Estimating Rates of Behavior from Hansen Frequencies[1]

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Estimating Rates of Behavior from Hansen Frequencies[1)]

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ABSTRACT. Occurrences of a behavior pattern are sometimes recorded by tabulating, for each time period in the sample, whether the behavior occurred at least once in that period. Since repeated occurrences are not included, the tabulation does not furnish an estimate of the true rate at which the behavior is occurring. Nevertheless, under certain conditions, the rate can be estimated from such data, using the Poisson distribution.

A scoring technique that is used frequently in the study of animal behavior is to record whether a behavior of interest occurred at least once during some fixed interval of time, say 15 seconds. Those who have studied primate behavior at the University of Wisconsin primate laboratory refer to these as *Hansen frequencies*, from the work of E. W. HANSEN (1966).

Examples of the use of Hansen frequencies can be found in the work of ALEXANDER (1966), ARLING (1966), GRIFFIN (1966), MITCHELL (1968a), and SEAY (1966). Perhaps the first person to use this scoring system in behavior studies was OLSON (1929). MITCHELL (1968b) has recently analyzed correlations of the behavior of rhesus mothers and infants, using Hansen frequency data from several of the authors cited above. He writes (p. 87):

"It is emphasized here that a Hansen frequency is not a true frequency of occurrence. When it is stated that a Hansen system was utilized to measure visual orients of a mother toward her infant it is not meant that each and every glance at the infant was recorded. Only one visual orient was recorded whether the mother looked at her infant once during a fifteen second interval or several times during that interval."

The basic data of the Hansen scoring system are the total number of intervals in the sample, and the number of these that included at least one occurrence of the behavior in question. We shall now show how such data can be used to estimate the rate at which the behavior is occurring.

Suppose that the temporal distribution of the behavior can be described by a Poisson process; we will return later to what this implies. If so, then the probability p_0 of no occurrence of the behavior in an interval of length t is given by

$$p_0 = \frac{(\lambda t)^0}{0!} e^{-\lambda t} = e^{-\lambda t}, \quad (1)$$

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where λ is the mean rate of occurrence of events, and e is the base of natural logarithms. From eq. (1) we have $\log_e p_o = -\lambda t$, and thus $\lambda = (-\log_e p_o)/t$. The maximum likelihood estimate of p_o is obtained from the number n of intervals in which the behavior did not occur divided by N, the total number of intervals. Thus, λ can be estimated as follows:

$$\lambda = -\frac{\log_e(n/N)}{t} \tag{2}$$

For example, if the mother glanced at her infant at least once in each of 66 out of 97 fifteen-second observation periods, $\lambda = (-\log_e\frac{31}{97})/15$ sec $= .07605$ occurrences per second. (Notice that this corresponds to more than one occurrence per 15 seconds, a result which is not at all obvious from the observed 66 'successes' out of 97 'trials.')

The single parameter λ is all that is required to fix a particular Poisson distribution. From it, one can obtain the likelihood of any given number of events in an arbitrary time interval, the mean interval between events, and so forth (see, for example, Cox & LEWIS, 1966).

Use of the Poisson distribution implies that the behavior occurs randomly at a constant rate, that the chance of two or more simultaneous occurrences of the behavior is negligible, and that the chance that a particular behavior will occur during an interval is independent of the time that has elapsed since the last occurrence of that behavior. Of course, as with any mathematical distribution, the underlying assumptions are never perfectly fulfilled in nature. "The Poisson process is a mathematical concept and no real phenomenon can be expected to be exactly in accord with it" (Cox & LEWIS, 1966). The question that must be asked in each situation is whether the Poisson process is a reasonable first approximation. The approximation is probably better for brief events (e.g. maternal glances) than for durative ones (grooming), and probably better for those that have a weak influence on subsequent behavior than for those with marked effects. Where the underlying assumptions are untenable, other sampling methods should be considered.

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