Putting Process and Product Conceptions of Natural Selection and Genetic Drift to the Test

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Two Claims

1. The question of *process* vs. *product* is independent of the question of *causal* vs. *statistical*
2. Biological evidence can be brought to bear on process vs. product – two cases weigh in favor of process definitions

Causal vs. Statistical

- *causalist interpretation* — selection and drift are causal processes; some draw analogy with Newtonian forces (Sober, Beatty, Hodge, Millstein, Brandon, &c.)
- *statisticalist interpretation* – selection and drift are non-causal; causation lies at other levels (individual, genetic, biochemical); Newtonian analogy fails (Walsh, Lewens, Ariew, Matthen, &c.)

Process vs. Product

- *selection (process)* – a process of sampling that discriminates between individual organisms based on differences in fitness (or merely any physical or causally-relevant differences whatsoever)
- *selection (product)* – a change (result, outcome) which is predicted (or explained, or both) by differences in the fitnesses of traits
- *drift (process)* – a process of sampling that does *not* discriminate between individual organisms
- *drift (product)* – a change (result, outcome) which is *not* predicted (or explained, or both) by differences in the fitnesses of traits

The Two Questions

- Beatty, Hodge, Millstein, Bouchard and Rosenberg, Filler: all causalists, all process-selection and process-drift
- Walsh, Lewens, Ariew, Matthen, Brunnander: all statisticalists, all product-selection and product-drift

Logical Independence: Processes

Two ways to define "process":

- "Process" = *causal process* (then process-definitions = causalist)
- "Process" = *minimal process* (then process-definitions = either causalist or statisticalist)

Salmon (1994): Process "can reasonably be regarded as a primitive concept that can be made sufficiently clear in terms of examples and informal descriptions"

Logical Independence

The two questions are *logically independent from one another*

- Indiscriminate or discriminate sampling processes could be either causal or non-causal, for a thin definition of process
- Selection and drift product-explanations could be applied to situations where those outcomes were generated either by a single causal process or by no single causal process

Two Independent Questions

First claim: The questions of process vs. product and causal vs. statistical are independent of one another

Empirical Evidence

In the biological literature, "drift is spoken of interchangeably as effect and cause, pattern and process." Historically, "[t]hat drift is referred to as both effect and cause is not new," dating back to Wright and Fisher (Plutynski, 2007, pp. 157, 161).

Abstract: Case 1 (accidental outcomes)

[A]n indiscriminate sampling process can produce what looks like a directed outcome (mimicking the most likely outcomes of a discriminate sampling process). (Millstein 2005, p. 172)

It is an unfortunate consequence of [the conjunction of process-drift and product-selection] that drift-the-process [i.e., drift as indiscriminate sampling] causes selection-the-effect [i.e., the absence of drift as outcomes not explained by trait fitness differences]. (Walsh 2010, p. 154)
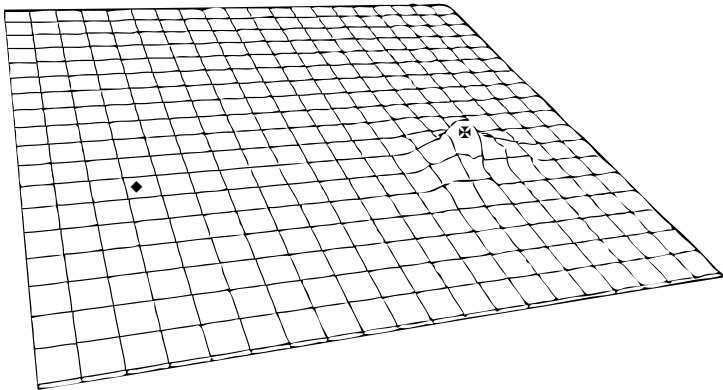
Abstract: Case 2 (balancing factors)

Any population in which a fitness-discriminating process is *acting,* but that process *fails to produce* the expected outcome will constitute process-selection without product-selection (see Shapiro and Sober 2007).

Concrete: Case 1 (fluctuating selection)

[Life-history] traits experience strong selection that can fluctuate with nearly any kind of ecological change. The landscape for major fitness components, that is, (stage or age specific) viability and fecundity, is almost purely directional with little or no curvature to generate a stabilizing influence. (Arnold et al. 2001, p. 21)

Concrete: Case 1 (fluctuating selection)

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1. The adaptive landscape is almost entirely directional (i.e., no local stability)
2. Changes in trait distributions are extremely sensitive to current local selective pressure
3. Current local selective pressure varies wildly over space and time

product definitions: only one expected (selective) change, toward increased fitness — all other change is drift
process definitions: these processes are *all* selective, as they involve organismic fitness — this change is selection

Concrete: Case 2 (mutation-selection)

- Most mutations are deleterious ($\approx 95\%$ in *Drosophila* (Sawyer et al. 2007))
- To what extent are they maintained in populations? Difficult to determine empirically (Mitchell-Olds et al. 2007)
- Keller and Miller (2006): Schizophrenia and other common, harmful, highly heritable mental illnesses are maintained under *multiple-gene mutation-selection balance*

Concrete: Case 2 (mutation-selection)

product definitions: no selection, because we don't see the expected drop in allele frequency
process definitions: traits are *highly* disfavored selectively, but this is balanced by mutation pressure, resulting in no change

Empirical Evidence Matters

Second claim: Empirical evidence *can* be brought to bear on the process/product question. The two examples here support process definitions, but this does *not* settle the issue.

Future Work

- More empirical case studies!
- Include other definitions of drift and selection

Questions?

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Preprint of paper available on the PhilSci-Archive

The time scale of selective explanations

[S]election is generally rather strong and fluctuates on all time-scales such that abrupt changes can occur over short periods of time and gradual directional change occurs over long periods of time. (Bell 2010, p. 90)