Addenda to Chapters 2–4

DISTINGUISHING BETWEEN OPERATIONS AND PROCESSES

In distinguishing between operations, what gets done, and processes, what happens as a result, this text emphasizes experimental operations, but that is mainly because it is about research findings drawn from the laboratory. Operations are related to processes in pretty much the same way as procedures are related to outcomes. Those familiar with the standard sections of experimental papers in psychology will recognize this distinction as similar to that between the Method section, which describes experimental procedures and other details, and the Results section, which describes data obtained from the experiment.

But here this distinction will often be interpreted more broadly. Events in the world can produce changes in behavior, and whether or not those events are explicitly arranged it is convenient to call them operations and to call the changes in behavior that they produce processes. Note also that once we have observed changes in behavior, we may interpret them, and interpretation corresponds most closely to what happens in the Discussion section of an experimental article.

SHINING LIGHT ON ESTABLISHING OPERATIONS

Establishing operations were introduced in Chapter 2 and discussed further in Chapter 4. The most straightforward way to distinguish between consequential operations and establishing or motivational operations is to see whether the consequences of responding change or stay the same. Consider a flashlight. It lights when you operate the switch that turns it on. It does so whether you operate the switch in the light or in the dark, but turning it on matters to you only when it is dark. Thus, a change outdoors from daylight to darkness or a change indoors from artificial light to the darkness of a power outage are each examples of establishing operations with regard to whether you are likely to turn on the flashlight. In each case, something happened that made it important for you to turn on the flashlight, but you could have turned it on even if those events hadn't occurred.

If your flashlight battery has gone dead, however, operating the switch that usually turns it on no longer does anything. The consequences of opereating the switch have changed: It used to work but now it doesn't. Thus, the dying of the battery is not an establishing operation. Instead, it is a consequential operation: it changes whether operating the switch will be reinforced by the onset of light.

But the dead battery may be establishing or motivational in a different way. It might not have mattered before, but now finding a fresh battery has become important. Once you find one and replace the dead battery, your flashlight is functional again. In other words, the battery going dead had two effects at the same time: it had a consequential effect, because it changed what happened when you tried to turn on the flashlight, but it also had an establishing or motivational effect, because it made finding a fresh battery important. (And if you can't find a fresh battery, you might start looking for candles and matches; not everything that becomes established as a potential reinforcer will necessarily be available when that happens.)

Establishing operations and consequential operations work together. Usually you can't have one without the other, but it is important to be clear about which behavior is related to each. In these examples, turning on the flashlight was a response with consequences, but the light versus dark conditions established whether it was important for you to turn it on; similarly, when the battery went dead, replacing the battery was a response with consequences, but the failure of the flashlight to work established whether it was important for you to change the battery (cf. Michael, 1989).

EVOLUTION, CHAOS THEORY, AND DARWIN'S BUTTERFLY

Chapter 3 hinted at the probabilistic contingencies involved in the evolution of life on earth. Let us elaborate on those contingencies here by considering some implications of a branch of mathematics called chaos theory that deals with nonlinear systems.

Darwin included butterfly collecting among his many interests. Assume that in his youth, in the summer of 1828 in North Wales, he caught a butterfly. Actually, he almost certainly caught more than one, but the capture of any butterfly by Darwin or by any other butterfly collector during the first half or so of the nineteenth century would suit our purposes. Whichever capture we consider, all our lives hung upon it.

This conclusion follows from the butterfly effect in chaos theory. The nonlinear systems treated by chaos theory involve recursive computations, or computations in which the output of an equation serves as the input for its next iteration. Many natural phenomena, including the weather, are best described in terms of chaotic systems. One of their significant properties is that they are drastically affected even by very tiny changes in initial value. Mathematical models for predicting the weather made significant contributions to chaos theory, and the butterfly effect refers to the finding that when we try to predict weather patterns using models that incorporate nonlinear equations, the entry of initial values differing by as little as the displacement of air produced by the flap of a butterfly's wings can influence our prediction of the direction in which a storm system will move some days or weeks from now.

Now consider the implications of Darwin's butterfly capture. If it had not happened, weather patterns throughout the world, little by little, would have begun to deviate from those in our own history. We might consider their impact on major historical events: for example, the battle would probably have gone differently at Gettysburg if the weather had been different. And even if Darwin had set sail on the Beagle in that world as well as in ours, his voyage might have come to a different conclusion.

But there would have been still and for us even more profound effects, because each of us is the product of a particular union of sperm and egg. Would that particular union have come to pass - would any of us have come into existence - if our parents' act of procreation had occurred at a somewhat different time or place? Almost certainly not. A lovely sunset where in our world it was overcast; a meeting at an agreed time where in our world a delay was caused by rain; a wedding forced indoors by storm where in our world it occurred in open air; illness following from rain and damp where in our world a parent remained healthy. Spun out over time, these alternative circumstances would eventually extend to every person on our planet.

Long before the twentieth century, things would have so differed that no individual now alive would have been conceived in that other world. No doubt some individuals would have been given the same names as their existing counterparts, but all would have been different, both in their genetic endowments and in their upbringings. Would an Igor Stravinsky in that world have composed "The Rite of Spring"? Would a Pablo Picasso have painted "Guernica"? Would an Albert Einstein have formulated the Theory of Relativity? Of those who determined the fates of so many in our world, no Lenin or Roosevelt or Hitler or Churchill or Gandhi or Mao. Others in their places and in ours, but neither you nor me. Had that butterfly evaded Darwin's net, we would not be here. And now think of all the flaps of all the butterflies across all the lepidopteran millenia of our world.

SEXUAL SELECTION: THE ROLE OF FEMALE PREFERENCE

In the discussion of natural selection in Chapter 3, the neck of the giraffe was presented as an example in which environments with food high on tall trees selected for long necks. But the evidence is mounting that the long neck of the giraffe is not a product of selection by such environments. Instead, female giraffes prefer males with long necks, and this sexual selection by the female has driven the evolution of long necks. One line of evidence is in studies of the male neck preferences of female giraffes; another is the simple observation that male giraffes have much longer necks than the females, whereas accounts solely in terms of environments with tall trees are inconsistent with such large gender differences (Coe, 1967; Gould, 1996; Simmons & Scheepers, 1996).

The role of sexual selection has long been appreciated in accounting for other evolutionary extravagances, of which the tail of the peacock is a familiar example . The peahen, the female of that species, is more likely to mate with a male with a larger and/or more colorful tail. Despite the metabolic and other costs of their elaborate tails, such males are more likely to be healthy and therefore to provide favorable genes to their offspring. These contingencies of sexual selection are consistent with the other aspects of Darwin's account of natural selection. We'll encounter a related example later, when we see how the female cowbird may shape the dialect of a male cowbird's song through differential attention (see Chapter 7).

HABITUATION AND LANGUAGE ACQUISITION IN INFANTS

Habituation, described in Chapter 4, has had practical applications in studies of whether preverbal children can distinguish among important features of spoken language such as intonations, rhythms, and the basic speech sounds or phonemes of the language of their caregivers (e.g., Eimas & Miller, 1992; Ramus, 2002). A response often used in such studies is nonnutritive sucking. Essentially, the infant is given a pacifier connected to a device that records the pressure exerted while sucking. If the infant hears a voice speaking a consonant, say *b*, the infant will typically stop or slow its sucking briefly. If the *b* is repeated, it has less and less effect. In other words, the response to *b* has habituated.

But now suppose the speaker says *p* instead of *b*. The *b* and *p* differ in that the former is voiced (the vocal chords vibrate) whereas the latter is not. Given an infant several weeks old who has been raised by English-speaking caregivers, the first instance of *p* will ordinarily produce a pause in sucking, even though the response to *b* had habituated (this might be called dishabituation). The different responses to *b* and *p* show that the infant distinguishes between the speech sounds even though not yet able to produce them.

Not so, however, if the infant has been raised by caregivers who speak a language in which the distinction between *b* and *p* is unimportant. In Arabic, for example, a single voiced consonant somewhat like the English *b* has no corresponding voiceless *p*. If this infant's pause in sucking has habituated to the sound *b*, changing to *p* makes no difference. The infant responds similarly to both consonants.

There is a procedural issue. Measuring pauses in nonnutritive sucking calls for having some sucking in the first place, so procedures of this sort typically require some sucking as a criterion for presenting the speech sounds. When some studies showed increases rather than decreases in sucking after the speech sounds were presented, the relations between the responses and the stimuli were examined more closely. If sucking is required to produce a sound and sucking then occurs more often, perhaps the sound has functioned as a reinforcer. Research on infants' responses to speech sounds has explored such possibilities not only with nonnutritive sucking but also with such other responses as direction of gaze toward one or another sound source. We must be able to distinguish between habituation and other behavioral processes to figure out what is going on within such procedures.

In any case, one lesson from these studies is that infants begin to learn about the sound features of the languages they hear around them long before they become skillful in differentially producing those features. What the infant hears and therefore learns in the English-speaking household is different from what the infant hears and learns in the Arabic-speaking household. We'll consider what such findings imply in Chapter 14.

REFLEXES, FIXED ACTION PATTERNS, AND OTHER CLASSES OF BEHAVIOR

The reflex relation was defined in Chapter 4 in terms of response probabilities given the presence or the absence of an eliciting stimulus. This criterion allows other conditional relations between stimuli and responses, such as those between releasers and the fixed action patterns they release, to be expressed in similar terms.

Other features of behavior, however, may provide a basis for other distinctions. For example, most reflex relations involve responses the magnitude of which varies with stimulus magnitude, as when, in the patellar reflex, the magnitude of the knee jerk increases with increasing force of the tap to the patellar tendon. A fixed action pattern, however, such as the mating dance of the stickleback fish upon sight of the swollen belly of a female, is typically all-or-none: Once it has begun, it occurs full-blown and runs its complete course.

The kineses and taxes described in Chapter 3 (see Loeb, 1918/1973) are also response systems that differ from reflexes and fixed action patterns. These and other types are worth knowing about because most remain as components of our own human behavior. Important examples include laughter, yawning and tickle (e.g., Provine, 2000).