Behavioural Processes 114 (2015) 26–33

Contents lists available at ScienceDirect

Behavioural Processes

journal homepage: www.elsevier.com/locate/behavproc

The role of induction in operant schedule performance

William M. Baum[a,b,*]

[a] University of California, Davis, USA
[b] University of New Hampshire, USA

ARTICLE INFO

Article history:
Available online 14 January 2015

Keywords:
Competition
Induction
Matching law
Reinforcement
Variable-interval schedule
Variable-ratio schedule

ABSTRACT

Baum and Davison (2014b) showed that Baum's (2012) recasting of reinforcement as induction may be quantified by assuming that induction follows a power function of reinforcer rate. This power-function induction is readily integrated with theory based on the matching law. Herrnstein (1970) originally assumed background activities (B_O) and their associated reinforcers r_o to be constant, but r_o should vary with B_O. Further, power-function induction implies that B_O should vary with reinforcer rate. Baum (1993) reported performance on a wide range of variable-ratio (VR) and variable-interval (VI) schedules. Pigeons' VR peck rate followed an inverted U-shaped relation, but VI peck rate separated into three ranges of food rate: low-to-moderate, moderate-to-high, and extremely high. As food rate increases, the concave downward relation in the low range reaches an inflection point and gives way to a concave upward relation in the higher range. At the extremes of food rate, VI peck rate decreases. A model based on competition between induced pecking and B_O accounted for VI peck rate in the moderate to extreme range of food rates. Further research will account for all three ranges, either by integrating power-function induction with matching theory or with a model based on competition between induced activities.

A previous paper (Baum, 2012) recasts the various processes of reinforcement and punishment, stimulus control, classical conditioning, adjunctive behavior, and instinctive behavior as just one process, induction, as defined by Segal (1972). A subsequent paper (Baum and Davison, 2014b) began developing a quantitative model of induction that accounts for operant performance on variable-interval (VI) schedules and concurrent VI VI schedules. The present paper takes a further step toward quantifying induction and integrating it with the matching law (Herrnstein, 1961).

Herrnstein (1961) originally presented the matching law as a relation between two behavioral alternatives in the form:

$$\frac{B_1}{B_1+B_2}=\frac{r_1}{r_1+r_2} \tag{1}$$

where, B_1 and B_2 are response rates or times spent at Alternatives 1 and 2, and r_1 and r_2 are reinforcer rates at Alternatives 1 and 2.

Herrnstein (1970) subsequently proposed generalizing the matching law to any number of alternatives n in the form:

$$\frac{B_i}{\Sigma B}=\frac{r_i}{\Sigma r} \tag{2}$$

where, B_i represents response rate or time spent at any one of n alternatives, B represents the total of responding or time spent at the n alternatives, r_i represents reinforcer rate at any of the n alternatives, and r represents the total or the n reinforcer rates.

Using Eq. (2), Herrnstein (1970) derived an equation for responding at just one recorded alternative:

$$B=\frac{Kr}{r+r_O} \tag{3}$$

where, K replaces ΣB on the assumption that other, unmeasured, activities occur and that, with B_O representing those other activities, and $\Sigma r = r + r_o$, with r_o representing reinforcers due to B_O.

Herrnstein (1970) fitted Eq. (3) to several data sets from Catania and Reynolds (1968). Subsequently de Villiers (1977) fitted it to additional data sets, and it has generally proven successful in describing performance across variable-interval (VI) schedules.

One feature of the fits to Eq. (3) seems incorrect, however: r_o is assumed to be constant as r varies. Baum (1981) and Davison (1993, 2004),) pointed out that this assumed constancy is inconsistent

---

[*] Correspondence address: 611 Mason #504, San Francisco, CA 94108, USA. Tel.: +1 415 345 0050.
E-mail address: wbaum@sbcglobal.net

http://dx.doi.org/10.1016/j.beproc.2015.01.006

with our general understanding of reinforcement contingencies, because B_O must vary as B varies, and r_o should vary with B_O. By definition, a contingency creates a dependence of reinforcer rate on response rate; such a dependence is called a feedback function. For example, the feedback function for a variable-ratio (VR) schedule is given by:

$$r = \frac{B}{V} \tag{4}$$

where V is the average number of responses required per reinforcer, and the feedback function for a VI schedule is approximately:

$$r = \frac{1}{t + \frac{a}{B}} \tag{5}$$

where t is the average interval and a is a constant that represents a tendency to bursts at low reinforcer rates (Baum, 1992). Thus, a feedback function should exist between r_o and B_O:

$$r_o = f(B_O) \tag{6}$$

At least two questions arise: (1) what is B_O? and (2) what is the feedback function f relating r_o to B_O? Baum (1981) and Davison (1993) suggested that the function should have characteristics of a ratio schedule (Eq. (4))—that is,

$$r_O = \frac{B_O}{V} \tag{7}$$

The basis for this conjecture was that B_O activities ought to produce r_o directly, with no time-limiting factor such as would characterize an interval schedule (Eq. (5)).

Davison (2004) found evidence that B_O is not one activity but a conglomerate, but Baum and Davison (2014b) found that treating B_O as one activity allowed calculating variation in r_o and discovering that Eq. (7) is the feedback function relating r_o to B_O, at least at high reinforcer (food) rates.

An earlier paper (Baum, 2012), relying on the process of induction outlined by Segal (1972), suggested that phylogenetically important events induce activities denoted adjunctive or interim or terminal (Staddon, 1977). Following this reasoning, B_O would be induced by a reinforcer such as food, and B_O would depend on the food rate r. Baum and Davison (2014b) found that B_O varied with r and, through this variation and Eq. (7), that r_o varied with r. Thus, at least part of the other activities represented in Eq. (6) as B_O and implicit in Herrnstein's hyperbola (Eq. (3)) is induced by the food (r). To be accurate, Baum and Davison (2014b) proposed that Eq. (3) should be modified to include activities unrelated to the food rate r—what Staddon (1977) called "facultative" activities. They represented these activities as B_N and the reinforcers associated with B_N as r_N:

$$B = \frac{Kr}{r + r_O + r_N} \tag{8}$$

with the understanding that K equals $B + B_O + B_N$ and that some function g relates B_O to r:

$$B_O = g(r) \tag{9}$$

Eq. (9) results in r_o depending on r indirectly:

$$r_O = \frac{g(r)}{V} \tag{10}$$

To fit data from two large data sets (Baum and Davison, 2014a; Baum and Davison, 2014a), Baum and Davison (2014b) assumed that induction follows a power function:

$$B_O = c_o r^{s_o} \tag{11}$$

where the exponent s_o may be thought of as the sensitivity of B_O to r, and the coefficient c_o accounts for reconciling of units.

Baum (1993)

A data set that allows testing these proposals further for both VI and VR schedules was gathered in an experiment reported in

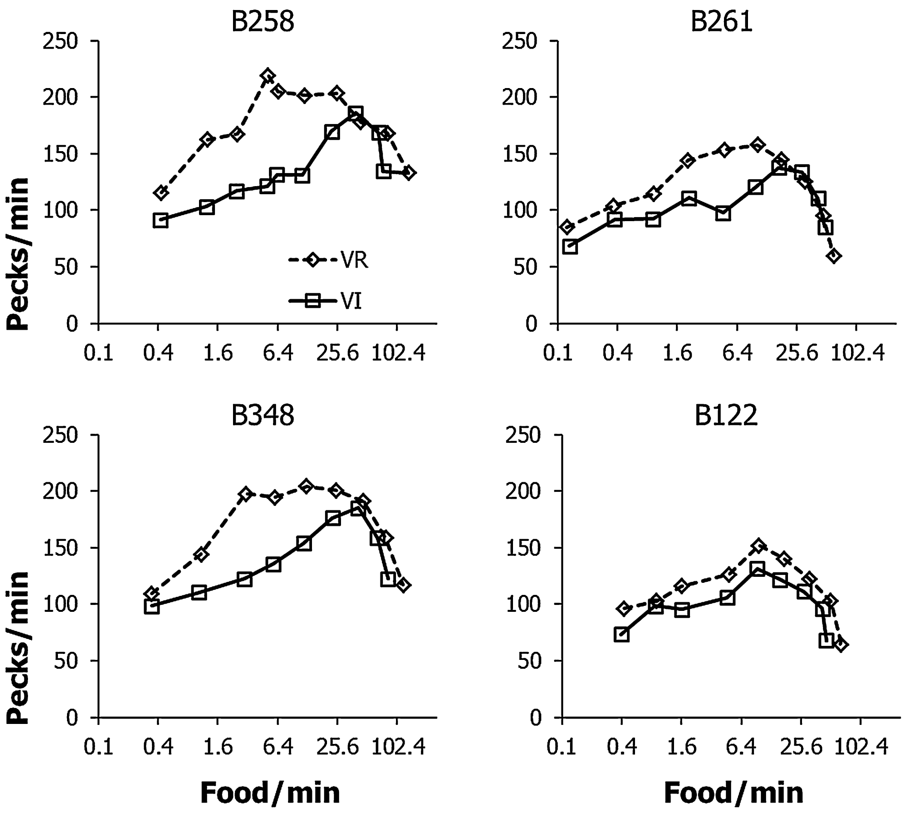

Fig. 1. Pecks per minute versus food per minute from Baum (1993). Data are from a multiple VR VI schedule in which the VI component was yoked to the VR component.