Do Stimulus Classes Exist Before They are Tested?

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This paper addresses verbal practices that are common when behavior analysts talk about stimulus classes. Specifically, we examine some of the conditions that may set the occasion for saying "Stimulus classes exist prior to the tests that document their formation." We suggest that "stimulus class" should tact behavior that is a function of training and test procedures, not entities that "form" or "exist" in any independent sense. To frame our arguments, we review relevant research findings and suggest descriptive language that is more consistent with behavior analytic traditions.

Can stimulus classes be said to exist prior to test outcomes that set the occasion for saying that classes currently exist? Phrased in this way, the question sounds odd, but it is semantically equivalent to those that often come up when behavior analysts talk about stimulus classes. Moreover, there have been a number of experiments conducted to try to gather evidence of class formation prior to the tests (e.g., K. Saunders, Spradlin, & R. Saunders, 1989a). The provenance of these efforts appears to have been a few lines in an article by Sidman, Kirk, and Willson-Morris (1985) on six-stage equivalence class formation. They wrote that "Strong rational support . . . exists for supposing that classes of equivalent stimuli form during the test rather than during the original teaching" (p. 39). Subsequently, Sidman went on to clarify this position: He suggested that the equivalence tests may pro-

vide additional experience that helps separate equivalence relations from others that are possible in the experimental situation (Sidman, in press). However, Sidman and colleagues' (1985) discussions have been interpreted as asserting something more—that the tests for reflexivity, symmetry, and transitivity (Sidman & Tailby, 1982) are in fact necessary to form the classes. What followed naturally were efforts to show that equivalence classes can form before the tests.

The fact that experiments like this are being conducted shows important growth within behavior analysis. Particularly in the past decade, behavior analysts have sought answers to ever more complex questions about behavior involved in cognition. In the excitement of pursuing new questions, however, it is easy to lose sight of the fundamentals temporarily. We see evidence of that when we examine some of the verbal behavior that is used to discuss work on stimulus equivalence and related phenomena. The purpose of this article is to help to encourage verbal practices that are more consistent with behavior analytic traditions.

We suggest that questions such as "Do stimulus classes exist before they are tested?" are not good ones to ask. In our view, such questions create conceptual problems that behavior analysis usually helps us to avoid. We also suggest alterna-

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tives that help to avoid the conceptual problems.

Two examples will help frame our arguments. The examples involve emergent behavior that seems to have features in common with that emitted on tests for stimulus class formation. The first is a sentence spoken by Alfred North Whitehead to B. F. Skinner while they were dining at the Harvard Society of Fellows (Skinner, 1957, p. 457). Whitehead said "Let me see you account for my behavior as I sit here saying 'No black scorpion is falling upon this table.'" Whitehead's challenge was for Skinner (and behavior analysis in general) to identify the variables that determine production of novel sentences that had never been spoken before and thus had no explicit history of reinforcement. Skinner's attempt to do that ultimately resulted in *Verbal Behavior*, and much stimulus equivalence work has a similar purpose. For our purposes, we may ask about the status of Whitehead's sentence before it was spoken. Did it exist in some sense and if so how?

Our second example is that of the skilled musician who departs from his or her printed music and improvises entirely new variations on old familiar themes. What is the status of those improvisations before they are played for the first time? Do they exist and if so how?

In what way is the behavior involved in these examples comparable to that emitted on equivalence tests? Most behavior analysts would agree that all three types of behavior are a function of variables that "lie outside the organism, in its immediate environment and in its environmental history" (Skinner, 1953, p. 31). What separates emergent matching-to-sample performances, novel sentences, and improvisations from other forms of behavior is largely that they have not been previously emitted. Of course, a fully comprehensive science of behavior must have a framework for accounting for emergent behavior. In behavior analysis, the traditional approach has been to trace emergent performances to other behavior previously acquired (behavioral prerequisites; cf. Epstein, 1985; Holland, Solomon, Doran, &

Frezza, 1976). As an example, consider Skinner's (1957, pp. 187-190) account of the conditions leading to the emission of a mand for the first time. Some prerequisites may be obvious and others perhaps not so, but they must be specifiable in terms of previous environment-behavior interactions if the science of behavior is to succeed. In the behavior analytic tradition, one would never say that Whitehead's sentence and the musician's improvisation existed before they were emitted. Rather, one would say only that prior experience established the prerequisites for the emission of the new behavior at the appropriate time. We suggest that verbal behavior describing stimulus classes (and their "formation") should remain faithful to this tradition.

When we assert that stimulus classes exist before they are tested, we edge toward subtly transforming "class formation" into an event that is outside the domain of behavior analysis. For example, one might view class formation as a biological event. It seems self-evident that any behavioral change must have a biological correlate. But when we work at a purely behavioral level, we must be cautious to avoid unintended pursuit of problems in neuroscience and neuropsychology. In our judgment, few behavior analysts would do so. More likely, however, is the potential for unintended analysis of the formation of connections in some conceptual nervous system or a cognitive analog of it. Such analyses, of course, are clear departures from the behavior analytic enterprise, the goal of which is to document functional relations between specific environmental operations and changes in behavior. When we say that "classes exist before they are tested," we are not consistent with the nature of our science.

The problem that we are addressing is similar in kind to that which occurs when we try to determine what feature(s) of a complex discriminative stimulus have controlled a given response during training. We present the subject with new displays that do or do not contain specific features, and measure the subject's response. Under some conditions of testing, our findings

seem to indicate that, say, Feature A did control and that Feature B did not (e.g., Reynolds, 1961). If we use somewhat different test procedures, however, we may obtain very different results (cf. Wilkie & Masson, 1976). Such findings illustrate that the test procedures themselves exert control over what the subject does. This fact should caution us against casual use of test outcomes to support our inferences about the stimuli that controlled prior to the test. All that we are truly certain about is that the subject, who has had exposure to certain training contingencies, interacted with the test conditions to produce the test outcome.

In this light, how can we describe findings taken as evidence that classes exist before they are tested? We will consider two examples. One very clever effort was reported by K. Saunders, Spradlin, and R. Saunders (1989a). Figure 1 presents the essence of their experimental design. (Their design actually involved more stimuli, but it has been simplified here to aid exposition.)

Mentally retarded human subjects first learned the conditional-discrimination performances represented in the left portion of Figure 1. The procedure was matching to sample; arrows point from samples to comparisons. The subjects learned to select visual comparison stimuli from Set A conditionally upon samples from Sets B and C. Subjects also learned to select comparison stimuli from Set E conditionally upon samples from Sets F and G. Unreinforced tests

for emergent matching performances documented the formation of four three-member stimulus classes: A1-B1-C1, A2-B2-C2, E3-F3-G3, and E4-F4-G4.

That is, on test trials subjects selected C1 conditionally upon B1, C2 upon B2, G3 upon F3, and so forth. Note that the ABC and EFG classes were independent of one another.

The middle portion of Figure 1 illustrates the next phase of the experiment. K. Saunders and colleagues instituted conditions sufficient for a merger of the classes via an "unreinforced conditional selection" procedure (R. Saunders, K. Saunders, Kirby, & Spradlin, 1988). Unreinforced trials displayed Set F stimuli as samples and Set A stimuli as comparisons. Consistent with previous reports of unreinforced conditional selection, subjects reliably selected one comparison in the presence of one sample and the other comparison in the presence of the other sample. For purpose of illustration, let us consider the case shown in the center portion of Figure 1 in which the subject selects A1 conditionally upon F3, and A2 upon F4. Based on the findings of R. Saunders and colleagues' (1988) study, one would predict the merger of the ABC and EFG classes into two larger classes, A1-B1-C1-E3-F3-G3 and A2-B2-C2-E4-F4-G4. Such class formation would be documented by test trials in which subjects selected G3 conditionally upon A1, G4 upon A2, E3 upon B1, and so forth. However, the tests for class formation were not conducted at this point.

Fig. 1. A simplified version of the experimental designed used by Saunders, Spradlin, and Saunders (1989a).

The right portion of Figure 1 diagrams the final phase of the experiment. In it, the performances that were previously displayed via unreinforced conditional selection were reversed with a differential reinforcement procedure. Subjects were taught explicitly to select A1 conditionally upon F4, and A2 upon F3. Given such training, a reasonable prediction would be the resulting stimulus classes A1-B1-C1-E4-F4-G4 and A2-B2-C2-E3-F3-G3; the predicted emergent performances would be selection of G4 conditionally upon A1, G3 upon A2, E4 upon B1, and so forth. When class-formation tests were conducted, however, the results were contrary to that prediction. Instead the relations that emerged were in fact consistent with the subjects' original unreinforced conditional selections (as shown in the middle portion of the figure): selection of G3 conditionally upon A1, G4 upon A2, E3 upon B1, and so forth.

One interpretation of these findings is that the classes had formed earlier—prior to the reversal phase and, of course, prior to the tests for class formation. However, an analysis in terms of specifiable environment-behavior interactions tells us merely that the behavior emitted on the class tests was consistent with the training history prior to the reversal phase. A logical next question is whether this outcome will always occur or whether the test behavior might be consistent with the reversal under some circumstances. Is anything added by asking whether classes formed prior to the tests?

One might argue that "classes form before the tests" adds a convenient, harmless way to tact a relationship of sufficiency between a given history and a given test outcome. Our next example illustrates why such practice can lead to conceptual difficulties and why it should be avoided, especially when less troublesome and equally spare descriptions are available (K. Saunders, Spradlin, & R. Saunders, 1989b).

Recent experimental work has demonstrated transfer of discriminative (e.g., de Rose, McIlvane, Dube, Galpin, & Stoddard, 1988) and conditioned reinforcing (Hayes, Brownstein, Devany, Kohlenberg, &

Shelby, in press) functions among conditionally related stimuli. In de Rose and colleagues' study, subjects acquired a simple, simultaneous discrimination in which visual stimuli A1 and A2 served as S+ and S- respectively. A1 and A2 also served as samples on conditional-discrimination trials, controlling selections of comparisons B1 and B2, respectively. When B1 and B2 were displayed in the simultaneous discrimination format, subjects typically selected B1 and rejected B2; the A- and B-stimuli were thus shown to be members of the same functional stimulus class under these conditions.

One might go on to suggest that the transfer of functions is a characteristic of equivalence class members, and that such transfer is evidence that equivalence classes (A1-B1 and A2-B2) had formed previously (cf. Hayes, 1990). By this logic, positive transfer findings would be evidence that equivalence classes can exist prior to reflexivity, symmetry, and transitivity tests. This interpretation, however, is not consistent with recent research findings. For example, Sidman, Wynne, Maguire, and Barnes (1989) reported a case in which equivalence-class test outcomes were negative even though discriminative functions transferred among the stimuli. Moreover, an accumulating body of evidence is documenting that functional class membership (as exemplified by de Rose and colleagues' study) and equivalence class membership may be independent under some circumstances (de Rose, McIlvane, Dube, & Stoddard, 1988; McIlvane, Dube, Kledaras, Iennaco, & Stoddard, 1989). Also, it is well known that oral naming can but need not transfer among members of equivalence classes (e.g., Lazar, Davis-Lang, & Sanchez, 1984). The implications of these various findings seem clear. Although emergent matching-to-sample performances, function transfers, and the like may have many overlapping behavioral prerequisites, their independence under some conditions shows that they do not have identical prerequisites.

These findings may surprise us only when we think or speak of emergent

behavior as the product of stimulus classes that form somewhere. When we do that, we may find ourselves looking around for the various manifestations of class formation and expecting those manifestations to covary. However, when "stimulus class" merely tacts test outcomes that are a function of prior exposure to specified training contingencies, then we find it unremarkable that, for example, functional classes are displayed in the absence of equivalence classes and vice versa. Further, to the extent that our verbal behavior sets the occasion for other behavior—our own, our colleagues', or our students'—we then may be more likely to attempt to relate such findings to specific experimental procedures and behavioral histories.

REFERENCES

- de Rose, J.C., McIlvane, W.J., Dube, W.V., Galpin, V., & Stoddard, L.T. (1988). Emergent simple discrimination established by indirect relation to differential consequences. *Journal of the Experimental Analysis of Behavior*, 50, 1-20.
- de Rose, J.C., McIlvane, W.J., Dube, W.V., & Stoddard, L.T. (1988). Stimulus class formation and functional equivalence in moderately retarded individuals' conditional discrimination. *Behavioural Processes*, 17, 167-175.
- Epstein, R. (1985). The spontaneous interconnection of three repertoires. *The Psychological Record*, 35, 131-141.
- Hayes, S.C. (1990). A relational control theory of stimulus equivalence. In L.J. Hayes & P.N. Chase (Eds.), *Dialogues on verbal behavior: Proceedings of the First International Institute on Verbal Relations* (pp. 19-40). Reno, NV: Context Press.
- Hayes, S.C., Brownstein, A.J., Devany, J.M., Kohlenberg, B.S., & Shelby, J. (in press). Stimulus equivalence and the symbolic control of behavior. *Revista Mexicana de Analisis de la Conducta*.
- Holland, J.G., Solomon, C., Doran, J., & Frezza, D.A. (1976). *The analysis of behavior in planning instruction*. Reading, MA: Addison-Wesley.
- Lazar, R., Davis-Lang, D., & Sanchez, L. (1984). The formation of visual stimulus equivalence in children. *Journal of the Experimental Analysis of Behavior*, 41, 251-266.
- McIlvane, W.J., Dube, W.V., Kledaras, J.B., Iennaco, F.M. & Stoddard, L.T. (1989). Stimulus-consequence relations and stimulus classes in mental retardation. *Experimental Analysis of Human Behavior Bulletin*, 7, 17-20.
- Reynolds, G.S. (1961). Attention in the pigeon. *Journal of the Experimental Analysis of Behavior*, 4, 203-208.
- Saunders, K.J., Spradlin, J.E., & Saunders, R.R. (1989a). *Detecting equivalence relations that develop prior to testing*. Proceedings of the 22nd Annual Gatlinburg Conference on Research and Theory in Mental Retardation and Developmental Disabilities, 32.
- Saunders, K.J., Spradlin, J.E., & Saunders, R.R. (1989b). Assessing the prerequisites for merger of equivalence classes. *Experimental Analysis of Human Behavior Bulletin*, 7, 20-21.
- Saunders, R.R., Saunders, K.J., Kirby, K.C., & Spradlin, J.E. (1988). The merger and development of equivalence classes by unreinforced conditional selection of comparison stimuli. *Journal of the Experimental Analysis of Behavior*, 50, 145-162.
- Sidman, M. (in press). Equivalence relations: Where do they come from? In H. Lejeune & D. Blackman (Eds.), *Proceedings of EMEABII*. Hillsdale, NJ: Erlbaum.
- Sidman, M., Kirk, B., & Willson-Morris, M. (1985). Six-member stimulus classes generated by conditional discrimination procedures. *Journal of the Experimental Analysis of Behavior*, 43, 21-42.
- Sidman, M., & Tailby, W. (1982). Conditional discrimination vs. matching-to-sample: An expansion of the testing paradigm. *Journal of the Experimental Analysis of Behavior*, 37, 5-22.
- Sidman, M., Wynne, C.K., Maguire, R.W., & Barnes, T. (1989). Functional classes and equivalence relations. *Journal of the Experimental Analysis of Behavior*, 52, 261-274.
- Skinner, B.F. (1953). *Science and human behavior*. New York: Macmillan.
- Skinner, B.F. (1957). *Verbal behavior*. New York: Appleton-Century-Crofts.
- Wilkie, B.M., & Masson, M.E. (1976). Attention in pigeon: A reevaluation. *Journal of the Experimental Analysis of Behavior*, 26, 207-212.