The Psychological Record, 1998, 48, 187-210

THE OPERANT-RESPONDENT DISTINCTION REVISITED: TOWARD AN UNDERSTANDING OF STIMULUS EQUIVALENCE

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The distinction between operant and respondent behavior classes has received considerable attention throughout the history of behavior analysis. Some have contended that because operant and respondent processes share a number of similarities, the distinction should be dropped. Others, for lack of a better theoretical alternative, have supported the continued distinction. It is suggested that the failure of behavior analysts to recognize the ever-present role of respondent relations in operant conditioning experiments may be impeding the formulation of an effective explanation for stimulus equivalence, which has been investigated primarily as an operant phenomenon. Conceptual issues historically relevant to the operant-respondent distinction are discussed, and equivalence researchers are urged to consider the involvement of both classes of behavior in their analyses.

Criticisms and critiques of two-factor learning theory are not new to behavior analysis. Over the course of the past several decades, periodic doubts have been raised regarding the distinction between the operant, a "class modifiable by the consequences of the responses in it" (Catania, 1992), and the respondent, a "class of responses defined in terms of stimuli that reliably produce them" (Catania, 1992), for a variety of empirical and theoretical reasons. For a lack of convincing evidence disclaiming the operant-respondent distinction (e.g., Herrnstein, 1977), and for the failure of behavior analysts to devise a more useful paradigm (e.g., Pear & Eldridge, 1984), some have supported the continued distinction between operant and respondent behavior. Despite the treatment received by this issue in behavior analytic literature, few resolutions have been proposed in recent years that have attracted much consensus. In light of a behavioral phenomenon which is well investigated yet not well understood, it is time to revisit this problem anew.

Stimulus equivalence is a research topic of this sort. In this area of

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study, stimulus classes consisting of previously unrelated stimuli can be developed by way of the conditional discrimination procedure known as matching-to-sample (Sidman, 1971; Sidman & Cresson, 1973; Sidman, Cresson, & Willson-Morris, 1974; Sidman & Tailby, 1982). Once such stimulus classes are developed, subjects are able to match members within each class although they have had no direct training on those matches, hence the use of the adjectives "derived" and "emergent" to describe such performances. Newer evidence indicates that when a particular function is trained to any one stimulus, that function will "transfer" to other stimuli that are related symmetrically or equivalently to the first stimulus (e.g., Barnes & Keenan, 1993; Dougher, Augustson, Markham, Greenway, & Wulfert, 1994; S. Hayes, Kohlenberg, & Hayes, 1991). In other words, stimuli can come to exert control that has not been explicitly established. The growing body of stimulus functions that have been shown to transfer in this way has extended the scope of "derived" responding, yet has also added more mystery to the equivalence phenomenon. This area of research has been problematic for behavior analysis mainly because the fact that behavior can be repeatedly emitted without *ever contacting reinforcement contingencies* questions the organism's history as being the primary determinant of behavior. A variety of theories, explanations, and descriptions (S. Hayes & Wilson, 1996; Horne & Lowe, 1996; Sidman, 1994) have been proposed to account for the formation of equivalence classes and the transfer of functions from class members to other class members, but much controversy surrounds each of these accounts. The larger problem of *what equivalence is* is often reduced to procedural issues, such as whether matching-to-sample is the only means by which the relations can form (Leader, Barnes, & Smeets, 1996); what the largest possible number of "nodes" separating class members can be (Fields, Adams, Verhave, & Newman, 1990); and whether nonhumans can pass equivalence tests (K. J. Saunders & Spradlin, 1996; R. R. Saunders & Green, 1996). In short, the behavior analytic community has not reached any *one* answer as to what equivalence classes are, what behavioral processes underlie their formation, and what is their basic nature.

In the present paper, we suggest that our reluctance to do away with the distinction between operant and respondent learning may be impeding our ability to arrive at an explanation for stimulus equivalence. Equivalence has been investigated primarily as an operant problem, with few exceptions (L. Hayes, 1992; Leader et al., 1996). Given that an agreed-upon explanation for equivalence has not been forthcoming, we argue for a close examination of how respondent processes might be involved in the phenomenon. We first provide a sampling of the theory and data which have supported and opposed the operant-respondent distinction historically, followed by a discussion of empirical and theoretical advances that support the role of combined operant and respondent processes in stimulus equivalence. Although a number of empirical studies in the past several decades have questioned the distinction between the operant and the respondent, a full treatment of each of those research areas will not be given here. Rather, we discuss only those areas believed to be conceptually relevant to the problem at hand: We wish to raise the possibility that instances of operant behavior as they have been observed in equivalence experiments may also be instances of respondent behavior occurring concurrently. We then ask, is it necessary that the two learning processes be distinguished? Might we solve the equivalence puzzle if the distinction were discarded?

The Operant-Respondent Distinction: An Overview

The earliest debate as to whether operant and respondent conditioning are two fundamentally distinct learning processes consisted of a series of exchanges between Konorski and Miller (1937a, 1937b) and Skinner (1935, 1937). Skinner (1935, 1937) established that a prior stimulus was unnecessary for the emission of an operant, yet acknowledged that often stimuli do occasion responses through their temporal correlation with reinforcement. He called the discriminated operant a "pseudo" reflex because of its potential confusion with the Type II reflex, the respondent, in which behavior also occurs following a stimulus presentation. The difference is that the presentation of a stimulus is necessary for the elicitation of a response, but not for its emission. Konorski and Miller (1937b) disagreed with Skinner's distinction between the operant and the respondent on this basis, contending that virtually every response occurs after some stimulus presentation, and that Skinner's Type I reflex, the operant with no antecedent stimulus, does not exist.

Despite their disputes, all agreed that the two reflex types are outcomes of two unique processes. Likewise, the three agreed on the *differential location* of the two types of learning, asserting that respondent conditioning occurs in the autonomic nervous system and operant conditioning occurs in the skeletal system. In addition, different types of relations were held to distinguish respondent from operant conditioning. Operants are established via temporal correlations between reinforcing or punishing stimuli and responses, whereas respondents are established through correlations between unconditioned stimuli and neutral stimuli (Skinner, 1937). The exchanges between Konorski and Miller (1937a, 1937b) and Skinner (1935, 1937) thus set the occasion for the evolution of behavior analysis formulated on three assumptions: First, no prior stimulus is required in operant conditioning but is a necessary condition in respondent conditioning; second, operant and respondent behavior involve different muscle systems; and third, in operant conditioning relations between responses and stimuli are established and in respondent conditioning relations between stimuli are established.

The Development of Radical Behaviorism

Respondent and operant paradigms grew into largely separate research traditions, the former becoming the dominant experimental tradition in Europe and the latter developing into radical or Skinnerian behaviorism in the United States. Operant thinkers, taking Skinner's lead, were mainly interested in the consequential control of behavior. Although Skinner devoted much attention to the role of the discriminative stimulus in setting the occasion for behavior (Skinner, 1938), control by this stimulus was established only through its relation to reinforcement or punishment and was thus secondary to consequential control (L. Hayes, Adams, & Dixon, 1997). For instance, Skinner (1953, p. 107) affirms "Operant conditioning may be described without mentioning any stimulus which acts before the response is made;" similarly, Skinner (1957, p. 31) states of the acquisition of verbal behavior, "In formulating this process we do not need to mention stimuli occurring prior to the behavior to be reinforced." With the reinforcer being the primary causal agent in operant behavior and the antecedent stimulus being the primary causal agent in respondent behavior, respondent and operant contingencies are held to consist of different temporal sequences of responses and their causes. The cause of the respondent precedes it, and the cause of the operant succeeds it. Any eliciting or causal functions of discriminative stimuli were thereby eliminated from Skinner's account.[1]

Not only did respondent conditioning receive little attention by radical behaviorists, it was also ascribed a qualitatively different character. For instance, Schoenfeld (1976) contended that respondents are seen as obeying "static" laws whereas operants obey "dynamic" laws; Schlosberg (1937) suggested that respondent conditioning may involve the conditioning of preparatory responses of an emotional or perceptual type, whereas operant responses are precise and adaptive; and Rescorla and Solomon (1967) noted that operant behavior is implied to be free and varied and respondent behavior is rigid and automatic. It is not surprising that each research tradition developed its unique terminology. Operant conditioners, for instance, speak of the reinforcement of a *response*, in that a reinforcer delivered contingent upon a response increases the future probability of that response, whereas respondent conditioners, taking Pavlov's lead, may speak of the reinforcement of a *stimulus*, in that a neutral stimulus correlated with a UCS acquires the eliciting properties of that stimulus (Schoenfeld, 1978). This has made communication between operant and respondent experimenters at times difficult and has served to strengthen the detachment of one research enterprise from the other. Operant conditioners have been, for the most part, atheoretical (Skinner, 1950), arguing against the use of hypothetical constructs in behavioral explanation; and respondent conditioners at times have been quite theoretical and willing to include hypothetical constructs in their analyses (e.g., Williams, 1984). In addition, the automaticity of response elicitation permits large group comparisons, leading to the frequent use of

[1]See Ribes (1997) for a more elaborate discussion of the different causal natures of operant and respondent conditioning.

between-group designs among respondent researchers. This practice is generally uncharacteristic of operant research, in which the learning histories of single subjects are emphasized.

The Mediational Role of Respondents

Although proposed as separate processes, ample evidence has shown that operant and respondent classes do *not* occur in isolation, but frequently interact. In such situations, respondently conditioned stimuli come to systematically affect ongoing operant responding. It has been claimed that the respondent mediates or regulates the emission of the operant in these circumstances, taking place at a level where observation is difficult. The most well-known example of research of this sort is in the area known as conditioned suppression (Estes, 1948; Estes & Skinner, 1941), in which a signal for an aversive US suppresses reinforcement-maintained responding below its baseline rate. This observation was traditionally interpreted to mean that the CS elicits an unobservable emotional response, such as fear, which disrupts ongoing operant responding. A similar explanation was offered for conditioned avoidance (Mowrer, 1947), in which it was argued that a stimulus which signals an aversive event elicits anxiety, which in turn instigates avoidance responding. Avoidance responses were said to be reinforced not only by the removal of the conditioned stimulus and the postponement of the aversive event, but also by the alleviation of the respondently conditioned emotional response. Attempts to explain appetitive responding in this way were also made, in which it was assumed that primary reinforcers elicit joy, which in turn instigates continued operant responding. Operant responses were thus held to be maintained not only by the delivery of the reinforcer itself, but by the continued joyful state (see Rescorla & Solomon, 1967).

These mediational accounts have not survived experimental scrutiny, however. Attempts have been made to inhibit the elicitation of conditioned emotional responses in conditioned suppression and avoidance preparations, assuming that such responses occur in the autonomic nervous system. Autonomic blocking agents, CNS tissue ablation, and drugs have all been used to block the conditioning of emotional behavior, resulting in a wide range of deviations from stereotypical operant response patterns (e.g., Dawson, Rupniak, Iversen, & Curnow, 1995; Overmier & Papini, 1986; Pallares, Nadal, & Ferre, 1992; Quartermain, Hawxhurst, Ermita, & Puente, 1993; Zielinksi, Walasek, Werka, & Wesierska, 1993). However, operant responding has *not* been noted to cease altogether in such preparations, as would be expected if respondently conditioned emotional responses did, in fact, mediate operant responding. In addition, while Shapiro (1960, 1961) found that elicited salivation consistently preceded discriminated lever pressing on differential reinforcement of low-rate (DRL) schedules, hence supporting the mediational role of the respondent, Williams (1965) observed lever pressing prior to salivation on fixed ratio (FR) schedules, thus disputing such a mediational role. Moreover, the finding that avoidance responding can be reliably maintained in the absence of a prior stimulus (e.g., Sidman, 1953) further challenged mediational accounts of avoidance and other operant behavior.

It is not surprising that these mediational explanations have not fared well. Although some evidence exists as to the changes in physiological functioning brought about by respondent conditioning (e.g., Ferreira, Gollub, & Vane, 1969), the behavior of organisms does not take place in the nervous system. In some situations it may be useful to describe the neural properties of an organism's interaction with its environment, but behavior is a psychological event which involves the functioning of the entire organism, not just its nervous system (L. Hayes, 1992). The notion that operant and respondent learning have different loci within organisms has continued to impact behavior analytic thought, despite evidence that autonomic responses can come under operant control and skeletal responses can come under respondent control (see Black, Osborne, & Ristow, 1977, for a description of methodological factors pertinent to the operant conditioning of autonomic responses; see also Rescorla & Solomon, 1967). Some behavior analysts remain not fully convinced of our level of analysis, instead supporting Skinner's idea that certain complex behaviors will be understood when the "physiologist of the future" fills in the missing gaps (Skinner, 1945) (see Baer, 1996; Bullock, 1996; Donahoe, 1996; Poling & Byrne, 1996; and Reese, 1996, for discussions of the role of biology in behavior analysis). Learning does not take place in organisms; it takes place in organisms' interactions with their environment (L. Hayes et al., 1997). Any appeal to two-process learning must look to differences in the environmental variables of which behavior is a function, not to differences in anatomy and physiology alone.

Conceptualizing Operant-Respondent Interactions

Although the mediation of the operant by the respondent has not been unequivocally demonstrated, it is nonetheless difficult to argue that instances of operant behavior do not also include instances of respondent behavior. This has been concealed, in part, by Skinner's elimination of the discriminative stimulus as a necessary condition for response emission. Just *when* operant behavior occurs in the absence of stimuli remains to be addressed in Skinner's analysis, however. Some have contended that it is impossible for behavior to occur separate from the stimulating environment; the organism is always behaving and the environment is always present (Donahoe, 1991; L. Hayes, 1994). The organism may thus interact with both eliciting and occasioning stimuli in a single setting, as well as conditional stimuli which actualize the discriminative functions of other stimuli, and contextual stimuli which actualize relations between conditional and discriminative stimuli. Thus, the environment is never absent, nor is it ever static; an organism's interaction with the environment may consist of a multitude of stimulus functions which continually stimulate responding, which in turn stimulates the functions of environmental stimuli. Given this, one might ask whether the distinction between operant and respondent behavior on the basis of the role of prior stimuli—given that behavior never occurs in the absence of stimuli—is worthwhile.

Related to the argument that operant and respondent behavior are similar in that both always occur in the presence of stimuli and never in their absence, is the contention that the operant-respondent distinction has been made on the basis of single instances of behavior. Schoenfeld (1976) notes that in operant procedures, the experimenter arranges for a stimulus to follow each response instance, and in respondent preparations, the experimenter arranges for a stimulus to precede each response instance. The problem, as Schoenfeld (1976) explains, is that behavior as it naturally occurs is not partitionable into separate instances, although we may choose to record it that way. Behavior does not occur on a trial-to-trial basis, but rather occurs as a continuous "stream" (Schoenfeld, 1976). Conceptualized this way, it is apparent that behavior streams of both operants and respondents involve stimuli and responses. Donahoe, Burgos, and Palmer (1993) assert that in operant preparations, organisms are always in contact with some source of stimulation prior to reinforcer deliveries, such that respondent relations between stimuli may also be established, along with operant relations between reinforcers and responses. Likewise, in respondent preparations, organisms are always engaged in responses prior to the presentation of unconditioned stimuli, such that operant relations between responses and unconditioned stimuli may also be established, along with respondent relations between stimuli. Hence, every instance of an operant contains an embedded respondent, which operant thinkers would do well to consider (Rescorla, 1988; Rescorla & Holland, 1976). Our job, then, is to distinguish one from the other in a given stream of behavior.

However, this has not proven to be an easy task. A number of similarities between operant and respondent contingencies have been observed, questioning the utility of the distinction. Kimble (1961) presented one of the first summaries of the similarities between the operant and the respondent, all of which have been since confirmed: Operant and respondent stimulus generalization gradients have been shown to be similar, in that responding will be either elicited or occasioned by test stimuli most similar in form to training stimuli (e.g., Parker, Serdikoff, Kaminski, & Critchfield, 1991). The blocking effect, in which a prior history of respondent conditioning with one stimulus attenuates the later development of stimulus control by another stimulus (Kamin, 1969), has also been observed in operant procedures (e.g., Williams, 1975). Topographical similarities of behavior during acquisition and extinction have been shown for the two preparations (see Kimble, 1961), and prior temporal conditioning has been found to facilitate fixed interval (FI) schedule control when the same temporal intervals are used (Trapold, Carlson, & Myers, 1965). Indeed, the only qualitative difference between operant and respondent contingencies that has been noted is the effect of partial reinforcement, which is more effective than continuous reinforcement in maintaining operant behavior but less effective than continuous reinforcement in maintaining respondent behavior (Crawford, Holloway, & Domjan, 1993). Clearly, operant and respondent conditioning are both forms of stimulus control, and the utility of any further distinction must be questioned.

An important piece of this problem involves the difference between operant discriminative stimuli and respondent CSs, which are both temporally correlated with USs. If it is acknowledged that behavior is always occurring prior to a US presentation in the respondent paradigm, it is conceivable that the CS also acquires discriminative functions. Likewise, if it is acknowledged that organisms are always in contact with stimulus features of their environments prior to a reinforcer delivery in the operant paradigm, it is similarly conceivable that such stimuli are established as conditioned reinforcers as well as discriminative stimuli. That discriminative stimuli might also serve as conditioned reinforcers and vice versa is suggested by studies which have shown that the establishment of operant discriminative control is facilitated by a prior history of respondent stimulus control (Bower & Grusec, 1964; Kurse, Overmier, Konz, & Rokke, 1983). However, as Colwill and Rescorla (1986) point out, it is the temporal correlation between a neutral stimulus and a primary reinforcer which is necessary to establish the former as a conditioned reinforcer. In operant preparations, responses may not be emitted in the presence of discriminative stimuli, such that reinforcers may not always be delivered when discriminative stimuli are present. The correlation between discriminative stimuli and reinforcers may not be of a value high enough to bring about sufficient conditioning of the discriminative stimulus. Other procedural difficulties have been noted, including the subject-controlled delay between the onset of a discriminative stimulus and reinforcer delivery in operant procedures, which may further preclude respondent conditioning of the discriminative stimulus (see Dinsmoor, 1983, for a discussion of these and other procedural variables relevant to the distinction between discriminative stimuli and conditioned reinforcers).

Procedures versus Phenomena

It seems that no final answers have emerged from laboratory research. In fact, it is possible that the issue is not to be resolved by further data; but rather, by *what we say* about our data and the procedures from which they are generated. As we have seen, the operations involved in respondent and operant conditioning differ. Rescorla and Solomon (1967) concede that in respondent preparations, experimenters have full control over all features of their experiment, regardless of the subject's behavior, but in operant preparations the experimenter is at a disadvantage, only able to change the environment following response emission. The distinction between these operations refers to the behavior of experimenters, not the behavior of organisms. The distinction between relations among stimuli and relations among stimuli and responses is based on how the experimenter chooses to manipulate the organism's environment, for if behavior is conceptualized as an ongoing stream (Donahoe et al., 1993; Schoenfeld, 1976), there will exist both relations between responses and stimuli and relations between stimuli and other stimuli, *from the perspective of the organism.* Superstitious behavior, for example, is traditionally defined procedurally as the noncontingent presentation of a UCS, as in a respondent procedure, but the outcome of the procedure is identical to the outcome of an operant procedure, in that behavior is strengthened as a result of the delivery of a primary reinforcer (Terrace, 1973). Regardless of whether experimenters intend to establish correlations between stimuli and responses or stimuli and other stimuli, organisms are always interacting with their environment. It might be asked, aren't *all* stimulus features of the environment with which an organism interacts temporally correlated with its behavior? Is there any difference between contingent versus noncontingent stimulation for an organism that is always behaving? Although respondent and operant procedures may appear to be very different from the perspective of the experimenter, is it possible that they are similar, if not identical, from the perspective of the behaving organism? It is these questions that have led some thinkers to contend that respondent and operant procedures are not two types of conditioning, but simply two laboratory techniques that differ with respect to what relationships the experimenter chooses to manipulate (Donahoe, 1988, p. 38; 1991, p. 123).

That the operant-respondent distinction might be based upon simple procedural differences is problematic, for two reasons: First, if the behavior of the experimenter is the basis for our descriptions of behavioral events, the descriptions of those events might be confused with the events themselves (L. Hayes et al., 1997). Interacting with descriptions of events as opposed to the events themselves may cause important features of the behavior under investigation to be overlooked. Second, the measurement of events may be taken to be the defining feature of those events. In some situations the recording of an elicited response by a previously neutral stimulus is taken as evidence for respondent conditioning, and in other situations the recording of a change in response frequency is taken as evidence for operant conditioning. Just because the experimenter has chosen to measure behavior this way, this does not necessarily imply that in the case of the former, responses are *not* also changing in frequency, and in the case of the latter, responses are *not* also being elicited. Responses are measured and recorded at the experimenter's discretion, but this is not to say that these are the only behaviors occurring. It may be a mistake to define our phenomena according to our measurements thereof (L. Hayes, 1992).

Nonetheless, arguments have been made for the preservation of the operant-respondent distinction, mainly due to the lack of a better alternative (Pear & Eldridge, 1984; Rescorla & Holland, 1976). Rescorla and Holland (1976, p. 185) point out that the challenge is to "parcel out" the contributions of the respondent relation and the operant relation in each instance of behavior. However, perhaps they *need not be parceled out*. It is important that operant researchers recognize the ever-present role of respondent processes in their research paradigms and entertain the idea that it may not always be necessary to distinguish between the two concomitantly occurring—yet differently classified—contingencies. Perhaps rejecting the operant-respondent distinction is not the best solution at present; but, a reanalysis and assessment of operant and respondent interactions in certain areas of research might prove profitable. One such area is the study of stimulus equivalence, to which we now turn.

Stimulus Equivalence, Transfer of Functions, and the Operant-Respondent Distinction

As previously stated, theory and research in the area of stimulus equivalence has emerged largely from an operant framework. A plenitude of studies in recent decades has shown that when normal, verbally competent humans or developmentally disabled humans with sufficient verbal repertoires are provided with histories of reinforcement for making conditional discriminations, they will subsequently be able to make new, untrained conditional discriminations. For example, if comparison stimuli B1 and C1 are established as discriminative for a selection response on the condition that sample stimulus A1 is present, test performances will demonstrate "derived" discriminative control by stimulus A1, and "derived" (hereafter referred to as "untrained") conditional control by stimuli B1 and C1. In other words, stimuli which are explicitly established as conditional stimuli in this procedure also come to exert discriminative control over subjects' responding, and stimuli which are explicitly established as discriminative also come to exert conditional control over subjects' responding, though subjects' reinforcement history has established only one of the two functions for each of the stimuli. It has been held that the extent to which stimuli can be shown to be related either symmetrically or equivalently in this manner is the extent to which one stimulus is *symbolic for*, or *means,* the other (Sidman, 1986). The apparent failure of nonhumans and humans with severely limited verbal repertoires to perform successfully on equivalence tests (see S. Hayes, 1989) has established the notion that the formation of equivalence classes is unique to humans and closely related to, if not the basis of, verbal behavior (e.g., Devany, Hayes, & Nelson, 1986).

Operant Explanations

The multitude of studies that have attempted to demonstrate equivalence in nonhumans, reported the transfer of novel stimulus functions through equivalence classes, or included other variations in subjects' verbal performances such as rule-following and talking-aloud, reflect the excitement that has pervaded behavior analysis since the genesis of the equivalence mystery (see Sidman, 1994 for a review). At last, there seemed to be the beginning of an operant analysis of a behavior as complex as human language and meaning. Positive test results for untrained relations obtained in one laboratory have been replicated and reproduced numerous times in other laboratories over the course of the past nearly two decades. Indeed, equivalence class formation has been shown to have great generality across settings and procedures. It might seem, therefore, that there should be little apprehension in accepting current accounts of stimulus equivalence as explanations for such seemingly complex performances.

But there *should* be apprehension. Operant psychology is based on the probability of response emission in the present being a function of reinforcement contingencies of the past. So, if a subject is reinforced for matching sample stimulus A1 to comparison stimulus B1 in the past, it is difficult to appeal to that history of reinforcement in accounting for the subject's matching of sample stimulus B1 to comparison stimulus A1, on a test trial for symmetry, and sample stimulus B1 to comparison stimulus C1, on a test trial for equivalence, in the present. The untrained performances of subjects during tests for equivalence pose a serious dilemma for operant researchers, for it is difficult to see how histories of reinforcement give rise to such performances. It is particularly problematic that only subjects with some degree of verbal proficiency are able to successfully complete such tests, as though these subjects possess a unique ability that enables them to perform in ways superior to subjects with less developed verbal skills. A concern for behavior analysts might be that there is *some other factor responsible* for these seeming emergent performances, and because this elusive variable can not be readily identified in subjects' learning histories, physiological or cognitive processes might be seen as better alternatives to a behavior analytic explanation.

It would seem that, given the collection of previously noted similarities between operant and respondent control, it might be beneficial for researchers and theorists in the area of stimulus equivalence to examine the role of respondent processes in equivalence class formation. Although there may be no *observable* response elicited in conditional discrimination procedures, it is reasonable to speculate that untrained performances arise via the establishment of stimulus-stimulus contingencies in the respondent sense, in addition to stimulus-response contingencies in the operant sense. However, leading theories in the area of stimulus equivalence have relied almost exclusively on the foundation of operant psychology for their formulations. Horne and Lowe's (1996) naming hypothesis, for example, contends that the basis of successful performances on equivalence tests is subjects' application of a class-consistent name for each of the stimuli: Subjects' overt or covert naming of sample-comparison pairs is held to occasion an orienting response, which brings correct comparison stimuli into subjects' perceptual contact and occasions correct comparison selection. Though evidence exists for the intraverbal naming of stimuli during experimental sessions (e.g., Dugdale & Lowe, 1990; Lowe & Beasty, 1987), the strongest evidence for naming as the basis of equivalence class formation is proclaimed to be the failure of nonhumans and verbally deficient humans to demonstrate equivalence, presumably because of their inability to name stimuli. This theory, though operant in nature, has been criticized for the mediational role assumed by names and the seemingly unnecessary role of the environment in maintaining accurate performance (e.g., Barnes, 1996; K. J. Saunders & Spradlin, 1996).

Another example of an operant theory of stimulus equivalence is S. Hayes' (1991) relational frame theory, in which it is argued that after a reinforced history of responding relationally to arbitrarily applicable stimuli in a particular context, responding will generalize to novel stimuli in that same context. Relating, or equivalencing, is thus a generalized operant class that is contextually controlled, similar to generalized imitation. Although a variety of studies are claimed to provide evidence for relational frame theory (e.g., Steele & Hayes, 1991; Wulfert & Hayes, 1988), other explanations have been held to explain the same body of results just as well (Sidman, 1994). In addition, the *specificity* of the reinforcement history necessary for such generalized responding to emerge remains unclear (Horne & Lowe, 1996). Sidman (1994), in particular, asks how a history of reinforcement for relating arbitrary stimuli can generalize to novel stimuli that have nothing in common except that they can be arbitrarily related. Thus, while appealing to subjects' reinforcement history as the sole variable responsible for equivalence class formation, relational frame theory does not completely resolve the mystery for many researchers.

Yet another leading position is that of Sidman (1994), who sustains the operant nature of stimulus equivalence by claiming that reinforcement contingencies give rise to it, yet suggests that contingencies of survival have made some species susceptible to control by discriminative and conditional stimuli. Thus, in the absence of evidence as to why or how reinforcement contingencies sometimes give rise to equivalence and sometimes do not, Sidman (1994) acknowledges that equivalence may have to be accepted *a priori.*

Conceptualizing Operant-Respondent Interactions

Our understanding of equivalence might be improved were we to examine the respondent processes potentially involved. Two points that were raised earlier merit consideration here: First, behavior must be conceived of as an ongoing "stream" involving both stimulus-stimulus relations and stimulus-response relations (Donahoe et al., 1993; Schoenfeld, 1976). Second, temporal relations between stimuli and other stimuli and between stimuli and responses may be other than those which are established by the experimenter. In matching-to-sample procedures both stimulus-stimulus contingencies and stimulus-response contingencies are in effect, the interaction of which may well be responsible for subjects' untrained performances. It is possible that the problems inherent in appealing to subjects' reinforcement histories will be overcome upon examination of such an operant respondent interaction.

Recent evidence suggests that operant contingencies may not be all that are in effect in stimulus equivalence performance. The "respondent-type" training procedure employed by Leader et al. (1996) convincingly demonstrates that a history of differential reinforcement is not necessary for equivalence classes to form. In lieu of matching-to-sample training, subjects were presented with a series of nonsense syllable pairs. No response was required during this training; subjects were simply required to attend to the presentation of the stimuli. Then, subjects were tested for symmetry and equivalence relations in the typical matching-to-sample test format. All subjects demonstrated the establishment of both relations, accuracy being highest when training had consisted of longer between-pair delays relative to within-pair delays. The authors, comparing their high success rate to that of studies using matching-to sample training, claim that the respondent-type training procedure may actually be a more efficient means of establishing equivalence relations (Leader et al., 1996). From these results, it can be concluded that a history of explicitly reinforced conditional discriminations is not necessary for successful equivalence testing; the temporal contiguity between stimuli may be sufficient.

Other evidence that stimulus equivalence may not be the outcome of operant conditioning alone stems from studies employing complex samples, or stimulus compounds, as conditional stimuli (Markham & Dougher, 1996; Stromer, McIlvane, Dube, & Mackay, 1993; Stromer, McIlvane, & Serna, 1993; Stromer & Stromer, 1990a, 1990b). The notion of stimulus compounding has been important for the study of equivalence because some conceptualizations of conditional discrimination learning speculate that conditional and discriminative stimuli form inseparable compounds over the course of training, and together come to exert simple discriminative control (see Cumming & Berryman, 1965, p. 286; Holland, 1983). The equivalence relation defeats this notion, however, as stimuli that appear contiguously during training (i.e., A1 and B1) are able to function independently during testing when they are contiguous with stimuli with which they have never been paired (i.e., B1 and C1) (see Sidman, 1986). One possibility is that stimuli that occur contiguously form a compound of "separable and substitutable" elements (Stromer, McIlvaine, & Serna, 1993).

That stimulus compounding of this sort need not be restricted to an operant analysis is shown by studies in which two-element visual-visual or visual-auditory compounds are presented as sample stimuli during matching-to-sample training. During tests, the compounds are separated and each element is tested alone for relations between the other stimuli. Not only have symmetry and equivalence relations been shown between each sample stimulus element and the stimuli which served as comparisons during training, but untrained relations between the elements themselves have also been observed (Markham & Dougher, 1996; Stromer, McIlvaine, Dube, & Mackay, 1993). Stromer, McIlvaine, & Serna (1993) propose that the contiguity of the sample stimulus elements during training may be sufficient to establish relations between those elements, and equivalence relations may likewise arise by a similar associative means.

A theoretical formulation of how contiguous arrangements of stimuli are involved in the demonstration of untrained relations is suggested by L. Hayes (1992). L. Hayes (1992) argues for the respondent nature of symmetry relations, whereby just as neutral stimuli in respondent preparations acquire the functions of the USs which they reliably precede, sample stimuli in matching-to-sample procedures acquire the functions of their matching comparison stimuli, hence the untrained conditional control exerted by the stimuli on tests for symmetry. However, respondent conditioning has been reliably demonstrated to occur in one direction only, so it is difficult to explain equivalence relations in this way without also assuming the acquisition of sample stimulus functions by matching comparisons, the parallel in respondent procedures being the acquisition of neutral stimulus functions by a US, a phenomenon for which there is little empirical support. This is resolved by suggesting that when two stimuli become functionally similar, the functions of one stimulus are present in a subject's interaction with the other stimulus (L. Hayes, 1992). A subject may actually come to perceptually "see" the matching comparison stimulus when the sample stimulus is present, in which case it is argued that the stimuli have become formally similar. With respect to equivalence relations, it follows logically that if sample stimulus A1 becomes functionally and formally similar to comparison stimulus B1 and C1, by virtue of their shared form with A1, both stimuli are now similar in form and function to one another.[2] This process is made possible by the temporal contiguity between the stimuli (L. Hayes, 1992). A similar description of the functions of comparison stimuli being actualized perceptually upon the presentation of sample stimuli is depicted by Barnes (1994). Both L. Hayes (1992) and Barnes (1994) use the term *indirect reflexivity* to describe the formal similarity established between stimuli on the basis of their shared function. Although subjects' test performances have never been reinforced, they have, according to these formulations, been trained indirectly.

One problem with explaining equivalence relations with solely a stimulus-stimulus contiguity process of this sort is that in most

[2]This process has been described here according to a preparation in which A-B and A-C relations are trained and B-A, C-A, B-C, and C-B relations are tested. A preparation in which A-B and B-C relations are trained and B-A, C-B, A-C, and C-A relations are tested can also be described by this account.

conditional discrimination procedures, three comparison stimuli are presented on each trial. What is to prevent the establishment of relations between sample stimuli and nonmatching comparisons, particularly early in training when errors are frequently made? Comparison stimulus B2, for example, is just as temporally correlated with sample stimulus A1 as is comparison stimulus B1. Should subjects continue to select B2 given sample stimulus A1, is it not just as likely that, from the perspective of the subject who is always interacting with the stimulating environment, A1 and B2 come to be similar in function and form, given their temporal contiguity? This may be where the combined roles of respondent and operant processes come into play. The experimenter-arranged reinforcer deliveries may well serve to strengthen only particular stimulus-stimulus relations. Though all comparison stimuli are present on a given trial, the attending of subjects to only the correct comparison may be inadvertently strengthened by reinforcement, such that perceptually, A1 becomes temporally correlated with B1 only over the course of repeated training. As such, the role of reinforcement need not be abandoned entirely, but equivalence could be seen as the outcome of respondent and operant learning in conjunction.

Transfer of Function Reconsidered

The notion of indirect reflexivity also describes the increasing number of experimental reports of the transfer of stimulus functions through equivalence classes. Transfer of function, or the untrained acquisition of a psychological function via participation in an equivalence class (Dougher & Markham, 1994), has been regarded as one of the most interesting extensions of research on stimulus equivalence, as it broadens the domain of untrained performances and adds more questions to the equivalence mystery. In transfer of function experiments, a particular function is trained to a given stimulus, and the stimulus is then made equivalent to other stimuli. These other stimuli are then shown to exert the same control over a subject's behavior as that which was explicitly trained to the first stimulus, presumably by virtue of the stimuli's shared membership in an equivalence class. Eliciting (Dougher et al., 1994), contextual (Gatch & Osborne, 1989; Kohlenberg, Hayes, & Hayes, 1991; Lynch & Green, 1991; Wulfert & Hayes, 1988), consequential (Greenway, Dougher, & Wulfert, 1996; S. Hayes et al., 1991), and discriminative (e.g., Barnes & Keenan, 1993; Catania, Horne, & Lowe, 1989) functions have all been shown to transfer through equivalence classes. The nature of the relation between transfer of function and equivalence remains unclear. Whether one causes the other or both are outcomes of some other process is at present uncertain (see Dougher & Markham, 1994).

If it is recognized that the functions of one stimulus are actualized upon the presentation of a contiguously presented stimulus, the transfer of function through equivalence classes may not denote such a magical process (as indeed it has been proclaimed to; see Sidman, 1994, pp. 392-393). The untrained acquisition of conditional and discriminative functions during matching-to-sample training is itself an example of a transfer of function; so too might other previously established stimulus functions be acquired by stimuli that are contiguously arranged. Here too, research suggests that a history of reinforcement is not necessary for such transfer to occur. Smeets (1991) and Smeets, Barnes, Schenk, and Darcheville (1996) demonstrated the acquisition of S+ and S- functions by stimuli which had simply appeared in compounds with S+'s and S-'s. These results suggest that the transfer of functions through equivalence classes may not necessarily be an operant phenomenon.

That functions transfer between stimuli that are temporally contiguous is not only a close parallel to the outcome of respondent conditioning procedures, *it is identical*. Though transfer of function processes have not been traditionally used to characterize respondent conditioning, the acquisition of eliciting functions by a CS resulting from its correlation with a US is, nonetheless, an example of a transfer of function (Dougher & Markham, 1994). Given this, it might be asked on what basis a distinction between equivalence and respondent conditioning can be drawn. To answer this question, it is necessary to examine: (a) the necessary conditions for both outcomes, and (b) the defining outcomes themselves. First, the establishment of equivalence classes and respondent conditioning both involve a transfer of functions, although the procedures for bringing about the transfer of functions differ for the two types of experiments. In one case, experimenters arrange for reinforcer deliveries following correct conditional discriminations during training, and in the other case, experimenters arrange for the noncontingent presentation of stimuli. This distinction is based on the behavior of experimenters, not the behavior of organisms. As previously discussed, organisms are always behaving, and it is a mistake to assume that organisms' interactions with the environment are so simple to consist only of relations that are explicitly established by experimenters. Moreover, the procedure of Leader et al. (1996) and some of the findings reported by Markham and Dougher (1996) and Stromer, McIlvaine, and Serna (1993) indicate that an operant history is not necessary for the formation of equivalence classes. The temporal contiguity between stimuli during training appears to be sufficient, in which case *the behavior of experimenters during equivalence experiments need be no different from the behavior of experimenters during respondent experiments*. Hence, stimulus-stimulus contingencies or contiguities are the necessary condition for both respondent conditioning and equivalence class formation.

The remaining difference between stimulus equivalence and respondent conditioning is the defining outcomes of both phenomena. Equivalence is assumed when subjects respond accurately, under extinction, to a high percentage of test trials for untrained relations, whereas respondent conditioning is assumed when a previously neutral stimulus is observed to elicit a response. These differences are based on the measurements of behavior that experimenters choose to make. As aforementioned, measurements of behavioral events are frequently and erroneously confused with the events themselves (L. Hayes, 1992). Percentage correct is not a behavioral event, nor is a record of an elicited response a behavioral event. These are measurements, and measurements of phenomena are not the defining features of those phenomena. It is a mistake to confuse one with the other. Furthermore, the reports of Smeets (1991) and Smeets et al., (1996) of the transfer of S+ and S- functions through stimulus compounds suggest that not only automatic responses of a true respondent sort will transfer through simple stimulus pairings. It seems useless, then, to treat respondent conditioning as a separate phenomenon from other examples of transfer of function simply because elicited responses can be recorded in respondent procedures. Perhaps respondent conditioning is a special case of equivalence, as suggested by Sidman (1994, pp. 393-406).

To summarize, an organism's interaction with the environment does not occur on a trial-by-trial basis; rather, behavior is a continually evolving stream involving relations between stimuli and stimuli and stimuli and responses, which, from the perspective of the organism that is always interacting with its stimulating environment, may include more than that which is explicitly arranged by the experimenter. In addition, measurements of behavioral events are only measurements, they are not the events themselves. Consistent with these ideas, it seems that operant and respondent contingencies are simultaneously in effect in the establishment of equivalence classes. Performances that have been characterized as derived, emergent, and untrained may simply be the outcomes of interactions between operant and respondent processes. Moreover, respondent conditioning may be a special case of stimulus equivalence, one in which the transfer of eliciting functions can be observed, in one direction only. We do not mean to imply that stimulus equivalence should no longer be examined as an operant phenomenon, but we are suggesting that an operant analysis alone may not be able to account for stimulus equivalence, and for possibly a variety of other forms of complex behavior. Rescorla (1988) elucidates the important and often overlooked role of respondent conditioning in behavior that is typically considered by behavior analysts to be under operant control; stimulus equivalence is just one example of such an area of research.

Future Directions

Upon this realization, a number of research questions—aimed at isolating the role of respondent relations in equivalence class formation—abound. Additional information may be gained from further investigations of the respondent-type training procedure (Leader et al., 1996). Given the success of this procedure in establishing symmetry and equivalence relations, how effective might a "true" respondent procedure, involving a UCS and neutral stimuli, be? If such a procedure proved to be effective, what implications might this have for the variety of species which have not shown capable of successful test performances for equivalence and might they demonstrate untrained relations following such training (see Sidman, 1994, pp. 393-406, for further detail)? In addition, perhaps nonhumans and verbally deficient humans who have failed tests for equivalence will be successful if training is conducted according to the respondent-type preparation (Leader et al., 1996). Finally, a prior history of respondent-type training may prove to facilitate the effectiveness of matching-to-sample training in class formation for such subjects.

Continued examinations of compound stimuli may likewise be important. The role of blocking and overshadowing, processes traditionally of interest to respondent conditioners, might be explored. Research in our own lab has shown that when subjects first receive matching-to-sample training with unitary sample stimuli, and then receive matching-to-sample training with those same sample stimuli appearing in compounds with novel elements, the first elements will block the second, redundant elements from entering into relations with the other stimuli. In addition, accuracy on tests for relations between the elements of the compounds themselves has been shown to be low when such blocking does occur (Rehfeldt & Hayes, 1997). Research using complex samples might be extended to preparations in which complex comparison stimuli are also employed, to further address the notion of separable and substitutable compound stimulus elements in equivalence class formation (Stromer, McIlvaine, & Serna, 1993).

A related area deserving attention is the distinction between contiguity and contingency in the study of stimulus equivalence. Those researchers who have proposed the examination of respondent or associative processes involved in the phenomenon have spoken of the contiguity or proximity between stimuli as being a sufficient condition for the relations to form. In respondent conditioning, contiguity has been shown to be a necessary but not sufficient condition; stimuli must also be temporally correlated or contingent (Catania, 1992, pp. 192-193). It would be worthwhile to examine whether this is true also with equivalence relations: Is contiguity indeed sufficient, or must the stimuli be temporally contiguous *and* contingent to become equivalence class members? Experiments might be conducted in which compound stimulus elements are contiguous with one another, in that they appear in pairs on a certain proportion of trials, but are not highly correlated, in that the presentation of one stimulus element does not reliably predict the presentation of the second element. Results from procedures of this sort might be compared to results from procedures in which the elements are both contiguous and highly correlated: Under which set of conditions, if either, are the elements more likely to enter into equivalence classes?

Other research questions include examining whether stimuli that are physically similar to compound stimulus elements that are employed during matching-to-sample training will (a) enter into relations between the other elements of those compounds, and (b) enter into equivalence relations with the other stimuli. In addition, assuming that members of stimulus compounds do function as separable and substitutable elements (Stromer, McIlvaine, & Serna, 1993), if subjects have a prior history with compound stimuli but receive matching-to-sample training with only one element from those compounds, might the elements with which the matching-to-sample stimuli were initially paired *also* be shown to become members of equivalence classes?

Addressing research questions such as these will undoubtedly be of value in continuing to resolve the equivalence puzzle. However, it is likely that, as stated previously, conclusions will be reached not by data alone, but also by what we choose to say about our data. It is necessary that we broaden our assumptions regarding the distinction between operant and respondent classes. True, there may be some peculiarities of respondent conditioning which are not observed in operant learning, and vice versa. But we do know that the two contingencies seldom, if ever, occur in isolation, and both ought to be considered in analyses of complex behavior. Some thinkers have rightfully acknowledged that sustaining the operant-respondent distinction has proven to be worthwhile for behavior analysis (Pear & Eldridge, 1984). But when a behavioral phenomenon remains unexplained by existing theoretical frameworks, it is necessary to examine the assumptions of one's science and modify them until they again offer some utility and effective explanations are forthcoming. It is hoped that examinations of operant-respondent interactions and equivalence class formation will yield fruitful experimental efforts and successful theoretical explanations.

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