The Formation of Stimulus Equivalence Classes Through Implicit Responding

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Abstract

The Formation Of Stimulus Equivalence Classes

Through Implicit Responding

Kurt Gordon Brenner

April 3, 1988

Private events (Skinner, 1957) and implicit behavior (Kantor, 1924; 1977) both refer to phenomena such as thinking, visualizing, and reasoning, although they are analyzed in different ways. Specifically, private events refer to responses that occur in the presence of certain stimuli which are accessible to the individual alone. Implicit behavior occurs when the original stimulus object is absent and a response is instead made to a substitute stimulus object. To date, little or no empirical research examining private events or implicit behavior has been generated. This thesis performed such an empirical analysis by using a stimulus equivalence paradigm, where the transitive relation between two stimuli -one that was seen previously and one that was new- could only have been made via a substitution of the original stimulus. Overall results showed that 13 of 20 subjects either immediately or eventually acquired 4-stage equivalence. The results are discussed in terms of the role that implicit responding has in equivalence classes, and possbile implications of these findings on psychopathology.

The Formation of Stimulus Equivalence Classes Through Implicit Responding

Behaviorism can be defined as a "doctrine that regards objective and accessible facts of behavior or activity of man and animals as the only proper subject for psychological study" (Random House College Dictionary, 1984). A great deal of research, theorizing, and discussion, all centered around the above axiom, has been forwarded in an attempt to better understand the lawful relations which control and predict behavior. Radical behaviorism has attempted to understand behavior through rigorous empirical observation in an effort to develop and promote psychology as a natural science. This naturalistic approach, however, has at times resulted in radical behaviorism being misunderstood in an important way: that being, it ignores or at least underrates such phenomena as thinking, imagining, attitudes, and reasoning, also known as private events.

This misinterpretation is unfortunate, for radical behaviorism does, in fact, accommodate events that are observable only to the behaver. Skinner (1953, p. 258) has asserted that private stimuli are influencial and, as such, should not be excluded from an analysis of behavior simply because they are inaccessible to an outside observer. Indeed, a complete account of behavior demands that private events be dealt with and understood in a meaningful way. To fail to do so is to compromise a complete explanation of a science of behavior at best, or devaluate a significant and fascinating part of human activity at worst.

J.R. Kantor (1924, 1975) has also discussed thinking, feeling, and the like under the rubric of "implicit behavior." Implicit behavior refers to a response that occurs in the absence of the original stimulus and instead through the operation of a substitute stimulus. The original stimulus comes to transfer its stimulus function to the substitute stimulus through a partial identity in form or function, or through a contiguous temporal or spatial relation which occurred at some point in the individual's history. We may ruminate over a particular problem, reminisce about a memorable vacation, verbally describe a person or object, or kiss a photograph of a loved one, for example. A response is made to a substitute stimulus which functions in lieu of some other stimulus in whose presence the original behavioral event occurred. It should be mentioned that implicit behavior and private events deal with the same sorts of phenomena, although they are analyzed in different ways. Both treatments will be discussed in more detail below.

Skinner and Kantor both present certain similarities in their discussions of events of this type. The stimulus phases in both types of analyses (i.e., the private stimuli in Skinner's treatise and the original stimulus and, in some cases, the substitute stimulus in Kantor's analysis) are private in the sense of being observable only to an audience of one (Skinner, 1953, p. 257; Kantor, 1924, p. 298). In addition, the response phases in both treatments can be either private or public (Moore, 1980; Kantor, 1924, p. 312). There is, however, an important feature that differentiates the two analyses in an important way. Implicit behavior always involves a substitution of one stimulus for some original stimulus. Private events, however,

may or may not involve the operation of a substitute stimulus. At times, the response is made through more direct contact with a private stimulus, with no intervention by a substitute stimulus. For example, the utterance "I have a headache" may be a response controlled by a state of pain in one's head, with no necessary involvement of a substitute stimulus. A central concept in this study involves responding that occurs through the operation of a substitute stimulus. Although Skinner's analysis of responses to private stimuli does not neccesarily include this substitutive feature, a discussion of his viewpoint will be included here because it does provide theoretical background relevant to this study.

Although radical behaviorists are willing to talk about private events, few have attempted to study them experimentally. This may be the case because the covert nature of private stimuli makes them more difficult to study than behavior of a more overt variety. The often subtle nature of responses to private stimuli has not been dealt with very effectively, in part because it has yet to be fully realized by some behavior analysts that an object can have functions other than those that their natural properties would suggest. That is, not only can stimuli simply serve as stimuli in their own right, but they can also be a substitute for other stimuli. The responses to these substitute stimuli could function beneath one's own skin, as in thinking about an object or feeling behavior. Clearly, the utility and implications of substitute functions of stimuli are not yet fully understood.

A second reason for the paucity of empirical analysis of these types of phenomena might involve a reluctance of some behavior

analysts to include unobservable events in their descriptions of observable behavior relations. Covert responses involve seemingly unobservable mediating activities, activities that are susceptible to being invented at will to quickly solve any difficulties in the relationships among observable stimuli.

This objection, however, reflects a misunderstanding of the defining properties of implicit behavior. The response phases of implicit activities are, in fact, commonly readily observable (Kantor, 1924, p. 312). The difficulty of observation lies not in the response phase, but the stimulus phase of the action. One can easily observe the happy expression of someone recalling some personal good fortune, for example. It is considerably more problematic, however, to determine the precise nature of the private stimuli with which the person interacted. Implicit events are understood in terms of the relationship between the responding of an organism and the stimulating of an environment. Further, this relationship must be examined with respect to its origins and history of development.

Thirdly, radical behaviorists have tended to translate such things as thoughts, feelings, and visualizing into behavioral language and stopped there. Private events are ~~not~~ adequately explained by mere translation, however. Clearly, an empirical analysis of complex human functioning is required to better understand this difficult, but important, phenomenon. The significance of such an analysis becomes even more apparent when it is realized just how often we engage in behavior that does not directly affect events or objects.

To be sure, there are very real difficulties in observing and understanding subtle acts of thinking, seeing in the absence of the

thing seen, hearing in the absence of the thing heard, and so on. Making matters even more intricate is the fact that each of us brings a complex history into the present situation and interacts with a complex environment. However, a thorough and complete account of behavior demands adequate explanations for implicit events. This study attempts to contribute to such an analysis.

Discussion of Key Terms

There are three major concepts that deserve further explanation: private events, implicit behavior, and stimulus equivalence.

Private Events

Private events refers to those responses that occur with respect to certain stimuli, stimuli that are accessible only to the individual alone (Skinner, 1957, p. 257). Since the stimuli are not available to others, they are said to be private. The responses that occur from this private stimulation, however, may themselves be private or public; that is, the response may be detectable to the individual exclusively or by outsiders as well.

Although private stimuli are characterized by their availability to the behaver alone, Skinner (1957, p. 258) is careful to point out that stimuli situated beneath one's own skin are no different than external stimuli. Further, responses to private stimuli have no special properties that distinguish them from responses to public stimuli. Both types of responses are subject to the same laws and principles that shape and maintain behavior. Both are learned by an individual primarily through differential reinforcement. The major difference between the two is that, in the case of private events, the

verbal community must circumvent the problem of privacy: reinforcing responses that occur in the presence of inaccessible stimuli operating beneath one's own skin, and are therefore unobservable to outsiders. Because the stimuli are hidden, the community can never be absolutely certain of the exact nature of the private event. Nor can we suppose that private responses, by their covert nature, are inherently superior to overt responses. They can both be accounted for in terms of the same conceptual framework, which shall be further discussed shortly.

According to Skinner (1974, p. 17), private stimuli cannot be said to cause public behavior. That is not to deny the possibility that a private event may have some degree of discriminative, elicitive, and reinforcing effectiveness over an explicit behavior. However, the identification of the "cause" of private responses comes by examining the contingencies of reinforcement which control and are responsible for this behavior type. Skinner in fact ascribes causal status to public stimuli only (Parrott, 1986).

Parrott (1986) took issue with Skinner on this point, however. She brings attention to an inconsistency in Skinner's formulation: although both public and private stimuli have discriminative, elicitive and reinforcing properties (properties which typically are sufficient to give a stimulus causal status), only external stimuli are depicted as having causal functions. Skinner did not clarify why causal status is not given to private stimuli, even though they can operate in a way similar to public stimuli.

Private events are comprised of two classes: 1. Private stimuli reported verbally, and 2. Covert behavior such as thinking,

imagining, and the like. Each is now separately considered.

Verbal Report of Internal Sensations. We must be able to give an adequate account of how a private event can result in the develpment and maintenance of a verbal report of that event. A useful analytic framework for better understanding verbal descriptions of internal sensations is the three-term contingency of reinforcement. This contingency consists of an antecedent discriminative stimulus, which sets the occasion for a response to occur, followed by reinforcement. To put this contingency in the context of a private event, the discriminative stimulus is some particular internal event, such as hunger pangs in one's stomach. The response in connection with this private stimulus may be the verbal report of the sensation: "I am hungry." The verbal community, now having gained access -albeit indirectly- to the private event, may reinforce the response by acknowledging the report or offering some food.

The verbal community, however, is faced with a difficulty. They do not have direct access to the private discriminative stimulus occurring within the individual, making it difficult to identify the variables controlling the behavior (Skinner, 1953, p. 259). They cannot account for the response by pointing to a controlling stimulus in the same way they could for a stimulus situated in the external environment. Only the person who is being internally stimulated has this priviledged contact with the private stimuli. Yet it is the verbal community which, through differential reinforcement, develops the connection between the internal stimulation and the person's verbal report of these sensations.

Without this direct contact with the person's internal state of affairs, the verbal community encounters a more difficult task in establishing the contingencies of reinforcement which produce verbal responses to private stimuli than is the case when the discriminative stimulus is public and common to both parties.

This dilemma is not entirely insurmountable, however. Skinner (1957, p. 131) provides four explanations as to how the verbal community can differentially reinforce verbal reports of private events, thereby enabling individuals to attach a verbal label to their internal sensations. All four explanations are based in some form on public stimuli that are associated in a reasonably consistent way with the private stimuli (Moore, 1980).

In the first case, a public accompaniment of the private event enables the verbal community to gain indirect access to the internal stimulation.' The verbal community could accept a person's report of pain (for example, "Ouch! That smarts!") if there was a public accompaniment, such as seeing the individual stub their toe against a hard object (Skinner, 1957, p. 131).

A second possibility is that reinforcement by the community occurs because the verbal response to the private event is accompanied by some collateral response. A person who reports feeling nauseous may also hold his or her stomach and emit groans of discomfort, for example (Skinner, 1957, p. 131).

Thirdly, the verbal response which is descriptive of the speaker's private events may have originally developed as an overt response controlled by public stimuli. Any private stimuli that were concurrently present with the external stimuli may also gain some

measure of control over the verbal response. As a result of this pairing of public and private stimuli, the latter may continue to exert control, even in the absence of the external stimulus. In other words, although the response was initially developed in the presence of external stimuli, any covert stimuli that were present along with the public stimuli may come to gain some degree of control over the same verbal response (Skinner, 1957, p. 132).

In the fourth case, an overt response reinforced in the presence of public stimuli may be transferred to a private event by virtue of common properties. To illustrate, we learn to describe a particular kind of stomach discomfort as "sharp" as a result of certain properties of sharpness shared by the stimuli produced by pointed objects (Skinner, 1957, p. 133).

Covert Phenomena. The second class of private events are covert behaviors. This type of event includes such phenomena as thinking and remembering. These events are viewed as private behaviors which are no different in principle from public behaviors. The form that these private behaviors take, however, may differ from public events. Covert behaviors may occur on such a small scale and reduced magnitude that only the individual in question can observe the emitted behavior (Skinner, 1957, p. 141).

Covert behavior is usually first acquired and manifest as overt behavior which then becomes private for any one of three reasons. First, covert behavior is at times simply more convenient than overt behavior. It is easier to silently verbalize our thoughts than to say them aloud. As well, we can "test" a response by trying it on

ourselves first at a covert level and, depending on the anticipated consequences, then decide whether or not to emit the response overtly. In other words, verbal behavior which was once performed outwardly may become reduced in magnitude until it no longer is visible to others. This silent form of responding, being easy to do and serving a useful purpose, is often reinforcing to the speaker and consequently maintained (Skinner, 1957, p. 141).

Secondly, behavior may occur at a covert level so as to avoid aversive consequences should the behavior be performed publicly (Skinner, 1957, p. 141). The person who enjoys talking may be reinforced for his or her verbal behavior up to a point, but if he or she continues to speak incessantly, the listener may punish the speaker by showing signs of disinterest, or worse, by walking away. Similarly, to speak aloud during a solemn church service is to risk being reprimanded by some or all of the congregation. We may enthusiastically sing in the shower when we are alone and without the threat of punishment from a displeased listener.

Thirdly, overt behavior may become covert because the stimuli that commonly operate during the public behavior become weak or defective, resulting in a correspondingly weak response (Skinner, 1957, p. 142). For example, if two people are looking for a friend in a well lit, uncrowded store, one might say "There she is!" upon seeing their acquaintance. However, if this scenario took place on a foggy night (where the visual circumstances are weak and ambiguous), one might softly mumble or say to oneself, "I think she might be over there, but I'm not sure."

Implicit Behavior

Humans often engage in behavior in a way that does not directly affect events or objects. We may covertly plan the events of the day, feel love towards someone, or daydream about that perfect vacation, for example. Within the realm of this indirect, or mediate, contact with one's surroundings are complex activities called implicit responses. Implicit behavior refers to mediate activity whereby the object reacted to is absent and is responded to only through a substitute stimulus object (Kantor, 1924, p. 295; 1975, p. 198). An individual engaging in implicit behavior does not produce any direct effect on the original stimulus, such as turning the page of a book or opening a door, because the original stimulus is absent. Rather, a response is made to a substitute stimulus which functions in lieu of some other stimulus in whose presence the original behavioral event occurred.

The fact that a response is made to a substitute stimulus and that, further, this response is ineffectual with respect to the original stimulus object are the essential qualities of implicit responding. This makes possible a wide variety of activities that could not otherwise occur. Implicit behavior may occur simply as an end in itself, or alternatively as a precurser to overt behavior. In the former case, the implicit action is done for its own sake; it is not a preliminary event occurring before behavior of a more direct variety. Examples of these "independent implicit reactions" (Kantor, 1975, p. 200) include daydreaming, reminiscing, and ruminating behaviors. These activities are engaged in simply as an end in itself; they do not necessarily result in any practical behavior.

Sometimes, however, implicit behavior is connected with direct behavior. In these cases, it is a precondition to overt activities, or what Kantor (1975, p. 200) calls "subordinate implicit behavior." The implicit action is a component of a chain of behavior in which the final reaction is an overt behavior producing change in some object. These preliminary implicit actions are required for effectuating some concrete final result. Consider the musician at her piano composing a score for a theatrical play. Before actually writing the music, the individual must respond implicitly to the nature of the scenes, the desires of the producer, the length of each act, and the general mood of a particular episode. Another illustration would involve a man who, upon seeing a stranger wearing a coat similar to that of a friend's, remembers to give that friend a telephone call and actually does so. The implicit action (calling the friend) was aroused by a substitute stimulus function found in the the stranger's coat. In other words, the coat represented the friend towards whom the final behavior was directed.

Subordinate implicit behavior may also occur as a reaction to past events or future possibilities. It may take the form of a substitute or replacement action, such as when someone clenches his or her fists upon recollection of an insulting remark made by someone in the past. Further, the day's events may be planned before actually being done, or the possible consequences of buying a house considered before making the actual purchase. As well, someone may retreat into their past experience to examine previous reactions and thereby gain insight as to how to behave in the present circumstances. That is, an inventory of past behavior that occurred during similar situations is

taken, and the most appropriate choice made, before the performance of explicit action. Subordinate implicit activity, then, is essentially a process of covertly performing an action before any overt and effective behavior begins.

All types of implicit behavior, no matter how complex, are derived from previous direct contact with the environment. Creativity and ingenuity represent combinations, exaggerations, and coordinations of actual contacts with things in the individual's history. The theories of Einstein were formed by the integration and extrapolation of principles and hypotheses with which he had previous familiarity. His postulations were not created out of nothing; even his imagination was able to operate only within the limits set by actual experience.

The Development of Implicit Actions. An implicit behavior is developed through some prior immediate contact of the reacting person with the original stimulus. Implicit responding can be seen as a detachment of a reaction from its original stimulus-response relation, whereby the reaction is instead connected with substitute stimulus objects. As a result of this dissociation of a response from its original relation, the implicit reaction not only can take on a different form from the original response, but can also increase in complexity (Kantor, 1924, p. 303). Thus, this detachment from the original stimulus may result in behavior that becomes increasingly dissimilar in form until it bears little or no resemblance to the original response.

At this point we may well ask, How can an implicit behavior occur when it is detached from the situation in which it was first acquired?

The solution lay in the fact that there must be some common element between the stimuli and/or setting factors found in both the original and implicit behavioral episodes for the latter to occur. Specifically, an implicit action can occur if some common feature of the past and present stimuli exists. For example, a child will suck on anything remotely resembling a nipple. Secondly, common setting factors of the stimuli may be responsible for a particular behavior. We may, for instance, act towards a stranger in a manner similar to the way we act towards a friend simply because the stranger is in a place commonly occupied by the friend.

The Nature of Implicit Behavior. Implicit reactions operate in the absence of the original stimulus which generated the original behavior. In other words, implicit behaviors are aroused by a substitution of the original stimulus, and the individual engages in some form of previously developed behavior. The response can be of a very subtle nature, especially if the behavior is far removed from the stimuli with which the individual is currently interacting. Such is the case during daydreaming behavior, for example. In this case, the implicit activity may be difficult to observe. When we cannot identify the substitute stimulus involved, know little about the person's behavioral history, or cannot observe the response emitted in the presence of the substitute stimulus, we can only speculate about the nature of the individual's implicit action. It is important to note that although an implicit action may not have a direct effect on the environment and may be difficult to observe, it is no less definite a response to stimuli than is an explicit behavior. Further, the complexities found in implicit behavior are no greater than those

found in correspondingly complex explicit actions. In fact, these two types of reactions are complementary and continuous modes of behavior (Kantor, 1924, p. 298). Clearly, implicit behavior constitutes anywhere from a small to a large role in almost all complex human action, and are thus integral and significant components of behavior.

The degree of similarity between the implicit behavior and the original reaction can vary widely (Kantor, 1924, p. 299). Conventionalized responses, such as verbal behavior, often show a high degree of resemblance in topography between the implicit and replaced activity. Conversely, the implicit response is more likely to be different from the original behavior when the the latter is an idiosyncratic response to a particular isolated circumstance. Nonetheless, there are definite determining conditions, usually found in the original environmental setting of the stimuli, that indicate precisely what degree of correspondence an implicit action will have with the original behavior.

Although implicit responding covers a wide range of behaviors, they can be broadly grouped into one of two classes: representative or substitutive (Kantor, 1924, p. 304). Representative implicit actions refers to the implicit reaction taking on a similar form as the initial response performed in the presence of the original stimuli. Being a direct remnant of a previous behavioral episode, it has at least some shared topography as the former response. In other words, there is a fairly close relation between representative implicit responses and the original stimulating situation. Imagery responses fall into this category; for example, a homesick soldier who finds army food unpalatable may be able to see and even smell his

mother's home cooking, even though he is far away from home.

Substitutive responses, on the other hand, have no resemblance to the behavior initially performed in the presence of the original stimulus. These responses may be entirely symbolic and, as such, very far removed from the behavioral contingencies which formed the original behavior. Dreaming, thinking, and planning are examples of substitutive reactions. The person engaged in such behavior may be totally unaware of his or her symbolic reactions. Further, observation of substitutive implicit reactions can be difficult to observe directly, and typically requires the use of inference.

Between the two poles of fully representative and fully substitutive reactions is verbal behavior (Kantor, 1924, p. 305). Verbal behavior is an extremely effective type of detached reaction because of the ease with which it can be performed, its distinct morphology, and its ability to be readily modified. As a result, verbal behavior serves as a most adequate substitutive mechanism in describing objects and events.

Kantor further subdivides implicit behavior into seven different types (Kantor, 1924, pp. 306-312). The first of these are repetitive implicit responses, which are actions that are essentially identical to behavior previously performed while in contact with the original stimuli. For example, a mother who is asked what her daughter's reaction was when she received a gift might mime the facial and bodily expressions that occurred during the original reaction; the implicit and original responses are very similar in topography.

The second type of implicit responses are incipient reactions, which refers to the implicit response only partially duplicating the

original behavior. One possibility here is the implicit response duplicating the original action initially, but does not remain identical to completion. This type of reaction can be effectively illustrated by a "tip-of-the-tongue" phenomenon where part of the pronounciation of a name can be emitted but the remainder cannot because of the absence of an adequate stimulus to evoke the complete response (Kantor, 1924, p. 306).

The third type of implicit behavior, vestigial implicit responses, is a response involving fragments of actions from previous performances. Vestigial implicit behavior can be differentiated into one of two different forms: images and vestigial movement responses. Image responses are reaction systems left over from previous perceptual contact with specific stimuli. The individual behaves in a manner similar to when he or she was in direct contact with the stimuli. Should the image be vivid enough, one may seem to almost see, hear, or smell things, or talk and otherwise react to a person, and the like. The intensity of the imagining is a function of the magnitude and vividness of the original circumstance, as well as the amount of time that has intervened between the imagined and original situation. An intense image reaction usually has accompanying movement and physiological responses as well. Recollection of a distressing event, for instance, may involve physical gestures, cardiac palpitations, and glandular activity accompanying the visualized event itself.

Some implicit acts incorporate and integrate previous responses to form new and useful concepts. These reactions, called organizational implicit actions, enable us to consolidate segments of

past behavior so that effective action can be taken in the present. An architect designing a building, for example, will draw upon previous experiences when other buildings were designed, select aspects of each experience that would be useful to the present situation, and synthesize them to form a blueprint of the new structure. This type of implicit response, then, both substitutes for and orchestrates previous experiences in a form that can be usefully applied in the present circumstance. Concepts can be derived from implicit reactions that sum up the individual's past experience, or from one's contact with information, including reading books or hearing others speak about topics related to the particular concept.

Kantor (1924, p. 309) points out that the ability to develop concepts is closely correlated with verbal ability, for concepts are stimulated into action through words, whether spoken or written. A speaker's words, then, can be seen as an extension of that person's implicit reactions whereby past behaviors are collected, integrated, and formulated into the present verbal utterances.

The fifth type of implicit reaction are combinative responses, which seem to be difficult to distinguish from organizational implicit action. Nonetheless, combinative implicit behavior refers to the creation of a new form of behavior, an ingenious mode of thinking, or the development of an ideal of some sort. Combinative actions arise as a result of the detached nature of implicit reactions, which allows for combinations of previous activities to form new and distinctive behaviors.

Fanciful implicit responses are those which are engaged in as an end in itself and are totally disconnected from any close contact with

external stimuli. Daydreaming or being absorbed in one's stream of thought are examples of this type of implicit response.

The final response type is referential implicit action. Verbal behavior is the most prominent, although by no means exclusive, form of referential implicit action. Verbal behavior is referential in the sense that it refers the listener to objects or events. An infant will utter a vocal response to refer the listener to a particular need or object. The child, unable to accomplish some task on its own, develops the ability to emit a verbal response as a substitute for this action. The listener functions as a mediator in performing the requested behavior. The verbal response, then, has taken on a referential function. Verbal behavior often consists of references to objects, events, persons, or conditions. Verbal utterances in this case can be seen as detached responses to objects, made possible by the application of substitute stimuli.

The Observation of Implicit Reactions. Many implicit behaviors are observable and morphologically similar to overt responses; these cases can be readily studied empirically. In other cases, however, the implicit act is not directly observable and an inference regarding the nature of the implicit behavior is necessary. We know about the nature of planning, reasoning, and rehearsing only when some related explicit behavior is manifest as well. This does not necessary suggest, however, that the implicit act cannot be accurately identified. Knowledge of the implicit response can be realized through observation of concomitant direct behaviors or through their verbal explanation.

Understanding the implicit reactions of a person occurs by

assiduously observing the individual under various stimulating environments (Kantor, 1924, p. 312). Once a comprehensive knowledge of the person's reactions to various contacts with the environment is achieved, understanding the nature of his or her implicit behaviors becomes more plausible. It is difficult to know what kinds of implicit behavior someone is engaged in simply because the original stimuli are absent and we may not have access to the substitute stimuli. The task becomes somewhat easier if we know the person's history of contacts with the environment and can thus reconstruct past interactions. This point is exemplified by the fact that we can predict with much greater accuracy what an intimate friend's opinions on a given topic will be as opposed to that of a stranger's, if only because we have greater knowledge of the friend's history.

Further, since each person has a different history of behavioral repertoires, and since implicit responses are performed in the absence of the original stimuli (resulting in countless variations of substitute stimulus types being possible), individual differences are more pronounced in implicit reactions than in other types of behaviors.

Stimulus Equivalence

It has been demonstrated that when humans are taught a series of conditional discriminations, the individual stimuli used in these discriminations may become related to each other in new ways that were not explicitly taught previously (Devany, Hayes, & Nelson, 1986; Dube, McIlvane, Mackay & Stoddard, 1987; Lazar, 1977; Lazar, Davis-Lang, & Sanchez, 1984; Lazar & Kotlarchyk, 1986; Sidman, 1971;

Sidman & Cresson, 1973; Sidman, Kirk & Willson-Morris, 1985; Sidman & Tailby, 1982; Stromer & Osborne, 1982; Wetherby, Karlan & Spradlin, 1983). If an individual is taught to match A to B and then A to C, he or she will be able to match B to A, C to A, B to C and C to B without additional training.

To illustrate, a picture of an apple, the written word APPLE, and the spoken word "apple" are stimuli that initially have no relation to each other in terms of meaning or physical topography. Given the appropriate contingencies, however, these physically dissimilar stimuli become functionally interrelated to form a class of equivalent stimuli.

A stimulus equivalence class is said to exist if the stimuli in the class show the three defining properties of reflexivity, symmetry, and transitivity (Sidman & Tailby, 1982). Reflexivity refers to generalized identity matching, whereby a novel stimulus is matched to itself under conditions of no reinforcement. For example, reflexivity would be demonstrated if the subject, having been shown the written word APPLE, could select that same word from a list of words even if reinforcement of that choice was not forthcoming. Put another way, a reflexive relation can be expressed as "if A, then A; if B, then B," and so on.

Symmetry is said to exist if two different stimuli are functionally reversible: "if A, then B; if B, then A." Symmetry refers to an untrained bidirectional relationship between two stimuli. If the stimuli in each training pair are also related in the reverse order without direct training, symmetry is said to exist. For example, in the presence of the written word APPLE, a picture of an

apple is selected and reinforced. Then, without reinforcement, in the presence of a picture of an apple, the written word APPLE is chosen.

The third defining property of the equivalence relation, transitivity, requires at least three stimuli. If the relations "if A, then B" and "if A, then C" are taught, transitivity would be demonstrated if the relation "if B, then C" emerged without additional training. Transitivity refers to the relatedness of a given stimulus pair as a result of a prior linkage to a common mediating stimulus. To illustrate, if a picture of an apple is selected in the presence of the written word APPLE, and if the spoken word "apple" is selected upon seeing the written word APPLE, transitivity is said to occur if, without additional teaching, the spoken word "apple" is chosen upon seeing a picture of an apple.

This experiment will modify this basic model by using substitute stimuli, stimuli the subjects will have not seen previously in this context, instead of the original stimuli during the equivalence testing phase. Thus, the paradigm outlined above would now become "if A, then B" and "if A, then C," but now the transitive relation becomes "if B, then new C." If this new transitive relation emerges, we can conclude that the new stimulus effectively functioned as a substitute for the original stimulus, thereby demonstrating implicit behavior. The properties of an equivalence relation are summarized in Table 1 (see Table 1).

Stimulus equivalence has been demonstrated with a variety of subjects. It has been shown in normal children and adults (e.g., Lazar, 1977; Sidman et al., 1985; Sidman, Rauzin, Lazar, Cunningham, Tailby, & Carrigan, 1982; Sidman & Tailby, 1982), and mentally

Table 1

Properties of the Equivalence Relation.

1. Reflexivity: "If A, then A. If B, then B" etc.
2. Symmetry: "If A, then B. If B, then A."
3. Transitivity: "If A, then B; If A, then C. Therefore, if B, then C."

handicapped individuals (e.g., Devany et al., 1986; Dixon & Spradlin, 1976; Dube et al., 1987; Sidman et al., 1974; Stromer & Osborne, 1982). Equivalence relations have also emerged using arbitrary stimuli (e.g., Devany et al., 1986; Lazar, 1977; Lazar et al., 1984), with stimuli presented in the visual modality (e.g., Lazar et al., 1984), or in both visual and auditory modalities (e.g., Dixon & Spradlin, 1976). Sidman et al. (1985) found that the equivalence model could be expanded to six-member equivalence classes.

Although conditional discriminations have been shown in pigeons (e.g., Kendall, 1983), monkeys (e.g., D'Amato, Salmon, & Columbo, 1985; Sidman, Lazar, Cunningham, Tailby & Carrigan, 1982), and dolphins (e.g., Herman & Thompson, 1982), the emergence of equivalence relations in non-humans has yet to be demonstrated. The failure of non-humans to demonstrate the formation of equivalence classes indicates that equivalence will not automatically occur should an organism learn various conditional discriminations. Hayes & Wulfert (1987) suggest that stimulus equivalence may be related to language ability. The findings of Devany, Hayes & Nelson (1986) lend support to this notion. They found that stimulus equivalence will emerge in normal or retarded children with language ability but not in language-impaired retarded children.

To date, however, no published research has used the equivalence paradigm to demonstrate implicit behavior. The main purpose of the present research is to empirically demonstrate implicit behavior by inserting a substitute stimulus in place of the original stimulus during the equivalency testing phase. The study of when and how an individual engages in implicit behavior is a function of one's

familiarity with the person's history of responses to various conditions of stimulation. This knowledge enables the observer to discern and predict which objects are substitutable for other objects, and to draw appropriate conclusions. This study will examine the formation and demonstration of implicit responding. By creating and monitoring a history of responding in each subject, it will be able to predict which substitute stimuli are controlling their implicit reactions.

There are four main questions this thesis will address:

1. Can implicit behavior be demonstrated using a stimulus equivalence model?
2. Can the stimulus phase of the implicit response be identified?
3. Is there any difference in the acquisition of stimulus equivalence when pictures are used during the training phase and are then substituted by words during the test phase versus words being used in training and pictures used during testing?
4. What implications might this have on psychopathology (i.e., labelling and interpreting situations and experiences)?

Method

The equivalence paradigm used in this experiment is outlined in Figure 1. Four classes of stimuli were used, each class consisting of three stimuli. Three of these classes always contained arbitrary, abstract stimuli (see Figure 1). The fourth class consisted of photographs of faces in one condition of the experiment, and nouns in the second experimental condition. Solid lines in the figure indicate

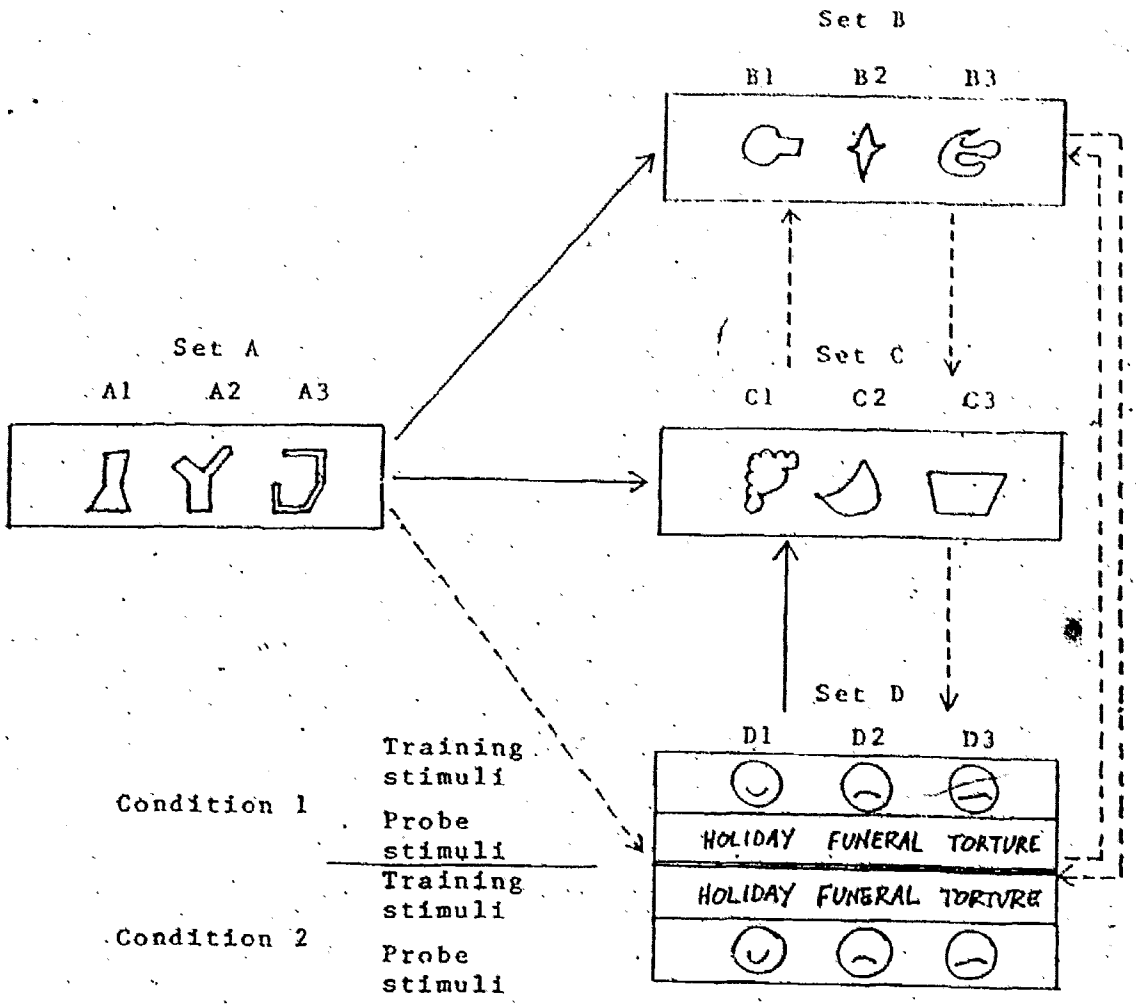


Figure 1. The equivalence model used in this experiment. The stimuli in Sets A, B, and C are arbitrary nonsense shapes. Set D stimuli are, in condition 1, photograph slides of faces, and in condition 2, nouns that each describe one of the faces. During the testing for equivalence phase, nouns were substituted for faces in condition 1, and faces for nouns in condition 2. Arrows point from sample to comparison. The solid arrows AB, AC, and DC represent conditional relations that were explicitly taught to the subjects. The broken arrows DB, BD, AD, BC, CB, and CD indicate those relations that were tested for emergent equivalency or symmetry.

relations that were explicitly taught during the training phase. Dashed lines indicate the equivalence relations which were probed for during the testing phase.

Subjects

Twenty University students, ten males and ten females, participated in the experiment. Their ages ranged from 18 to 25, with a mean of 19.5 years. They came to the laboratory for two sessions lasting approximately one hour each, the exact duration depending on the amount of training each subject required to learn and maintain baseline matching performances. Each individual was paid, upon completion of the experiment, seven dollars for his or her participation.

Apparatus

Subjects sat before a panel consisting of a screen onto which photograph slides of the stimuli were projected; three keys, each of which corresponded to one of the three comparison stimuli shown on the screen; and a green and red light, indicating whether the subject's selection was correct or incorrect.

The experimenter was situated in an adjacent room. He manipulated a control panel consisting of an advance slide button, as well as a correct response and an incorrect response button. He also noted subjects' responses on a master data sheet.

The stimuli consisted of 9 abstract nonsense shapes, 3 photograph slides of faces, each with a different facial expression, and 3 nouns which were related to the faces. The facial expressions and corresponding nouns were: a happy face - HOLIDAYS; a sad face -

FUNERAL; and a mean face - TORTURE.

The photographs of the three facial expressions were chosen from Ekman's (1976) Pictures of Facial Affect. The same individual, a male, appeared in all three pictures. Each photograph was chosen on the basis of Ekman's (1976) normative data of observer's ratings for each facial expression. Those expressions scoring in perceived rating of happiness, sadness, and anger were used.

These nouns were chosen because they corresponded with the facial expressions yet were not overly obvious in their relatedness to the photographs (as would be the case if the words HAPPY, SAD, and ANGRY were chosen, for example). In other words, the nouns were selected because they had a common cultural relatedness to the facial expressions, and thus would serve as suitable counterparts to the faces.

In one experimental condition, the abstract shapes and facial photographs were used during the training phase, and the nouns were substituted in place of the photographs during the testing for equivalence phase. In the second condition, the shapes and nouns were used during the training phase, and the photographs substituted for the adjectives during the test phase.

Each slide consisted of a sample stimulus, shown at the top of the screen, and three comparison stimuli, displayed in a row below the sample. Each stimulus was approximately 2" X 1.5".

Procedure

There were three phases in this experiment: an identity matching phase (to test for reflexivity), a training phase involving the correct matching of one of three comparison stimuli to a sample

stimulus, and a test phase which investigated, whether or not equivalence had emerged. Each subject was taught individually, and each underwent the same training sequence. A general outline of the sequence of the experiment is shown in Table 2 (see Table 2).

The identity matching phase involved the subject matching a given sample stimulus to an identical comparison stimulus. This served as a test for reflexivity and also helped the subject become oriented to the testing environment. After each response, correct choices were followed by the illumination of a green light. Incorrect choices were followed by a red light. (Similar feedback was also given for all other types of relations, with the exception of the test-for-equivalency probe items, where no feedback was administered). Once the subject met the criterion of 24 correct out of 24 items, he or she began the training phase.

During the training phase, subjects were told to try and match, through a trial and error process, the correct comparison with the sample stimuli. Subjects first learned to select B1 in the presence of A1, B2 in the presence of A2, and B3 in the presence of A3 (i.e., AB matching). The same three comparison stimuli, one correct and the other two incorrect, appeared on every trial. Subjects went through balanced sets of 30 items until they achieved a criterion of at least 29 correct trials in a set. Thus, if a subject achieved 28 or fewer correct items out of a 30 item set, he or she was administered another set of 30 items of the same training relation. This procedure was done until he or she scored a minimum of 29 correct out of 30 for that particular relation, after which the next type of training relation would commence. The training relations are presented in Figure 2 (see

Table 2

Training and Testing Sequences.

I. Identity Matching (test for reflexivity)

II. Training Phase: Teaching Matching to Sample.

1. AB: Set A (samples) and Set B (comparisons)
2. AC: Set A (samples) and Set C (comparisons)
3. AB and AC: Mixed trial from phases 1 and 2.
4. DC: Set D (condition 1, picture samples; condition 2, noun samples) and Set C (comparisons)
5. AB, AC, and DC: Mixed trial from phases 3 and 4

III. Testing for Equivalence Phase

1. DB: equivalence probes in baseline of AB, AC, and DC
2. BD: equivalence probes in baseline of AB, AC, and DC
3. AD: equivalence probes in baseline of AC and DC
4. BC: equivalence probes in baseline of AB and AC
5. CB: equivalence probes in baseline of AB and AC

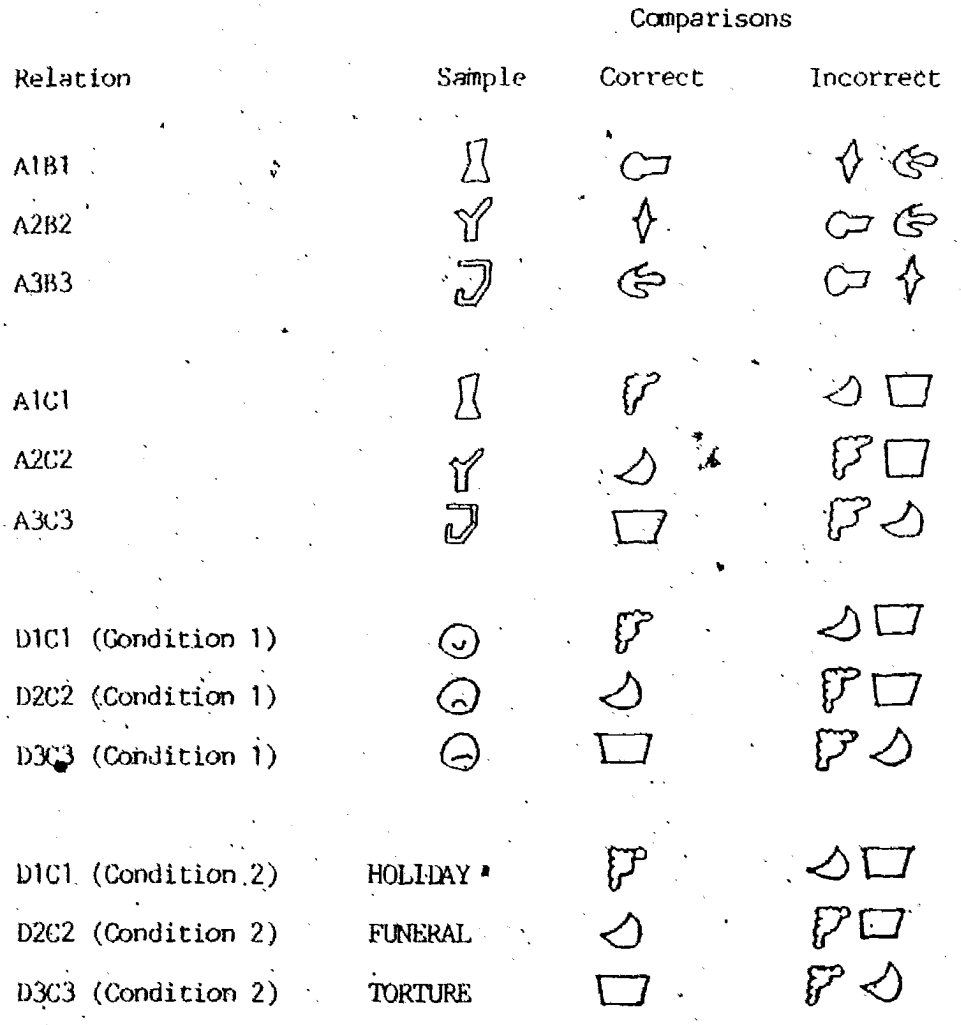


Figure 2. Each row depicts a particular training relation, including the sample stimulus as well as the correct and incorrect comparison stimuli. Set D, Condition 1 stimuli were actual photographs of happy, sad, and angry facial expressions respectively.

Figure 2).

The next step involved the subjects' learning AC matching, where A1 was paired with C1, A2 with C2, and A3 with C3. Once they reached criterion (29 out of 30 correct), they advanced to step 3, in which AB and AC items were combined and mixed. Here, the subjects had to demonstrate correct matching of comparison stimuli from Set B or Set C to a sample stimulus from Set A. Balanced sets of 30 items each were presented until they were able to achieve at least 29 correct in a set.

Step 4 of the training phase consisted of teaching DC relations. In condition 1, the abstract comparison stimuli from Set C were to match the correct sample stimuli, the pictures of faces, from Set D. In condition 2, the format was identical with the exception that nouns were used in place of the pictures. Again, 29 correct trials out of 30 were required before the subject proceeded to step 5 of the training phase.

Step 5 involved mixing all three AB, AC, and DC trial types in balanced sets of 45 trials. Demonstration of mastery at this step occurred when the criterion of 43 correct items out of 45 was reached.

Once the subjects achieved the learning criterion of the combined AB, AC, and DC task, they underwent a test phase in which probes of various untaught relations were intermittently inserted into a baseline of the previously taught baseline relations. This procedure indicated whether or not equivalence relations had emerged. Subjects were told that they would not be informed as to whether their answer was correct or incorrect for some of the items (i.e., the probe trials), but would be informed for the remaining items (i.e., the

baseline trials).

In step 1 of the test phase, DB items were inserted into a baseline of AB, AC, and DC trials. In order to demonstrate whether or not implicit behavior was occurring, the nouns were substituted in place of the pictures of faces for subjects in condition 1, and the pictures of faces for the nouns for those in condition 2. That is, in cases where the pictures were used during the training phase, the nouns were now used instead during the test-for-equivalence phase. In cases where the nouns were used during the training phase, the pictures were substituted instead during the test phase.

During step 2, BD probes were inserted in a similar baseline of AB, AC, and DC. Each DB or BD test consisted of 90 baseline and 30 probe trials, for a total of 120 trials. Again, the stimuli in Set D were substituted for by either the pictures of faces or the nouns, depending on the type of Set D stimuli the subject received during the training phase.

Step 3 involved the insertion of AD probes into a baseline of AC and DC items. Step 4 and step 5 saw BC and CB probes, respectively, inserted into a baseline of AB and AC trials. Steps 3, 4, and 5 consisted of 90 items each, including 60 baseline and 30 probe trials. The probe test relations for Conditions 1 and 2 are shown in Figures 3 and 4, respectively (see Figures 3 and 4).

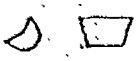
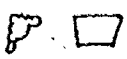
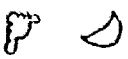
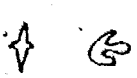
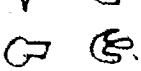
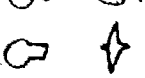
Relation	Sample	Comparisons: Correct	Comparisons: Incorrect
D1B1	HOLIDAY		
D2B2	FUNERAL		
D3B3	TORTURE		
B1D1		HOLIDAY	FUNERAL, TORTURE
B2D2		FUNERAL	HOLIDAY, TORTURE
B3D3		TORTURE	HOLIDAY, FUNERAL
A1D1		HOLIDAY	FUNERAL, TORTURE
A2D2		FUNERAL	HOLIDAY, TORTURE
A3D3		TORTURE	HOLIDAY, FUNERAL
B1C1			
B2C2			
B3C3			
C1B1			
C2B2			
C3B3			
C1D1		HOLIDAY	FUNERAL, TORTURE
C2D2		FUNERAL	HOLIDAY, TORTURE
C3D3		TORTURE	HOLIDAY, FUNERAL

Figure 3. Each row depicts a particular Condition 1 probe relation, including the sample stimulus as well as the correct and incorrect comparison stimuli.

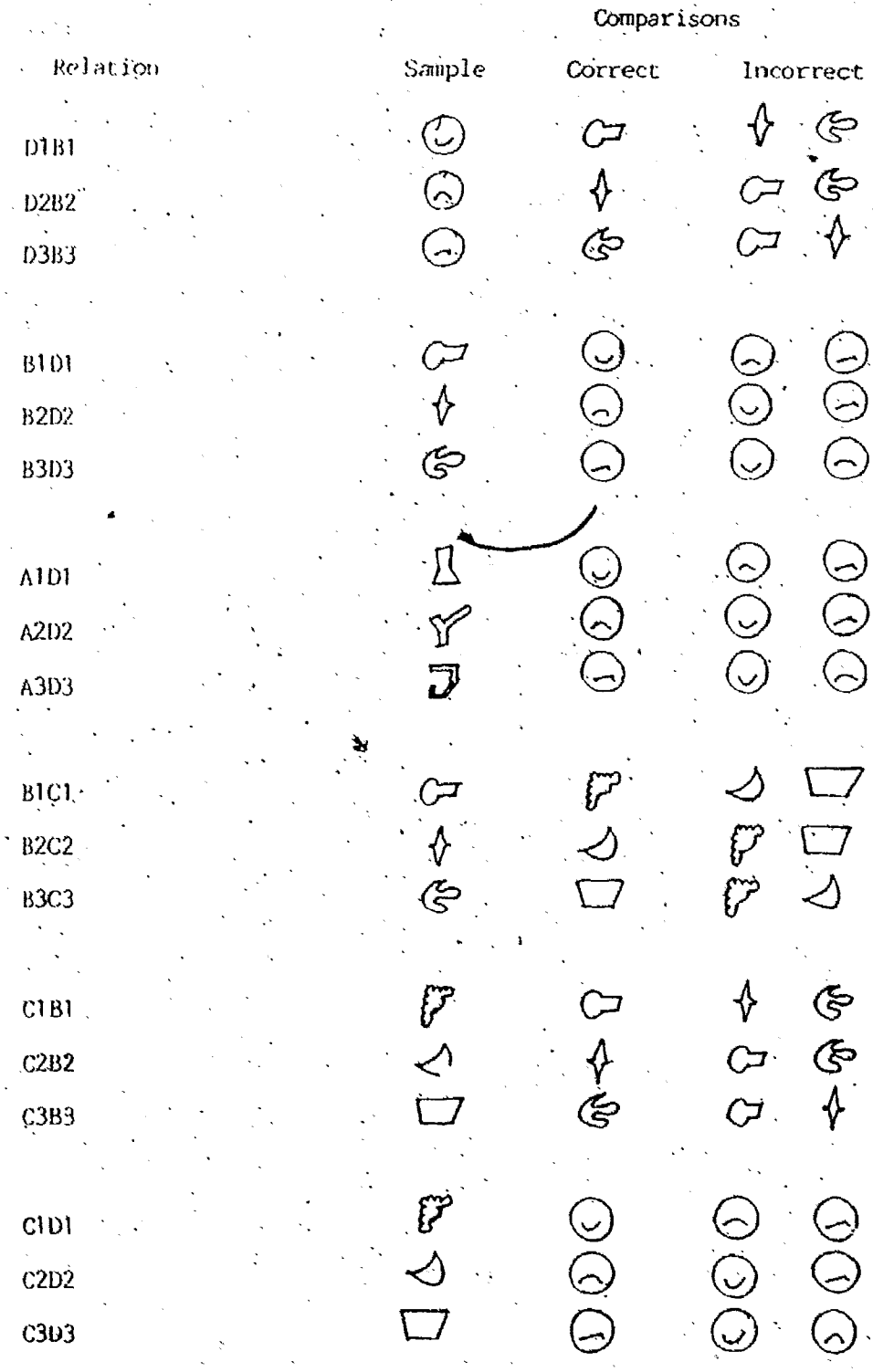


Figure 4. Each row depicts a particular Condition 2 probe relation, including the sample stimulus as well the correct and incorrect comparison stimuli. Set D stimuli were actual photographs of happy (D1), sad (D2) and angry (D3) facial expressions, respectively.

Data Analysis

Analysis of the data was relatively straightforward. The number of sets of trials required for each subject to achieve the training criterion were recorded. As well, percentage of correct responses were calculated for both the baseline training trials and the equivalence testing trials. A subject's score had to be at least 90% correct in the testing phase for it to be concluded that equivalence relations had been formed. Special attention was given to whether or not Set D stimuli (i.e., the stimuli that will be substituted for during the equivalence testing phase) formed equivalence relations with other sets of stimuli. If equivalence were to emerge with the substituted stimuli of Set D -stimuli that the subject will not have seen before the test phase- then it may be asserted that implicit behavior had been empirically demonstrated.

Those subjects who received Condition 1 (i.e., nouns substituted for faces) were compared to those in Condition 2 (i.e., faces substituted for nouns) to examine whether any differences existed regarding the rate of learning during the matching-to-sample-phase and, especially, the acquisition of equivalence relations.

Reliability

Reliability data of the scoring of responses were collected in 20% of the sessions. Two undergraduate students alternated between sessions as scorers. Each observer was given a general overview of the nature of the research, but were not conversant with the nature of the experiment in any detail.

The experimenter and the second scorer were situated in the control room in a way that ensured neither one could observe the

other's data sheet. As well, measures were taken to conceal the feedback (i.e., the green and red lights for correct and incorrect responses) given by the experimenter to the subject following each response.

The following formula was used to calculate reliability:

(Agreements/Agreements + Disagreements) X 100.

A given item was considered an "agreement" if the experimenter and observer both recorded the response as correct or incorrect. Any discrepancies in scoring were considered a "disagreement." As illustrated in Table 3, interobserver agreement never fell below 99% for any given block of items (see Table 3).

Table 3

Reliability scores: Interobserver agreement (in percentages) throughout multiple sessions.

Number of trials	Agreement
279	99
474	100
534	100
195	100
399	100

Results

Briefly, in Condition 1 (i.e., nouns substituted for faces), five of ten subjects unequivocally demonstrated 4-stage equivalency for both DB and BD relations. Two additional subjects, D.F. and T.O., eventually acquired 4-stage relations. Subject D.F. did not provide evidence for equivalence during the DB probe phase, but did acquire 4-stage relations during the BD probes. Subject T.O. did not meet the criterion for any equivalency relations until the latter part of probe testing. His perfect performance on the CD probes led to a retesting of the DB probes, where he demonstrated the new formation of 4-stage relations. Subjects D.D., S.J., and L.W. failed to demonstrate equivalency for the DB and BD probes.

A third probe type, AD, required the substitution of words for faces. Six of ten subjects successfully demonstrated equivalency for this probe relation.

Performance on the BC and CB probes was generally improved, with nine of ten subjects either immediately or eventually demonstrating equivalence.

The remaining probe type, CD, was a test of symmetry. Again, all those who previously substituted the words for the faces quite naturally demonstrated symmetry of CD relations as well. A total of eight subjects gave evidence for symmetrical relations.

For Condition 2 (i.e., faces substituted for nouns), a total of six of ten subjects either immediately or eventually demonstrated 4-stage equivalence relations. These same six subjects provided evidence for 3-stage AD relations as well. One subject, N.G., gave superficial evidence of emergent 4-stage equivalency during the BD

probe test. For reasons given below, however, it is doubtful that she in fact substituted the faces for words until the final CD test. Eight of ten subjects demonstrated BC and CB equivalence relations. Only one person, N.S., failed to show the CD symmetrical relation. He later disclosed that he indeed had knowledge of the relationship between the words and faces, yet chose to follow an alternative strategy of his own.

Presented below are detailed results of each subject's performance.

Condition 1 (nouns substituted for faces)

Subject D.D.

Subject D.D. reached criterion at each stage of the conditional baseline training relations in one set of 30 trials, with the exception of sets AB and AC, which required two sets of trials each. Her training relation scores were as follows: set AB - 25/30 (83.3%) and 30/30; set AC - 27/30 (90%) and 29/30 (96.7%); set AB and AC mixed - 30/30; set DC - 29/30; and set AB, AC and DC mixed - 45/45. Training relation scores for all 20 subjects are shown in Table 4 (see Table 4).

During the ensuing testing-for-equivalence phase, her accuracy for baseline relations throughout the entire testing phase was 100 percent. The insertion of novel probe trials among the explicitly taught training items, therefore, did not disrupt her baseline performance.

Subject D.D. failed to demonstrate equivalence class formation for any probe type during the testing phase. The results reflect

Table 4

Subjects' scores on explicitly taught conditional discrimination training relations. Each score represents one set of items. Training was continued until criterion for each type of relation was met: 24/24 for Reflexivity items; 29/30 for sets AB, AC, AB/AC mixed and DC; and 43/45 for set AB/AC/DC mixed.

Subject	Reflexivity	AB	AC	AB/AC	DC	AB/AC/DC
1. (D.D.)	24/24	25/30	27/30	30/30	29/30	45/45
		29/30	30/30			
2. (K.M.)	24/24	26/30	25/30	30/30	27/30	45/45
		30/30	30/30		30/30	
3. (S.J.)	24/24	24/30	30/30	30/30	28/30	45/45
		30/30			30/30	
4. (L.W.)	24/24	25/30	28/30	30/30	30/30	44/45
		29/30	30/30			
5. (D.F.)	24/24	24/30	30/30	30/30	29/30	45/45
		30/30				
6. (H.J.)	24/24	27/30	24/30	30/30	29/30	45/45
		30/30	30/30			
7. (J.O.)	24/24	21/30	28/30	30/30	30/30	44/45
		30/30	30/30			
8. (R.B.)	24/24	30/30	26/30	30/30	30/30	45/45
			30/30			
9. (G.G.)	24/24	0/30	27/30	30/30	26/30	45/45
		27/30	30/30		30/30	
		30/30				

Table 4 (Con't)

Subject	Reflexivity	AB	AC	AB/AC	DC	AB/AC/DC
10.(J.W.)	23/24	22/30	28/30	30/30	30/30	45/45
	24/24	30/30	30/30			
11.(N.G.)	24/24	25/30	20/30	30/30	25/30	44/45
		30/30	29/30		30/30	
12.(J.S.)	24/24	25/30	22/30	30/30	26/30	45/45
		30/30	30/30		30/30	
13.(B.C.)	24/24	19/30	21/30	29/30	26/30	45/45
		28/30	30/30		30/30	
		21/30				
		30/30				
14.(A.G.)	24/24	27/30	28/30	30/30	27/30	45/45
		30/30	30/30		29/30	
15.(C.J.)	24/24	13/30	18/30	27/30	30/30	45/45
		30/30	26/30	30/30		
			30/30			
16.(H.S.)	24/24	24/30	30/30	30/30	26/30	45/45
		30/30			30/30	
17.(N.S.)	24/24	25/30	29/30	30/30	27/30	45/45
		30/30			30/30	
18.(S.C.)	24/24	18/30	28/30	30/30	27/30	45/45
		30/30	30/30		30/30	
19.(S.B.)	24/24	25/30	23/30	30/30	26/30	45/45
		30/30	30/30		30/30	
20.(B.D.)	24/24	28/30	29/30	30/30	30/30	45/45
		30/30				

forms of stimulus control that were unrelated to the explicitly taught baseline relations. Questioning following the experiment revealed that she selected comparisons during probes on the basis of whether or not the shape of the comparison stimulus seemed to "match" the sample stimulus in some arbitrary way, and not on any knowledge of previous relations.

In the 4-stage DB and BD probe trials, she scored 10/30 (33.3%) probe trials correct in both cases. Her pattern of responding remained relatively consistent for these probe items. During BD probe testing, in the presence of sample stimulus D1 (HOLIDAY), she chose B2; when sample stimulus D2 (FUNERAL) arose, she chose either B3 or B1; and for sample stimulus D3 (TORTURE), she chose B3 on all ten trials. During BD probe testing, similar stimulus relations were maintained, with samples B1, B2, and B3 resulting in comparison choices of D1, D2, and D3 respectively.

Her performance during the 3-stage BC and CB probe tests also failed to provide evidence for equivalence class formation. Her 20/30 (66.6%) score during the BC test was the result of the correct matching of C1 with B1 and C2 with B2, but the erroneous matching of C1 with B3. This pattern of responding was similar during the CB probe test, although comparison stimuli B3 was at times erroneously paired with C1 as was B3 with C3. She scored 22/30 (73.3%) during the CB probe test.

The final probe type, the CD test for symmetrical relations, resulted in a 23/30 (76.6%) score. In the presence of C1, she correctly chose D1 on seven items and then switched to D3 for the final 3 trials of that type. Comparison stimulus D2 was correctly

matched with C2 for all ten trials, as was D3 with C3 in the first six cases, with D1 being matched with C3 for the remaining four items. Results of the probe performances for subjects 1, 2, 3 and 4 are depicted in Figure 5 (see Figure 5).

Subject K.M.

Subject K.M. was able to achieve the required criterion for the training phase with relative ease. She needed only one set of items to demonstrate sufficient learning for the reflexivity set, as well as sets AB/AC mixed and AB/AC/DC mixed. All other matching-to-sample relations (AB, AC, and DC) required two sets before criterion was reached. Accuracy level for any given set never fell below 25/30 (83.3%). These explicitly taught relations were maintained at a 100% level of accuracy during the test-for-equivalence phase as well.

Subject K.M.'s overall performance during the probe test phase indicated, without exception, the demonstration of equivalence class formation for each type of probe. For the DB probe items, her first two of three answers were incorrect, after which she got all the remaining items correct for a score of 28/30 (93.3%). She then scored a perfect 30/30 on the BD probe tests, and 29/30 (91.7%) on the three-stage AD probes. Her performance during these three probe tests, which required the substitution of the appropriate words for the faces, suggested that the type of implicit behavior hypothesized in this study was indeed occurring.

The remaining BC, CB, and CD probe tests each showed scores of 30/30, indicative of three-stage equivalence formation and, in the latter case, of symmetry.

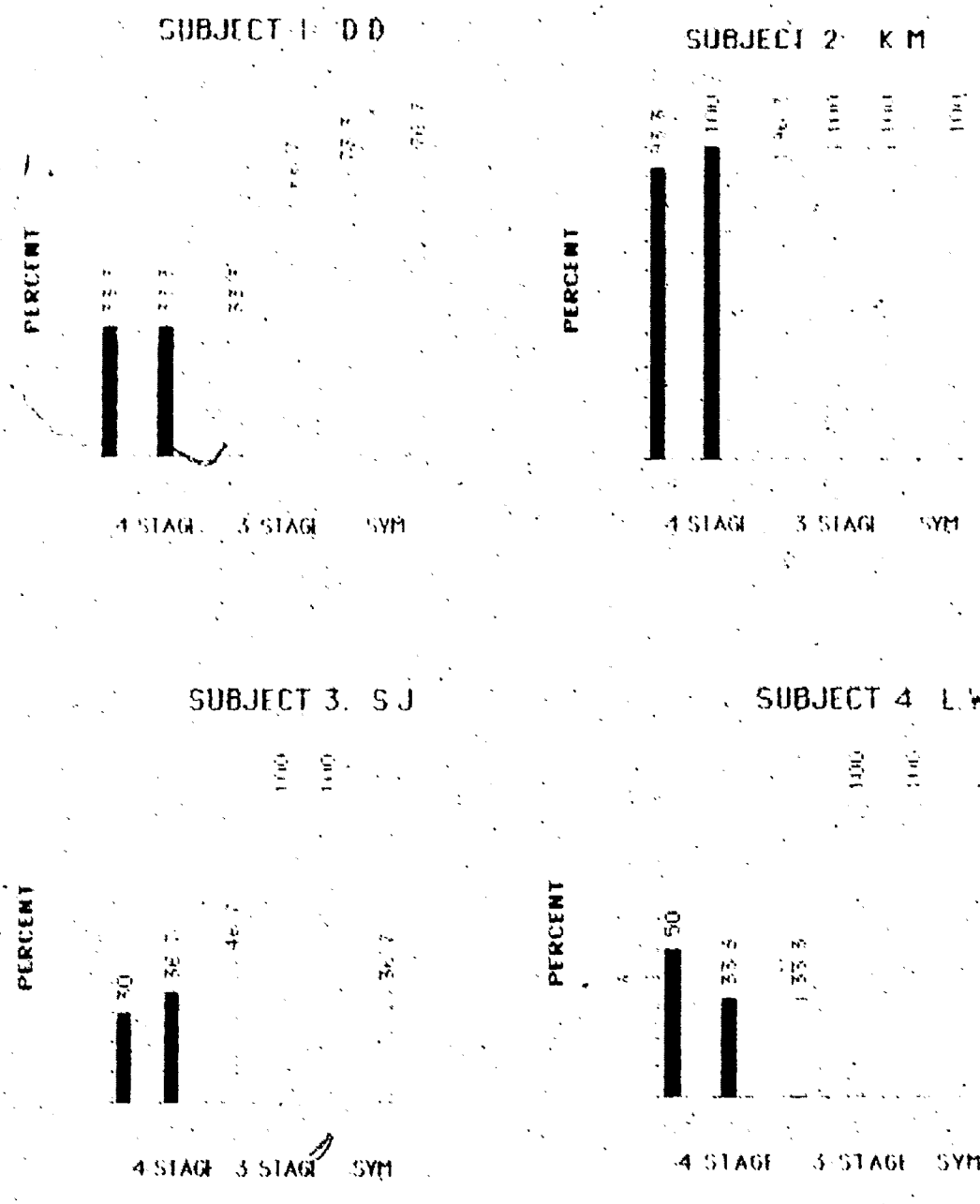


Figure 5. Four-stage (DB and BD), three-stage (AD, BC and CB) and symmetry (CD) probe performances for subjects 1, 2, 3 and 4. Relations DB, BD, AD and CD involved the substitution of adjectives for values

Subject S.J.

Subject S.J. learned the various baseline relations with few difficulties. He achieved the necessary criterion for learning in one set of items in most cases, with the exception of sets AB and DC. His lowest score occurred in the first set of AD items (24/30 or 80%), followed by the first DC set he attempted (28/30 or 93.3%). All remaining sets during the training phase were 100% correct. Subject S.J.'s baseline performance was uniformly excellent throughout the testing phase as well. He made only two baseline errors during the testing sequences.

Subject S.J. was unable to provide evidence of equivalence relations for any of the probe tests involving substitution of faces with words. The four-stage DB and BD tests resulted in him correctly matching D3 with B3 in most cases, but erroneously matching D1 with B2 and D2 with B1. He scored 9/30 (30%) on the DB probes and 11/30 (36.7%) on the BD probes.

In the next test, his 15/30 (50%) score consisted of the correct matching of A3 with D3 for all ten trials, A2 with D2 on the first three trials of that probe type, and A1 with D1 on the first two instances of that particular probe. The remaining probe trials resulted in the pairing of A1 with D2 and A2 with D1.

His perfect scores on both the BC and CB probe tests provided solid evidence for the existence of three-stage equivalence relations.

Once again, however, the CD symmetry test, a test which involves stimulus substitution, failed to demonstrate knowledge of the relation between the adjectives and faces. He scored 11/30 or 36.7% correct. A fine-grained analysis of his errors revealed a similar pattern as

other probe tests. The third member of the probe class of stimuli, D3, was correctly matched with the corresponding sample stimulus, C3. Stimulus C1 was consistently matched with D2, as was C2 with D1.

Subject S.J.'s consistent pattern of responding suggested forms of control that were unrelated to classes of stimuli formed during the training phase. A debriefing session following the experiment revealed that, during the probe phase, he initially formed his own classes by randomly matching a shape with an adjective. Once this pattern was established, he continued with it throughout the experiment. Interestingly, he mentioned that he came to associate the faces with the adjectives during the CD symmetry test, but continued with his original stimulus classes nonetheless. Thus, despite eventual knowledge of the relation between the faces and words, he remained consistent with his own class formation strategy.

Subject L.W.

Subject L.W. was able to demonstrate mastery over each of the explicitly taught relations in one set, with the exceptions of set AB and AC, which required an additional set of items. Her lowest score, 25/30 (83.3%), was obtained on the first trial of set AB. The level of accuracy for baseline items was also high during the testing-for-equivalence phase. She made only three baseline errors throughout the entire course of the testing phase.

During the four-stage DB and BD probe tests, her performance did not reflect the emergence of equivalence relations. She scored 15/30 (50%) on the DB test, with her errors occurring by the matching of B2 with D1, and B1 with D2. Her score dropped to 10/30 (33.3%) during the BD probe test. Here, she always chose D2 in the presence of B1,

and D1 in the presence of B2. Stimulus D3 was correctly matched with B3 on all ten occassions.

Subject L.W.'s 10/30 (33.3%) score on the three-stage AD probe test was a function of the correct matching of D1 with A1 in all ten cases, but the incorrect pairing of D3 with A2 and D2 with A3. It was clear that she was making her choices based on her own set of rules and not on any substitution involving previously taught relations.

The three-stage BC and CB probe tests, which involved only equivalence relations and not any substitutive response, were perfectly done in both cases. Thus, she could in fact demonstrate equivalence so long as no substitution of stimuli was involved.

Interestingly, the CD symmetry test, a test which requires the substitution of faces for words, was also perfectly done. Is it possible that she finally came to realize the word's relation to the faces, and would now be able to demonstrate the more difficult four-stage class formation? Unfortunately, she was unable to stay for further testing to confirm this possibility.

Upon completion of the experiment, however, she mentioned that she had, indeed, associated the nouns with the corresponding faces. Despite this knowledge, she followed her own rules during sets DB, BD, and AD. For example, one such rule might be expressed as follows: "In the presence of the word FUNERAL, chose stimulus B1 since it resembles a casket." Clearly, the results for sets DB, BD and AD can at least be partially explained by her tendency to match a noun to the sample stimulus based on the latter's shape, and not on the previously taught relations.

Subject D.F.

Subject D.F. reached criterion in one set for each of the various types of explicitly taught relations, in each case making only one or no errors. the only exception to this was set AB, in which she scored 24/30 (80%) in the first trial and thus required a second attempt (where a perfect 30/30 score was attained). Further, her baseline accuracy rate remained almost perfect throughout the probe testing phase, with only one item being incorrectly matched.

In the testing-for-equivalence phase, she began the DB probe test by incorrectly chosing B2 in the presence of D1 on six occassions, and B1 in the presence of D2 on four occassions. About halfway through the DB probe test, however, she changed her response pattern such that B1, B2, and B3 were all correctly matched with D1, D2 and D3 respectively. This change in response strategy would seem to suggest an acquisition of the four-stage DB equivalence relations. It is plausible that the pivotal point came when she eventually understood the relationship between the faces and words, and was thereafter in a position to acquire DB equivalence.

The remaining probe tests (BD, AD, BC, CB, and CD) all provided strong evidence for the existence of four- and three-stage equivalence classes as well as symmetrical DC relations. All these test types were done flawlessly, with 30/30 scores in each. Therefore, once equivalence emerged in the DB probe test, she readily demonstrated knowledge of other untaught relations between classes of stimuli. The probe performances of subjects 5, 6, 7 and 8 are shown in Figure 6 (see Figure 6).

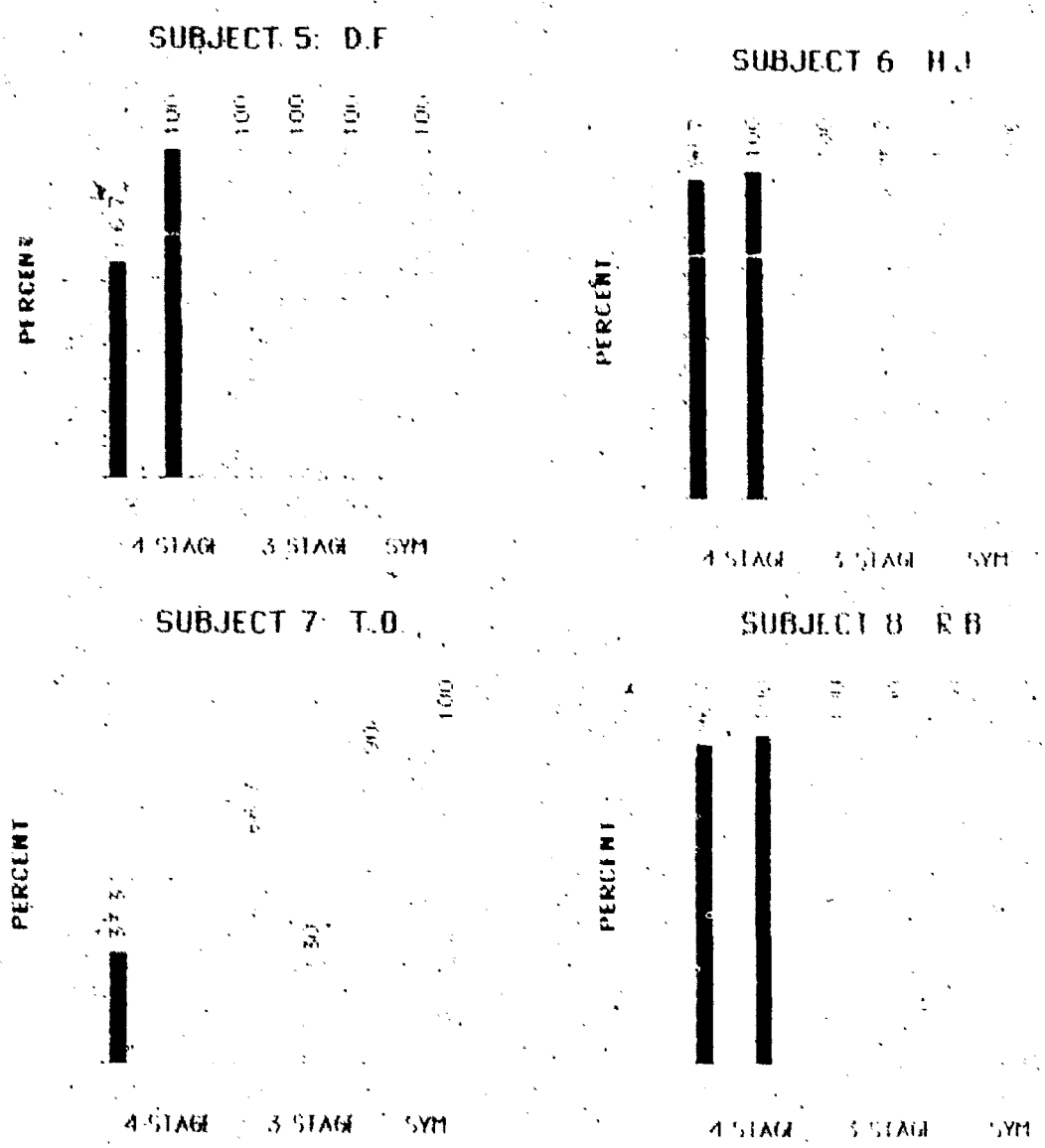


Figure 6 Four-stage (DB and BD) three-stage (AB, BA and [illegible]) and symmetry (CD) probe performances for subjects 5, 6, 7 and 8.

Relations DB, BD, AD and CD involved the substitution of [illegible] faces. Subject 7 (T.O.) scored 90% upon retesting of the BD probe.

Subject H.J.

In the training phase, subject H.J. had some minor difficulties in demonstrating the prerequisite learning. Both the AB and AC sets required two sets of trials before criterion was met. She attained a score of 27/30 (90%) in the first AB set before subsequently scoring 30/30. As well, she scored 24/30 (80%) on her first AC set before scoring 30/30 on the next. The remaining types of relations were learned in one set. During the ensuing probe tests, she maintained an excellent accuracy rate on baseline items, making only one error throughout the entire test phase.

Subject H.J. demonstrated equivalence relations for each test type. In fact, after answering the very first probe test item (in set DB) incorrectly, she got all the remaining probe items in the testing phase correct. She later reported that she connected the faces with nouns after this first probe item error, and was able to correctly match the remaining probe items with relative ease. Clearly, H.J. unequivocally demonstrated the formation of every type of equivalence and symmetrical relation tested during the probe phase.

Subject T.O.

In the training segment of the experiment, Subject T.O. required two sets of items AB and AC. He scored 21/30 (70%) on the first AB set and 28/30 (93.3%) on the the first AC set, after which he demonstrated a satisfactory level of learning. The other sets of explicitly taught conditional discriminations were all done adequately in one trial. Further, no baseline errors were made during probe testing.

The testing-for-equivalence phase resulted in an interesting

sequence of events. He did not provide evidence for the emergence of equivalence relations initially, but acquired it near the latter part of the testing phase. During the debriefing session, he reported that, during those initial sets where words were incorporated into the probe items, he made his choices based on which stimulus shape seemed most closely associated with a particular noun. For instance, during the DB probe test, when the word HOLIDAY (D1) was presented, he chose stimulus B2 because it resembled an oddly-shaped beach towel to him. When FUNERAL (D2) was presented, he chose stimulus B3 because he imagined it to be a coffin. Finally, when TORTURE (D3) apppeared, he also chose B3 because it looked like a device that could inflict pain on others.

He scored 10/30 (33.3%) on the DB test and 0/30 on the BD test. His answers for the BD test were consistent with the DB items outlined above, with the exception that he matched D3 with B1. Why this change of strategy occurred is unclear.

His 20/30 (66.6%) score on the AD test was somewhat of an improvement, although it could not be said to be indicative of equivalence relations. Stimuli A2 and D2 as well as A3 and D3 were correctly matched, whereas A1 was incorrectly paired with D3.

Subject T.O.'s low score on the BC probes (9/30 or 30%) also indicated a failure for equivalence to emerge. He correctly chose comparison stimulus C2 in the presence of sample stimulus B2 on nine occassions. He erroneously matched C1 with B3 and C3 with B1 in ten trials of each and C1 with B2 on one occasion.

The CB test, however, resulted in a 27/30 (90%) score, thus meeting criterion for the existence of three-stage equivalence

relations. It appears as though this probe test might have been a turning point for him in the sense that, from this point on, he was able to demonstrate both equivalence and symmetrical relations.

The CD test for symmetry was perfectly done by subject T.O. As as result of this demonstrated knowledge of lower level relations, he was retested on the DB probes. The results, a 27/30 score (90%), indicated the acquisition of four-stage stimulus equivalence. Thus, the overall pattern of results suggest an absence of equivalence relations initially; however, from the CB probe test onwards, subject T.O. was able to successfully demonstrate symmetry as well as four-stage stimulus equivalence.

Subject R.B.

Subject R.B. learned all of the various types of explicitly taught conditional discriminations in one set of items, with the exception of the AC relations, which required a second set. His accuracy level was 100% for each of the reflexivity, AB, the second AC trial, AB/AC, DC, and AB/AC/DC sets, and 26/30 (86.6%) for the first AC trial. No baseline errors were made during the testing phase.

During probe testing, subject R.B. demonstrated equivalence relations for every probe type. He made one probe error during the DB test, but got every probe item for every test type thereafter correct. His performance provides clear evidence of four- and three-stage equivalency as well as symmetrical relations.

Subject G.C.

Subject G.C. began the experiment by scoring 24/24 on the test of reflexivity. She then obtained a 0/30 score on the first AB set,

for she misunderstood the instructions and did not pay attention to the green and red lights which indicated a correct or incorrect response. Following clarification of the task, she met criterion for the AB relations in two sets. The AC and DC relations also required two sets each, with scores never falling below 26/30 (86.6%). The AB/AC and AB/AC/DC sets were perfectly done in one set of items. She continued to perform flawlessly for the explicitly taught baseline items inserted between probe testing items.

Her performance during the probe phase was demonstrative of stimulus equivalence and symmetrical relations throughout the entire testing sequence. In fact, she never made one error during the entire sequence of probe tests. Probe performance results of subjects 9, 10, 11 and 12 are shown in Figure 7 (see Figure 7).

Subject J.W.

Subject J.W. required two sets of reflexive relations as well as AB and AC discriminations because a satisfactory level of mastery was not shown in the first set. He scored 23/24 and 24/24 on the reflexivity test, 22/30 (73.3%) and 30/30 on the AB training set, and 28/30 (93.3%) and 30/30 on the AC training set. Perfect scores were attained in one trial for the remaining types of relations found in the training phase. As well, he made only one baseline error during the probe testing phase.

Subject J.W. immediately provided evidence of equivalence relations during the probe phase, and scored a perfect 30/30 for each type of relation tested. These results indicate not only stimulus equivalence but, for probe types DB, BD, and AD, the appropriate

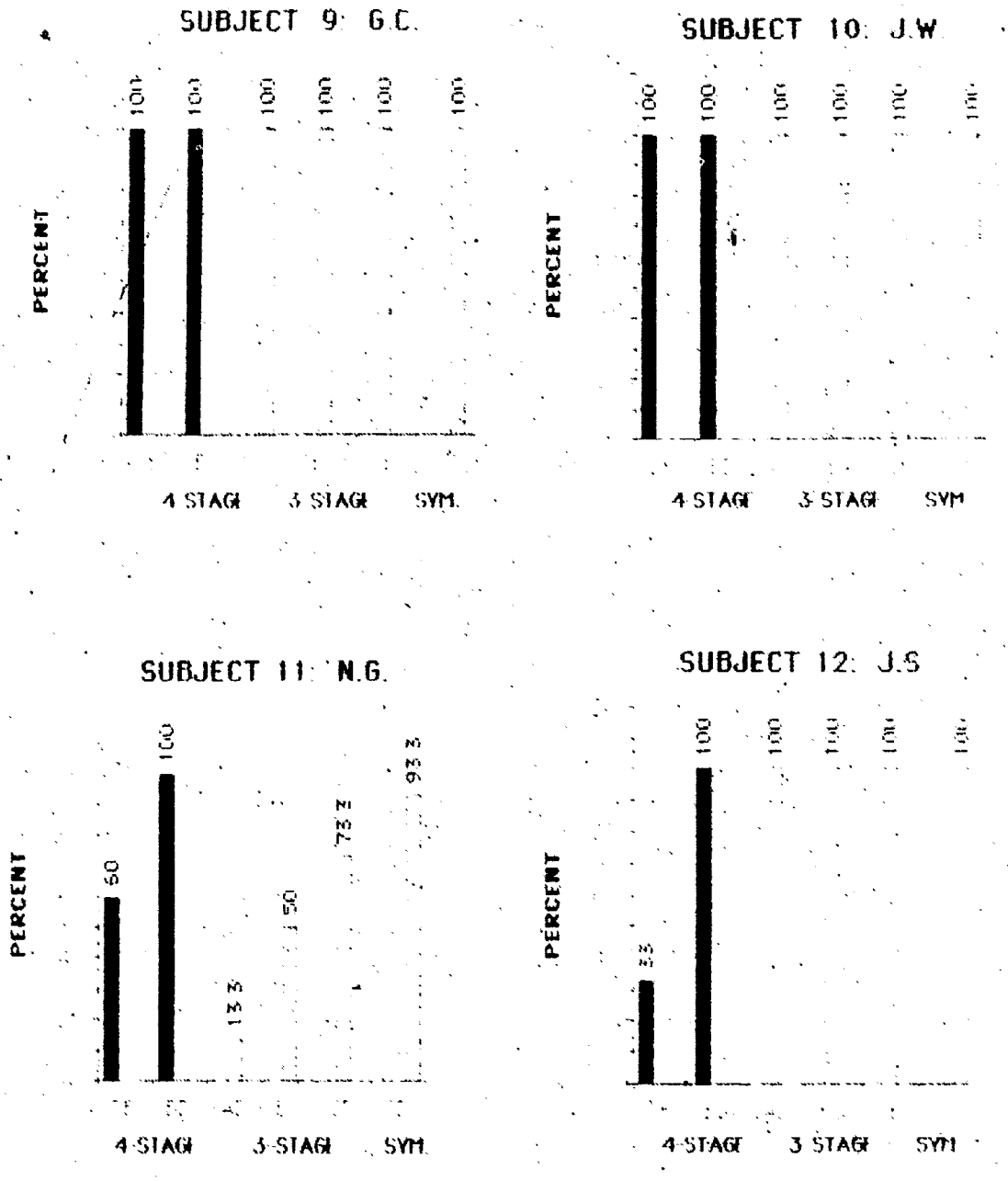


Figure 7. Four-stage (DB and BD), three-stage (AD, BC and CB), and symmetry (CD) probe performances for subjects 9, 10, 11 and 12. Relations DB, BD, AD and CD involved the substitution of adjectives for faces for subjects 9 and 10, and faces for adjectives for subjects 11 and 12.

prerequisite substitution of nouns for faces.

Condition 2 (faces substituted for nouns)

Subject 11: N.G.

Subject N.G. required two sets of explicitly taught conditional relations for sets AB, AC, and DC. She scored 25/30 (83.3%) and 30/30 on set AB, 20/30 (66.7%) and 29/30 (96.7%) on set AC, and 25/30 (83.3%) and 30/30 on set DC. Criteria for the remaining reflexivity, AB/AC, and AB/AC/DC sets were met in one set of items. During the probe testing phase, she made eight baseline errors, resulting in a 97.5% accuracy rate for these explicitly taught items inserted amongst the probes.

The results of her probe tests suggest a response strategy based on random guessing for some tests, or some idiosyncratic relationship between the nonsense stimuli's shape and the face for other probe tests. This was confirmed by the fact that the subject, unsure of herself, often asked about her level of performance between sets. She was told by the experimenter to simply respond in a way that she saw best. She also reported during the debriefing session that she had no awareness of the association between the words and faces until the final CD set. Unfortunately, she was unable to continue the experiment after this point, thus preventing the possibility of retesting for four-stage DB relations.

Her 18/30 (60%) score on the DB probes was the product of a random guessing procedure. In the presence of the D1 probe (i.e., happy face), she chose B1 on four occasions, B2 on three items, and B3 three times. Further, her errors were haphazardly scattered amongst

correct probe reponses, reflecting a lack of any definite answering strategy. When D2 was presented, she chose B1 once, B2 seven times, and B3 twice, again, in a more or less random fashion. She correctly paired B3 with D3 on three occasions.

At first glance, Subject N.G.'s 30/30 performance on the BD probes might be considered indicative of four-stage equivalence. However, other evidence would seem to render any firm conclusions to be premature. First, if she did in fact demonstrate four-stage relations here, then she also would have very likely shown three-stage equivalence and symmetrical relations as well. This was not the case. Second, her queries such as "How do I know if I'm doing O.K.?" indicated a lack of confidence in her problem-solving approach. Most of the subjects who had demonstrated equivalence were for the most part fairly self-assured in their responses, even if they were initially tentative and did not show equivalence earlier. Third, she later reported that she had no awareness of the connection between faces and adjectives until the CD set; therefore, she could not possibly have responded in the way she did because of any previous substitution process. It seems more likely that she continued with the same random approach and by accident happened to answer all the probe items correctly. Thus, although we cannot altogether discount the possibility, however remote, that she did, in fact demonstrate equivalence during the BD probe test, such conclusions cannot be stated with much certainty given the contrary evidence.

For the AD probe test, her answering strategy involved various relationships between the shape of the stimulus and the face. For example, she correctly matched D1 with A2 on the first two trials, but

then chose D3 for the remainder of the test. She later reported that she did this because she imagined an object shaped like A1 falling on someone resembling D3. Further, she erroneously chose either D1 or D3 in the presence of A2. For the items involving sample stimulus A3, she correctly chose D3 on three occassions and D2 on seven trials.

The BC and CB test results again reveal an irregular response pattern. For the BC probe items, she correctly matched B1 and C1 once, but incorrectly chose C2 or C3 for the remaining items. All B2 probes resulted in a correct C2 response. When B3 arose, she chose either C3 or C1. The total score for the BC probes was 15/30 (50%).

Although her 22/30 (73.3%) score on the CB probe test was somewhat improved, her performance did not reflect the emergence of stimulus equivalence. She correctly matched C1 with B1 on six occasions, but erroneously chose B3 four times. Stimulus probe C2 was correctly matched with B2 with the exception of one instance where B1 was chosen. Stimulus C3 was paired with B3 seven times, and with B1 on the remaining three trials.

During the test for symmetry of CD relations, however, her 28/30 (93.3%) score suggested that she finally made the connection between the nouns and facial expressions. This was confirmed by her subsequent report that she now did, indeed, have an awareness of this relationship that had not emerged during previous probe sets. As mentioned above, time constraints did not allow for her to undergo a second examination involving DB probes to investigate the possible development of four-stage equivalence relations.

Subject J.S.

During the training phase, subject J.S. met criterion in one set

of trials for conditional relations AB/AC, AB/AC/DC, as well as the test of reflexivity. Two sets were required for relations AB (25/30 or 83.3%; and 30/30), AC (22/30 or 73.3%; and 30/30) and DC (26/30 or 86.7%; and 30/30). Her baseline performance was excellent throughout the probe testing phase, with only two errors made in the entire sequence of tests.

Following a 10/30 (33.3%) score on the DB probe test, she consistently scored 100% on the remaining four- and three-stage relations as well as the CD test for symmetry. For the DB test, her errors resulted from the matching of B3 pwith D2 and B2 with D3. She later mentioned that she chose the latter combination because stimulus B2 seemed to symbolize the anger shown in the facial expression of D3. Similarly, in the presence of D2 (i.e., sad face), she chose B3 because it resembled a frown turned on its side. Interestingly, she knew about the substitutive function of the faces for the words, but decided to follow her own strategy for set DB nonetheless.

For the remaining probe types involving the substitution of stimuli, however, she replaced the face for the word and consequently demonstrated equivalence. The remaining BC, CB, and CD probe types also resulted in clear evidence of equivalence relations.

Subject B.C.

During the training phase, subject B.C. required four sets before reaching criterion for the AB relations. The AB scores were 19/30 (63.3%), 28/30 (93.3%), 21/30 (70%), and 30/30. Two sets were done for each of AC (24/30 or 80%; and 30/30) and DC (26/30 or 86.7%; and 30/30). Conditional discriminations AB/AC, AB/AC/DC as well as the reflexivity test were done satisfactorily in one set. During the

testing-for-equivalence phase, he made only one baseline error.

Subject B.C. demonstrated stimulus equivalence for every type of probe relation tested. In fact, after making an incorrect choice on the very first DB probe item, he thereafter got every probe of every type of relation correct. Also, the CD symmetry test resulted in a 30/30 score. He later related that, although he went through a trial-and-error pattern of responding during parts of the training phase, he almost immediately substituted the faces for words (for sets DB, BD, and AD) during the test phase, and consequently was able to demonstrate equivalence. Probe performances of subjects' 13-16 are illustrated in Figure 8 (see Figure 8).

Subject A.G.

After successfully completing the reflexivity test in one set, subject A.G.'s performance during the training phase was as follows: set AB - 27/30 (90%) and 30/30; set AC - 28/30 (93.3%) and 30/30; set AB/AC - 30/30; set DC - 27/30 (93.3%) and 29/30 (96.7%); and set AB/AC/DC - 45/45. Further, baseline items interspersed between probe items during the testing phase were all done correctly.

During the DB test of the probe phase, subject A.G. initially did not show evidence of equivalence. Eight of the first ten probe items were answered incorrectly. He did, however, respond to the remaining probe items correctly for a final score of 22/30 (73.3%). Thus, his performance on the DB probes reflect an acquisition of learning of 4-stage equivalence relations.

He continued to demonstrate stimulus equivalence throughout the remainder of the test phase, with perfect 30/30 scores for each of

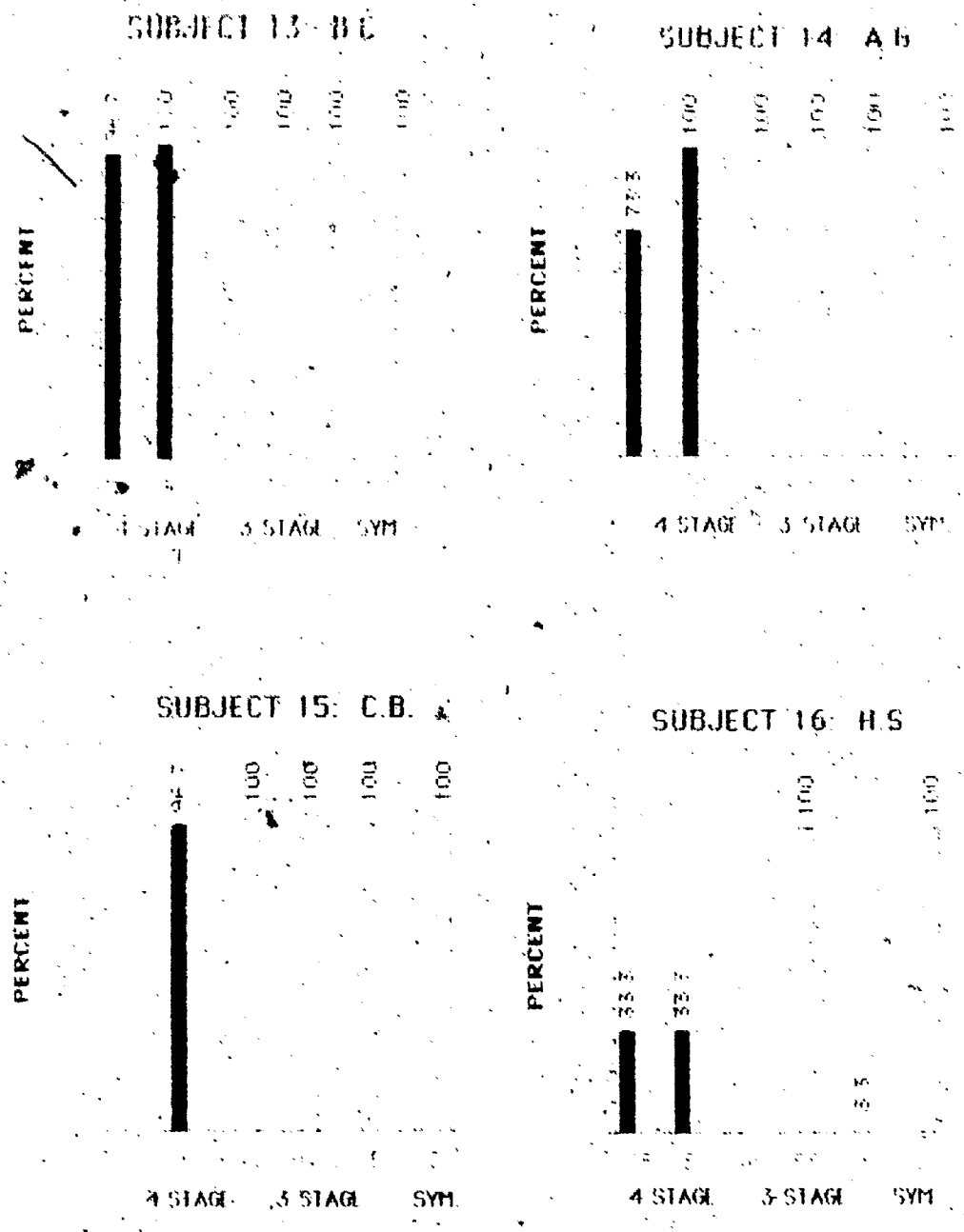


Figure 8. Four-stage (DB and BD), three-stage (AD, BC and CB) and symmetry (CD) probe performances for subjects 13, 14, 15 and 16. Relations DB, BD, AD and CD involved the substitution of faces for adjectives. Subject 16 scored 30% upon retesting of the DB probes.

probe sets BD, AD, BC, and CB. He also gave evidence for knowledge of the symmetrical relations CD with a 30/30 score.

Subject C.J.

During the explicitly taught training relations, Subject C.J. had scores of 13/30 (43.3%) and 30/30 for set AB; 18/30 (60%), 26/30 (86.7%), and 30/30 for set AC; 27/30 (90%) and 30/30 for set AB/AC; 29/30 (96.7%) for set DC; and 45/45 for set AB/AC/DC. She maintained a high baseline accuracy rate during the probe trials, making only one baseline error throughout the entire test phase.

During the first AD probe test, she did not answer one probe item correctly. She later reported that her matching of D1 with B2, D2 with B3 and D3 with B1 was based on an arbitrary pairing of a given face with a particular shape.

During the next probe test, however, she gave evidence of stimulus equivalence with a 29/30 (96.7%) score. It was here that she realized the substitutive relation between the nouns and faces. Three-stage equivalence relations were also demonstrated, with perfect scores in probe tests AD, BC and CB.

After obtaining a 30/30 score on the CB test for symmetry, subject C.J. was given the AD test again. This was done to examine her ability to demonstrate equivalence by first making the appropriate substitutions. She clearly demonstrated the acquisition of equivalence with a perfect 30/30 score.

Subject H.S.

Subject H.S. successfully completed the reflexivity items in one set, as well as training sets AC, AB/AC, and AB/AC/DC. The remaining

relations required two sets: AB (24/30 or 80%; and 30/30), and DC (26/30 or 86.7%; and 30/30). There were two baseline errors made during the probe phase.

Subject H.S. failed to demonstrate four-stage equivalence relations. She did not make the word-to-face substitution in any of the sets requiring such a manipulation. Instead, she made her own associations between a given face and a stimulus shape. For example, her 10/30 (33.3%) on DB probes reflected the correct matching of D3 with B3, but the incorrect pairing of D1 with B2 and D2 with B1. She later explained that the face in D1 reminded her of a movie star, so she matched that particular face with the star-shaped B2 stimulus. Further, she associated the sad face in D2 with the flask-shaped B1 stimulus and would tell herself that this person did not want to study chemistry. The correct matching of D3 with B3 was not due to any substitution process, but to the pairing of the "ugly face with the ugly shape." This pattern of responding continued throughout the BD set as well, where she also scored 10/30 (33.3%).

She then scored 0/30 on probe test AD. Here again, her responses were derived by chosing a shape that seemed to correspond to the face in some way that was meaningful to her. She imagined that the gun-shaped stimulus of A2 was being pointed to the head of person D3, and that the flask-shaped A1 stimulus was contributing to D2's unhappiness. She matched the remaining D1 stimulus with A3.

For the BC probe test, she performed at a 100% accuracy rate, suggesting three-stage equivalence relations. However, she scored only 10/30 (33.3%) on the ensuing CB probe test. Why this is so is not clear. One possible explanation is that, due to several episodes

of equipment malfunctions during this time, she lost her previous train of thought and responded using a different strategy as before. This failure to demonstrate knowledge of symmetrical relations between BC and CB lends only partial support to any claims that she formed three-stage equivalency.

Her 30/30 on the CD probe test of symmetry led the experimenter to give her a retest of the AD probe. This was done on the assumption that perhaps she finally made the connection between the words and faces, and could now demonstrate the emergence of four-stage relations. Unfortunately, such was not the case, as she again reverted back to the same strategy as the initial DB probe test and scored 10/30. Thus, it was evident that she never associated the faces with the nouns and consequently was unable to form equivalence relations for those probe types requiring substitution. This was confirmed during the debriefing session following the experiment.

Subject N.S.

Subject N.S. demonstrated mastery of the reflexivity test (24/24) and relations AC (30/30), AB/AC (30/30), and AB/AC/DC (45/45) in one set. Relations AB (25/30 or 83.3%; and 30/30) and DC (27/30 or 90%; and 30/30) required two sets before criterion was reached. His baseline performance during the probe phase was excellent, with no errors being made on any explicitly taught items.

Subject N.S. did not demonstrate equivalence relations for any probe type contingent on stimulus substitution. A fine-grained analysis of his 9/30 (30%) score on the DB probes revealed that all nine correct matches involved D2 with B2. He consistently matched D1 with B3, and D3 with B1 for the remaining probe items.

His 15/30 (50%) score on the BD probes was the result of the correct pairing of all ten B2D2 items, as well as an initially correct matching of B1 with D1 on the first two occasions. After scoring nine of the first ten probe items correct, subject N.S. changed back to the same response strategy as in the DB probes. He later mentioned that, although his answers were correct initially, he felt unsure of himself and reverted back to his previous response pattern.

The three-stage AD probes also provided no evidence for the acquisition of equivalence relations. His 10/30 (33.3%) score was the product of the correct matching of A2 with D2, but the erroneous pairing of A1 with D3 and A3 with D1.

Subject N.S. did, however, demonstrate equivalence relations for probes where stimulus substitution was not necessary. Perfect scores were obtained for both BC and CB probes.

When he was tested with CD probes, however, he again remained consistent with his previous response patterns. He answered all C2D2 items correctly, but paired C1 with D3 and C3 with D1 for a score of 10/30 (33.3%). Interestingly, he later reported that he realized the nouns and faces were related during this set, but retained his response strategy to maintain consistency with his previous responses. Performance on the probe relations for subjects' 17-20 are presented in Figure 9 (see Figure 9).

Subject S.C.

During the training segment of the experiment, subject S.C. needed only one set of reflexivity items, as well as AB/AC and AB/AC/DC training relations before reaching criterion. Two sets were

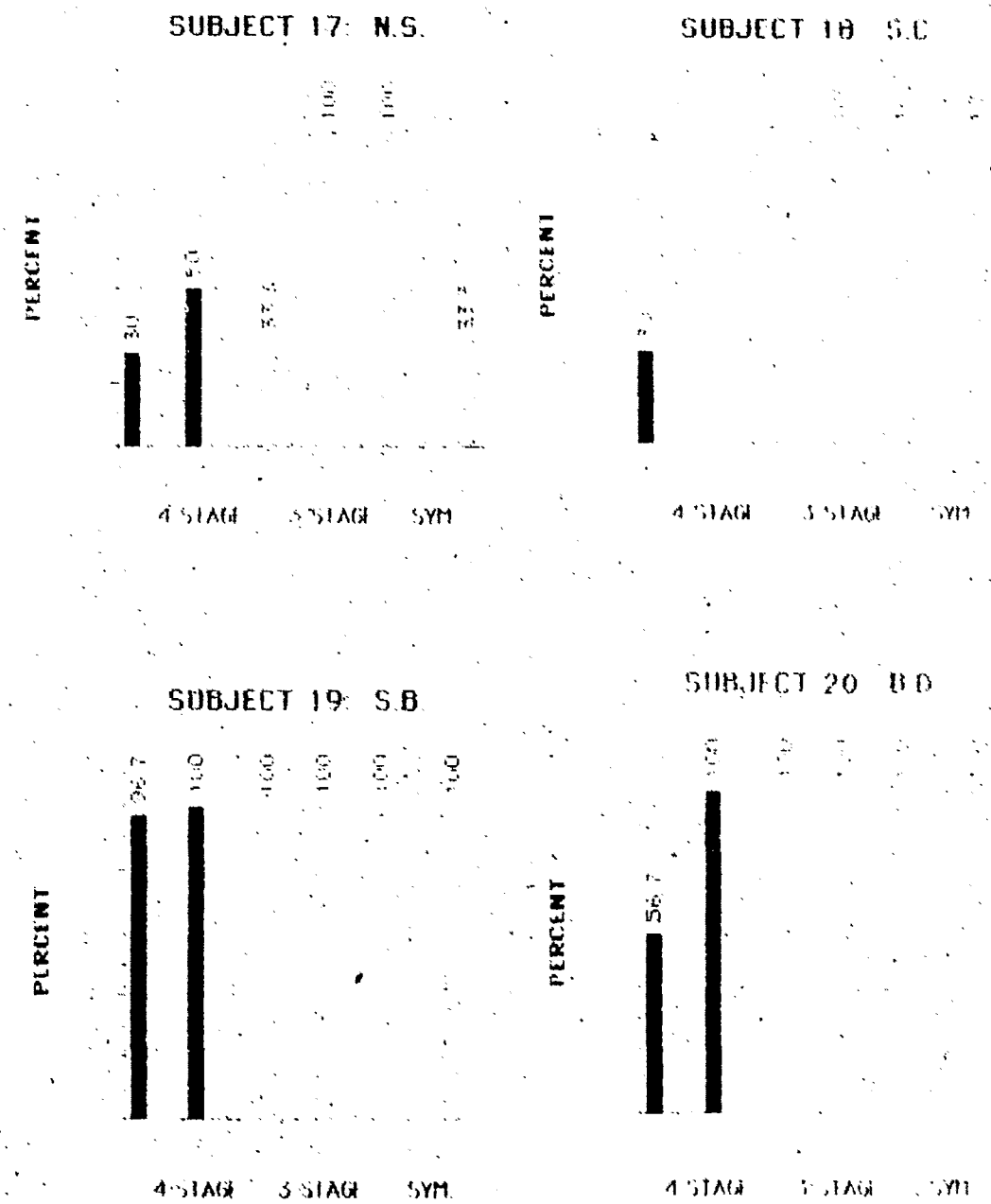


Figure 9. Four-stage (DB and BD), three-stage (AD, BC and CB) and symmetry (CD) probe performances for subjects 17, 18, 19 and 20. Relations DB, BD, AD and CD involved the substitution of [illegible] objectives. Subject 19 scored 20% upon retesting of the DB or BD

required for relations AB (18/30 or 60%; and 30/30), AC (28/30 or 93.3%; and 30/30) and DC (27/30 or 90%; and 30/30). His performance on baseline items inserted between probes during the testing-for-equivalence phase resulted in no errors being made.

Subject S.C. did not demonstrate equivalence relations for probes DB, BD, or AD -each of which required the appropriate substitution of faces for adjectives for successful completion. His performance on the DB probe test produced 9/30 (30%) probe items correct. As with the other subjects who failed to demonstrate equivalence for relations requiring substitution, his responses were a function of his own idiosyncratic rules for matching faces to nouns. For example, he tended to pair D1 with B1 because both the sad face (D1) and D1 had a round appearance. Stimulus D2 (smiling face) was matched with B3 because B3, if rotated 45 counterclockwise, resembled a smile to him. Finally, D3 (i.e., angry face) and B2 were paired because the pointed sides of B2 reminded him of the grimace found in D3's facial expression.

His response strategy changed somewhat during the BD probes. Responses were again based on some relationship between the stimuli's shape and the facial expression. His 0/30 score was the result of a matching of B1 and D2, B2 and D3, and B3 and D1.

For the AD probes, A2 and D3 were matched because the gun-shaped A2 stimulus seemed to logically go together with the angry face of D3. Stimuli A3 and D1 were paired since A3 "looks like an ear, and you could see this person's (i.e., stimulus D1) ear the best." Lastly, A1 and D2 were matched simply because they were the only two leftover stimuli. He scored 0/30 on the AD probes.

Subject S.C. did demonstrate three-stage BC and CB relations with a perfect score for each. This finding is not surprising, since neither relation type requires any stimulus substitution.

His 30/30 score on the CD test of symmetry on the surface suggested that he was finally putting the faces in place of the corresponding adjectives and making the correct selection. With this in mind, he was retested on the DB probes. His 6/30 (20%) score on the DB test failed to confirm this hypothesis, however.

The reason for the non-emergence of four-stage equivalence relations upon retesting is straightforward. His perfect CD score was not the result of any substitution process, but of a response strategy once again based on stimulus shape. It was purely coincidental that he happened to match any stimuli together correctly. He later mentioned that the C1D1 pairing occurred because the person in D1 seemed to be daydreaming, and stimulus C1 resembled an ethereal symbol. Stimuli C2 and D2 were matched because the smile-shaped C2 was the opposite of the frown found in D2. Stimuli C3 and D3 were paired because subject S.C. envisioned the angry looking person using a guillotine (i.e., C3).

Subject S.B.

After demonstrating reflexivity in one set, subject S.B. was taught the explicit training relations. Her scores were as follows: AB (25/30 or 83.3%; and 30/30), AC (23/30 or 76.7%; and 30/30), AB/AC (30/30), DC (26/30 or 86.7%; and 30/30), and AB/AC/DC (45/45). She made only one baseline error during the probe testing phase.

During the test-for-equivalency phase, subject S.B. demonstrated equivalence relations for each probe type. After incorrectly

answering the first probe item on the DB test, she performed flawlessly for the remainder of the experiment. She later mentioned that she almost immediately connected the faces to the nouns, and therefore was able to demonstrate equivalence for those tests requiring substitution as well as the regualar probe items.

Subject B.D.

The training phase went smoothly for subject B.D., with criterion being met in one set for all relations except for set AB, which required two sets. The scores were, in order: reflexivity (24/24), AB (28/30 or 93.3%; and 30/30), AC (29/30 or 96.7%), AB/AC (30/30), DC (30/30), and AB/AC/DC (45/45). His baseline performance was maintained at a high level of accuracy throughout the probe phase, with only two errors made.

His score on the DB probe test did not suggest the emergence of equivalence relations. Although he correctly matched D1 with B1 on nine occasions and D3 with B3 on eight trials, his response pattern was generally random in nature. He later mentioned that the presence of the faces initially confused him, and he responded on a trial-and-error basis. Approximately halfway through the DB test, however, he realized the faces were related to the nouns, yet retained his original pattern of responses to maintain consistency.

The following set, BD probes, produced evidence of appropriate stimulus substitution and the consequent four-stage equivalence relations. He scored a perfect 30/30 on the BD test probes.

Further, he continued to demonstrate stimulus equivalence or symmetry for the remaining AD, BC, CB, and CD relations. All these probe tests were perfectly done, with 30/30 scores in each.

Discussion

The development of equivalence relations for DB, BD, AD, and CD probes required the subjects to first engage in an implicit response before they could demonstrate transitivity (or symmetry for CD relations). In other words, the only way equivalence could have been successfully shown for these four probe types was for the subject to make a prerequisite substitution of the words for the corresponding faces or vice versa, depending on the experimental condition. This was the case, without exception, in this experiment. Those individuals who were able to make this substitution demonstrated correct DB, BD, AD and CD relations with little difficulty. Those who never made this substitution provided no evidence of emergent equivalence relations.

To recapitulate, seven of ten subjects in Condition 1 acquired 4-stage relations. An eighth subject, L.W., was in a position to show potentially acquired 4-stage equivalence relations but did not due to time constraints. Two subjects, D.D. and S.J., never associated the faces to the words and therefore did not demonstrate equivalence for relations involving substitution.

For Condition 2, although seven subjects demonstrated 4-stage relations, one of these subjects, N.G., could not be said to have conclusively shown this type of equivalency for reasons mentioned earlier. This subject, who finally demonstrated knowledge of the relation between the words and faces during the CD symmetry test, may have provided more decisive evidence of 4-stage equivalency had she been able to stay for retesting of the DB probes. An eighth subject, N.S., reported that he had realized the connection of the substitute

simuli to the original, yet maintained his established pattern of responding nonetheless. The remaining subjects, H.S. and S.C., performed in a manner that suggested no knowledge of the substitution process.

The results indicate that symmetry and equivalence can emerge even with stimuli that only share functions with training stimuli and are different in physical topography. Equivalence formation can occur even when a stimulus entirely different in form takes the place of the original. The original and substitute stimuli must have some shared function, however (Parrott, 1986). The original Set D stimuli used in training must have transferred their stimulus functions to the substituted Set D stimuli as a result of their partial functional identity.

This transfer in stimulus function can be understood in terms of symbolic activity. Devany et al. (1986) suggest that stimulus equivalence is closely related to symbolic activity. The etymology of the word "symbol" comes from the root words meaning "together" and "to throw." Symbols, then, can be conceptualized as stimuli that are "thrown together" with other stimuli. The stimuli in this study, including the substitutes, were symbolic in the sense that one was representative of the others and vice versa in a particular equivalence class. The fact that the implicit reactions took place in the presence of a substitute stimulus makes it reasonable to assert that the substitute became symbolic of the original object. Stated differently, the testing phase required the individual respond to a stimulus which was representative of the absent original stimulus. For example, the noun HOLIDAYS and the photograph of the happy face

became interchangeable for those subjects who demonstrated equivalence involving these stimuli. In Condition 1, the nouns were representative of the faces. In Condition 2, the faces were representative of the nouns.

The implicit responses were precurrent reactions which brought into operation the next segment of behavior, namely, the overt act of matching the comparisons to the sample stimuli. The demonstration of equivalence can be seen as the final adjustment in a segment of behavior, a segment which required the implicit response to serve as an intermediary between the presentation of the substitute stimulus and the observable act of choosing the correct comparison.

One advantage of the present study's experimental approach in examining implicit behavior is that it allowed for the control of the individual's history of contacts with the environment. The observation of the subjects' responses under various stimulating conditions during the training and testing phases enabled one to better understand and predict the nature of their implicit responding. This approach also allowed for the control of the substitute stimuli with which the subjects interacted.

As a result, the stimulus phase of the implicit response could be readily identified in those subjects who demonstrated DB, BD, and AD equivalence and CD symmetrical relations. The stimuli in these cases were the nouns in Condition 1, and the faces in Condition 2. In both cases, the substitutions were representative of the original Set D stimuli reacted to during the training phase of the study.

In addition, there were few differences regarding the rate of acquisition of equivalence between the two experimental conditions. A

total of seven subjects in Condition 1 and six in Condition 2 either immediately or eventually demonstrated equivalence involving substitution of stimuli. As well, an additional subject in each condition gave evidence of an awareness of the relation between the original and subsitute stimuli during the CD symmetry test, yet were unable to stay for retesting of higher-level relations. Two individuals in each condition were unable to provide evidence for equivalency that involved substitution.

One minor difference between the two groups was that five subjects (K.M., H.J., R.B., G.C., and J.W.) in Condition 1 (nouns substituted for faces) showed immediate emergence of equivalence (i.e., during the DB probe test), whereas only two subjects (B.C. and S.B.) in Condition 2 (faces substituted for nouns) demonstrated equivalence right from the start of the testing phase. It is difficult to ascertain exactly why this occurred. One possibility is that the stimulus substitution required in Condition 2 was a less likely event (as a result of the historically developed relations) than that required in the first condition. Also, the difference may have been a function of individual subject differences between the two groups. Specifically, a greater number of subjects in Condition 2 acquired equivalence more gradually during the test phase as compared to those in Condition 1. This "acquisition effect" has been noted in other equivalence studies as well (e.g., Devany et al., 1986; Sidman et al., 1985).

The implicit behavior of interest in this study occurred in the presence of the substitute stimulus. It is impossible to identify the precise nature of the "private" experience each person had while

interacting with the probe substitutes. Nonetheless, it can be deduced that, for those who successfully demonstrated equivalence (and even for one subject, N.S., who did not but was aware of the substitutive relations among the stimuli), at least some part of their implicit reactions must have included an association of a symbol (i.e., the substitute) to its referent (i.e., the original stimulus).

A parenthetical point made above raises an interesting question. Why did subject N.S. maintain an incorrect answering strategy when he eventually realized the relatedness between the original and substitute items? Part of the answer might lie in the fact that subject N.S. may not have emitted a response which was congruent with the intended covert substitution process because some self-generated rule was at strength, for example. Zettle & Hayes (1982, p. 78) define rule-governed behavior as "behavior in contact with two sets of contingencies, one of which includes a verbal antecedent. These verbal antecedents are rules." In the case of subject N.S., one set of contingencies were related to the overt behavior of interest -choosing the comparison stimulus. The second set was a self-generated verbal instruction. Based on his pattern of responses, some of his self-generated rules might have been similar to the following: "In the presence of the word HOLIDAY, choose the stimulus that looks like an umbrella (i.e., B3). In the presence of the word TORTURE, choose the stimulus that resembles a coffin (i.e., B1)," and so on.

The responses of those subjects who did not engage in the intended substitution of the original stimuli, and who consequently did not demonstrate equivalence, can also be explained in terms of self-generated rule-governed behavior. In most cases, the pattern of

responding was remarkably consistent, suggesting some form of self-instruction. Because self-rules are often covert in nature, it is difficult to unambiguously decipher their exact nature. Nonetheless, the subjects' verbal reports following the experiment provided some insight regarding the form of the rules. These rules almost inevitably involved matching a substitute stimulus to the shape of one of the nonsense stimuli in some personally relevant manner.

For instance, subject T.O. stated that he paired D1 (HOLIDAY) with B2 because "B2 looked like a funny-shaped beach towel that you might take on a vacation." This same subject matched D2 (FUNERAL) with B3 because "B3 looked like a strange coffin in which someone might be buried." He also chose B3 in the presence of D3 (TORTURE) because the shape of B3 "resembled an instrument that might be used to torture someone." Subject H.S. had self-instructions for her consistent pairing of B2D1 that might be stated as: "Stimulus D1 reminds me of a movie star. Therefore, in the presence of the star-shaped stimulus B3, chose D1." Her matching of B1 with D2 possibly involved the following rule: "People generally do not like to study chemistry. Therefore, in the presence of the flask-shaped object B1, chose D2."

Clearly, those subjects who did not demonstrate equivalence for relations involving substituted Set D stimuli responded as they did for a common reason. They tended to form their own classes based on an idiosyncratic matching of the shape of a given nonsense stimulus to a particular substitute stimulus. Although care was taken to ensure the stimuli in Sets A, B and C were as "meaningless" as possible, the physical topography of these items was nonetheless given more importance by these particular subjects than was intended by the

experimenter. The paradigm used in this study might be improved if different abstract shapes were to be used, shapes which had less potential for the subjects to derive some image or meaning from them. This perhaps would have resulted in a decreased likelihood that the pairing of a substitute with another stimulus would be based on some relationship between the latter's shape and the substitute stimuli.

It is also possible that these subjects failed to demonstrate equivalence because, for them, the nouns did not correspond to the facial expressions in a way that is intuitively recognizable to most people in our culture. That is, perhaps these subjects' individual experiences with funerals, holidays and/or torture were different from those of the majority of people. For example, one subject may have at one time experienced a sense of peace during a funeral; his or her responses during the probe phase may consequently have reflected this prior history with funerals. In these cases, individual differences may have overridden any culturally-defined associations between the nouns and faces.

Another methodological point should be considered. Since the order of the comparison stimuli remained constant throughout the experiment, there is a possibility that a position effect might have influenced responding. Although none of the subjects reported basing their answers on the position of the comparisons as they appeared on the screen, this does not negate the possibilty of the occurrence of such an effect.

A spinoff of stimulus substitution experiment is worthy of mention. As outlined above, a main finding was that substitute stimuli could enter into various equivalence classes, even though the

subjects had not seen them in this context before the testing phase. The substitutes and the original stimuli were effectively interchangeable (otherwise the substitution and resulting equivalence would not have occurred). Although not directly tested here, it is reasonable to assume that equivalence relations would have also been demonstrated if the original stimuli were used as probes during the testing phase (much like a typical equivalence experiment). If so, one can readily see how implicit responding or, more specifically, historically associated events have the potential to increase the number of equivalence classes considerably.

To illustrate, the subjects were taught nine conditional discriminations in the training phase (i.e., three groups of three stimuli each, derived from explicitly taught relations AB, AC and DC). This resulted in 30 new conditional discriminations that were not previously taught (ten groups of three stimuli each, derived from untrained relations DB, BD, AD, BC, CB and CD. Note that those probe relations involving Set D stimuli now includes both the original and substitute stimuli entering an equivalence class). The ratio of emergent to explicitly taught relations is 30/9. This ratio would be 18/9 if only the original stimuli were to enter equivalence classes. The implication of this finding is that an equivalence class has the potential to become greatly enlarged should one stimulus take on a substitutive function for the original stimulus. Further investigation, perhaps involving probe substitutes for more than one set of stimuli, might clarify just how much potential implicit responding has on enlarging equivalence classes. This would help explain our capacity to develop some of the exceedingly complex and

intricate networks of equivalence relations operating in our everyday lives.

The results of this study also have some bearing on pychopathology. Our thoughts, beliefs, feelings and plans have a characteristic property of being, for the most part, verbal in nature. It is customary for humans with language ability to share their private events in a verbally sensible form. Stimulus equivalence indicates that humans can learn [redacted] arbitrary stimuli, such as those which are verbal in nature, can symbolize other stimuli (Devany et al., 1986).

In the present experiment, the process of substituting one stimulus for another can be conceptualized as the attachment of a label (a noun) to a face in Condition 1, and vice versa in Condition 2. Thus, HOLIDAYS became associated with a smiling face, FUNERAL with a sad one, and TORTURE with an angry face. Further, this substitute was able to enter into equivalence relations with other stimuli as though it were the original stimulus.

Common experience dictates that people regularly engage in a similar, although more elaborate, process of giving labels to various objects, events, and even other people in their lives. Most of us are inclined to interpret and categorize situations in an attempt to better understand our world. Moreover, the verbal community reinforces our attempts to evaluate events that occur around us. We are often asked by others "What do you think of..." or "How do you feel about..." Of course, there is nothing inherently wrong with sharing one's opinions and feelings about a given topic. The point is, however, that through this encouragement by the verbal community

to interpret our world, it is relatively easy to lose sight of the simple fact that our interpretations are just that -interpretations. They are not the object or event to which the label was directed. It is when evaluations are distorted, inaccurate, and consume too much attention that psychological problems inevitably become manifest (Beck & Emery, 1985; Hayes, 1987; Meichenbaum; 1977).

Hayes (1987) points out that the stimuli in an equivalence class can be loosely related, whereby the stimuli, although related to one another, are often functionally distinct from each other in many situations. Conversely, an equivalence class can also be tightly related, where each stimulus can be easily exchanged for each other in most circumstances. Further, the arbitrary nature of verbal stimuli, such as those involved in labeling events, typically results in the development of tight equivalence classes.

It is this tightness of an equivalence class that can lead to problems. The equivalence classes between one's implicit behaviors and the world can become so closely related that it becomes difficult to distinguish between the evaluations and the actual objects and events per se. The labels and the various stimuli that recieve these labels essentially become interchangeable. This phenomenon is particularly debilitating when the labels are of a catastrophic nature (Beck & Emery, 1985). Thus, this person is perceived as "bad," that speech as "horrifying," and this predicament as "hopeless." The more one's private thoughts are taken literally and left unquestioned regarding their accuracy, the tighter will be the equivalence class.

There is good reason for equivalence classes to at times involve tight relations amongst stimuli. This is the case, for example, when

someone makes a simple, non-evaluative statement such as "the book is on the table." This description presents little problem if taken literally. It is simply a description of stimuli in the environment.

The scenario changes considerably, however, if an evaluation is included in the statement. For example, one might say "there is a really good book on the table." This statement cannot in its entirety be taken literally because there is no stimulus "good" present in the situation. The notion of "goodness" arises from that person's reaction and evaluation of the book, and not from any topographical feature of the stimuli. It is fairly easy to lose awareness of the distinction between these two types of statements. In the first example, the book itself was described whereas the second illustration included an interpretation of the book. The latter statement can potentially be confused with the first, understood as factual, and taken quite literally. An evaluation of an object has now become part of a tight equivalence class.

This phenomenon can be translated to a clinical example. Most people are able to determine fairly rapidly whether a stimulus, such as the presence of physiological arousal after hearing a sudden, loud noise, is a signal of real danger. They are likely to label this arousal as insignificant or simply ignore it altogether. The level of arousal would soon diminish and return to normal. In contrast, individuals with Panic Disorder are likely to fixate their attention on this arousal and interpret it as a danger signal. Their implicit response might be: "My heart is racing, I've got sweaty palms, and I feel tense. Something's wrong with me. I can't handle this. Maybe I'm having a heart attack. I'm going to die." The result of this

evaluation is an exacerbation of their physical arousal, which in turn leads to more fearsome thoughts and a continued escalation of symptoms. In reality, rarely do events themselves cause stress. Rather, it is the evaluation bestowed upon the event and the attention given to this interpretation that leads to a stress reaction (Beck & Emery, 1985; Meichenbaum, 1977).

Obviously, the sorts of implicit responding demonstrated in this study are comparatively simple when contrasted with the tremendously complex private reactions of which humans are capable. Confounding matters are problems of observation, identification, and analysis. Nonetheless, these obstacles to a more complete understanding of complex implicit behaviors must not impede an empirical analysis of these events.

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