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J.E.R. Staddon

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Personal History

John Eric Rayner Staddon was born on March 19, 1937, in Grayshott, Hampshire, England, a village about 74 km (46 miles) southwest of London. He was the first child of Leonard John (Jack) Staddon and Dulce Norine Rayner Staddon. The parents had met when Jack Staddon was serving in the military in Rangoon. The Staddons, including his grandmother, Irene Florence Rayner, moved to London a year later and settled finally in Cricklewood, an area of northwest London. Staddon's earliest memories center around World War II and the bombing of London. His father was on active duty and his mother was working outside of the home. Staddon was raised during this time by his grandmother.

Staddon attended Burgess Hill, a progressive school that permitted much student freedom. Staddon remembered he was able to avoid math and that every boy had a knife. The 2 fun years of Burgess Hill did not prepare Staddon well for the *eleven plus* exams that determined the next educational step. Staddon did well enough to be accepted at St. Marylebone Grammar School, although he was to need additional tutoring in math. About this time, Staddon began to develop a serious interest in biology. He had several aquaria and had purchased a used microscope. Staddon's record of *A-level* passes did not guarantee acceptance at a top-level research university. He matriculated at Battersea Polytechnic, which was accredited to grant degrees from the University of London. The school was not a good match, and Staddon discovered that he could transfer into the psychology track at University College London (UCL) if he did well enough on a standardized test. Staddon enjoyed UCL; he skipped a lot of lectures and tutorials and became involved with the student newspaper as a movie and art reviewer.

Staddon's father had moved to Northern Rhodesia for work. The family joined him there, including John Staddon in the middle of his UCL career. Staddon found a job working for a program to study disease (e.g., malaria and bilharzia) and nutrition in the region. Staddon worked as a lab and physician's assistant on the project. Staddon lived there from 1957 to 1959 and then returned to England to finish his final year at UCL.

Staddon passed his exams at UCL, but not at the level to be accepted for postgraduate work at a research university. Nor did he have research lab experience that might have led to a stronger personal recommendation. Staddon decided to try his luck in North America. He found ads at the UCL Psychology Department for research assistantships at Kansas State University, McMaster University in Hamilton, Ontario, Canada, and Hollins

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College in Roanoke, VA. He received a similar offer from all three schools. He chose Hollins because it would be warmer and less flat.

Staddon arrived at Hollins in 1960 to discover that it comprised only women students at the undergraduate level. Another shock was the American educational system, which required regular class attendance and featured frequent testing. Staddon was to meet Robert Bolles, who introduced Staddon to Murray Sidman's (1960) *Tactics of Scientific Research.* Sidman was a student of B. F. Skinner. The book explained Skinner's methodology, which was focused on the performance of individual subjects. This approach was to be used by Staddon throughout his career. A second memorable event of Staddon's time at Hollins was that he met his first wife, Nada Ballator. Hollins did not offer a Ph.D. degree, and Staddon applied to three programs, receiving an acceptance at Harvard University.

The Harvard Psychology Department was located in the enormous basement of Memorial Hall. At one end were the pigeon labs and the office of B. F. Skinner. The other end contained the office of S. S. "Smitty" Stevens, famous psychophysicist and methodologist. The combined location of faculty, graduate students, and labs on the same floor led to extensive interactions among the labs. Staddon took several courses at the Massachusetts Institute of Technology where he learned to think about feedback systems from a computational viewpoint.

Richard Herrnstein was the supervisor of Staddon's dissertation, B. F. Skinner having retired from active laboratory work. Research activity in the operant conditioning lab was focused on Herrnstein's *matching law*, the principle that relative (or proportional) response rate would match relative reinforcement rate in a two-choice conditioning task. Staddon, however, was interested in a different topic, the influence of timing on responding. Pigeons can adapt to a *Fixed-interval 30-s* schedule, in which food is available only after a period of 30 s and will not respond for a period of 10 to 15 s from the beginning of the interval. However, if the task is to pause 10 s before making the next response, then pigeons find this to be a very difficult task. Staddon investigated whether providing feedback signals of too early or late responses would improve performance. The results were mixed and showed that pigeons did not use feedback in a human-like manner.

Staddon's first job was at the University of Toronto in Canada, and it did not proceed as anticipated. The winters were interminable, and the intellectual temperature in the department was cool, too. The major animal learning theorist in the department was a neo-Hullian, Abram Amsel, famous for his *frustration theory.* Frustration was a drive-like condition that was supposed to be elicited by the nonoccurrence of an expected reward. Staddon developed a more parsimonious explanation of the effect and presented it to the Amsel group. Predictably, it did not produce a welcome reaction. (See Staddon and Innis 1969, for the analysis.)

Staddon began to look about for a new position and saw an ad for a position at Duke University. His interview was in January and it was sunny and balmy in Durham, NC. The animal learning atmosphere was warmer, too. The senior learning person was Norman Guttman, a former student of Skinner. Staddon took the job and remained at Duke for the rest of his career. He retired in 2007 as a James B. Duke Professor of Psychology and Neuroscience but has remained intellectually active since then.

Interested readers should consult Innis (2008) and Staddon's autobiography (Staddon 2016) for additional details of his career.

Brief Overview of Staddon's Work

Staddon's most cited paper is the replication of Skinner's (1948) superstition experiment (Staddon and Simmelhag 1971). Skinner reported when food was presented to a hungry pigeon on a periodic basis independent of the pigeon's behavior, then an operant conditioning effect was produced. Whatever behavior occurred closest in time to presentation of the food was repeated such that it was likely to reoccur close in time to the next food presentation. The effects were interpreted to indicate the power of temporal contiguity of a reinforcer to stamp in a response even when there was no causal connection between the two events. It is important to note that almost no data is presented in the article. Instead, Skinner presents verbal descriptions and his conclusions.

Staddon and Simmelhag (1971) replicated the basic procedure of Skinner (1948) of presenting response-independent food, with important additions. They developed a coding system to record the different activities by the pigeons and the temporal location of the activities during the interfood interval. Their results showed that the behavior closest in time to food in the initial sessions (e.g., head in the feeder) was often displaced abruptly by another activity (e.g., pecking the wall near the feeder) in later sessions. The result was a direct contradiction of the account that temporal contiguity of response and reinforcer alone can explain the emergence or persistence of behavior.

Staddon and Simmelhag noted that the other activities (dubbed *interim activities*) occurred also in a reliable sequence. The observation led to the question of the cause of the regular occurrence of those activities since they are both unnecessary for and temporally distant from food reinforcement. Their insight was that a hungry animal was not in search of food alone. Instead, it had several requirements (food, water, avoidance of predators) that had to be met. The problem for the animal was *allocation of behaviors*, when is the best time to do what activity. A period of low food probability is a good time to engage in other activities. This issue of the problem of behavior allocation was to occupy Staddon for several years.

Staddon (1979) pursued the issue formally (mathematically) by recasting operant conditioning as a behavior allocation issue. Reinforcement schedules restrict an organism's access to one activity by requiring it to engage in a second activity. The problem for the animal is how to balance the preferred levels of both activities (the *free behavior point*) given the constraints imposed by the contingency. Staddon used both geometrical and algebraic analyses in his *minimum distance* model to suggest that the final performance is one that brings the mix of behaviors closest to the mix of the free behavior point. Staddon (1980) edited a volume of contributions that showed the allocation issue ranged from plants to human behavior in the suburbs.

A Simple Example of Staddon's Modeling Approach: Habituation

Staddon's (2001) current method of investigation is to create formal models of the manner in which behavior changes in time. These models are black box models. No attempt is made to justify these models by appealing to current views of the nervous system or cognitive metaphors, such as *expectancy*. The approach follows the Turing test argument. You have an adequate model of thinking when a reasonable questioner cannot discriminate between a machine and a human being. The goal of development of these models is *parsimony*. The more simple the mechanism then, the more widely it may be used in nature.

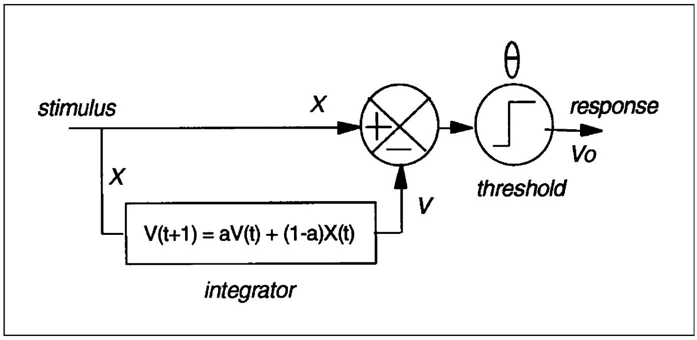
An example of Staddon's approach can be seen in a simplified description of his analysis of habituation (Staddon 1993). *Habituation* is the waning of the strength of a response with repeated elicitation by a specific stimulus. The speed of habituation increases when the frequency of presentation of stimulus is increased. There is recovery from habituation when the stimulus is not presented for some time period. Habituation represents a dynamic case of behavior change in time.

Figure 1 shows a diagram of a basic habituation unit (Staddon 1993). The relevant equations are

$$V(t+1) = aV(t) + (1-a)X(t), 0 < a < 1 \tag{1}$$

$$Vo = X - V, \text{if } Vo > \theta \tag{2}$$

The model operates like a digital clock, with each increment in t the equivalent of a tick of the clock. The figure indicates two effects induced by the stimulus ("X"): an excitatory component where stimulus strength directly increases response strength and an inhibitory component ("V") that suppresses responding. Equation 1 describes the effect of the current trial on V for



J.E.R. Staddon, Fig. 1 Diagram of habituation unit adapted from Staddon (1993). See text for details

the next tick of the clock. When $X > 0$, then inhibition will increase and $aV(t)$ is described as a *leaky integrator*. The leaky integrator sums (integrates) prior experience with the stimulus, but the inhibitory effect (V) will wane (leak) with time according to the value of the constant, a, with smaller values producing greater leakage in V. The occurrence and strength of the response are predicted in Eq. 2 by the mathematical difference between current excitatory and inhibitory values (i.e., $X - V$) if it exceeds a threshold (θ). If the stimulus is absent ($X = 0$), then $V(t + 1)$ will decrease according to the size of $aV(t)$.

The question of interest to Staddon is whether this mathematical equation will reproduce the basic dynamic effects of habituation, as described above. If the model does so, then it has passed a kind of Turing test, an equivalency of the behavior of the model and an animal. The advantage of the model is that the behavior has been described without a commitment to a specific theoretical account. The basic unit may then be combined with other habituation units in series or parallel to describe more complex behaviors (Staddon 1993, 2005; Staddon and Higa 1996, 1999).

Current learning theories tend to fall into a small number of approaches, using mainly cognitive or neuroscience metaphors. Staddon's emphasis on the descriptive powers of mathematical models offers a third, distinctive approach.

Cross-References

▶ Behavior Allocation
▶ Behavior Competition
▶ Habituation
▶ Mathematical Modeling
▶ Optimality
▶ Reinforcement Schedule
▶ Superstition Experiment

References

Innis, N. K. (Ed.). (2008). *Reflections on adaptive behavior: Essays in honor of J. E. R. Staddon*. Cambridge, MA: MIT Press.

Sidman, M. (1960). Tactics of scientific research. Basic Books, NY.

Skinner, B. F. (1948). Superstition in the pigeon. J. of Experimental Psychology, 38, 168–172.

Staddon, J. E. R. (1979). Operant behavior as adaptation to constraint. *Journal of Experimental Psychology. General, 108*, 48–67.

Staddon, J. E. R. (Ed.). (1980). *Limits to action: The allocation of individual behavior*. New York: Academic.

Staddon, J. E. R. (1993). On rate-sensitive habituation. *Adaptive Behavior, 1*, 421–436.

Staddon, J. E. R. (2001). *Adaptive dynamics: The theoretical analysis of behavior*. Cambridge, MA: MIT Press.

Staddon, J. E. R. (2005). Interval timing: Memory, not a clock. *Trends in Cognitive Sciences, 9*, 312–314.

Staddon, J. (2016). *The Englishman: Memoirs of a psychobiologist*. Buckingham: U. of Buckingham Press.

Staddon, J. E. R., & Higa, J. J. (1996). Multiple time scales in simple habituation. *Psychological Review, 103*, 720–733.

Staddon, J. E. R., & Higa, J. J. (1999). Time and memory: Towards a pacemaker-free theory of interval timing. *Journal of the Experimental Analysis of Behavior, 71*, 215–251.

Staddon, J. E. R., & Innis, N. K. (1969). Reinforcement omission on fixed-interval schedules. *Journal of the Experimental Analysis of Behavior, 12*, 689–700.

Staddon, J. E. R., & Simmelhag, G. L. (1971). The "superstition" experiment: A reexamination of its implications for the principles of adaptive behavior. *Psychological Review, 78*, 3–43.