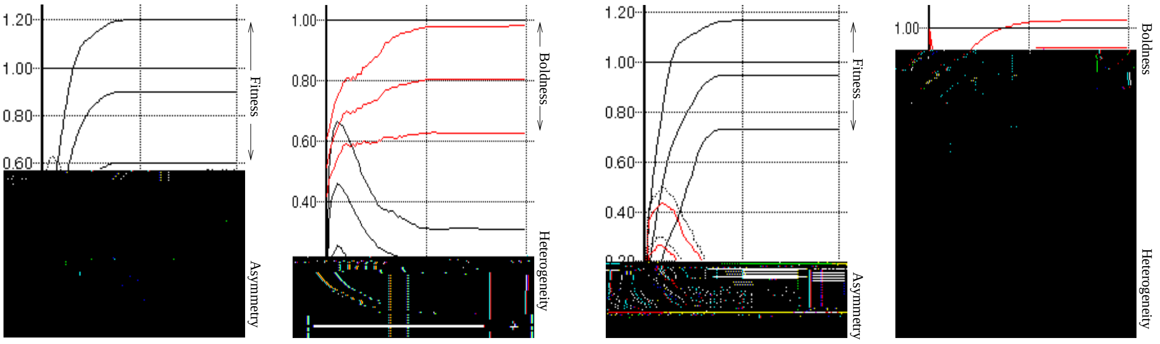
Figure 2: Five signals typical of the 20 evolved under Enquist and Arak's (1994) presentation regime. Each signal is





(a) (b)

Figure 5: Initially (a) random, and (b) bilaterally symmetrical signals were subjected to a presentation regime comprising nine translation, and sixteen 22.5° rotation transformations. In addition, signals depicted in graphs (a) were subjected to a bilateral reflection transformation. Graphs depict metrics as per Figure 3.



(a) (b)

Figure 6: Initially (a) homogeneous signals and (b) maximally bold homogeneous signals were subjected to a presentation regime comprising nine translation, and sixteen 22.5° rotation transformations. Graphs depict metrics as per Figure 3.

resulted in evolved signals not significantly different from those generated from random initial conditions, indicating that, as well as failing to *generate* symmetrical structure, the sensory bias presented by Enquist and Arak (1994) could not *maintain* pre-existing bilateral symmetries (see Figure 5b).

Further experimentation reveals that not any homogeneous signal suits any network. Seeding 20 simulations initially with signals homogeneous in a random colour resulted in evolved signals not significantly different from those evolved from random initial signals under the same presentation regime. However, as networks evolve to prefer signals of above average brightness, the final evolved signals were significantly more bold than their earliest ancestors (t=10.734, d.f.=19, p<0.01; see Figure 6a).

Seeding 20 simulations with signals initially homogeneous in one colour chosen randomly from the six maximally bold colours that the networks were not penalised for favouring (i.e. one of green, red, blue, magenta, cyan, or yellow, but not white brac0.32(ulatk13000.7(Cl(a)p-41-d599.4(w90Td(b)Tj)383.549.50Td(one)j12.48010Td(a)T)999.349(olv)99

conclusions drawn from their results at best tenuous. We feel that the colours present in the evolved signals are the result of their non-uniform mutation operator (which effectively favours mutations towards the extremes of the colour space and suppresses mutations away from those extremes[6]) and the predispositions of simple artificial neural networks to favour extreme valued inputs, rather than any evolutionary force analogous to that responsible for the generation of naturally occurring brightly coloured signals.

The hill-climbing algorithm employed by Enquist and Arak (1994) suffers from problems typical of local search algorithms. Roughly 1 in 20 simulations failed to make any progress, as no mutant retina could discriminate the initial signal at above chance, and no mutant signal was discriminated at above chance by the initial retina. Arak and Enquist (1995a, p.340) seem predisposed to attribute evolutionary, functional explanations for this type of phenomenon rather than explain it as a consequence of the simplicity of their model evolutive process. A population size of greater than one (i.e. a parallel search algorithm more typical of evolutionary simulation models) reduces the incidence rate of such 'sterile' initial conditions, which rapidly falls to near zero as the size of each population increases beyond 100.

The two-step nature of Enquist and Arak's (1994) algorithm also proves problematic. As has already been stated, precautions must be taken in order to avoid preferentially evolving either network or signal. Furthermore the notion of successive 'generations' in Enquist and Arak's (1994) description of their algorithm is suspect, as individuals do not exist concurrently. This approach precludes the appreciation of frequency-dependent selection effects, or other effects of the interaction between individuals. In addition, the arbitrary length of each evolutionary 'step' (i.e. the value given to n in this paper) is a free parameter, the effect of which is difficult to predict or explore effectively.

In a wider sense these problems are symptomatic of a failure on the part of modellers within the evolutionary simulation modelling paradigm to appreciate the methodological issues pertaining to the use of neural networks and genetic algorithms in the modelling of adaptive evolutionary processes. As has been shown here, evolutionary simulation models are not tolerant of poor simplifying assumptions, or simple adaptive mechanisms. The results of such models are always potential artefacts, the products of exploitation, bias and what (Arak & Enquist, 1993) have dubbed 'hidden preferences'.

8 Conclusion

In conclusion, Enquist and Arak's (1994) model of the evolution of symmetrical patterns was found to be seriously flawed in a manner which suggests problems for evolutionary simulation models in general. In light of this, although the hypothesis that symmetrical patterns may be the result of sensory exploitation is still healthy (see Osorio, 1996, for an alternative formulation of this hypothesis), the prospect of evolutionary simulation models suffering exploitative evolutionary dynamics is a less welcome challenge for researchers working within this paradigm.

Therefore, in order that evolutionary biologists can usefully employ the techniques being developed within the simulation of adaptive behaviour community, two commitments must be undertaken. First, a commitment to more tightly-coupled interdisciplinary collaboration between scientists studying natural and artificial systems. Secondly, a commitment to the wider dissemination of studies explicating the methodological issues pertaining to research within what we have referred to here as the evolutionary simulation modelling paradigm.

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[6] See footnote 2.

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