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CONCEPTUAL DIFFERENCES IN THE ANALYSIS OF STIMULUS EQUIVALENCE

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The emergence of structure from undifferentiated beginnings has long been a fundamental problem in science. In biology, the issue was one of form versus function, and in psychology psychologists struggled with how infants make sense of, and consolidate, the flood of sensory input they are faced with. Although the concept of discriminative responding has proven useful in this regard, describing the emergence of structure which sometimes follows conditional discrimination procedures as stimulus equivalence has had important implications for subsequent research in the field.

Arising from the plethora of research on stimulus equivalence, the theoretical treatises of Sidman (1994), S. C. Hayes (1994), and Horne and Lowe (1996) have distinguished themselves quickly in a crowded field. As all three of the substantive positions appear to be developing parallel to each other, some history of the field as well as inherent shortcomings of each of the theoretical positions are discussed. Secondary theories and important new methodologies suggest where the field is or should be heading if we are to keep sight of our original goals.

The emergence of structure from undifferentiated beginnings has long been a fundamental problem in science. For example, in biology, the debate over whether form or function takes precedence was a divisive issue (Gould, 1977) until it became clear that an interaction between the two, at all levels of development, was most parsimonious. In psychology, James (1890), in describing a newborn's preliminary response to the world, referred to a "great blooming, buzzing confusion" (p. 488) of which the child must make sense. James also describes the "pristine unity" of the infant's first impressions of the world, suggesting that all sensory input will fuse into "a single undivided object" until its parts become discriminated. This discrimination is what organizes a previously disorganized world, or "great blooming, buzzing confusion."

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Therefore, discriminative responding is at the center of any description of the emergence of structure (Catania, 1996).

Describing the emergence of structure which may follow conditional discrimination procedures as stimulus equivalence has had important implications for subsequent research in the area. Whereas the phenomenon was "rediscovered" by Sidman in 1971, later research (Sidman & Tailby, 1982) asserted that the concept of equivalence as used in mathematics could be applied to performances on conditional discrimination tasks in ways that would bring methodological rigor to the definition and the identification of "behavioral" equivalence. The three defining characteristics of mathematical equivalence (reflexivity, symmetry, and transitivity) were, thus, borrowed and applied to behavioral relations.

Stimuli are said to be members of an equivalence class if without specific training they exhibit, within arbitrary matching procedures, the properties of reflexivity, symmetry, and transitivity. In the reflexivity relation ($x \rightarrow x$, as in identity matching), a stimulus is matched to itself. In the symmetry relation (if $x \rightarrow y$, then $y \rightarrow x$) , the positions of sample and comparison are reversible. In the transitivity relation (if $x \rightarrow y$ and $y \rightarrow z$, then $x \rightarrow z$) , a stimulus that serves as comparison in one instance of matching and as sample in another establishes a matching relation between the sample of the first instance and the comparison of the second. Whether this logico-mathematical model maps well or not to specific behavioral outcomes is unclear (e.g., Saunders & Green, 1992).

The functional significance of equivalence-class formation lies in the possibility that the discriminative functions of one stimulus within such a class will subsequently transfer to all of the other members. For example, consider the child who has learned to obey the words "go" and "stop" when crossing the street with a parent. If the child is then taught that the green traffic light is equivalent to "go" whereas the red light is equivalent to "stop," it would be valuable to know whether the differential behavior established with respect to the words "go" and "stop" will transfer to all traffic lights without additional direct instruction.

Stimulus equivalence and its related phenomena have created much excitement and considerable research activity within the behavior analytic community. One reason for this excitement is that equivalence is not readily explained by the concept of conditional discrimination. A typical one-to-many preparation explicitly trains subjects to choose Stimulus B and Stimulus C in the presence of Stimulus A, and then during testing, subjects will normally choose B in the presence of C and C in the presence of B, without further reinforcement for doing so. The concept of conditional discrimination does not easily account for such untaught outcomes. A history of differential reinforcement as a conditional discriminative stimulus must exist for both B and C with respect to each other, without which neither stimulus should reliably control selection of the other.

Another reason for interest in stimulus equivalence is its presumed

relation to complex human behavior. This claim is not without basis. First, a wide variety of verbal humans have shown equivalence class formation, but this has yet to be shown unequivocally in nonverbal humans and infrahumans (Dugdale & Lowe, 1990; S. C. Hayes, 1989). Second, after failure on an equivalence test, children then taught to name the stimuli subsequently show equivalence responding (Eikeseth & Smith, 1992). Third, there is evidence that the language deficits of verbally disabled individuals may be remedied by equivalence procedures (Cowley, Green, Braunling-McMorrow, 1992; Matos & Hubner-d'Oliveira, 1992). Fourth, a number of researchers have used equivalence phenomena to develop a behavior analytic interpretation of symbolic meaning and the generative nature of grammar (Barnes & Hampson, 1997). Finally, recent findings have shown that equivalence is important to a behavioral analysis of social categorization (Grey & Barnes, 1996; Roche & Barnes, 1996), as well as advanced human reasoning abilities (Lipkens, 1992).

As early as 1934, radical behaviorism found itself faced with a challenge to its goal: a science of human behavior. Finding himself seated next to the eminent philosopher Alfred North Whitehead, Skinner attempted to promote his science of behavior. Dr. Whitehead acknowledged that science may account for most human behavior but not verbal behavior. He framed his challenge by asking Skinner to "account for my behavior as I sit here saying, 'No black scorpion is falling upon this table.'" (Skinner, 1957). The task was to identify the variables that determine production of novel sentences that had never been spoken before and thus had no *explicit* history of reinforcement.

Most behavior analysts would agree that the aforementioned behavior is a function of variables that "lie outside the organism, in its immediate environment and in its environmental history (p. 31)" (Skinner, 1953). What separates emergent matching-to-sample performances, novel sentences, exponential language acquisition, and conditioned seeing from other forms of behavior is largely that they have not been previously emitted (McIlvane & Dube, 1990). The traditional approach has been to trace emergent performances to other previously acquired behaviors. That is, prior experience has established the "behavioral prerequisites" for the emission of the new behavior at the appropriate time (Epstein, 1985).

Behavioral prerequisites were accepted as satisfactory in describing emergent behaviors such as mentioned above, save one, emergent matching-to-sample performances. Within 10 years of Sidman's (1971) hallmark study of the acquisition of auditory-visual equivalences, many laboratories had begun replicating and extending emergent matching-to-sample (MTS) performances. Another decade and these same laboratories were prepared to offer theoretical accounts of the emergent behaviors they had been studying.

Behavior analysis has enjoyed widespread popularity as a result of its ability to account for and manage behaviors that had, until the middle of this century, remained untreated. And yet, as with Dr. Whitehead's

challenge some 60 years ago, behavior analysis has continued to struggle for an account of apparently novel verbal behavior within a system constrained by a limited theory of private events (Skinner, 1963). A general theory of language and complex human behavior remain the prize for which three distinct positions have emerged to lay claim, and it is to an explication of these theories to which we now turn.

Equivalence as Evolutionary Given or Behavioral Primitive

In 1971, Sidman revived an area of research with his paper on visual-auditory equivalence. In this study, a young boy with mental retardation was unable to read printed words orally or with comprehension. He could only match spoken words to pictures and name pictures. After he was taught to match the spoken words to printed words, he was capable of both reading comprehension (matching the printed words to pictures) and oral reading (naming the printed words aloud).

Sidman borrowed the mathematical relations of reflexivity, symmetry, and transitivity, and used them as defining features of stimulus equivalence (Sidman & Tailby, 1982). According to Sidman (1992), equivalence relations must be reflexive; such that *a*R*a*, where R stands for relation, generically. They must also be symmetrical (If *a*R*b*, then *b*R*a*), and transitive (If *a*R*b* and *b*R*c*, then *a*R*c*). These defining features were sufficiently clear and simple to generate much research and considerable consensus on exactly what it was that interested researchers so.

According to Sidman, equivalence (like reinforcement, discrimination, etc.) represents a primitive function not derivable from other behavior processes (Sidman, 1992, p. 22). Although earlier he had described the conditions in which equivalence relations arise as relying on four-term contingencies (Sidman, 1986), recently the analysis has distilled down to three- and even a two-term contingency (Sidman, 1994). The four-term contingency gave way to a system in which stimuli (discriminative, conditional, and reinforcing) and responses, as a result of participation in reinforcement contingencies became members of an equivalence relation. Within the event pairs that define the equivalence relation, the distinction between stimulus and response loses significance. He concluded that, "Equivalence relations have their own defining characteristics, none requiring the stimulus/response dichotomy" (1994, p. 386).

Sidman identifies naming and rules (or rule-governed behavior) as two possible verbal sources of equivalence. For present purposes, the naming argument is simply that the same name assigned to several stimuli might mediate a common class membership for those stimuli. Sidman (1990) asks, rightfully so, that if a subject assigns a name to several stimuli without being taught to do so, where does the common name come from? To say that naming accounts for equivalence quickly becomes a circular argument. That is, if naming accounts for equivalence, then what accounts for naming?

There is some evidence that rules may account for equivalence class formation. Some subjects are able to describe a network of directly taught and derived relations even in complex, interlocking sets of conditional discriminations (Bush, Sidman, & de Rose, 1989). And yet, Sidman argues that if the rule does come first, where did it come from? On this point, Sidman again refers to the argument against logic as the source of equivalence. If indeed equivalence gives rise to rules, then for a rule to specify a contingency may simply mean that the rule and the contingency are members of the same equivalence class. As with naming, there is, as yet, no definitive evidence forthcoming.

After failing to derive equivalence from something more basic, Sidman concludes that equivalence relations emerge from conditional discriminations for the same reason our behavior is reinforceable, and for the same reason our behavior is controllable by discriminative and conditional stimuli: because contingencies of survival have made us that way over the course of phylogenic evolution. That is, equivalencing behavior is conceptualized as a behavioral primitive or evolutionary given: something which cannot be derived from some more basic principle and thus, is taken for granted.

Commentary

Of the three main positions, Sidman's sets itself apart from the other two in important ways. First, he sees equivalence as a behavioral primitive and, as such, the basis for not only derived relational responding but rule-governed behavior (1992, pp. 21-22), conditioned reinforcement (Sidman, 1986), and respondent conditioning (1994, pp. 403-404). If these precarious points hold true then nonhuman animals susceptible to conditioned reinforcement and/or respondent conditioning should also show evidence of equivalence, but no convincing evidence to this end has been forthcoming (S. C. Hayes & L. J. Hayes, 1992).

Further, if equivalence is an evolutionary given, then, assuming some continuity of species, nonhuman animals should readily show equivalence. Again, this has not been convincingly shown, the closest attempts demonstrated in sea lions (Schusterman & Kastak, 1993) and chimpanzees (Yamamoto & Asano, 1995). For his part, Sidman argues that the stimuli and functions examined have not been ethologically relevant and that to map the standard features of conditional discrimination training onto nonhumans may be problematic. These are valid counterpoints but the fact remains that his theory makes specific predictions regarding equivalence, and these predictions have yet to materialize.

Putting aside some degree of continuity between species, we find that, at the very least, Sidman's equivalence may be a behavioral primitive for the human species, and yet, nonverbal humans fail to show stimulus equivalence (e.g., Devaney, Hayes, & Nelson, 1986). Again, the stimuli and their functions may not be relevant to nonverbal humans and conditional discrimination training may be inappropriate for them as well, but this seems to beg the question of the importance of verbal behavior

in stimulus equivalence. Sidman (1992) is aware of this criticism and argues that equivalence as a primary stimulus function arises first, but is later circumscribed by verbal rules (p. 22). Again, there is no empirical evidence for equivalence in early childhood. In fact, data indicating that some degree of linguistic competence is necessary for equivalence is abundant (deRose, deSouza, Rossito, & deRose, 1992). Further, if verbal rules somehow sabotage equivalence class formation in early childhood why do nonhuman animals, presumably free of the ill effects of verbal rules, not show equivalence?

Equivalence as Arbitrarily Applicable Relational Responding

The Relational Frame Theory (RFT) account of stimulus equivalence was developed by Steven Hayes (1991, 1994). One of the goals of RFT has been an accurate description of the specific type of behavior-environment interactions responsible for equivalence responding and other complex human behaviors (S. C. Hayes & L. J. Hayes, 1989, 1992). Unlike the position of Sidman (1994), in which stimulus equivalence is reduced to a basic stimulus function, RFT explains equivalence as the result of prolonged exposure to the contingencies of reinforcement operating within a verbal community. In RFT, equivalence is explained as arbitrarily applicable relational responding brought to bear on the matching-to-sample preparation (Barnes & Holmes, 1991).

At the heart of RFT is the notion that many organisms are capable of responding relationally to any stimulus event. A psychological function exists if the stimulus functions of one event depend upon the stimulus functions of another event. Nonarbitrary relations such as "smaller than" and "darker than" are easily taught to organisms capable of complex types of learning. In addition, verbally able humans possess a history of learning to respond to the relations between stimuli where these relations are not defined by the physical form of the stimulus, but by additional contextual cues, for example, a person, place, or thing (Barnes, 1994).

Such relations are arbitrarily applicable in that they may be brought to bear on any set of stimuli, regardless of their physical properties, given only an appropriate context to do so. RFT consists of the three key processes of mutual entailment, combinatorial entailment, and the transformation of function as a specific subset of psychological stimulus relations: those in which the relation involved is arbitrarily applicable, derived, learned, and controlled by its context (S. C. Hayes, 1994).

Mutual entailment states that in any given context, if A is directly related to B, then, in that same context, a derived relation between B and A is mutually entailed. If the stimulus functions of B depend on A, then by derivation those of A depend on B. Mutual entailment is the generic case of "symmetry" in the equivalence literature. That is, symmetry is a special case of mutual entailment, where the trained and derived relation is one of *sameness*.

Combinatorial entailment means that if there are two trained relations between A and B and between B and C, then in a given

context, these two relations combine to entail two derived relations between both A and C and C and A. Thus, transitivity and equivalence are special cases of combinatorial entailment in which the trained and derived relations are the same.

The third, and somewhat overarching property of arbitrarily applicable relational responding is the transformation of stimulus functions. In a given context, if there is a mutual relation between A and B, and A has some additional psychological functions, then, in a context that actualizes that function as relevant, the stimulus functions of B may be transformed consistent with its mutual relation to A. For example, consider the learned response "Hello" in the context of encountering a familiar face. With little training, the response "Hola" will be actualized given the specific context to do so. This transformation of behavioral functions is based on the function of HELLO and the derived relation between HELLO and HOLA. The power of this transformation of functions lies in its ability to circumvent lengthy training with each and every stimulus and response.

Both mutual entailment and combinatorial entailment are necessarily special cases of the general case of transformation of functions. Therefore, in general, a relational frame refers to patterns of mutual transformations in stimulus functions. However, it remains useful to distinguish between entailment processes and transfer of functions because the former defines the basic unit upon which increasingly complex transfer of functions may occur.

Commentary

The most common criticism of relational frame theory is that it lacks a detailed description of the history of reinforced relational responding required before a frame of coordination (equivalence) may be realized (e.g., Boelens, 1994, pp. 599-600; Stemmer, 1995). Upon careful consideration, this concern seems unfounded. First, RFT considers equivalence, naming, rule following, and framing to be forms of operant behavior and, as such, their histories and the mechanisms of their actualization are empirical issues. To ask for the behavioral principles that govern the establishment of relational frames is the same as asking for the behavioral principles that govern that establishment of operants. Interestingly, both Sidman's (1994) behavioral primitive account and Horne and Lowe's (1996) naming hypothesis exclude themselves from the same requirement.

Although Hayes has not provided a detailed description of the history he posits, this has been done for him by other researchers. Both Horne and Lowe (1996) and Boelens (1994) have put forth detailed descriptions of possible histories which they feel would lead to equivalencing established as an operant. Also, Schusterman and Kastak (1993) provided the archetypal history of reinforced relational responding in their study of a California sea lion. That Hayes has left the detailed description of possible histories to others seems to be more of an oversight than a weakness. The development of a pragmatic theory of

language that has much to offer in both scope and depth precludes a detailed description of any one history. When Hayes describes equivalence as being the result of a "prolonged exposure to the contingencies of reinforcement operating within a verbal community," it appears that he is referring to the same history that Horne and Lowe describe in such detail.

Hayes, as well as Sidman, has been criticized for positing two different types of equivalence, contingency generated and verbally controlled, but even this seems to be a moot point. The operant nature of RFT includes increasingly complex behavior conceptualized as multiple layers of relational frames which are all reflective of the same basic operant process (Barnes, 1996) in a fractal-like manner. RFT addresses relational responding in general, at no time restricting itself to equivalence in specific, be that contingency generated or verbally controlled.

Of more immediate concern is the nature of the transfer or transformation of stimulus functions that plays the most crucial role in RFT (S. C. Hayes & L. J. Hayes, 1989, p. 170). For example, Hayes (1994) says, "In a given context, if there is a mutual relation between A and B, and A has some additional psychological function, then, in a context that selects that function as relevant, the stimulus functions of B may be *transformed* [italics added] consistent with its mutual relation to A" (p. 11). In this example, the transformation of stimulus function is described by reference to itself. We are told that stimulus functions of B are transformed consistent with its mutual relation to A, but we are no closer to an understanding of transformation itself.

Few would doubt the validity of this aspect of RFT, that functions transfer, because there is data to support such a claim (Dymond & Barnes, 1995; Steele & Hayes, 1991). Yet a satisfactory description of the process of transfer or transformation is absent. RFT relies heavily on three main concepts: mutual entailment, combinatorial entailment, and the transfer or transformation of stimulus functions. Whereas the first two components are described clearly, the third, and most important, principle remains vague.

Naming as a Technical Term

The final major[1] account of equivalence class formation is referred to as the naming relation (Dugdale & Lowe, 1990; Horne & Lowe, 1996). In this position, stimulus equivalence is mediated by the naming relation in either of two possible ways. First, two or more stimuli may become equivalent after they have been given the same name. If a subject initially fails equivalence tests, subsequent success may be assured by having the subject assign a common name to the sample-comparison pairings (Lowe & Beasty, 1987).

Second, naming can mediate equivalence even if the subject gives each stimulus a different name, provided the names can be incorporated

[1]For present purposes, "major" refers to an account that has received wide publicity across a range of published articles.

in a verbal rule linking each sample to its corresponding comparison. The naming skill requires the formation of two symmetrically related components: A particular stimulus should control a subject's verbal response and the response should also exert control over other behavior (e.g., selection) with respect to that particular stimulus. Naming would then involve both language production and comprehension. In addition, it would require the subject to function both as a speaker and as a listener within the same skin. Finally, the two skills (production and comprehension) are not functionally independent. They are linked within a single "emergent" symmetrical relation.

The account assumes that after a child has learned both to echo and to listen to an auditory stimulus, naming then takes place. The whole process is complex and requires a step-by-step description (Figure 1). The sequence begins when a caregiver points to a shoe and says "shoe." The auditory stimulus /shoe/ now occasions the child's looking at the shoe while echoing "shoe." The sight of the shoe then becomes a frequent antecedent and then discriminative stimulus for the child's saying "shoe." From then on, when the child sees the shoe, it alone occasions the child's saying "shoe." At this point naming is established such that the shoe may be visualized when it is not, in fact, present. This conditioned seeing may be evoked by a reliably accompanying object (e.g., a sock). The resulting stimulation, a discriminative stimulus, may also occasion the utterance "shoe."

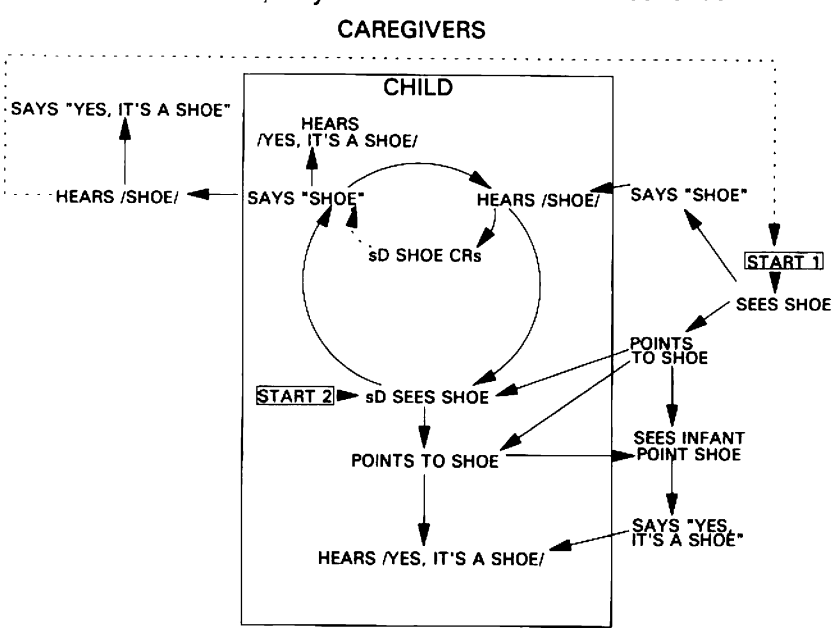

Figure 1. A schematic account of how naming is learned by a child who has already learned both to echo and to listen to the auditory stimulus /SHOE/. The sequence begins (START 1) when the caregiver points to a shoe and says "shoe." The auditory stimulus /SHOE/ now occasions the child's looking at the shoe while echoing and reechoing "shoe." Thereafter, when the child (START 2) sees the shoe, it alone occasions the child's saying "shoe." Adapted from Horne and Lowe (1996, p. 200).

Thus, naming involves the establishment of bidirectional or closed-loop relations between a class of objects and events and the speaker-listener behavior they occasion. Naming is a behavior, and like any other behavior, it occurs in relation to objects and events but is not to be confused with those objects and events. The degree to which Horne and Lowe's description of this behavior corresponds with empirical data will be considered separately.

Commentary

Horne and Lowe's (1996) analysis of the specific case of naming is an invaluable contribution to the literature. They went to great lengths describing one way in which a history of reinforced relational responding may occur. As mentioned previously, they provide an example of the very thing they fault RFT for not providing. And yet it is many of the faults they find with RFT of which they are equally guilty.

First, the naming hypothesis explains equivalence on the basis of verbal mediation and appeals to derived relations between stimuli and names that are of the same sort as the derived relations they are meant to explain. This is done in the same way that RFT appeals to transformation to explain transfer of stimulus function. It is unclear why Horne and Lowe include the naming construct at all. As mentioned, they do an excellent job of detailing how a history of reinforced relational responding might occur. Perhaps motivated by a fear of action at a distance, the process is said to be mediated by the generic concept of naming.

Second, the naming relation itself is conceptualized as a self-contained circle with no role for a stimulus, contextual or otherwise, that determines the conditions under which the name relation as a behavioral unit will occur. Such a model removes any way in which to manipulate a stimulus or setting event to occasion a particular instance of naming. Further, the naming account relies on events that are spatio-temporally contiguous, leaving it prone to criticism as simply another example of stimulus-response psychology.

Third, Horne and Lowe claim that "naming is a higher order bidirectional behavioral relation" (p. 207). Their justification for this claim is that a caregiver's naming of, and pointing to, a new object becomes sufficient *in its own right* to evoke the full sequence leading to the name relation. Thus, direct reinforcement is no longer required to bring about the speaker and listener components of the naming paradigm. There is no evidence provided for such a claim (Dugdale, 1996) because the behavioral principles by which this higher order relation might evolve are never described. This leads one to consider whether higher order responding and Hayes' framing are just different terms for the same basic phenomenon.

Finally, the name relation as provided by Horne and Lowe includes both covert responses and stimuli which allows the theory to account for any behavioral outcome. At the same time, a central assumption underlying the naming hypothesis is that subjects cannot hear names

unless they are preceded by an articulated response, (i.e., a topographically distinct response that is produced by the subject or someone else). Contrary to this assumption, there is empirical evidence (Bishop & Robson, 1989) that subjects can covertly hear words without speaking, and that such responses may be functional as well.

A Respondent Conditioning Analysis of Equivalence

A lesser known alternative to these interpretations is offered by L. Hayes (formerly Parrott, 1984; L. Hayes, 1992, 1996). Hayes' perspective is based on Kantor's (1959, 1977) psychological theory. In this perspective, the functions or actions of stimuli are more explicitly distinguished from their object sources, much as responses are distinguished from their organism sources. The aim of this distinction is to permit a conceptualization of psychological events as functions obtaining between responding and stimulating. On implication of this conceptualization is that both responding and stimulating may occur in substitutional form. The case of stimulus equivalence, from this perspective, involves substitute functions of stimuli. More specifically, stimulus functions inhering in one object source may come to inhere in another source under conditions of association, namely, spatio-temporal proximity of the source objects. In a match-to-sample preparation these conditions are present whereby stimulus functions may transfer from one source object to another. For example, during training, the sample and comparison stimuli appear together on the screen. Responding with respect to these stimuli in concert results in the perceptual stimulus functions of each stimulus operating through each other stimulus. Reinforcement for correct responding selects and strengthens the operations of these functions from particular sources. As such, given reinforcement for selecting B1 in the presence of A1, the perceptual functions of A1 come to inhere more powerfully in B1 than in B2 or B3, and conversely, the perceptual functions of B1 come to inhere in A1. This is to say that seeing A1 occurs with respect to B1 and vice versa. Although similar to a respondent conditioning analysis, the present analysis is not dependent on the usual temporal arrangement of stimulus objects because the preparation is such that all of the stimuli involved are simultaneously presented. Given this analysis, symmetry occurs as a form of substitutional reflexivity.

The same circumstance applies in the case of A1 and C1, namely, that the perceptual functions of A1 come to operate through C1 such that seeing A1 occurs with respect to C1. A test for equivalence between B1 and C1, therefore, also occurs as a form of substitutional reflexivity. What makes B1 more like C1 than C2 or C3 is that seeing A1 occurs in the contact with both B1 and C1 but not in the contact with C2 and C3.

The value of this interpretation is that it overcomes the problem of accounting for the matching of stimuli which have not previously occurred together. This problem arises only when stimuli are conceptualized as objects. When it is the functions of stimuli and not

their object sources that are assumed to have psychological significance, the fact of particular objects not having occurred together in a particular subject's history is not a problem.

Stimulus Equivalence as a Special Case of Functional Equivalence

The final position is included not because it is a complete description but as a possible indication of future directions the field may take. Conceptualizing stimulus equivalence as a special case of functional equivalence (Markham & Dougher, 1993), Dougher and Markham (1994) use the definition of stimulus equivalence agreed on by others, namely, that stimulus equivalence refers to the derived stimulus relations of reflexivity, symmetry, and transitivity. Similarities end there, as the analysis suggests that equivalence might be the result, not the cause of, functional equivalence. Or even that both might be a function of other behavioral processes.

Functional stimulus classes are comprised of stimuli that share a common stimulus function. That is, they all exert the same functional control over a specific class of behaviors. Shared function and transfer of that function are the defining features of functional equivalence classes. Stimuli are functionally equivalent to the extent that they have similar functions and to the extent that a variable applied to one similarly affects the others. The derived nature of stimulus equivalence relations set them apart from functional classes. Functional equivalence occurs whenever there is a sharing of interchangeability of function. Stimulus equivalence occurs when this interchangeability of function occurs in a conditional discrimination arrangement, thus, stimulus equivalence may be a special case of functional equivalence.

Dougher and Markham contend that the substitutability or interchangeability of the elements in a compound is a kind of functional equivalence. The elements exert a reciprocal influence on each other in such a way that when some critical combination of them occurs, it evokes a response. "Critical," in this case, is defined by the specific training and testing requirements. For example, it does not matter whether AB is the sample and C is the comparison or whether AC is the sample and B is the comparison. The combination of elements in a particular way evokes a response to whatever element is presented as a comparison stimulus.

Regardless of whether stimulus equivalence is seen as the result of interchangeability within a hierarchical, conditional stimulus control arrangement or as a result from interchangeability within a separable-compound discriminative stimulus control arrangement, it is a kind of functional equivalence. And it is functional equivalence, according to these authors, which must be explained.

Conclusion

The three main theories share common ground on at least two points. First, all three agree that it is important to establish how subjects, without

direct training, can in some contexts treat structurally different stimuli as if they are interchangeable. Second, there is the recognition that the phenomenon of interest is somehow closely related to linguistic behavior. More often than not, RFT and the naming hypothesis make similar predictions, in contrast to the theory of Sidman (1992, 1994) who, by his designation of equivalence as primitive, paints himself into a theoretical corner.

Except for Sidman (1992, 1994), there is a common assumption that the phenomenon of interest arises as a result of a learning history, although Horne and Lowe add what a child says and hears, as well as listener behavior to their account. In an attempt to set themselves apart from Sidman (1992, 1994) and Hayes (1991, 1994), Horne and Lowe assert that by calling a set of behavioral relations on standard MTS tasks "equivalence" or "relational frames" serves only to use the construct as an explanation for what is observed. As previously discussed, it is unclear how the naming construct is any different in this respect.

By definition, equivalence relations give rise to stimulus classes as products. Mutual substitutability, as described using the concepts of reflexivity, symmetry, and transitivity, is considered the defining feature of the class concept referred to as "equivalence classes." The problem arises when class formation is also understood as a process. By using class concepts both as products and processes the analysis of derived stimulus relations has remained mired in competing paradigms (S. C. Hayes & Barnes, 1997). When class formation is understood as a process, equivalence classes require no further explanation.

The accounts of both Sidman (1994) and Horne and Lowe are class based in that stimulus classes are the central issue and focus for their analyses. To discern the fine distinctions being drawn in this case the data of Steele and Hayes (1991) will be used as an example. Steele and Hayes used relational cues such as OPPOSITE and SAME to establish classes. If a subject selected C3 given A1 and OPPOSITE, Sidman (1994) would say the subject is putting C3 and A1 in a class under the control of the OPPOSITE contextual cue. In contrast, Hayes and Barnes (1997) assert that the subject is relating C3 and A1 as opposite. By appealing to contextual control in order to explain multiple stimulus relations, authors such as Sidman fail to explain "contextual control" and further, we are no closer to an adequate account of multiple stimulus relations. Further, classes established by way of more complex relational cues (i.e., opposite) and new forms of equivalence classes (e.g., ordinal/sequential; see Green, Stromer, & Mackay, 1993) require more elaborate analyses.

Horne and Lowe's account of equivalence as naming is also class based. Like RFT, Horne and Lowe see stimulus class formation as the result of operant activity. As mentioned previously, naming emerges as a higher order behavioral relation when speaker and listener behaviors combine (Lowe & Horne, 1996, p. 315). Yet it is not clear why a named stimulus relation might operate as a stimulus relation simply because it has been named. Undoubtedly, subjects can name relations (e.g., cold,

hot, wet, dry), but this only shows that stimulus relations can enter into a frame of coordination with a name. In the same way Sidman (1994) relies on contextual control to address this issue, Horne and Lowe rely on "naming."

Finally, the issue of verbal mediation as it relates to the three positions deserves comment. As a behavioral primitive, equivalence in Sidman's system dispenses with verbal mediation of any kind. RFT, with its reliance on the concept of "transformation" of stimulus function, introduces a mediating variable, as do Horne and Lowe by introducing the verbal construct of "naming" onto a straightforward account of a history of reinforced relational responding. Disagreement notwithstanding, if Schusterman and Kastak's (1993) study of a California sea lion showing the possible emergence of equivalence relations holds true, it would be hard to point to any instance of "naming" taking place in those performances.

As disparate as the three main positions may appear, it is a difference in degree, not in kind. Each of the positions falls victim to the formalistic fallacy (Vygotsky, 1978, p. 62), placing undue emphasis on the formal characteristics of behavior at the expense of a thorough analysis of the controlling relations and the role of verbal stimuli in stimulus equivalence. For example, Sidman's (1990) position focuses on a mathematical definition of equivalence which is then mapped onto individual instances of human behavior (Saunders & Green, 1992). Another related example of this type of reasoning might be behavioral momentum and its reliance on physical laws borrowed from physics (Mace, 1996; Nevin, 1995). To a different degree, both Hayes and Horne and Lowe are guilty of the same thing with respect to the verbal constructions of "transformation" and "naming," respectively.

All three of the main theories are adaptable to any outcome, thus making any empirical evidence to the contrary unlikely, although RFT has accumulated the most empirical evidence it its favor. What should be remembered above all else is that each of the theories is a specific way of speaking, and as such, is easily mapped onto generic occurrences of any type. We are left wondering if any one of the theories presented here is any more "true" than any of the others.

Adopting a pragmatic truth criterion, it appears that all of the theories are "true" to the extent that each of their proponents finds them useful. There are inherent strengths and weaknesses to each of the positions described here. As it stands, the three main theories, with their goals of prediction and control, will continue to develop in parallel with respect to each other, all the while moving farther from.their original goals; that is, a thoroughgoing theory of complex human behavior. By including a clearly descriptive analysis of events which they themselves have avoided describing, it is hoped that the practical goal of prediction and control of linguistic events may then be realized.

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