Comments on 'The Reduction of Strategic Plasticity'

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Kevin and Rory use game-theoretic tools to study the effects of one form of environmental variation on phenotypic plasticity: frequency-dependent selection. The paper presents two sets of results. First, Kevin and Rory investigate whether a population of plastic individuals will be maintained by evolution. They show that only under some circumstances plasticity is a stable strategy and that often it will be eliminated (section 3). Second, Kevin and Rory study the evolutionary dynamics of populations of plastic individuals. The results of their model is said to illustrate the Baldwin effect (section 4).

Before discussing their results, let me sketch some background against which these can be evaluated. It helps to start with the Baldwin effect. In its most general formulation, the Baldwin effect refers to the transition by which behaviors learned by members of a population eventually become part of the behavioral repertoire of the population that is genetically sustained. Godfrey-Smith describes the effect in an illustrative way:

> Suppose a population encounters a new environmental condition in which its old behavioral strategies are inappropriate. If some members of the population are plastic with respect to their behavioral program, and can acquire in the course of the lifetime new behavioral skills that fit their new surroundings, these flexible individuals will survive and reproduce at the expense of less flexible individuals. The population will then have the chance to produce mutations that cause organisms to exhibit the new behavioral profile without the need for learning. Selection will favor these mutants, and in time the behaviors which once had to be learned would be innate. (Godfrey-Smith, "Between Baldwin Skepticism and Baldwin Boosterism", p. 54.)

As Godfrey-Smith points out, the Baldwin effect actually refers not to one but to two transitions:

Transition #1. It occurs when individuals within a population acquire the capacity to learn new behaviors to deal with a new situation. At this stage, natural selection favors genotypes associated with the capacity to learn.

Transition #2. It occurs when some genotype is able to produce the behavioral response that once had to be learned. At this second stage, natural selection favors that genotype over the genotype that produces behavioral plasticity.

With this quick introduction in mind, let me go back to the results presented by Kevin and Rory. I shall discuss them in inverse order.

Comment # 1

Section 4 presents a study of the population dynamics within the three classes of 2x2 games. The replicator dynamics in figures 5 and 7 show an early stage in which the proportion of learners within the population increases, followed by a stage in which it declines and a mutant invades. Kevin and Rory claim that these dynamics exemplify the Baldwin effect. They conclude from their study that, "the Simpson-Baldwin effect may be more widespread in strategic situations than previously supposed".

My first comment is that it is not entirely clear that Kevin and Rory have offered examples of the Baldwin effect[1].

Consider what kind of learner $\mathcal{L}$ is. $\mathcal{L}$ plays best response against every other strategy and some Nash equilibrium (NE) against itself. Notably, $\mathcal{L}$ can only exhibit some behavior already available to some non-learners in the population. Thus, even though $\mathcal{L}$ exhibits some plasticity that non-learners lack, learning does not provide the individual with a behavior that is not otherwise available to some members of the population.

Compare this to Godfrey-Smith's description of the Baldwin effect and his emphasis on learning a *new* behavior. The emphasis is important. The Baldwin effect is often invoked in discussions about the evolutionary advantage that plasticity confers to individuals. But plasticity *simpliciter* is not the focus of these discussions. The focus is on the kind of plasticity that leads a population to hit upon a *new* advantageous behavior. The point is nicely illustrated in Dennett's discussion of the Baldwin effect:

[1] I am aware that there are many different interpretations of the effect, but the point discussed here is independent of these controversies.

> If we give individuals a variable chance to hit upon (and then 'recognize' and 'cling to') the Good Trick in the course of their lifetimes, the near-invisible needle in the haystack… becomes the summit of a quite visible hill that natural selection can climb… If it weren't for the plasticity, however, the effect wouldn't be there, for 'a miss is as good as a mile' *unless* you get to keep trying variations until you get it right. (Dennett, *Consciousness Explained*, p. 186.)

Let me restate my comment in the form of a request. I would like to ask Kevin and Rory to say a bit more about how they understand the Baldwin effect. In particular, I would like to know how exactly to think about the relation that holds between the results obtained in section 4 and the Baldwin effect.

Comment #2

Suppose one decides to focus on the stage of the Baldwin effect I label *transition # 2*. Suppose that there is a learning strategy and some mutations are produced that can display the behaviors that were previously available only to learners. Discount forms of environmental variation other than frequency-dependent selection. Would the mutants invade the population of learners?

Section 3 of the paper provides an answer to this question –at least, this is what I take to be the major contribution of this part of the paper. The answer is mostly negative. Kevin and Rory argue that, except in some peculiar cases, mutants will invade learners. I summarize the results of their study in *table 1* below.

My second comment concerns their study of the game presented in figure 2. This is a 3x3 game with a pareto-dominant mixed-strategy NE (PDMNE). Kevin and Rory show that in the game there is a learning rule that would render $\mathcal{L}$ an ESS. In their opinion, this would be a 'bizarre learning rule'.

My second comment is that this rule is not as bizarre as it might seem.

Consider a version of the modified paper-rock-scissors game. In the game there is a PDMNE and playing the PDMNE is better than playing any other strategy against itself.

Let (s^*, s^*) be the PDMNE of the game. Suppose the game has some type of learner $\mathcal{L}$, such that $\mathcal{L}$ is an ESS. Then, it is the case that, for any alternative strategy s,

$$u^L(\mathcal{L},\mathcal{L}) \geq u^L(s, \mathcal{L}) \quad (1)$$

The question that arises is under what conditions (1) holds.

Suppose that (s^*, s^*) is not an ESS. Then it follows that, for some strategy $s' \neq s^*$, $u^L(s', s') \geq u^L(s^*, s')$. In this case, because $u^L(s^*, s^*) > u^L(s', s')$, it is the case that,

$$u^L(s^*, s^*) > u^L(s^*, s') \quad (2)$$

But now it seems that under these conditions (1) can be satisfied. On the assumption than the costs incurred by learners are smaller than the difference between any two pay-offs in the game, (1) is met whenever $\mathcal{L}$ plays s^* against itself and plays s' against s^*.

If I am right about this, the circumstances in which $\mathcal{L}$ is sustained in a game with a PDMNE (such as the one depicted in figure 2) might be not as bizarre as they seem. These are the circumstances in which the PDMNE is not an ESS. In these circumstances, it would not be bizarre that $\mathcal{L}$ would adopt the learning rule described above. Learners would play against themselves the strategy that carries the PDMNE. They would play against that same strategy, precisely the strategy that prevents the PDMNE from being an ESS.

Again, my comment can be restated in the form of a request. I would ask Kevin and Rory to say more about games with PDMNE. This kind of games is not widely explored in their paper. But it would be interesting if these games were to help us understand why learning strategies seem to be sustained by natural selection.

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">Exogenous Costs</td><td rowspan="2">Endogenous Costs</td></tr>
<tr><td>Costs on learners</td><td>Costs on all interactions</td></tr>
<tr><td rowspan="2">NO PDMNE</td><td>Pure strategy NE</td><td>$\mathcal{L}$ is not an ESS (prop 1).</td><td rowspan="2">$\mathcal{L}$ is an ESS if it plays SONE against itself and costs are uniform (props 3 and 4).
$\mathcal{L}$ is an ESS if in a world of learners it is more costly to be a learner than a non-learner (prop 5).</td><td>$\mathcal{L}$ is not an ESS, except in game of type II in figure 4. (prop 6)</td></tr>
<tr><td>MNE</td><td>$\mathcal{L}$ is not an ESS (prop 1)
But it is part of a mixed ESS in type III games (prop 2).</td><td></td></tr>
<tr><td colspan="2">PDMNE</td><td>$\mathcal{L}$ is an ESS, but $\mathcal{L}$ is bizarre (pp. 8-9)</td><td></td><td></td></tr>
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Table 1: First set of results. All games considered are symmetric two-player games. Shaded areas are possibilities not explored in the paper. PDMNE = Games with a pareto-dominant mixed-strategy Nash equilibrium. MNE = Games with mixed-strategy Nash equilibria. SONE = Socially optimal Nash equilibria. Type I are dominance-solvable games, Type II are coordination games, Type III are games such as Hawk-Dove.