



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

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### ABSTRACT

Are natural selection and genetic drift best thought of as processes, as products, or as some hybrid of the two? While this is a well-known issue in the interpretation of evolutionary theory, it has seemed in the last several decades to have both made relatively little progress and not often enough connected to actual biological examples. In this paper, I lay out this problem, diagnose the reasons that it might have been difficult to resolve, and indicate the direction in which I believe a solution can be found. Of course, since process and product notions of selection and drift are intended to be definitions of the same concept, their extensions – the individual biological instances that they mark out as selection and drift – will be nearly identical. But their intensions – the conceptual structures that they propose for evolutionary theory – are quite different. The fact that this stark choice between interpretive frameworks in evolutionary theory is not mirrored by equally stark consequences for our classification of biological cases, I claim, can help explain why this debate has been intractable. How, then, should we expect to move forward? While the extensions of these differing concepts are nearly identical, they are not precisely identical, and it is here that we can make progress. There do exist (even plausibly empirically relevant) biological cases that these definitions of selection and drift classify differently, and it is here that we can hope to determine which of these conceptual frameworks is correct. I close by laying out a few examples and offerin...

### CITE THIS VERSION

Pence, Charles H.. *Putting Process and Product Conceptions of Natural Selection and Genetic Drift to the Test*. European Philosophy of Science Association 2013 (Helsinki, Finland, du 28/08/2013 au 31/08/2013). <http://hdl.handle.net/2078.1/224940>

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

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August 30, 2013 / EPSA 2013

## 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)

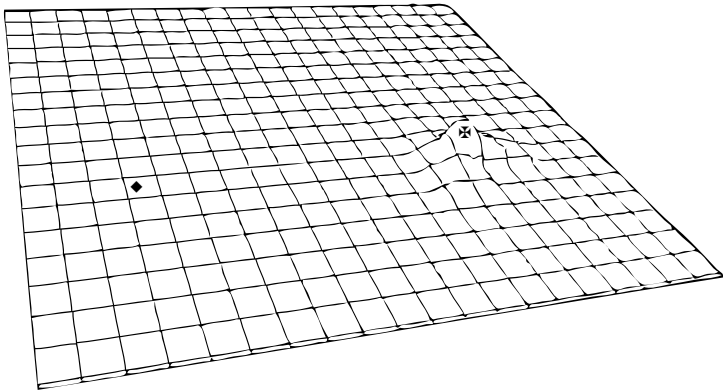
## **Abstract: Case 2 (balancing factors)**

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)



## Concrete: Case 1 (fluctuating selection)

- 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)