Can individual selection favour significant higher-level selection?

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How do new evolutionary units, supporting higher levels of functional organisation, arise from existing evolutionary units? The adaptive transformation of co-adapted species into new units, as in the major evolutionary transitions, is centrally implicated in the evolution of complexity but has proved very problematic for current evolutionary theory and understandably elusive in ALife. We investigate the evolution of new evolutionary units via individual adaptation in a multi-species ecosystem by modelling symbiotic associations that cause interaction probabilities to deviate from a freely mixed condition. It is well known that assortative grouping supports group selection in a well-defined sense, thus it is no surprise that enabling such associations will introduce some group selection effects. However, what form will this take when the control of such grouping is under individual adaptation? We tackle this by comparing the ecosystem attractors of the initial freely mixed system to those of the same system given the evolved association probabilities. In general we find that self-interested adaptation of associations tends to only reinforce species combinations that were already stable before the associations — which seems rather uninteresting. However, if the species densities of the ecosystem are occasionally perturbed whilst associations are developing this causes the system to visit different attractors and allows multiple, possibly incompatible, associations to be selected for in different contexts. Under these conditions, even when the attractors of the final system already existed as attractors in the freely-mixed system, competition between different combinations of species enlarges basins of attraction that lead to fit combinations at the expense of those that lead to less fit combinations. Thus, after the associations have evolved, a fit combination of species may be favoured in the niche that is constructed by the action of its association preferences, even if each species involved would be individually unfit if the system were freely mixed.

These findings show that evolved higher-level selection can have significant effects even when the new units result from the self-interest of the constituent sub-units. They also suggest that evolved complexes observed naturally may appear to be merely the result of individual selection because they are supported by individual self-interest, but in fact the reason that this complex persists and not some other is due to competition among species combinations.

Nonetheless, in small systems these mechanisms do not produce higher levels of complexity than those which occurred without evolved associations because the configurations that result were already visited in the initial freely-mixed system. However, we find that in large complex ecosystems with many local attractors, evolved associations naturally generalise over the relatively few attractors that are visited, enlarging attractors for fit species combinations even before they are visited. An idealisation of these processes has been shown to be far superior to conventional evolutionary algorithms on a fairly general class of difficult optimisation problems. This self-modification of ecosystem attractors therefore illustrates a mechanism that produces high-fitness biological complexes despite the fact that their evolution would seem highly implausible given the very small size of the basin of attraction that leads to this configuration under selection on the original units.