The Concept of Strength in the Analysis of Verbal Behavior

Chris Cherpas
Computer Curriculum Corporation

A textual analysis of the concept of strength is presented, based on patterns of its occurrence in the book *Verbal Behavior* (Skinner, 1957). A manual count was conducted of all instances of the word "strength," and closely related forms. Rates were then plotted and interpreted as revealing the kinds of situations where strength is most relevant. Strength appears to be most relevant (as measured by instances per page of text) whenever a detailed behavioral analysis involves 1) more than one source of strength for a response, 2) multiple responses or fragments being strengthened by one or more variables, 3) dynamic changes in behavior, or 4) behavior which is not currently or readily observed. Further research is needed to evaluate how textual analysis of this sort contributes to a science of behavior.

Imagine a student working at a computer-based instruction program. The student works most exercises correctly, but has recently missed a few questions. Now the student is confronted with a new exercise. What is the probability that the student will respond with the correct answer? The computer program keeps track of what responses the student has made and, to some extent, under what conditions. Given these data, how does the program determine the next instructional step?

These are practical questions about the prediction and control of verbal behavior. Within the tradition of behavior analysis, such questions are understood in terms of the concept of strength. A sequence of events, as might occur while an instructional program is running, allow one to predict that, with a given probability or strength, a current condition will evoke a given response. Likewise, if one knows the strengths of certain classes of behavior within a student's repertoire, one should be able to present the student with a condition which evokes a desired response and leads to the strengthening of a variety of future desired behaviors.

Analyzing behavior in terms of strength is not always straight-forward. Strength

apparently has many manifestations. Rate or frequency of response (Skinner, 1953) provides one measure of strength, but there are many others, including relative frequency (Herrnstein, 1970), resistance to change in rate (Nevin, 1974; Smith, 1974), and the number of responses in extinction (Skinner, 1938). Some researchers have taken the position of "objectivism" – that strength or probability of behavior should only be discussed in terms of a given measurement procedure (Espinoza, 1993). For example, an objectivist might argue for relative frequency as the true interpretation of probability (Herrnstein, 1970). By contrast, a "subjectivist" would take the more eclectic view that relative frequency is only one measure which can affect one's "degree of belief" about the probability of a given event (Mario Zanotti, personal communication). Some behavior analysts have even called for the elimination of strength or probability from scientific discussions because empirical and theoretical influences become mixed in the same term (see the survey conducted by Johnson & Morris, 1987).

A functional approach to understanding the concept of strength requires an analysis of the conditions under which people actually say (or write) "strength." Inevitably, one would want to identify particularly those conditions under which saying or

Suggestions offered by the reviewers and editor were greatly appreciated. Correspondence may be addressed to the author at Computer Curriculum Corporation, 1287 Lawrence Station Road, Sunnyvale, CA 94089.

writing strength is strongest or most probable. This leads back to a consideration of how to assess strength. In his book, *Verbal Behavior*, Skinner (1957, p 22) discusses several sources of evidence for strength, including whether a response is emitted at all, its energy level, its speed, the amount of repetition, and its overall frequency. Fortunately, written verbal behavior leaves a record which can be analyzed. While we may not observe the energy, speed, or frequency with which an author actually writes or says something, the product of the writer's behavior leaves some evidence which is readily available.

The purpose of this paper is to analyze the products of B. F. Skinner's verbal behavior with respect to the concept of strength. The data are limited to the textual content of the book, *Verbal Behavior*. It is hoped that such an exercise contributes to a better understanding of the concept of strength, particularly in the analysis of verbal behavior.

METHOD

Since no observations of Skinner actually writing *Verbal Behavior* were used for the current analysis, certain methodological issues should be made explicit. First, it is assumed that the order in which the final form of the text appears is not necessarily related to the order in which the text was written. Thus, even though a cumulative record was constructed in ascending page order, it is not meant to represent a flow of Skinner's behavior in real time. Second, the particular words and phrases chosen for data analysis are not taken to be the products of Skinner's *only* behavior relevant to the concept of strength; however, the frequency of those instances is at least sufficiently high to reveal significant patterning. Finally, the distribution or patterning of instances displayed in this paper are interpreted as suggesting that strength is more relevant to certain topics, themes, or abstract features of verbal behavior than to others. Thus, the higher the frequency of such words or phrases under certain headings in the book, the more it is assumed Skinner had a tendency to invoke the con-

cept of strength (i.e., the stronger the response "strength" was) while writing those sections.

A manual count was conducted of all instances of the word "strength" and closely related forms such as "strong" and "strengthening." Various forms of strength's complement, "weak," were also counted. The list below shows all words counted and how many of each were counted.

Word	Count
strength	308
strong	96
weak	56
strengthening	40
strengthen	31
strengthened	27
weakness	19
stronger	9
strengthens	5
strengths	5
weaken	4
weakened	4
weakly	4
strongly	3
weakening	3
strongest	1
weakens	1

Some occurrences of words on the list were not counted because they were part of statements which seemed unrelated to a technical description of individual behavior, as in the sentence, "The notion of catharsis, strengthened by the medical analogy, obscures this possibility" (p. 401). Synonymous forms, such as "probability" and "likelihood," were also not counted.

Other occurrences which might be seen as nothing more than standard, nontechnical English, as in the phrase, "strong tendency" (e.g., p. 23), were granted membership at the boundaries of this admittedly fuzzy set if they were judged to be part of a description of behavior. References to strength (without quotes) in the remainder of this paper will be to this set, not just to the word, "strength."

Certain stock phrases containing strength were also counted. For example,

the phrase, "sources of strength" appears 43 times (15 of which are included in instances of the phrase, "multiple sources of strength"), whereas the singular, "source of strength" occurs 22 times.

RESULTS

Apparently, the scope of things that can be strengthened (or weakened) includes literally all the so-called dependent variables in an analysis of verbal behavior: verbal behavior as a whole (p. 24), repertoires (p. 22), behaviors (p. 11), operants (p. 22), responses (p. 22), and fragments of responses (p. 308). Among the things that can strengthen (or weaken) are nonverbal

(p. 82) and verbal stimuli (p. 78), states of deprivation (p. 47), reinforcement (p. 66), punishment (p. 166), and extinction (p. 206). In other words, all the so-called independent variables of which behavior is a function are strengtheners and weakeners. Many of these variables are routinely described as being strong ("stimuli are...strong," p. 78; "strongly reinforced," p. 66). While it is sometimes difficult to determine whether a given instance of strength in *Verbal Behavior* exclusively refers to either an independent or dependent variable, it is safe to say that most instances in the book explicitly name dependent variables.

Fig. 1. Cumulative instances of strength across pages in *Verbal Behavior*. The five Parts into which the book is divided are labeled in Roman numerals at the top of the graph.

Chapters ordered by rate

Fig. 2. Bar chart of per-page rates of strength by chapters, ordered in descending order of rate. Chapter numbers are displayed in parentheses.

Strength appears 616 times in 468 pages, with an overall rate of 1.32 instances per page. Figure 1 is a cumulative record of instances of strength per page, and shows that the rate is variable. The graph starts out almost flat until the middle of Part I: A PROGRAM, where the rate increases abruptly. This is where the concept of strength is defined in *Verbal Behavior* (p. 22).

The rate then slows in Part II: CONTROLLING VARIABLES, where the simplest units of verbal behavior are defined

(e.g., mands, tacts, and verbal behavior under the control of verbal stimuli). While the rate increases as the discussion eventually shifts to groups of responses (i.e., audience control), and to dynamic changes in verbal operants, the result is an average rate in Part II of only 0.90, considerably lower than the overall rate.

By contrast, the average rate in Part III: MULTIPLE VARIABLES, is 2.58 instances per page, almost double the overall rate. Note that while Part II is largely spent on situations in which a single response has a

single source of strength, Part III is spent on the interactions of multiple responses and multiple sources of strength.

The rate slows again in Part IV: THE MANIPULATION OF VERBAL BEHAVIOR. It practically flattens in the beginning of PART V: THE PRODUCTION OF VERBAL BEHAVIOR. The rate then accelerates in the middle of Part V, where the discussion turns to the variables which speakers manipulate to strengthen verbal behavior that is already present, but requires additional sources of strength for its emission. After this, the rate drops again, remaining lower than half the overall average rate for the remainder of the book.

Figure 2 is a bar chart showing per-page rates of strength by chapters, displayed in descending order of rate. Like the cumulative record, the bar chart demonstrates variation in rates across chapters. The book's highest ranked chapters are Self-Strengthening (Chapter 17) at 2.8 per page, and Supplementary Stimulation (Chapter 10) at 2.7 per page, both more than twice the overall rate.

Both of these chapters focus on the practical problem of evoking verbal behavior which is not currently strong enough to be effective on a listener or reader. Commonly used techniques, such as formal and thematic prompts and probes, provide the additional sources of strength required for emission. The major difference between these two chapters is that the techniques are applied to the speaker's or writer's own verbal behavior in Chapter 17.

The greatest number of instances of strength per page in *Verbal Behavior* appears on page 404 of Chapter 17, with 13 instances. The discussion is concerned with the reasons why verbal behavior (e.g., tacts, intraverbals, and echoics) might be too weak to be emitted overtly. Page 287 of Chapter 10 contains nine instances of strength, the highest per-page count in that chapter, and is devoted entirely to supplementary stimulation and verbal humor. Explanations of "zany humor," "spoiling a joke," and wit are given in terms of the interplay of multiple variables.

Figure 2 shows that Multiple Causation

(Chapter 9) ranks third at 2.69 per page. This chapter exemplifies how describing the interactions of multiple variables, some of which may be difficult to observe, tend to involve frequent references to the concept of strength. Chapter 11, New Combinations of Fragmentary Responses, has the fifth-highest rate for a chapter at 1.94, indicating that strength is not only frequently invoked in descriptions of a single response controlled by multiple variables, but also when describing multiple behavioral fragments which combine to form new responses.

DISCUSSION

While the foregoing results represent only a first step towards understanding the concept of strength through textual analysis, the data are at least consistent with some preliminary interpretations. Strength appears to be most relevant (as measured by instances per page of text) whenever a detailed behavioral analysis involves 1) more than one source of strength for a response, 2) multiple responses or fragments being strengthened by one or more variables, 3) dynamic changes in behavior, and 4) behavior which is not currently or readily observed. These arrangements are commonly encountered in applied situations, exemplified at the beginning of this paper by a student running a computer-based instruction program.

Any analysis of strength also raises two issues about the definition of strength: its relation to probability and its relation to units of behavior. Figure 2 shows that the fourth highest rate among chapters is in General Problems (Chapter 2) at 2.55 per page, where the concept of strength is defined:

Every verbal operant may be conceived as having under specified circumstances an assignable probability of emission – conveniently called its "strength." We base the notion of strength upon several kinds of evidence. (p. 22)

Strength is defined in terms of probability, and yet, besides having fewer syllables, why is strength considered more "convenient" than probability? Perhaps it is

because strength has not suffered the history of debates associated with the term probability, such as those between objectivist and subjectivist interpreters of the concept (Espinoza, 1993; Johnson & Morris, 1987; Michael, 1979).

But there is something substantive that complicates a definition of strength in relation to probability. In addition to indicating the degree of belief one may have that some behavior will occur, strength is frequently applied to situations where a behavioral event *which has already occurred* is described as the combination of multiple variables, each contributing something to the total event; under some conditions, strength may simply be a known degree to which a variable contributes to such an event. Unlike probability, one may talk about degrees of strength while experiencing absolutely no uncertainty about the occurrence of a response.

Units of Behavior

The second definitional issue concerns the relation between strength and units of behavior. In other words, what gets strengthened? While a functional approach implies that behavior can be strengthened at many levels of decomposition or specialization, some units of behavior may be more generally representative of the "natural lines of fracture," which define classes of behaviorally relevant environmental and organismic events, than others (Skinner, 1938). Skinner's "kinds of evidence" for strength – including whether a response is emitted at all, its energy level, its speed, the amount of repetition, and its overall frequency – suggest that strength is a property *underlying* observed behavior. Constructions such as "evidence of strength," "sign of strength," and "indicator of strength" occur at least 15 times in *Verbal Behavior*, making strength come across as a kind of "state variable" which is not directly observable (Shull, 1993); in fact, the phrases "state of strength" and "states of strength" appear a total of no less than nine times in the text.

While Skinner undoubtedly did not set out to propose strength as a condition of

which behavior is only a symptom or sign, the data here show that it appears frequently in descriptions of inferred, private, or complex behavioral phenomena that may be difficult to measure. The state of a student's repertoire, for example, can be characterized in terms of the strengths of various fragments of behavior that combine at any given moment in the form of overt behavior. Such a characterization may seem to put more emphasis on what is not, rather than what is, observed. However, to resist invoking the concept in this way because it mixes empirical and inferential influences would seem to ignore its usefulness.

A view of behavioral units which is implicit in *Verbal Behavior*, especially where instances of strength are most frequent, is most explicitly stated in the following description from *Science and Human Behavior* (Skinner, 1953):

The traditional explanation of transfer asserts that the second response is strengthened only insofar as the responses 'possess identical elements.' This is an effort to maintain the notion of a unit of response. A more useful way of putting it is to say that the *elements* are strengthened wherever they occur. This leads us to identify the element as the unit of behavior. It is a sort of behavioral atom, which may never appear by itself upon any single occasion but is the essential ingredient or component of all observed instances. The reinforcement of a response increases the probability of all responses containing the same elements. Verbal behavior supplies especially good examples of the need to consider these atoms. (p. 94)

Verbal Behavior addresses "minimal" units in several places, but most generally in Chapter 11, *New Combinations of Fragmentary Responses*. As the title suggests, Skinner's analysis in this chapter is confined to combinations of behavior which occur for the first time. However, *Verbal Behavior* gives us a general conception of behavior, in the detailed examples of multiple causation, which makes "behavioral atoms" the primary targets of strengthening operations. The student engaged in a computerized curriculum has in his or her repertoire numerous behavioral atoms. The fact that each of these units "may never appear by itself on any single occasion" does not absolve us of the

responsibility to understand them. It is to behavioral atoms that we implicitly refer when "what gets strengthened" appears to underlie overt behavior.

Efforts to experimentally operationalize the concept of strength are usually directed towards the relatively simple cases, such as the steady-state behavior of nonhumans under schedules of reinforcement, where the concept may actually have least utility. Even here, there are complications that arise in no small part from difficulties in identifying what gets strengthened. For example, consider whether a distribution of responses represents different classes of behavior or simply changes in the strength of a single class. This problem has been debated in a number of contexts, including variable-interval performance (e.g., Shimp, 1969), stimulus generalization (e.g., Migler, 1964), and so-called continuous repertoires (Wildemann & Holland, 1972).

Another version of the problem is that of interpreting distributions of interresponse times (IRTs) in terms of probability of response in avoidance schedules. Johnson and Morris (1987), in their paper concerned with the concept of probability in behavior analysis, describe Anger's (1956) method of plotting IRTs as "often more accurate and predictive" than simply plotting the relative frequencies of IRTs of each class. Anger's method involves dividing the number of IRTs in a given class by the total number of IRTs *minus any IRTs of shorter duration*, rather than simply dividing by the total number of IRTs. When this "IRT per opportunity" approach is used, IRTs have different probabilities than when a traditional relative frequency is used. Anger's theory was that the time preceding each IRT-terminating response is a conditioned aversive temporal stimulus. This means that shorter duration IRTs take away "opportunities" for responses that might have terminated longer intervals – hence the term "IRTs per opportunity."

However, rather than viewing the unit of behavior as the termination of an IRT in the presence of a temporal stimulus, one could follow Shimp's general approach and interpret each IRT as a temporally dif-

ferentiated response that *includes* the interval within it. Instead of a distribution of responses occasioned by various temporal stimuli, a distribution of IRTs can be seen as a collection of free operants (i.e., not occasioned by particular stimuli) differentiated by duration. The appropriate way to plot IRTs would then revert back to the simple relative frequency distribution, since a long or short response can occur *any* time after the last response has occurred. Again, the probabilities for various classes of IRTs would be different than those plotted with the "IRTs per opportunity" approach.

Thus, even in simple experimental arrangements, determining the strength or probability of behavior is a difficult task because it depends in part on how units of behavior are defined. The experimental analysis of nonverbal behavior has not, as yet, overcome such difficulties. The most successful formulation of strength that has come from the experimental analysis of behavior, the matching law (e.g., Herrnstein, 1970), is not only static, it is purely parametric – it does not address the combinatorics of how units are formed and/or dynamically modified. On the other hand, *Verbal Behavior*, an almost purely interpretive piece, implicitly provides elements of a powerful qualitative conception of strength through numerous examples of the interaction of multiple variables.

The Fate of Strength

One might ask that if strength is so useful, why did Skinner not elaborate it further in future writings? Without the benefit of counts similar to those in the current paper, it does *seem* that Skinner shifted in subsequent works away from "behavior being strengthened" and more towards "behavior under the control of contingencies." But while the former may have unfortunate roots in associationism and classical conditioning, the latter has more of an all-or-none quality to it (i.e., under control versus not under control) that misses some of strength's more interesting micro-level qualities. Perhaps such a shift away from strength and towards contin-

gency control was helpful to deal with the complexities of macro-level, layered behavioral systems (e.g., culture). Unfortunately, an analysis of the dynamics and combinatorics occurring at the instant a response is emitted is not easily accommodated in the language of contingency control. It leaves a gap that is most likely to be filled by some version of optimization (e.g., "momentary maximization"), a framework too rigid for the analysis of verbal humor and wit, if not IRTs.

The present study aims to provide a first step towards understanding the concept of strength through textual analysis. A broader set of sources would enable one to confirm or disconfirm some interpretations made here. Clearly, we need to have the seminal literature of behavior analysis available on CD ROM (i.e., digitized on compact disks) if such analyses are to be carried out with more depth and breadth – and speed – than the present one. Of course, studying the products of scientific verbal behavior offers no guarantee of better understanding the science itself. Further studies of this kind should cast more light on what value textual analysis has for a science of behavior.

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