# The Acquisition of a Conceptual Repertoire: An Analysis in Terms of Substitution of Functions

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A functional class refers to a circumstance in which responding is controlled by features of stimuli that are common to all the class members. We argue that behavior with respect to conceptual stimuli entails more than discrimination among classes and generalization within classes. We suggest that an analysis of substitution of stimulus functions may contribute to understanding the distinctions among functional classes of different varieties, including conceptual classes.
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Notions such as abstractions, categories and concepts are relevant to the study of verbal behavior and cognition. Since the term "concept formation" was introduced in the behavior analytic literature by Keller and Schoenfeld (1950), it has been used to describe behaviors related to the discrimination of properties of stimuli.

Herrnestein & Loveland (1964), for example, demonstrated successful discrimination in pigeons with respect to pictures of trees, water, people, animals, etc. Their findings were interpreted as indicative of pigeons organizing stimuli into classes just as humans acquire repertoires of verbal categories (Cook, 2002; Sutton & Roberts, 2002).

Interpreting processes of discrimination and generalization as a demonstration of concept formation has resulted in the attribution of complex behaviors to non-human animals. Specifically, it has been suggested that responding differentially with respect to classes of stimuli may be evidence of complex behavioral events such as categorizing, abstracting or relating (Vaughn, 1988; Vonk and McDonald, 2002).

Interestingly, discussions of how these events may be related to verbal behavior or to the study of cognitive events remain unexplored for the most part. As a result, the implications of asserting that organisms acquire concepts are unclear and leave important theoretical issues unresolved. To be resolved is whether animals are capable of cognitive processes historically assumed to be exclusive to humans or if concept acquisition is unrelated to verbal behavior and thereby part of the behavioral repertoire that is common to both humans and animals.

Referring to behavior with respect to properties of stimuli as conceptual behavior adds little to the analysis of stimulus class acquisition. Alternatively, we contend that acquiring a verbal repertoire entails more than discriminative responding with respect to stimulus classes. Rather, it requires the additional component of responding with respect to a stimulus that, being arbitrary in form, substitutes for the shared functions of the class members. We argue that the notion of conceptual responding be restricted to circumstances involving responding of this sort, wherein conceptual behavior may also be characterized as verbal in nature. We will discuss how processes of stimulus and response substitution (see Kantor, 1982) are crucial to the definition of stimulus classes that involve conceptual behavior.

*Concepts as Classes of Stimuli*

Historically, the terms concepts, categories and classes have been used synonymously. Keller and Schoenfeld (1950) defined a concept as a group of stimuli with respect to which organisms respond similarly, this group being said to constitute a class. Similarly, Zentall, Galizio & Critchfield, (2002) defined categories as classes of stimuli which occasion common responses in a given context.

Different types of concepts have been defined in terms of the number of formal similarities among stimuli in the class. Other distinctions among types of concepts refer to classes of stimuli sharing formal properties versus classes of stimuli sharing functional characteristics only. For example, Zental et al (2002) differentiate perceptual concepts from relational and associative concepts. Perceptual concepts are defined as instances of responding with respect to stimuli that share one or more physical features, while relational concepts refer to responding differentially to more abstract properties of stimuli (e.g., identity and oddity). Lastly, Zentall et al., (2002), identify associative concepts as those involving stimuli that, although formally different, have common functional properties. Equivalence relations are presented as examples of associative concepts.

The difference between perceptual and associative concepts has been emphasized by calling them perceptual and conceptual classes (see Vonk & MacDonald, 2002). This distinction is not particularly useful though, since behaving with respect to stimuli always entails perceptual activity. Further, referring to behavior with respect to stimulus classes as conceptual behavior seems unnecessary. Behaving in the same way with respect to stimuli on the basis of their formal properties is adequately described in terms of processes of discrimination and generalization (see Delgado & Hayes, 2005).

In general, the fact that it has been difficult to identify the stimulus properties which acquire control over responding when the task entails great variation among stimulus properties has suggested the need for a new behavioral process, namely concept formation (Vonk & MacDonald, 2002). It is argued that significant variation in the formal properties of the stimuli (e.g., in background, colors, size, number of objects in a picture) renders explanations of behavior in terms of stimulus control and generalization unsatisfactory (see Herrnstein, Loveland & Cable, 1976; Vonk and MacDonald, 2002). Similarly, Zentall et al., (2002), suggest that when so many pictures and so many different trials are presented, it is likely that behavior cannot be accounted for in terms of the acquisition of a large number of single discriminations.

*Types of Stimulus Classes: An alternative View in Terms of Stimulus/Response Substitution*

In our view, whether subjects are responding to one or to several formal aspects of stimuli, what describes behavior with respect to the members of a stimulus class is nothing more than discrimination processes of different degrees of complexity. Research demonstrates that some primates acquire discriminative responding regardless of the level of abstraction of the conceptual class (Roberts & Mazmanian, 1988). We may organize such levels of abstraction into a taxonomy of stimulus classes. Different degrees of variation along physical dimensions between and within classes yield the following characterization of classes: a) low variation within classes: concrete and specific conceptual classes (e.g., apples, oranges), b) low variation between classes: classes most likely entail subgroups included within a larger category (e.g., two different types of apples), c) high variation within and between classes: abstract conceptual classes which include many different subgroups of exemplars (e.g., fruits versus non-fruits).

Further, responding to stimuli sharing similar characteristics is only one of the ways in which stimuli may constitute a class. That is to say, behavior evoked by similarity of stimulus forms is but one type of functional relation (Hayes, 1992). In addition to responding to classes of stimuli that differ in terms of the formal properties of their class members, organisms may also respond in the same way to stimuli sharing functional, non-formal, characteristics. Evidence of this has been provided by research demonstrating the acquisition of behavior with respect to classes of stimuli through operant matching to sample procedures (Sidman, 2000), or through respondent procedures (Hayes, 1991, Sidman, 1990; Sidman, 2000; Steele & Hayes, 1991).

Whether the members of a class share formal or functional properties, behavior with respect to them need not be considered conceptual in nature, though. In our view, conceptual behavior may be distinguished from sheer discriminative responding by the extent to which properties of class members are substitutable for one another. We now proceed to the examination of these more complex types of functional relations.

*Partial versus Absolute Substitution of Functions*

Organisms may acquire common responses to stimuli that do not share physical properties provided that at least some of the members of the stimulus class are presented under the same conditions. As previously noted, such learning may be achieved by using either operant or respondent procedures. In both cases, responding to stimuli as members of a class may be explained in terms of substitution of stimulus functions (Augustson & Dougher,1997; Tonneau & Gonzales (2004). Stimuli may be substitutable for one another in either an absolute or a partial sense, though.

Partial substitution of functions is observed in both Pavlovian conditioning processes and in the acquisition of stimulus classes through conditional discrimination procedures. In Pavlovian conditioning, the CS substitutes for some of the functions of the US. However, because both stimulus objects (i.e., CS and US) have additional functions for which stimulus substitution does not operate, stimulus substitution is only partial, applying only to the functions of stimuli that are shared as a result of conditioning.

Stimuli that undergo function transfer may be said to constitute a stimulus class. In processes such as second order conditioning, sensory preconditioning or conditioned facilitation, all involved CSs become members of the same stimulus class by virtue of the fact that organisms learn to respond in the same way in their presence.

The acquisition of behavior with respect to such classes is due to partial substitution of functions. As is also the case of perceptual classes, each of the members of a particular functionally related set of stimuli has, in addition to shared functions, other stimulus functions with respect to which an organism may respond. However, when organisms respond to any given stimulus object as a class member, they are responding only to the stimulus function that is shared with other stimuli in the same class. Hence, any of the stimulus members may be substitutable for any other member, but only in terms of their shared function. It is in this sense that substitution is partial or, in other words, relative to the function with which organisms respond across formally different stimuli.

By contrast, the formation of equivalence relations among formally dissimilar stimuli, whether acquired through respondent (e.g., Augustson & Dougher, 1997; Rehfeldt, Dixon, Hayes & Steele, 1998) or operant procedures (e.g., Sidman, 2000; Steele & Hayes, 1991), represents a circumstance of absolute substitution of function. The stimuli in such an equivalence class have only one property that is shared by all members of the class, and it is on the basis of this functional property that responses are emitted. Because these stimuli have no other functional properties that are not shared by all of the class members, substitution of functions may be said to be absolute. That is to say, there are no conditions under which a stimulus of particular formal features could not be equivalent to a formally different class member.

For example, when an organism learns to behave in the same way with respect to class members, *one, uno and 1*, it can be said that these stimuli are mutually and equally substitutable. They evoke the same response when all the members of the class acquire the stimulating function of any of the stimulus objects.

Stimuli characterized by absolute substitutability of function constitute arbitrary conventions. They are arbitrary in the sense that their function is not related to the physical characteristics of the stimuli as objects; and they are conventional in that their stimulating function is attributed by the practices of a verbal community. Note however that while all arbitrary stimuli may become mutually substitutable, but not all substitutable stimuli are arbitrary. Absolute substitution takes place only if an organism is able to respond to stimuli having no additional functional properties. As such, relations of stimulus equivalence constitute, in the strictest sense, relations of absolute substitutability of stimulus functions.

Contrary to more commonly held views, we suggest that the emergence of untrained relations is not an essential feature in the acquisition of behavior with respect to classes of stimuli and of equivalence classes in particular. Given that prior to the development of equivalence research, Pavlovian procedures (e.g., second order conditioning and sensory preconditioning) have provided evidence of such untrained relations (see Holland, 1981; Domjan, 2005) it is hard to understand why equivalence is often defined in terms of emergent relations. Emergence facilitates the acquisition of behavior with respect to class members but is neither necessary nor sufficient for responding to classes of stimuli.

To summarize, partial or absolute substitutability can be produced by any discrimination procedure used to establish class membership. The stimulus-stimulus relations involved in these preparations evokes the same behavior with respect to stimuli that differ in form. Classes that involve partial substitution of functions among class members do not require the acquisition of a conceptual repertoire though. We propose that phenomena described as conceptual be restricted to behavior with respect to stimuli that are susceptible to absolute substitution of functions.

*The Acquisition of Conceptual Behavior*

Although in the example above the three stimuli *one, uno and 1 and* belong to the same equivalence class, it could not be said that the class itself constitutes a concept. Each of the members of the equivalence class is a conceptual stimulus, however. They all refer to a property shared by different stimulus exemplars that, being different in form share the relational characteristic of quantity (e.g., one ball, one car, one person, one chair), as denoted by the forms *1, uno* and *one*.

When a stimulus acquires the shared functions of one or more stimuli, and when that stimulus has only one functional property providing substitutive stimulation for responses to any of the class members, the stimulus may be characterized as conceptual. in kind. In sum, organisms acquire conceptual behavior provided that: a) they behave in the same way with respect to objects and events in terms of their physical or functional similarities (i.e., they behave with respect to classes of stimuli), and b) they respond to an arbitrary stimulus that acquires the shared function of the class members. Specifically, it is the second condition, which describes responding verbally. The first however, constitutes a necessary condition for the acquisition of such types of responses.

*Perceptual and Functional Concepts*

A perceptual concept is a verbal stimulus that substitutes for the common formal features of stimuli that define their class membership (e.g., chair). A functional concept on the other hand constitutes a more complex relation wherein the conceptual stimulus substitutes for one or more class members sharing functional features only (e.g., art supplies, one-uno-1). Shared functions are often determined by the contextual conditions under which stimuli occur. In other words, the context in which stimuli appear may evoke the same behavior with respect to other stimuli in a group. In this type of relation, too, a verbal form may come to define and substitute for the relation between the members of the group.

The relations common among class members, for which the functional stimulus substitutes, could be subject to either partial or absolute substitution. If class members are susceptible to absolute substitution, they necessarily constitute verbal stimuli themselves (e.g., one-uno-1). In such cases, the conceptual stimulus (e. g., number) is a verbal stimulus that refers to a class of verbal stimuli. If relations between class members are susceptible to partial substitution, the conceptual stimulus serves as a substitute for those shared functions. These do not exhaust all of the functions of each stimulus event (e.g., art supplies), though.

When class members of either perceptual or functional concepts are stimulus objects (i.e., non-verbal stimuli), the relation of equality among members of a conceptual class is only partial or relative to the stimulus function shared by *all* stimuli in the class. Thus, a = b is true only with respect to the common functional features of *a* and b as class members. In a matching to sample procedure, for example, when the conditional discriminative stimulus is "fruit", responses to apples, or strawberries are equally correct and responses to potatoes and onions are incorrect.

In addition to the relations among class members, behavior with respect to conceptual stimuli presumes the acquisition of another type of stimulus relation, namely the relation between any given stimulus member (e.g., a, b) and the conceptual stimulus (*AB*). This requires an examination of the nature of the relation by which the verbal stimulus comes to evoke the same behavior in the presence of any of the class members, thereby representing the relations among them.

Note that the relation between *AB* and *a* or *b* is not one of equality or of functional substitutability of either the partial or the absolute type. Rather, it is a relation of inclusion or part-to-whole. To say that *a = AB* (i.e., an apple is the same as a fruit) is to say that the stimulus object *a*, is equal to only one of its properties or potential functional relations. As we noted earlier, *AB* is a construction of arbitrary form that refers to the shared functions of *a* and *b*. It isolates the relation of partial equality of *,* and *b* in terms of a particular feature shared by both stimuli.

In that sense, to say that *a = AB* is not merely insufficient in terms of *a,* but it is also improper in terms of *AB* since *AB* represents a relation that includes both *a* and *b*. If *a* alone was sufficient, that is, if a = AB were true, the conceptual relation would be redundant and unnecessary for there would be nothing added by the construction *AB* that *a* alone would not describe. Such relation of equality would correspond to a relation of absolute substitution, which is not a conceptual relation. It is merely an equivalence relation in which conceptual stimuli are class members. In sum, the conceptual stimulus *AB* does not substitute for any individual class member having that function; rather, it acquires the functions of *a* and *b,* but only those involved in the partial relation *a* = *b*.

Responding with respect to the conceptual stimulus *AB* occurs provided previous acquisition of responses demonstrating either partial or absolute substitution among functions of *a* and *b*. Having learned to behave in the same way in the presence of *a* as in the presence of *b* on the basis of an abstracted property common to both stimuli, an individual may respond effectively to a verbal stimulus that has acquired that common property.

*Contextual versus Conceptual Stimuli*

According to Lipkens (1992), relational responses can be evoked by exposure to contextual cues. Contextual stimuli may come to acquire the relational function shared by a set of stimuli that appear within that context. However, contextual stimuli are not necessarily conceptual. When subjects classify stimuli on the basis of a contextual relation, such a relation could be characterized as conceptual only if the stimulus acquiring the common properties of the class members is conventional and arbitrary.

Contextual control of behavior with respect to class membership was demonstrated in a study by Delgado & Hayes (2005). In this study, the contextual stimulus consisted of a color background framing each of the sets of comparisons in a matching to sample procedure. In this arrangement the color represented a property shared by the comparison stimuli in each group. We suggested that explicit training (i.e., reinforced trials) in the acquisition of behavior with respect to classes was not necessary for conceptual behavior to emerge. This study supported previous research findings indicating that discrimination of stimulus classes occurs by virtue of function transfer, and hence, in the absence of reinforced trials (Clayton & Hayes, 2004; Tonneau & Gonzales, 2004).

As described above, when an equivalence relation is established, arbitrary stimuli are substitutable for one another such that a = b. However, the relation between all members of the different classes is not sufficiently specified to conclude that A = B, as is usually assumed. It is only the relation between one set of comparisons and a second set (i.e., a1, a2, a3 and b1, b2, b3) that describes the complex relation among conceptual stimuli A = B. That is to say, A = B describes the relation between a1, b1 and c1 as being functionally equivalent to the relation between b1, b2, and b3. We suggest that behavior with respect to all of the comparisons in a group (e.g., a1, a2 and a3), as members of one same class A, may be acquired on the basis of their temporal contiguity given that in each matching-to-sample trial all such comparisons are presented together.

In Delgado & Hayes (2005), participants were exposed to different color backgrounds for each group of comparisons that were presented in trials of a standard equivalence preparation. We observed that subjects grouped the comparison stimuli together on the basis of a relation different from that established among the members of the equivalence class. That is, the relation between the contextual cue and the class members emerged in the context of a matching-to-sample procedure where relations of absolute substitution (i.e., equivalence) were trained. As expected, the subjects responded to the stimuli in each set of comparisons as members of a class. Note that in this type of arrangement two types of stimulus classes were simultaneously acquired with limited use of reinforcement, yielding a function that could be formally described as A = B = C.

The acquisition of stimulus functions by context stimuli has been documented extensively. Examples of cases where the context acquires conditioned stimulus properties have been systematically demonstrated in research on latent inhibition, extinction, reinstatement and renewal (see Bouton, 1994; Gray, Williams, Fernandez, Ruddle, Good, & Snowden, 2001; Bursch, Hemsley & Joseph, 2004; Nelson & Sanjuan, 2006). References to the meaning provided by the context in terms of responses to a CS are not uncommon. However, they do not imply that contextual stimuli are conceptual or verbal in any sense. Contextual stimuli differ from conceptual stimuli in that the former cannot be subject to absolute substitution of functions the way that verbal stimuli are.

As previously discussed, for absolute substitution to take place, an arbitrary stimulus needs to have acquired the functions of one or more stimuli. Such a stimulus is said to be arbitrary when its acquired functions are not related to its natural properties as a stimulus object (Kantor, 1982). Because a verbal stimulus is a convention that substitutes for a number of events, it may have any form; and further, changes in its formal characteristics does not alter its acquired functions. By procedures such as conditional discriminations or sensory preconditioning, any verbal form may acquire the function of another stimulus given repeated trials in which both are presented contiguously.

*Response Substitution*

Response substitution is a feature exclusive to verbal behavior or to responses that are conventional and arbitrary in form. It is their arbitrary nature, which permits absolute substitutability of the acquired function among different responses. We say that they are also conventional because members of a verbal community endow such arbitrary responses with their functions.

Depending on the point of view of the observer, verbal events may constitute either stimuli or responses. It is likely that as part of the evolution of the human behavioral repertoire, these events were first referential responses that substituted for objects and events. Verbal responses on the part of the speaker will constitute conceptual stimuli for a listener if he orients and responds appropriately to the behavior of the speaker and/or to the objects and events for which the verbal stimuli is a substitute. Therefore, any of the features of events as responses will also be features of those events when functioning as stimuli. In particular, responses that are characterized by absolute substitution are events that, when functioning as stimuli are also subject to absolute substitutability of functions.

*Conclusion*

Stimulus and response substitution are critical elements in the acquisition of behavior with respect to different types of stimulus classes. More effective adaptations to the environment result from learning to behave in similar ways with respect to stimuli that are associated with the same consequences or that occur in the same context.

Although the notion of function transfer may be sufficient to account for behavior with respect to stimulus classes, the acquisition of a verbal or a conceptual repertoire entails a more complex case of substitution in which verbal stimuli or responses are arbitrary forms subject to absolute substitution of functions. Absolute substitutability is possible given that such stimuli/responses, in being arbitrary in form, have no additional natural properties beyond those attributed by processes of culturalization.

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