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DISTINGUISHING BETWEEN DISCRIMINATIVE AND MOTIVATIONAL FUNCTIONS OF STIMULI

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A discriminative stimulus is a stimulus condition which, (1) given the momentary effectiveness of some particular type of reinforcement (2) increases the frequency of a particular type of response (3) because that stimulus condition has been correlated with an increase in the frequency with which that type of response has been followed by that type of reinforcement. Operations such as deprivation have two different effects on behavior. One is to increase the effectiveness of some object or event as reinforcement, and the other is to evoke the behavior that has in the past been followed by that object or event. "Establishing operation" is suggested as a general term for operations having these two effects. A number of situations involve what is generally assumed to be a discriminative stimulus relation, but with the third defining characteristic of the discriminative stimulus absent. Here the stimulus change functions more like an establishing operation than a discriminative stimulus, and the new term, "establishing stimulus," is suggested. There are three other possible approaches to this terminological problem, but none are entirely satisfactory.

Key words: stimulus control, establishing operation, establishing stimulus, deprivation, reinforcement

BACKGROUND CONCEPTS

Technical Terminology

Skinner (1957, pg. 430) described a three-stage process in the development of scientific verbal behavior: first, more effective forms of verbal behavior are discovered; these are then explicitly adopted and encouraged by the relevant technical and scientific community; finally, these verbal practices are themselves critically examined and altered to overcome what seem to be inadequacies or limitations. This paper fits into the third state of this process. Our way of talking about operant stimulus control seems to include but fails to distinguish between two quite different forms of control. We might improve our verbal practices by adopting a new technical term for one of these forms of control or at least by explicitly recognizing the problem. But before dealing with this issue it is necessary to refine the concept of the discriminative stimulus or S^D and to review the way deprivation affects behavior.

The Discriminative Stimulus

It seems in keeping with current usage to describe the presentation of a discriminative stimulus, or the change from S^Δ to S^D, in terms of three defining features. It is a stimulus change which, (1) given the momentary effectiveness of some particular type of reinforcement[1] (2) increases the frequency of a particular type of response (3) because that stimulus change has been correlated with an increase in the frequency with which that type of response has been followed by that type of reinforcement. (Frequency of reinforcement is the most common variable used to develop the discriminative stimulus relation. However, this relation

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[1]It would be more in keeping with current practice to make frequent use of the term "reinforcer," rather than "type of reinforcement" or "form of reinforcement," etc. However, I have argued in another paper (Michael, 1975) that "reinforcer" implies a static event, which cannot have the behavioral implications that "reinforcer" appears to have. "Reinforcement" properly implies stimulus *change*, and only change can function as a consequence for behavior. Therefore throughout this paper "reinforcer" is deliberately avoided.

can also be developed on the basis of reinforcement quantity or quality, the delay to reinforcement, the response requirement or effort, and other variables.) The first feature is sometimes taken for granted but for the present purposes it is better to be explicit: S^Ds do not generally alter response frequency when the organism is satiated with respect to the type of reinforcement relevant to that S^D. The second feature is important in distinguishing behavioral from cognitive accounts of stimulus control, where the stimulus supposedly "signals" the availability of reinforcement, without any direct implication for any particular type of behavior. Whereas the first two features describe the controlling relation once it has been developed, the third identifies the relevant history and thus makes possible a distinction between the operant discriminative stimulus and the unconditioned and conditioned stimuli of the respondent relation. There are a number of situations involving what is generally taken to be an S^D because the relation seems so obviously operant rather than respondent, but where the third defining feature is clearly absent. An attempt will be made to show that in some of these situations the stimulus change is functioning more like a motivational operation such as deprivation or aversive stimulation.

The Behavioral Effects of Deprivation

How does deprivation, of water for example, affect behavior? It is necessary to distinguish two quite different effects which cannot be easily derived from one another. One is an increase in the effectiveness of water as reinforcement for any new behavior which should happen to be followed by access to water. The other is an increase in the frequency of all behavior that has been reinforced with water and in this respect is like the evocative effect of an S^D. Operant behavior can thus be increased in frequency (evoked) in two different ways. Consider, for example, an organism that is at least somewhat water deprived and for which some class of responses has a history of water reinforcement. Assume further that the current stimulus conditions have been associated with a low, but nonzero, frequency of water reinforcement for those responses. Such responses can be made momentarily more frequent (1) by further depriving the organism of water, or (2) by changing to a situation where they have been more frequently followed by water reinforcement (the S^D effect). The distinction between these two ways to evoke operant behavior is the basis for the suggestion of a new term which is the main point of the present paper.

The Need for a More General Term: the "Establishing Operation"

The term "deprivation" has been generally used for relations such as the one discussed above but does not adequately characterize many of them. Salt ingestion, perspiration, and blood loss have similar effects but cannot be accurately referred to as water deprivation. Aversive stimulation also establishes its absence as reinforcement and evokes the behavior that has in the past removed it. Likewise temperature changes away from the organism's normal thermal condition increase the effectiveness of changes in the opposite direction as reinforcement and also evoke behavior that has resulted in such changes.

Skinner explicitly identifies deprivation-satiation operations and aversive stimulation as motivational variables (1957, pp. 31-33 and also 212), and with the term "predisposition" (1953, p. 162) includes the so-called emotional operations in this collection. Again, the two different effects of such operations seem clear. For example, to be angry is, in part, to have one's behavior susceptible to reinforcement by signs of discomfort on the part of the person one is "angry at," and also to be engaging in behavior that has produced such effects. Likewise, "fear," from an operant point of view at least, seems to consist of an increased capacity for one's responses to be reinforced by the removal of certain stimuli plus the high frequency of behavior that has accomplished such removal.

A general term is needed for operations having these two effects on behavior. There is, of course, the traditional "motive" and "drive," but these terms have a number of disadvantages, not the least of which is the strong implication of a determining inner state. I have found "establishing operation" appropriate in its commitment to the environment, and by abbreviating it to EO one may achieve the convenience of a small word without losing the implications of the longer term. An establishing operation, then, is any change in the environment which alters the effectiveness of

some object or event as reinforcement and simultaneously alters the momentary frequency of the behavior that has been followed by that reinforcement. (Students of J. R. Kantor may see some similarity to his term "setting factor," but I believe that his term includes operations that have a broader or less specific effect on behavior than the establishing operation as defined above.) There is still a problem with this usage in that "establishing" implies only "increasing," but changes obviously occur in both directions. "Deprivation" has the same limitation and is usually accompanied by its opposite "satiation." It does not seem useful at this time to introduce the term "abolishing" to serve a similar function, so perhaps in the present context "establishing" should be taken to be short for "establishing or abolishing."

The value of a general term is more than just terminological convenience, however. The absence of such a term may have been responsible for some tendency to disregard such effects or to subsume them under other headings. For example, it is common to describe the basic operant procedure as a three-term relation involving stimulus, response, and consequence. Yet it is clear that such a relation is not in effect unless the relevant establishing operation is at an appropriate level. A stimulus that is correlated with increased frequency of water reinforcement for some class of responses will not evoke those responses if water is not currently effective as reinforcement.

Furthermore, aversive stimuli and other events like temperature changes that quickly evoke behavior may appear to be discriminative stimuli but should not be so considered, although the argument is somewhat complex. As mentioned earlier, in order for a stimulus to be considered a discriminative stimulus the differential frequency of responding in its presence as compared with its absence must be due to a history of differential reinforcement in its presence as compared with its absence. Although it is not usually mentioned, there is in this requirement the further implication that the event or object which is functioning as reinforcement must have been equally effective as reinforcement in the absence as in the presence of the stimulus. It would not, for example, be considered appropriate discrimination training if during the presence of the S^D, the organism was food deprived and received food as reinforcement for responding, but in the absence of the S^D it was food satiated, and responding was not followed by food. Such training would be considered of dubious value in developing stimulus control because during the absence of the S^D, the satiated organism's failure to receive food after the relevant response (if that response were to occur) could not easily be considered "unreinforced" responding, since at that time food would not be functioning as reinforcement.

The type of differential reinforcement relevant to stimulus control ordinarily implies that in the presence of the stimulus, the organism receives the reinforcement with greater frequency than it receives the reinforcement in the absence of the stimulus. If in the absence of the stimulus, the critical event no longer functions as reinforcement, then receiving it at a lower frequency is not behaviorally equivalent to a "lower frequency of reinforcement." This supplement to the definition of the S^D relation is not usually mentioned simply because the S^D–S^Δ concepts were developed in a laboratory setting with food and water as reinforcement and with the S^D and S^Δ alternating during the same session. If food was reinforcing during the presence of the S^D, it would generally be equally reinforcing during its absence. With establishing operations that affect behavior more quickly, however, this aspect of the definition becomes more critical. Aversive stimulation is just such an establishing operation. Consider a typical shock-escape procedure. The organism is in a situation where the shock can be administered until some response, say a lever press, occurs. This escape response removes the shock for a period, then the shock comes on again, and so on. With a well-trained organism the shock onset evokes an immediate lever pressing response, and since the relation is obviously an operant one it might seem reasonable to refer to the shock as an S^D for the lever press. For the shock to be an S^D, it must have been a stimulus in the presence of which the animal received more frequent reinforcement—in this case shock termination—than it received in its absence. But in the absence of the shock, failure to receive shock termination for the lever press is not properly considered a lower frequency of reinforcement. Unless the shock is on, shock termination is not behaviorally functional as a form of reinforcement, and the fact that the lever does not produce this effect is irrelevant. The shock, in this sit-

uation, is functioning more like an establishing operation, such as food deprivation, than like an S^D. It evokes the escape response because it changes what functions as reinforcement rather than because it is correlated with a higher frequency of reinforcement. It would be quite possible, of course, to contrive a proper discriminative stimulus in the escape situation. Let the escape response terminate shock only when a tone is sounding; the shock remains on irrespective of the animal's behavior when the tone is not sounding. Lever pressing is clearly unreinforced when the tone is off, and the tone is thus clearly an S^D for lever pressing.

In summary, we could improve our verbal behavior about behavior if we could identify all environmental operations which alter the effectiveness of events as reinforcement with the same term, and especially if this term has also been explicitly linked to the evocative effects of such operations. "Establishing operation" might very well accomplish these purposes.

THE ESTABLISHING STIMULUS OR S^E

Establishing Conditioned Reinforcement

Most of the establishing operations discussed so far have been the kind that alter the effectiveness of stimulus changes that can be classified as unconditioned reinforcement. Stimulus changes identified as conditioned reinforcement are also established as such by various operations. The most obvious are the same operations that establish the effectiveness of the relevant unconditioned reinforcement. A light correlated with food becomes effective conditioned reinforcement as a function of food deprivation. Information about the location of a restaurant becomes reinforcing when food becomes reinforcing. There is, however, a common situation in which a stimulus change establishes another stimulus change as conditioned reinforcement without altering the effectiveness of the relevant unconditioned reinforcement. If the behavior which has previously obtained such conditioned reinforcement now becomes strong we have an evocative relation like that produced by an establishing operation but where the effect depends upon an organism's individual history rather than the history of the species. I would like to suggest the term "establishing stimulus" and S^E for this relation.

General Conditions for the Establishing Stimulus

The circumstances for an establishing stimulus (Figure 1) involve a stimulus change, S_1, which functions as a discriminative stimulus for a response, R_1, but under circumstances where that response cannot be executed or cannot be reinforced until another stimulus change, S_2, takes place. This second stimulus change, then, becomes effective as conditioned reinforcement, and the behavior that has in the past achieved this second stimulus change, R_2, is evoked. S_1, then, is an S^D for R_1, but an S^E for R_2.

A Human Example

Suppose that an electrician is prying a face plate off a piece of equipment which must be removed from the wall. The electrician's assistant is nearby with the tool box. The removal of the face plate reveals that the equipment is fastened to the wall with a slotted screw. We can consider the slotted screw under the present circumstances to be a discriminative stimulus (S_1) for the use of a screw driver in removing the screw (R_1). (The reinforcement of this behavior is, of course, related to the electrician's job. When the wall fixture is removed and a new one applied, payment for the job may become available, etc.) But removing the screw is not possible without an appropriate

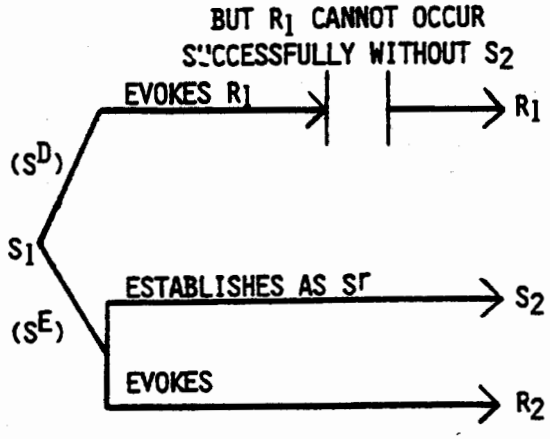

Fig. 1. General condition for an establishing stimulus. S_1, functioning as an S^D evokes R_1, but this response cannot occur or cannot be reinforced without the presence of S_2. Thus S_1 also functions as an S^E, establishing S_2 as a form of conditioned reinforcement and at the same time evoking R_2 which has previously produced S_2.

screw driver (S_2). So the electrician turns to the assistant and says "screw driver" (R_2). It is the occurrence of this response which illustrates a new type of evocative effect.

It is reasonable to consider the offered screw driver as the reinforcement of the request, and the history of such reinforcement to be the basis for the occurrence of this request under the present circumstances. It might also seem reasonable to consider the sight of the slotted screw as an S^D for this response, but here we should be cautious. If it is proper to restrict the definition of the S^D to a stimulus in the presence of which the relevant behavior has been more frequently reinforced, then the present example does not qualify. A slotted screw is not a stimulus that is correlated with an increased frequency of obtaining screw drivers. Electricians' assistants generally provide requested tools irrespective of the use to which they will be put. The presence and attention of the assistant *are* S^Ds correlated with successful asking, but not the slotted screw. However, it is an S^D for unscrewing responses —a stimulus in the presence of which unscrewing responses (with the proper tool) are correlated with more frequent screw removal—but not for asking for screw drivers. The evocative effect of the slotted screw on asking behavior is more like the evocative effect of an establishing operation than that of an S^D, except for its dependence on the organism's individual history. The slotted screw is better considered an establishing stimulus for asking, not a discriminative stimulus.

An Animal Analogue

It is not difficult to describe an S^E situation in the context of an animal experiment, but first it is necessary to describe two secondary features of the human situation giving rise to this concept. First, it must be possible to produce the second stimulus change (S_2) at any time and not just after the first stimulus change (S_1). Otherwise we are dealing with simple chaining. Furthermore, the second stimulus change should not be one which once achieved remains effective indefinitely with no further effect or cost to the organism, or it will become a standard form of preparatory behavior. In the electrician's situation, if there were some tool that was used on a high proportion of activities it would be kept always available. On the other hand, to ask for a tool when it is not needed would result in the work area being cluttered with unneeded tools (assume a small or crowded work area, etc.). This second feature would seem usually to involve some form of punishment for R_2 that prevents it until S_1 has made it necessary.

Now, for the animal analogue consider a food-deprived monkey in a chamber with a chain hanging from the ceiling and a retractable lever. Pulling the chain moves the lever into the chamber. Pressing the lever has no effect unless a light on the wall is on, in which case a lever press dispenses a food pellet. To prevent the chain pull from functioning as a standard preparatory component of the behavioral sequence, we could require that the chain be held in a pulled condition, or we could arrange that each chain pull makes the lever available for only a limited period, say five seconds. In either case we would expect a well-trained monkey ultimately to display the following repertoire: while the wall light is off (before the electrician has seen the slotted screw), the chain pull does not occur (a screw driver is not requested), even though it would produce the lever (even though the assistant would provide one). When the light comes on (when the slotted screw is observed), the monkey pulls the chain (the electrician requests the screw driver) and then presses the lever (and then unscrews the screw) and eats the food pellet that is delivered (and removes the piece of equipment, finishes the job, etc.).

Returning to Figure 1, S_1 is the onset of the wall light, which evokes lever pressing (R_1). Lever pressing, however, cannot occur without the lever (S_2), and thus the availability of the lever becomes an effective form of reinforcement once the wall light is on. The chain pull is R_2, evoked by the light functioning as an S^E rather than as an S^D because the light is not correlated with more frequent lever availability (the reinforcement of the chain pull) but rather with greater effectiveness of the lever as a form of reinforcement.

ALTERNATIVE SOLUTIONS

Larger Units of Behavior

It may seem reasonable to consider the response evoked by the S^E to be simply an element in a chain of responses evoked by an S^D. Thus, with the electrician, asking for the screwdriver might be interpreted as a part of a

larger unit of behavior evoked by the slotted screw and reinforced by successful removal of the screw. From this point of view, the S^E concept might seem unnecessary. That is, the slotted screw could be considered a discriminative stimulus for the larger unit, which is more likely to achieve the removal of the screw in the presence of a slotted screw than in the presence of a wing nut, a hex nut, etc. This analysis is not too plausible, however, since it would imply that requests are not sensitive to their own immediate consequences but only to the more remote events related to the use of the requested item. But even if this were true, we would still have to account for the formation or acquisition of the large unit of behavior. This has usually involved reference to repeated occurrence of chains of smaller units (for example, Skinner, 1938, 52ff and 102ff; Keller & Schoenfeld, 1950, Chapter 7; Millenson, 1967, Chapter 12), and the initial element of this particular chain would require the S^E concept. That is, we might be able to do without the S^E in the analysis of the current function of a large unit but would need it to account for the first element of the chain of smaller units out of which the large unit was formed.

Conditional Conditioned Reinforcement

The notion that a form of conditioned reinforcement may be conditional upon the presence of another stimulus condition is quite reasonable and requires no new terminology. This could be referred to as conditional conditioned reinforcement, and the S^E of the previous sections can be seen to be the type of stimulus upon which such conditioned reinforcement is conditional. This general approach, however, fails to implicate the evocative effect which is the main topic of the present paper and thus seems less satisfactory than the new terminology.

Retaining the S^D by Complicating the Reinforcement

If we consider the chain pull to be reinforced, not by the lever insertion into the chamber but by the more complex stimulus change from light on with lever out to light on with lever in, we may be able to retain the notion of the light onset as an S^D for the chain pull, because the more complex stimulus change can only be produced when the light is on. This involves adding a static component to our reinforcing stimulus change, which may be theoretically sound, but is certainly not the usual way we talk about reinforcement. In the human example this would mean that the screw driver does not reinforce the request, but rather the change from looking at a slotted screw without a screw driver in hand to looking at one with a screw driver in hand. As with conditional conditioned reinforcement this is not an issue regarding the facts of behavior, but rather our verbal behavior concerning these facts. Will we be more effective in intellectual and practical ways by introducing a new stimulus function and retaining a simple form of verbal behavior about reinforcement, or will we be better off retaining the S^D interpretation for both types of evocation but complicating our interpretation of reinforcement for one of them? I clearly favor the former.

SUMMARY

In everyday language we can and often do distinguish between changing people's behavior by changing what they want and changing their behavior by changing their chances of getting something that they already want. Our technical terminology also makes such a distinction, but only in the case of establishing operations such as deprivation and those kinds of reinforcing events called "unconditioned." Much more common are those stimulus changes which alter the reinforcing effectiveness of events ordinarily referred to as conditioned reinforcement, and which evoke the behavior that has previously produced this reinforcement. We do not have a convenient way of referring to such stimulus changes, and because of this they may be subsumed under the heading of discriminative stimuli. I have suggested the term "establishing stimulus" for such events, thus linking them with establishing operations such as deprivation, and I hope, suggesting the relation to the individual's history by the replacement of "operation" with "stimulus."

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