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Two stumbling blocks to a general account of selection: Replication and information

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Abstract: When one takes the evolution of operant behavior as prototype, one sees that the term replication is too tied to the peculiarities of genetic evolution. A more general term is recurrence. The important problem raised by recurrence is not “information” but relationship: deciding when two occurrences belong to the same lineage. That is solved by looking at common environmental effects.

The authors have made some good progress toward abstracting the concept of General Evolutionary Process. Particularly constructive are their emphasis on the iterative nature of the process of selection and their separation of interaction from replication. They are right also in their implication that part of the importance of this project lies in clarifying selection as a type of causality and as a valid basis for explanation (Baum & Heath 1992). The notion of operant behavior has been resisted by laypeople and scientists alike for the same reasons that evolutionary theory has been resisted: (1) an enormous preference for immediate (“push”) causes, even if they have to be imagined, and (2) the implied rejection of cherished imaginary immediate causes such as agency, will, purpose, and intelligence. I suggest, however, that the authors might have made more progress had they considered operant evolution (i.e., shaping) as a prototype, instead of genetic evolution.

In attempting to abstract the General Evolutionary Process, no necessity requires that genetic evolution be taken as the prototype. It has the advantages that it is widely accepted among the scientific community and that its mechanisms are partially understood, but it has the disadvantage that its peculiarities are easily taken for necessary attributes. If instead one takes operant evolution as prototype, at least two issues are clarified: the term *replication* and the concept of *information*.

Replication. Even if it is true that DNA is in a sense “copied” (and the facts of recombination make this doubtful), in no useful sense are repeated occurrences of a behavioral pattern copies. If I brush my teeth every night before I go to bed, in no sense is my brushing one night a replica of my brushing the night before. Even though we are ignorant of the way the workings of the brain affect behavior, nothing we know suggests there might be a replica or representation of tooth-brushing somewhere in the brain either. Rather, as with other natural events, such as sunrise, hurricanes, birth, and death, the event occurs when the conditions are right (bedtime, bathroom, toothbrush, toothpaste, and so on). (The historical origins of tooth-brushing in a history of reinforcement and punishment – that is, by iterative selection – are another matter, of course.)

A more neutral term would be *recurrence*, meaning just “oc-

curring again” or “turning up repeatedly.” Replication would be just one type of recurrence – recurrence by copying. Other mechanisms of recurrence may be imagined; for operant behavior, we have the effects of context and cues known as stimulus control. Thus, one need not search for some sort of copying when talking about the recurrence of behavior. In particular, one need not talk nonsensically about things like “memes” “jumping from brain to brain” when talking about the spread of a behavioral pattern within a cultural group (Baum 2000; Dawkins 1989a).

Information. The authors assert, “the notion of ‘information’ is fundamental to any account of replication” and “In replication the relevant information incorporated into the structure of replicators is ‘passed on’ to successive generations of replicators.” Even if these statements were true of replication, they are irrelevant to the more general idea of recurrence. The authors’ reliance on the notion of replication leads them to misstate the important issue involved, which is about relationship. Even if the structure of replicators is passed on, for purposes of evolutionary theory, the problem is not pondering the “information incorporated”; the problem is deciding when two sequential occurrences belong to the same lineage.

The short answer would be that two occurrences belong to the same lineage if they share common ancestry (Ghiselin 1997). This, however, raises the question of defining “ancestry” in general terms. Here again, the example of operant evolution sheds light, because it leads us to see that “common ancestry” means common history of selection. My tooth-brushings Monday night and Tuesday night belong to the same lineage, not because of any “information incorporated,” but because they may be attributed to a common origin – say, childhood training (i.e., exhortations from my parents and dentist, approval and disapproval, cavities or the lack of them, and so on; Baum 2000). The common origin and common history of selection, however, depend on common environmental effects. Both the origin of my tooth-brushing (exhortations, etc.) and the selection of my tooth-brushing depended on past effects of contributing to dental hygiene. Thus, common “ancestry” for behavior comes down to a common basis for selection or common history of environmental effects. In more abstract terms, two occurrences belong to the same lineage if they are attributed to the same history of interaction with the environment.

Dawkins (1989b) makes a parallel point for genetic evolution when he explains that the genes that promote dam-construction in beavers were selected by their effects on the beavers’ environment. Indeed the genes “for” dam-construction are defined by those effects, for they are nowhere apparent in the structure of the beavers’ DNA. Although the idea that genes influence behavior is widely accepted, the content of this idea differs little from the wide acceptance that the brain influences behavior. Almost nothing is known of how this occurs. If we had to rely on examination of structures in DNA or the brain to define the units of recurrence, we would be in deep trouble. But defining the recurring units in terms of their common environmental effects solves this otherwise intractable problem. Instead of “information,” environmental effects turn out to be the key to defining lineages. I doubt one would recognize this without considering the evolution of behavior, whether across generations or within a lifetime.

Should we essentially ignore the role of stimuli in a general account of operant selection?

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Abstract: The selectionist account of behavior is actually a focused discussion of operant selection. To this end, the authors essentially exclude stimuli from their analysis. This exclusion is inconsistent with the importance placed on environmental interaction in their general account. Fur-

ther, this exclusion limits the generality of their account by missing important sources of stimulus-elicited behavior (e.g., classical conditioning).

In the target article, Hull et al. clearly accomplish one of their goals. That is, they successfully describe individual, immune, and operant selection by repetition of three processes: variation, replication, and environmental interaction. Further, they provide the reader with much to think about. What is variation within each selection system? How does the repetition of the processes generate the variation and why is the variation differentially constrained? What retention mechanisms are required to retain past selected information for future selection? How can environmental interaction affect this retention?

Although I found the target article thought provoking, I was disappointed in the false advertisement of the title. I was expecting a "general account of selection" for behavior. However, they only provide a selection account of a narrowly defined sub-set of behavior. That is, the authors chose to emphasize "operant learning." I appreciate this choice given the daunting goal they set for themselves. Also, operant conditioning is a natural choice given that a selectionist framework has been more readily applied to research in that area. Perhaps my disappointment was greatest by their choice to seemingly ignore the role of stimuli in the generation of what the authors term "responses" or "interactors." This choice is made explicit when the authors state "In operant theory, activity designated as a 'response' does not require a stimulus." In the following paragraphs, I would like to note why I believe a general selectionist model of behavior (versus "operant theory") should take into consideration stimuli.

I will use the bar-press example employed by the authors as a starting point for discussing the importance of stimuli in a good selectionist model of behavior. The bar-press response would not be possible without the presence of the metal lever (bar) that extends into the experimental apparatus. This bar is a complex multi-modal stimulus likely including visual, olfactory, spatial, and tactile elements. One would be hard pressed to argue that the stimulus elements associated with the bar do not set the occasion, in part, for the response of depressing the lever. Other stimuli that will contribute to the pattern of responding include passage of time and environment (context).

Examination of response records of a well-trained animal on a schedule of reinforcement (e.g., FR) will reveal surprising variability in response generation. Such measures as initial response latency, inter-response time, and time to termination response will vary within a range (see Fig. 1 of target article). What are the sources of this variability? One answer to this question is that different inter-response times, and so on, were reinforced (i.e., selected by the consequence). Albeit likely, this answer is only partially satisfying. Direct observation of a rat receiving food reinforcement will reveal the development of interesting behaviors that compete with the bar-press response. These competing behaviors likely contribute to the variability. For instance, even though food has not been delivered, the rat will frequently move away from the bar and toward the food delivery area often sniffing, licking, and chewing the food cup or dipper entry. Clearly, this pattern of behaviors has been reinforced. However, why does this behavior occur in the food area and the not in the rear left corner of the apparatus? Those stimuli in the food delivery area are closely associated (temporally and spatially) with food.

Similarly, later in operant training sniffing, licking, and chewing type behaviors are also directed toward the bar. Students of operant conditioning will recognize this phenomenon as similar to that observed by Breland and Breland (1961). That is, stimuli closely associated with food (the metal bar in this example) will come to control food-related behaviors. These behaviors are conceptualized as evolutionarily selected response-tendencies to stimuli that have acquired motivational (appetitive in this example) value (e.g., Bolles 1975). To me, the present observations indicate that stimulus – outcome selection (Pavlovian/classical conditioning) likely occurs along with operant selection – regardless of the experi-

menter's intention. What sparse systematic research exists tends to support this notion. For example, Shapiro (1960) trained dogs to bar-press on a FI 2-min schedule of food reinforcement. In addition to measuring bar-pressing, the dogs were surgically prepared so that salivation could be monitored. As expected, bar-pressing was infrequent early in the interval and then increased as time to feed approached. Of interest to the present discussion was that salivation showed a similar pattern. This result has been taken to indicate that the cues associated with bar-pressing and passage of time acquire to ability to elicit salivation via stimulus-outcome selection (Donahoe & Palmer 1994; Kintsch & Witte 1962).

Hull et al. note the necessity of variability in a general selection account. I fully agree with this conclusion. One main point of the above discussion is to emphasize the importance of stimuli in the generation of variability. Responses do not occur in the absence of stimuli. Some of this stimulus-elicited variability is the result of "gene-based" selection; other variability is acquired during behavioral selection in the broad sense of the term. Along similar lines, the authors of the target article emphasize the importance of "environmental interaction" in a general account of selection. The very nature of the concept requires the object of selection ("responses" or "interactors" in the case of operant selection) to be affected by the stimulus conditions that define the environment. Indeed, in section 5.3, the authors briefly mention this fact by noting that "events" can have "discriminative, conditional, or motivating functions."

To close this commentary I would like to applaud the authors' emphasis on the importance of elucidating the physiological mechanism responsible for retention processes. This discussion would be further enriched by including stimuli into a selection account of behavior. This is especially true for stimulus-outcome selection (Pavlovian/classical conditioning). There are numerous well-studied in vivo and in vitro models of neural plasticity for classical conditioning (e.g., Boa et al. 1998; LeDoux 2000; Steinmetz 2000).

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A single-process learning theory

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Abstract: Many analogies exist between the process of evolution by natural selection and of learning by reinforcement and punishment. A full extension of the evolutionary analogy to learning to include analogues of the fitness, genotype, development, environmental influences, and phenotype concepts makes possible a single theory of the learning process able to encompass all of the elementary procedures known to yield learning.

The article by Hull et al. on the roles of variation, replication, and environmental interaction in selection processes hopefully will stand as a beacon in a long but only sporadically-connected line of works on the similarity between evolution by natural selection and certain physiological processes. The response to an article on learning and the evolutionary analogy I once wrote from my PhD. dissertation (Blute 1977, see <http://cogprints.soton.ac.uk/>) was either incomprehension or a rejection of all general learning theory including the utility of the analogy. Today, however, more psychologists understand evolutionary theory and they understand that something which evolves and is inherited necessarily also develops and functions physiologically.

Some elementary analogies between learning and evolution are obvious to those acquainted with both theories. Both are based on populational thinking. Reinforcement and punishment play the