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ON TERMS

On Terms: Frequency and Rate in Applied Behavior Analysis

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Abstract The term "frequency" in applied behavior analysis and behavior measurement generally refers to cycles per unit time, or a count (usually of behavior) divided by the time during which it occurred. In statistics, however, the term refers to a count of items in a data set. This meaning of "frequency" as synonymous with "count" has been adopted by one major text and the Behavior Analyst Certification Board®. Another major text uses "frequency" and "rate" interchangeably when referring to behaviors per unit time. Both texts advise readers not to use counts of behavior without reference to the time base of the observation, and in the context of that advice, the count and time information thus provide rate data. We suggest that within applied behavior analysis (ABA) and behavior measurement the term "frequency" should not refer to "count" but instead to "rate," and that references to counts without information about observation time should be avoided.

Keywords Behavioral measurement · Frequency · Rate

Skinner once cited rate of response and the cumulative record as his two greatest contributions (Evans 1968). A count of some behavior or class of behavior recorded over a known period of time provides the two components of rate, often stated as "count per unit time." Rates may be recorded over short time intervals (e.g., correct math problems solved in 60 seconds), during which time we may observe no other behaviors, or longer intervals (e.g., affectionate comments to spouse per week), during which time we might observe many behaviors of other classes or have periods when the spouse is not present. Thus, the basic

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formulation of "count divided by time" may conceal complexities such as periods during which the behavior cannot occur.

The decisions about how to count a behavior and how exactly to collect the temporal information for maximum utility and understanding are specific to the situation and the goals of the behavior analyst, and as such are beyond the scope of this paper. However, to illustrate just some of the issues with decisions about how to time and count the observation of behavior, we consider the following data about a hypothetical group-home resident named Tracey. The data all refer to the same week and set of six reported incidents of aggressive behavior.

1. Last week, there were six aggressive behavior incidents documented involving Tracey.
2. Last Tuesday, there were four aggressive incidents, and Thursday, there were two incidents with Tracey, but none on Monday, Wednesday, or Friday.
3. Last Tuesday, there were four incidents reported with Tracey during a two-hour bathing attempt, and Thursday, two more incidents during a bathing attempt that lasted 30 minutes. Monday, Wednesday, and Friday of last week, there were no incidents reported during the daily bathing.
4. The aide Diana was bathing Tracey during all six of the aggressive behavior incidents reported last week. The aide Marcia did Tracey's bathing on Monday, Wednesday, and Friday and reported no incidents.

The first three sentences state the rates of aggressive behavior incidents in the way we have defined rate (count over time). Statement 2 presents correct data and implies a trend (from four per day down to two per day.) Statements 3 and 4 reveal that the rates of incidents are doubling during Diana's bathing attempts, going from two per hour to four per hour, while there were none reported with Marcia. Although these statements differ in their precision and their utility for managing the situation, by definition, they all are accurate statements about rate. Most important, they imply a serious responsibility for behavior analysts to be specific and clear in the use of terms, definitions, and procedures for data collection, and understand the limits that the choices for data collection impose upon correct inference, in order to avoid anti-therapeutic decisions. For example, to an administrator, statement 2 (incidents going from four per day to two per day) may suggest that "things are getting better," and there is no need for action or referring the situation to a behavior analyst. However, the more precise rates given in statement 3 reveal that the reported incidents are accelerating—the situation is getting worse. Finally, statement 4 invites investigation into exactly what each of the aides is doing and reporting. Stopping inquiry at statement 2 invites a potentially worsening situation for Tracey as well as the staff members.

For some behavior analysts, the word frequency is equivalent to the word rate. For example, in the context of discussing schedules of reinforcement, Mace, Pratt, Zangrillo, and Steege (2011) state that "frequency is a synonym of rate" (p. 57). Other sources similarly equate these two terms, including Johnston and Pennypacker (1980, 1993, 2009), and Cooper, Heron, and Heward (2007). In contrast, some behavior analysts have used "frequency" as synonymous with "count" (e.g., Baer 1986). Both of these usages are not uncommon in the broader scientific literature. A

frequency distribution in statistics, for example, simply tells the reader how many of a particular entry appears in the set in question. Many dictionaries include both usages cited above, as well as many usages that apply to specific phenomena such as radio waves (e.g., frequency n.d., Dictionary.com).

In the second edition of the Task List (Florida Behavior Analysis Certification Program 1997), frequency was defined as synonymous with rate. In Task 7.2, the reader is directed to "Use rate (sometimes referred to as frequency)—the number of responses per unit of time." Also, the definitions of reinforcement and punishment in that Task List referred to changes in frequency. However, a revised definition of frequency appeared in the third edition of the Behavior Analyst Certification Board® (BACB) Task List (Shook, Johnston, and Mellichamp 2004), equating frequency with "count," and this new usage was maintained in the fourth edition (Mayer, Sulzer-Azaroff, and Wallace (2012); Behavior Analyst Certification Board® (2012)). Mayer et al. (2012) followed the usage of the BACB third and fourth edition Task Lists and define frequency as count, whereas Cooper and colleagues (2007) followed the second edition Task List usage and equate "frequency" and "rate."

For a student, the present contingencies seem to point to the following rule: use frequency as a synonym for count for the BACB examinations, and in all other situations seek to clarify the intended usage if one is the listener and avoid the term frequency entirely if one is the speaker. This tactic would reduce confusion in professional conversation and avoid an incorrect answer on the examination. However, an approach with a better impact on the field might be for the BACB to revise the usage in the next edition of the Task List to match its second edition, defining frequency to mean "rate" within the context of ABA (but not applying to usage of the term frequency distribution in the context of a statistical discussion, for example).

A related confusion was uncovered during our review that has additional ramifications for professional descriptions of behavior and the analysis of applied situations, and it bears upon the usage of the terms count, rate, and frequency. To speed explanation, we will first present the relevant elements of definitions from Cooper et al. (2007), and then from Mayer et al. (2012). Finally, we will consider implications for the BACB examinations and the field of applied behavior analysis.

To start, Cooper et al. (2007) state, "Count is a simple tally of the number of occurrences of a behavior" (p. 76). With respect to rate and frequency, they state, "Combining observation time with count yields one of the most widely used measures in applied behavior analysis, rate (or frequency) of responding, defined as the number of responses per unit of time." However, in Table 4.1 of the study by Cooper et al., under the column heading "Fundamental measures," we find:

> Count: The number of responses emitted during an observation period.
> Rate/frequency: A ratio of count per observation time; often expressed as count per standard unit of time (e.g., per minute, per hour, per day). (p. 85)

In Table 4.1, although rate and frequency are clearly equated, a closer look reveals little difference between the terms count and the terms rate and

frequency, with all three containing the elements of count and a known time period; hence, both parse to "count during some known observation time." A difference appears to be that with rate or frequency, one calculates and reports the rate, whereas in count, the rate is accessible, because the observation time is known, but rate is not actually calculated. Because the utility of a count is dramatically enhanced if one has the temporal information, Cooper et al. (2007), like Mayer et al. (2012), stress the need for including temporal information (consider the difference between eating 14 meals per week versus 14 per month), but the definitions appear conflated, nonetheless.

Mayer et al. (2012, p. 681) provide the fourth edition BACB Task List definition cited above, but earlier in their textbook, they provide the following explanations:

- …frequency/event, the number of times the response occurs… (p. 114)
- Event recording=number of times behavior repeated per specific period of time. (p. 115: box)

– Event or frequency recording involves counting how often a specific behavior occurs within an interval, session, class period, day, week, month, or observation period. (p. 115)

- At the simplest level, you can indicate frequency of occurrence (e.g., Marty swore nine times on Monday and ten times on Tuesday). (p. 115)

The intent in the Mayer text seems to be to equate event or frequency recording with simple count, but as in the example from Cooper et al. (2007), with the inclusion of the time period, both definitions parse to rate. Mayer et al. (2012) define rate in a way that brings us back to the other two definitions: "Rate=number of responses (divided by) standard time period and expressed as per___ (the time period)" (p. 116).

To us, it seems that the definitions above have the same basic elements of a known count and some known amount of time, and hence all eventually parse to rate (i.e., count divided by some known amount of time). Indeed, the swearing example above, which is supposed to illustrate count or frequency of occurrence, also translates exactly to swearing rates of nine per day and ten per day. It does not seem critically important to actually carry out the division process at each instance. The difference between 30 responses in 60 minutes, or 30 in an hour, or 0.5 responses per minute seems like hairsplitting, with the exception that the first two formulations also carry the important information about the length of the observation period, while the other does not. Still, the ultimate sense of pace or rate is the same, and they can be converted mathematically from one to another. Finally, they can actually be the same without any mathematical operations at all if the observation period is equal to some standard time period, such as a day, hour, or minute.

Therefore, because a consistent distinction is elusive, we suggest that rate and frequency be considered synonyms, with neither taken to mean simple count, outside of statistical use. We encourage behavior analysts to label and report this type of observed data as rate, frequency, or count per time unit, so that students or coworkers do not see reports of simple counts in the absence of any time data.

Nevertheless, the next edition of the BACB Task List might retain the usage of frequency as a synonym for count. If so, drawing upon the example from Mayer et al. (2012), we can imagine a question for the BACB examinations as follows:

"John ate three meals without choking on Tuesday" is an example of:

a. rate
b. frequency (count)
c. (foil)
d. (foil)

To reason that "three per day is a rate" is clearly defensible, but if the current BACB Task List definition is retained, one may also argue that the count of three without the explicit division by some time unit makes it a "frequency" (a.k.a. count) instead. Here, it bears repeating that the authors of the textbooks cited above emphatically and in multiple places caution against the use of simple counts of behavior without noting the duration of observation. Ignoring that advice, a modification of the question above that clearly differentiates between rate and count could be:

"John ate three meals without choking" is an example of:

a. rate
b. frequency (count)
c. (foil)
d. (foil)

Here, we have a clear correct answer, frequency, as currently defined by the BACB Task List to be synonymous with count, because there is no hint of an observation interval with which to calculate a rate. However, the cost of this clarity is that we lose the practical utility of the example. (Consider the implications of three in a day or week versus three in a decade.)

Using frequency synonymously with rate will not eliminate all variability in the various usages of these terms. For example, driving is commonly described with the term "speed" rather than rate, even though they are logically equivalent. Nevertheless, within the context of applied behavior analysis, the key guidance is to include the observation time with counts of behavior to avoid the confusion that can be occasioned by its omission. To that end, it seems clearer to retain and equate the terms rate and frequency, or to simply state both count and time (e.g., ten per class period) in all discussions. We suggest avoiding all references to isolated counts of behavior, and hence do not see a need for two words that both mean count. In contrast, because all behavior occurs across time, having two words meaning rate seems much more practical and useful.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no competing interests.

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