Concurrent Behavior: Are the Interpretations Mutually Exclusive?

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The experimental literature is replete with examples of behavior which occur concurrently with a schedule of reinforcement. These concurrent behaviors, often with similar topographies and occurring under like circumstances, may be interpreted as functionally autonomous, collateral, adjunctive, superstitious or mediating behavior. The degree to which the interaction of concurrent and schedule controlled behavior is used in the interpretation of behavior illustrated the importance of distinguishing among these interpretations by experimental procedure. The present paper reviews the characteristics of these interpretations, and discusses the experimental procedures necessary to distinguish among them. The paper concludes that the interpretations are mutually exclusive and refer to distinct behaviors, but that the distinction between any two of the interpretations requires more than one experimental procedure.

When a biologically effective event is presented to an organism according to a schedule with stable temporal properties, a variety of behaviors not readily classified as programmed operants or respondents may closely follow, and some may eventually precede that event. These behaviors are reliably produced by positive (Falk, 1966a) as well as negative events (Hutchinson & Emley, 1972) and represent classes of behavior which are assumed to have specific and very distinct properties. Unfortunately, different classes of behavior with similar topographies may occur under the same experimental conditions, distorting the distinctiveness of the classes. For example, the delivery of an appetitive reinforcer according to a fixed-time schedule (FT) can engender stereotyped and repetitive activity (Skinner, 1948), pecking directed toward a target animal (Flory, 1969), excessive water drinking, (Segal, 1965) or the consumption of wood shavings (Villarreal, 1967). The interpretation of this behavior may also vary. For instance, the appearance of pica concurrently with a schedule of reinforcement has been described as both adjunctive (Villarreal, Note 1) and mediating behavior (Laties, Weiss & Weiss, 1969).

A wide variety of behaviors engendered by the delivery of positive and usually appetitive reinforcers have been studied separately in diverse situations with different schedules of reinforcement, reinforcers and species. However, on only a few occasions (e.g., Falk, 1969; Laties et al., 1969; Laties, Weiss, Clark, & Reynolds, 1965) have researchers attempted to delineate the nature of the engendered behavior by systematic manipulations. Indeed, the study of Laties, et al. (1965) may serve as the basis for a review of experimental procedures required to distinguish among the five possible interpretations of engendered behavior (functional autonomy, collateral behavior, adjunctive behavior, superstitious behavior, and mediating behavior) which occurs concurrently with the delivery of positive events.

The interaction between concurrent and schedule behavior is an important part of the interpretation of behavior in the experimental analysis, yet there are no accepted rules or procedures for distinguishing among the potential interpretations of concurrent behavior.

The present paper considers the definition and the distinguishing characteristics of each of five interpretations, reviews the experimental procedures necessary for operationally distinguishing among the interpretations, and then offers some implications for behavior analysis. The Laties et al. (1965) paper is used as an initial model in this review, since that study

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concerns a DRL, the only schedule which engenders behavior appropriate to any one of the five interpretations. The paper argues that the addition of procedures not used by Laties et al. permits the unambiguous distinction among the interpretations. The paper then concludes that as few as three procedures could serve to distinguish among the interpretations, although at least two of the procedures are necessary to make that distinction.

DEFINITION OF TERMS

Functional Autonomy

Functional autonomy assumes that behavior originally derived for biological reasons may sustain itself indefinitely in the absence of any known biological reinforcer. The distinguishing feature of the behavior is its persistence in the absence of an external reinforcer and in spite of changes in environmental variables. By definition, functionally autonomous behavior is maintained by tactile or other stimulation arising from the behavior itself.

While the concept was originally derived as a major construct in Allport's (1937) theory of personality, there are some examples in the experimental literature (Olson, 1929) which appear appropriate to this interpretation. In the Olson study, an irritant was placed on a rat's ear and the animal continued to scratch the area long after the effectiveness of the substance was diminished. Recent studies (Fantino, 1968; Fantino, Braun, & Vollero, 1968; Fantino & Cole, 1968) also indicate that ear scratching, sand digging and hoarding may persist in the absence of reinforcement although perhaps not to the degree implied by Allport's original construct. The concept is included in the present paper as a possible interpretation for perseverative behavior that occurs independently of any external reinforcer.

Collateral Behavior

Collateral behavior refers to a class of behaviors which occur parallel to an operant maintained by a schedule of reinforcement, but is neither supportive of, nor required by, the events maintaining that operant. The distinguishing features

of collateral behavior are that it occurs with regularity, and imposes changes upon the operant only by its incompatibility with that behavior (Iverson, 1976).

By definition, collateral behavior is engendered¹ by the schedule of reinforcement, and its strength is determined by the degree of similarity between the present schedule and the past conditions from which it arose. Since collateral behavior is derived from prior and various conditions, it may not appear to be governed by a uniform set of rules.

One example of collateral behavior, which illustrates this aspect, is a learned pattern of eating which varied in its degree of incompatibility with lever pressing (Kelly, 1974). In this study, one monkey stopped responding to consume the reinforcer as a separate meal, yielding a non-continuous response rate, while the other continued to respond while eating, yielding a smooth continuous curve. The former was judged to be a tree dweller who could safely pause to eat, while the latter was judged to be a plains dweller who must continue to roam while eating to preserve its safety. In other studies, prior training on a fixed ratio schedule (Davis & Wheeler, 1967; Stein, 1977), the opportunity for water drinking (Segal & Deadwyler, 1964; Segal & Holloway, 1963), or other responses (Bruner & Revusky, 1958; Schwartz & Williams, 1971) yield collateral behavior which interferes with lever pressing and enhances the accuracy of responding on a DRL.

Adjunctive Behavior

Adjunctive behavior is an excessive increase in the frequency of an apparently unreinforced behavior in the presence of the intermittent delivery of a reinforcer, whether the delivery of the reinforcer is

¹The verb *engender* is used with collateral behavior and other phenomena in which the relationship between the schedule and the changes in behavior is not well established. The word means to beget, or generate, and implies behavior arising out of some general conditions. This ambiguous origin of behavior does not imply an orderly relationship between the behavior and the schedule once the behavior has appeared.

independent of (Segal, 1965), or dependent upon responding (Falk, 1966a). The three distinguishing features of this behavior (Falk, 1977) are excessiveness, locus of occurrence during the post reinforcement period, and its potential use as a reinforcer to maintain an operant. By definition, adjunctive behavior is induced² by the schedule of reinforcement.

Examples of adjunctive behavior include polydipsia (Falk, 1961), air licking (Ramer & Wilkie, 1977), escape (Thompson, 1964), various forms of pecking (Cohen & Looney, 1973; Miller & Gollub, 1974), attack and aggression (Flory, 1969; Gentry, 1968; Loney & Cohen, 1974, 1982), preening (Lyon & Turner, 1972), grooming (Wayner, 1975), and general motor activity (Levitsky & Collier, 1968; Wallace, Singer, Wayner, & Cook, 1975). Although only schedule-induced polydipsia (Falk, 1966b) and attack (Cherek, Thompson, & Heistad, 1973) have been shown to maintain an operant, most investigators assume that behavior which occurs to excess following the delivery of a reinforcer would maintain an operant.

Superstitious Behavior

"Superstition or superstitious behavior is strengthened through reinforcing contingencies not explicitly arranged within the environment, but nevertheless, effective in increasing the strength of the responses" (Ferster & Skinner, 1957, p. 732). The distinguishing feature of superstitious behavior is a persistent stereotyped pattern of behavior which precedes a reinforcer, and often "drifts" as the apparent relationship between the behavior and the reinforcer changes. By definition, superstitious behavior in its many forms is strengthened adventitious-

ly by a consistent correlation with food delivery (Zeiler, 1972).

There are four examples of superstitious behavior: (1) an increase in stereotyped activity when access to the reinforcer is presented independently of behavior according to a fixed time (FT) schedule (Skinner, 1948); (2) a change in response rate in the presence of a stimulus which occurs independently of behavior (Morse & Skinner, 1957); (3) a response-rate increase preceding a response-independent change from a period of no reinforcement to a period of reinforcement (Sidman, 1960); and (4) the persistence of behavior typical of an initial schedule of reinforcement under a subsequent response-reinforcer relationship (Neuringer, 1970; Weiner, 1965).

Mediating Behavior

Mediating behavior occurs between two instances of an operant and serves as the stimulus for the second response (Ferster & Skinner, 1957, p. 729). The distinguishing feature of mediating behavior is a stereotyped sequence of responses with a duration approximately equal to the period between the two instances of the operant. By definition, mediating behavior is neither engendered nor maintained by a reinforcer. It is extant behavior which serves as the basis for a discrimination. This discrimination is established since the probability of reinforcement is near unity following the behavior sequence and near zero prior to the initiation of the sequence.

Research concerning DRL schedules, which require the spacing of responses to correspond with the temporal requirements of the schedule, are replete with examples of mediating behavior (Kramer & Rilling, 1970). While some animals respond appropriately on a DRL without displaying a stereotyped pattern of behavior between responses (Anger, 1956; Kelleher, Fry, & Cook, 1959, see also Zuriff, 1969), many studies report complex behavior chains which appear to assist the animal in meeting the requirements of the schedule (Davis & Wheeler, 1967; Holz, Azrin, & Ulrich, 1963; Hodos, Ross, & Brady, 1962; Laties et al., 1965; Laties et al., 1969; Wilson &

² The verb *induce* is used exclusively with adjunctive behavior, e.g. schedule induced polydipsia. The word means to bring out, to call forth or to arouse by indirect stimulation. The term implies a degree of influence, however, which suggests the orderly relationship often found between the changes in the schedule of reinforcement and the strength of the adjunctive behavior, e.g. the bitonic function between the inter-pellet interval and amount of water consumed.

Keller, 1953). Other investigators have demonstrated that physical restraint, which prohibits the development of these overt behaviors, retards the acquisition of a DRL (Glazer & Singh, 1971; Richardson & Longhead, 1974), and prior training of a potential mediating response may contribute to DRL performance (Davis & Wheeler, 1967; Segal-Rectschafen, 1963).

METHOD OF ANALYSIS

The intent of the present paper is to review the evidence and the experimental methods for distinguishing among the five interpretations of concurrent behavior. Each interpretation implies unique characteristics of a class of behaviors, although the interpretations are often applied to behaviors which are similar in topography and occur under like circumstances. Several investigators have evaluated individual interpretations in isolation. Examples are, functional autonomy (Seligman, Ives, Ames, & Mineka, 1970), collateral behavior (Iverson, 1976), adjunctive behavior (Segal & Holloway, 1963), superstitious behavior (Stein & Landis, 1973), and mediating behavior (Laties et al., 1969; Stein, 1977). Only the work by Laties et al. (1965) provides sufficient data to develop an analysis and interpretation of behavior which appeared concurrent with a schedule of reinforcement. In that paper,

Laties et al. studied the relationship between tail nibbling in a single white rat and its lever pressing on a DRL 22-sec schedule as a function of five experimental conditions.

The five conditions used by Laties et al., which included an observational phase and four experimental manipulations, are presented in Table 1. The general change in tail nibbling and lever pressing are indicated across the top of the table, and the five interpretations are listed on the left margin. A "YES" entry in the cell indicates that the procedure listed at the top supports the interpretation of tail nibbling indicated in the left margin. A "NO" entry in the cell indicates that the manipulation disallows the interpretation on the left, asserting a distinction between this particular interpretation and others.

THE LATIES ET AL. MODEL

Each of the five conditions used in the Laties et al. study (1965) is discussed separately in terms of the changes in behavior and the interpretations which may be supported by the obtained results.

Correlation

The initial evidence presented by Laties et al. (1965) was a correlation between the duration of the tail nibbling and the time between successive responses on the DRL schedule. These data indicate several in-

TABLE 1
Experimental Manipulations and Results which Support or Deny the Five
Possible Interpretations of Nibbling in Laties et al., 1965

	Experimental Manipulations				
	Correlation	Response Prevention	Extinction	Punishment	Drug Analysis
	Measure nibbling duration	Remove lever	Empty dipper	P-aint tail; Cycloheximide	Inject Amphetamine
	Tail nibbling duration approximates DRL interval	Tail nibbling ceases to occur in absence of lever.	Tail nibbling and then lever pressing decreases.	Tail nibbling suppressed and lever pressing disrupted.	Tail nibbling and lever pressing similar function forms.
Functional Autonomy	Yes: Nibbling duration could equal DRL interval.	No: Nibbling should continue without reinforcer.	No: Nibbling should continue without reinforcer.	No: Nibbling suppression should not affect DRL.	No: Function forms should not be similar.
Collateral Behavior	Yes: Nibbling duration could equal DRL interval.	Yes: Nibbling should cease without reinforcer.	No: Nibbling should cease immediately without reinforcer.	Yes: Nibbling may fill DRL interval fortuitously.	No: Nibbling and lever pressing function forms should be dissimilar.
Adjunctive Behavior	Yes: Nibbling duration could equal DRL interval.	Yes: Nibbling should cease without reinforcer.	No: Nibbling should cease immediately without reinforcer.	No: Nibbling decrease should not affect DRL, supported by other punishment data.	No: Nibbling decrease should not affect DRL, supported by other data.
Superstitious Behavior	Yes: Nibbling duration should equal DRL interval.	Yes: Nibbling should cease without reinforcer.	Yes: Nibbling should decrease first as part of chain.	Yes: Nibbling suppression should disrupt DRL as part of sequence.	Yes: Nibbling and lever pressing should change in similar fashion as part of sequence.
Mediating Behavior	Yes: Nibbling duration should equal DRL interval.	Yes: Nibbling should cease without reinforcer.	Yes: Nibbling should decrease first as part of chain.	Yes: Nibbling suppression should change in similar fashion.	Yes: Nibbling and lever pressing should change in similar fashion.

stances in which the duration of the tail nibbling exceeded the DRL 22-sec requirement so that the next lever press was reinforced. The correlation data which testify to the existence of the concurrent may be used to support any one of the five behavior interpretations, but cannot be used to distinguish among them. A "YES" has been entered in each cell under correlation opposite the five interpretations in Table 1.

The notion of functional autonomy does not enjoy wide use in behavior analysis. The concept is of theoretical interest in the present context, since nibbling as a result of an irritation on the tail is a potential explanation of the behavior.

Response Prevention

The first of four manipulations conducted by Laties et al. (1965) was the prevention of the lever pressing response by removal of the lever for 15-min periods that alternated with lever-present periods. The removal of the lever did not lead to an immediate cessation of tail nibbling, but it gradually decreased and then disappeared in the fifth such period (Laties et al., 1965, p. 111).

This finding rules out functional autonomy since tail nibbling as a self-reinforcing behavior would have persisted in the absence of the lever. A "NO" appears in the response prevention column of Table 1.

A "YES" has been entered in the four remaining cells of column 2 since collateral, adjunctive, superstitious, and mediating behavior require the scheduled presentation of a reinforcer which cannot occur when the lever is removed.

Extinction

The second manipulation was extinction and reconditioning of the lever press through the removal and reintroduction of the milk solution used as the reinforcer. The data showed a gradual decrease in tail nibbling followed by a decrease in lever pressing (Laties et al., 1965, p. 109) similar to the change in a behavior chain in extinction. This finding rules out functionally autonomous, collateral, and adjunctive behavior, and a

"NO" appears opposite each of these interpretations under extinction in Table 1.

Functionally autonomous behavior is self-reinforcing and would not be disturbed by changes in the reinforcer for lever pressing.

Collateral behavior develops as a result of the similarity between present and prior conditions (Davis & Wheeler, 1967; Kelly, 1974). The introduction of extinction represents a considerable alteration and should have led to an immediate change in collateral behavior. Since the extinction process was very gradual, as anticipated in a behavior chain, these data were considered adequate to rule out collateral behavior.

Adjunctive behavior is a post-reinforcement phenomenon that requires the presentation of an appetitive reinforcer or other significant event. The removal of the milk reinforcer should have led to an immediate decrease in nibbling, rather than the gradual decrease observed by Laties et al.

The chaining analysis does not differentiate between superstitious and mediating behavior and a "YES" appears opposite both of these interpretations under extinction in Table 1. The nibbling behavior decreased first, followed by lever pressing, as expected of a behavior chain, but this sequence does not distinguish between behavior as a superstitious chain maintained by the reinforcer, and behavior as a mediating chain that serves as the stimulus for the reinforced response.

Punishment

The third manipulation was a punishment procedure which involved painting the animal's tail with 1.0% solution of cycloheximide, a distasteful substance often applied to wires to dissuade rodents from chewing on insulation. The cycloheximide interfered with the tail nibbling and immediately disrupted the DRL performance (Laties, et al., 1965, p. 111). The punishment procedure rules out functionally autonomous and adjunctive behavior, but not collateral, superstitious and mediating behavior.

Functional autonomy is easily dismiss-

ed since the cessation of tail nibbling would not have disrupted the DRL if nibbling was a self-reinforcing behavior.

Adjunctive behavior is dismissed by a comparison with previous data. Punishment of polydipsic drinking, a well-established example of adjunctive behavior, leads to the cessation of drinking but does not disrupt the schedule behavior (Bond, Blackman, & Scruton, 1973; Hymowitz, 1976, 1977; Hymowitz & Freed, 1974; Segal & Oden, 1969). A "NO" has been placed opposite functionally autonomous and adjunctive behavior in the punishment column of Table 1.

The distinction between tail nibbling as collateral or as mediating behavior is slight. One possibility is that the disruption of the DRL performance following the punishment of tail nibbling was due to the suppression of collateral behavior which had fortuitously created a diversion incompatible with lever pressing and with a duration approximately equal to the DRL interval. The second possibility is that the disruption of the DRL performance was due to the punishment of a mediating chain which served as a discriminative stimulus between one response and the subsequent reinforced response.

Finally, the procedure does not rule out superstitious behavior. If the tail-nibbling behavior were part of a two-component chain which terminated with the lever press and was maintained by the presentation of reinforcement, the disruption of the first part of the chain should disrupt the entire chain (Davis & Iriye, 1973; Kelleher, 1966).

For collateral, mediating, and superstitious behavior, concurrent nibbling is an integral part of a total behavior sequence, but with a distinctive function. While the functions differ, all three would predict the disruption of the DRL following suppression of the tail nibbling and a "YES" appears in the cell for each under punishment in Table 1.

The use of the DRL disruption as evidence for any one of the three interpretations might be considered suspect, since a punishment procedure involving

taste was used in an experiment with an appetitive reinforcer. While this point does not interfere with the theoretical analysis of the function of punishment, Laties et al. reported that temporary disruptions of nibbling were followed by concurrent gnawing and subsequent increases in the accuracy of the DRL performance. These data indicate that the decrease in the DRL following punishment was not due to a disruption of food directed behavior by a lingering foul taste.

Drug Analysis

The final manipulation was the injection of amphetamine at dose levels which would not interfere with eating. The amphetamine caused decreases in the frequency and duration of nibbling and disrupted the lever pressing. While these data do not indicate a monotonic relationship between dose size and changes in both behaviors, the changes followed similar function forms. The logic of the function-form analysis of nibbling and lever pressing assumes that if the two behaviors co-vary, their sources are identical; if the two behaviors do not co-vary, then their sources are distinctive. This analysis rules out functionally autonomous, collateral, and adjunctive behavior, but fails to distinguish between superstitious and mediating behavior.

By definition, functionally autonomous behavior is independent of schedule-controlled behavior and the drug effects should not show the same function-form for nibbling and lever pressing.

Adjunctive behavior is induced by the schedule of reinforcement, but should not change similarly to schedule behavior following the administration of amphetamine. Several investigators report independence between adjunctive behavior and lever pressing under amphetamine (Branch, 1975; DeWeese, 1977), and McKearney (1973) showed amphetamine has little effect upon schedule-induced licking, but produces a decrease in schedule-controlled licking.

The ambiguity inherent in the definition of collateral behavior, in terms of its possible source (Kelly, 1974) and fortuitous correlation with other behaviors (Segal & Deadwyler, 1964), prevents the

development of a precise notion about the function form for, and the effects of, pharmacological agents on collateral and schedule behavior. Depending upon the particular history of the organism and the development of behavior patterns appropriate for collateral behavior, there may be reason to argue that collateral and schedule behaviors should or should not co-vary. The amphetamine data, indicating an orderly relationship between nibbling and lever pressing, argues against the collateral behavior interpretation which is based upon a lack of an orderly behavior pattern under all circumstances. A "NO" appears in the cell for functionally autonomous, adjunctive, and collateral behavior in the drug column of Table 1.

Using the amphetamine data to distinguish between superstitious and mediating behavior is not without possible flaws. Tail nibbling either as superstitious or mediating behavior should co-vary with lever pressing under the influence of amphetamine since either behavior comprises a chain with lever pressing. Unfortunately, there are no data in the literature to substantiate the covariance of mediating and schedule behavior, and the effects of the drug do not always provide an unambiguous function-form for superstitious behavior. For example, Laties et al. (1965) cited data (Jetter, Lindsley, & Wohlwill, Note 2) that amphetamine increased superstitious bowing, but decreased superstitious barking in dogs. Other data suggest that amphetamine increases switching in a complex schedule, which might be considered as superstitious behavior (Moerschbaecher, Thompson, & Thomas, 1979). Since the nibbling and lever pressing did covary under the influence of amphetamine as expected of a behavior which forms either a superstitious or mediating chain with lever pressing, a "YES" has been entered for both in the drug column of Table 1.

TWO OTHER PROCEDURES

The previous discussion indicates that the distinction among the interpretations presented in Table 1 is inconclusive: (1)

the correlation does not distinguish between any two interpretations; (2) the response prevention procedure rules out only functional autonomy; (3) the amphetamine data lacked unequivocal support in the literature; and (4) neither extinction nor punishment distinguishes between superstitious and mediating behavior.

In this section, the correlation, response prevention, and amphetamine procedures are discarded and in their place two procedures not included in the Laties et al. paper are considered along with extinction and punishment. These procedures are: (1) a change in the reinforcement contingency to a fixed-time schedule (FT) in which the reinforcer is presented after a fixed period independently of the lever response, and (2) the introduction of an alternative schedule to determine if the opportunity to engage in nibbling is sufficient to maintain an operant response. The degree to which these four procedures can distinguish among the five interpretations are summarized in Table 2.

The 16 arrays of Table 2 were generated by determining all possible combinations of positive and negative results for each procedure. The appropriate entries for array #1 based upon the positive result (Chain, Disrupt, Occur, and Maintain) for each procedure were then determined. As in Table 1, a "YES" entry indicates support and a "NO" indicates no support for the interpretation. After the entries for array #1 were determined, the other 15 arrays in the table were completed by inserting the obverse of the cell entry in array #1 for each negative result, and replicating the entry in array #1 for each positive result. The negative is indicated by a bar over the positive result.

For example, extinction (EXT) leads to a change in behavior typical of a behavior chain (CHAIN) or atypical of a behavior chain (CHAIN); punishment (PUN) suppresses the tail nibbling and disrupts (DSRUP) or does not disrupt (DSRUP) the DRL; the fixed-time schedule (FT) will either lead to the occurrence (OC-CUR) or the non-occurrence (OCCUR) of nibbling; and the opportunity to engage in

TABLE 2
Experimental Manipulations and Results which Support or Deny the Five Interpretations

	EXPERIMENTAL MANIPULATIONS															
	EXT				PUN				FT				OPP			
	Cham	Drup	Occur	Maint	Cham	Drup	Occur	Maint	Cham	Drup	Occur	Maint	Cham	Drup	Occur	Maint
Functional Autonomy	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Collateral Behavior	NO	YES	NO	NO	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Adjunctive Behavior	NO	NO	YES	YES	NO	NO	YES	YES	NO	YES	NO	YES	YES	YES	YES	NO
Superstitious Behavior	YES	YES*	YES	NO	YES	YES	YES	YES	YES	NO	NO	NO	NO	NO	YES	YES
Mediating Behavior	YES	YES	NO	NO	YES	YES	NO	YES	YES	NO	YES	NO	NO	NO	NO	YES
Functional Autonomy	Cham	Drup	Occur	Maint	Cham	Drup	Occur	Maint	Cham	Drup	Occur	Maint	Cham	Drup	Occur	Maint
Collateral Behavior	YES	NO	NO	NO	YES	YES	NO	NO	NO	YES	NO	YES	YES	NO	YES	YES
Adjunctive Behavior	YES	YES	NO	NO	YES	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES
Superstitious Behavior	NO	YES	YES	NO	NO	NO	YES	NO	YES	NO	YES	YES	NO	YES	NO	NO
Mediating Behavior	NO	YES	NO	NO	NO	NO	NO	NO	YES	NO	NO	YES	NO	YES	YES	YES
Functional Autonomy	Cham	Drup	Occur	Maint	Cham	Drup	Occur	Maint	Cham	Drup	Occur	Maint	Cham	Drup	Occur	Maint
Collateral Behavior	NO	NO	NO	NO	YES	YES	YES	NO	NO	YES	YES	YES	NO	NO	YES	YES
Adjunctive Behavior	NO	YES**	YES**	YES	YES	NO	NO	YES	NO	NO	NO	NO	NO	YES	NO	NO
Superstitious Behavior	YES	NO	YES	NO	NO	YES	NO	NO	YES	YES	NO	YES	YES	NO	NO	YES
Mediating Behavior	YES	NO	NO	NO	NO	YES	YES	NO	YES	YES	YES	YES	YES	NO	YES	YES
Functional Autonomy	Cham	Drup	Occur	Maint	Cham	Drup	Occur	Maint	Cham	Drup	Occur	Maint	Cham	Drup	Occur	Maint
Collateral Behavior	NO	YES	YES	NO	YES	YES	NO	YES	YES	NO	YES	NO	YES	NO	YES	YES
Adjunctive Behavior	NO	YES	NO	YES	YES	NO	YES	NO	YES	YES	NO	YES	YES	NO	NO	NO
Superstitious Behavior	YES	YES	NO	NO	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	YES
Mediating Behavior	YES	YES	YES	NO	NO	YES	NO	YES	NO	NO	YES	NO	NO	NO	YES	NO

nibbling (OPP) will either maintain (MAINT) or not (MAINT) an operant response.

The entries for the extinction (EXT) and punishment (PUN) columns in array #1 of Table 2 are based on the discussion of Table 1. The entries in array #1 of Table 2 for the fixed time (FT) and the opportunity to engage in nibbling as a reinforcer for an operant (OPP) are discussed in the following two sections. Note: only array #1 is important here, and all references in these two sections involve that portion of Table 2.

Fixed Time

The fixed-time schedule is a change from the DRL to the presentation of a reinforcer at the end of the 22-sec interval independently of the animal's behavior. There are two possible changes: nibbling behavior would either occur or not occur on the FT schedule. This schedule and the corresponding changes in behavior rule out functionally autonomous, collateral, and mediating behavior from adjunctive and superstitious behavior, but do not

distinguish between the last two interpretations.

Since functionally autonomous behavior is self-reinforcing and, therefore, independent of an external reinforcer, it should not occur in an orderly fashion on an FT schedule. A "NO" appears opposite functional autonomy in the FT column.

Collateral behavior appears to an extent that the present circumstances are similar to prior conditions which gave rise to the behavior, and is measured by its effect on schedule behavior. Since the FT schedule does not require a response, collateral behavior would not be measurable and a "NO" appears opposite collateral behavior in the FT column.

The interpretation of nibbling on this schedule as adjunctive behavior is clear. An FT schedule can engender adjunctive behavior (Flory, 1969; Segal, 1965) and therefore a "YES" appears in the FT column.

The interpretation of superstitious behavior is also clear. The FT schedule

replicates the original superstition experiment (Skinner, 1948), and the occurrence of nibbling, prior to a response independent reinforcer would be interpreted as adventitious reinforcement of nibbling. A "YES" appears opposite superstitious behavior in the FT column.

The effect of the FT schedule upon mediating behavior is also explicit. Since the mediating response serves as a discriminative stimulus for a subsequent response, and the FT schedule does not require a subsequent response, mediating behavior has no function and therefore should not occur on an FT schedule. A "NO" appears opposite mediating behavior in the FT column. Note that of all of the procedures reviewed, the FT is the only one which distinguishes between superstitious and mediating behavior.

Opportunity as a Reinforcer

The determination of the degree to which the opportunity to engage in tail nibbling can maintain an operant requires the introduction of an alternative response. For example, tail nibbling might be prevented by some means until an FR schedule is completed on an alternative response mechanism, as demonstrated with polydipsia (Falk, 1966b) and attack (Cherek, Thompson, & Heistad, 1973). There are two possible results; the opportunity to engage in tail nibbling will either maintain or not maintain the alternative operant.

By definition, only the opportunity to engage in adjunctive behavior is sufficient to maintain an operant, and a "YES" appears opposite adjunctive behavior in the "OPP" column. The opportunity to engage in functionally autonomous behavior might also be sufficient to maintain an operant since it is an intrinsically reinforcing behavior. Unfortunately, this aspect is neither a part of the definition, nor has it been tested experimentally, and a "NO" appears opposite functional autonomy in the "OPP" column. By definition, the remaining three interpretations, collateral, mediating, and superstitious behavior, should not be sufficient to maintain an operant, and a "NO" appears in the "OPP" column opposite each of these interpretations.

IMPLICATIONS FOR BEHAVIOR ANALYSIS

There are two difficulties with Table 2. First, the table is a complete, but cumbersome reference, and second, the table includes the complex test of nibbling as a reinforcer. The opportunity procedure was included in the discussion since it is part of the definition. The procedure does not, however, distinguish between functionally autonomous and adjunctive behavior, and it is complex, since it requires both an additional schedule and an alternative response (Falk, 1966b).

The opportunity procedure was set aside and comparisons of the three procedures, punishment, extinction, and the FT schedule, are presented in Figure 1 as a three-dimensional matrix. The matrix shows the interpretation corresponding to the behavior change as a result of any two of the three procedures.

For example, the matrix indicates that the disruption of the DRL through suppression of the concurrent behavior by punishment, and the appearance of that concurrent on an FT schedule, identifies the concurrent as superstitious behavior (upper left cell of the center facing plane). This interpretation may be verified by identifying the pair of "YES" entries opposite superstitious behavior for PUN-DSRUP and FR-OCCUR (with asterisks) in the first array of Table 2. If the same concurrent appears on an FT schedule, but the DRL is not disrupted when the concurrent is suppressed by punishment, then the concurrent is adjunctive behavior (lower left cell of the center facing plane). This interpretation may be verified by identifying the pair of "YES" entries in the third array opposite adjunctive behavior under PUN-DSRUP and FT-OCCUR (with asterisks) in Table 2.

The matrix shows that punishment and the FT (the center facing plane) separate functionally autonomous, superstitious, and adjunctive behavior, but cannot be used to distinguish between mediating and collateral behavior. Extinction and punishment (the right hand facing plane) may be used to rule out collateral behavior, but fail to distinguish between superstitious and mediating behavior, or

FIGURE LEGEND

Figure 1. A three dimensional matrix indicating the appropriate interpretations for the obtained changes in behavior as a result of the introduction of any two of the experimental manipulations.

between functionally autonomous and adjunctive behavior. The cell for "typical of a chain" under extinction and "does not disrupt" under punishment, is empty, indicating the absence of an interpretation with these two properties.

The extinction and FT procedures (top facing plane) provide the most complete distinction among the interpretations as only collateral behavior and functional autonomy appear in the same cell. While these two interpretations are listed as atypical of a chain in extinction, the actual changes in behavior are different. Since collateral behavior requires the presentation of a reinforcer, extinction would lead to an immediate decrease in that concurrent. Since functionally autonomous behavior is self-reinforcing, the removal of the external reinforcer should not alter the concurrent and it would continue unabated.

CONCLUSIONS

The analysis of the procedures presented in the matrix provides the basis for three generalizations about concurrent behavior and its interpretation as functionally autonomous, superstitious, ad-

junctive, mediating, or collateral behavior.

First, the five terms are mutually exclusive and distinctive, and refer to behaviors with identifiable characteristics which can be demonstrated experimentally.

Functionally autonomous behavior is "self-reinforcing." If it occurs concurrently with a DRL, it will not change in an orderly fashion with the introduction of an FT schedule, it will not be disrupted by extinction, and it will not disrupt the schedule behavior if suppressed by punishment.

Collateral behavior is engendered by the similarities between the present schedule and prior conditions from which it arose. If it occurs concurrently with a DRL it will not appear if the reinforcement contingency is changed to an FT, it will stop immediately with the introduction of extinction, and it may disrupt the schedule behavior if suppressed by punishment.

Adjunctive behavior is a post reinforcement phenomenon induced by a schedule of reinforcement. If it occurs concurrently with a DRL, it will continue if the rein-

forcement contingency is changed to an FT, it will cease immediately with the introduction of extinction, and it will not disrupt the schedule behavior if suppressed by punishment.

Superstitious behavior is a stereotyped pattern of behavior and is a pre-reinforcement phenomenon. If it occurs concurrently with a DRL, it will continue if the reinforcement contingency is changed to a FT schedule, it will decrease gradually similar to a behavior chain with the introduction of extinction, and it will disrupt the schedule behavior if suppressed by punishment.

Mediating behavior occurs between two instances of a response and serves as the discriminative stimulus for the second reinforced response. If it occurs concurrently with a DRL, it will cease if the reinforcement contingency is changed to an FT, it will decrease gradually similar to a behavior chain with the introduction of extinction, and it will disrupt the schedule behavior if suppressed by punishment.

Inadvertently, the analysis lends support to superstitious behavior as a legitimate interpretation of behavior contrary to the suggestions of Staddon and Simmelhag (1970) and Staddon (1977). The present analysis of course does not pertain to the connotative aspects of superstitious behavior which Staddon discussed, but does provide a method for distinguishing superstitious behavior from the other alternatives. In the same manner, the present analysis asserts that functional autonomy refers to a distinctive form of behavior, but does not pertain to the connotative aspects of the term as discussed by Allport (1937).

Secondly, the present analysis indicates that any two of the five interpretations cannot be distinguished from one another by the use of a single experimental procedure, but require the identification of characteristic behavior under at least two procedures. For example, citing the similarity between mediating behavior and a chain in extinction is insufficient, since the same characteristics are expected of superstitious behavior; citing the characteristics of superstitious behavior on an FT is insufficient, since the same

characteristics are expected of adjunctive behavior; and citing the fact that punishment of mediating behavior disrupts a DRL is insufficient since the same disruption is expected for collateral and superstitious behavior. There is little danger perhaps in misinterpreting the stereotyped behavior on the FT in Skinner's superstition experiment (1948) and drinking on the FT in Segal's polydipsia study (1965), but nibbling on wood (Laties et al., 1969) or a tail (Laties et al., 1965) could be erroneously interpreted as superstition, adjunctive pica, or mediating behavior without the addition of appropriate procedures for distinguishing among the alternatives.

Finally, the importance to the experimental analysis of behavior is illustrated by the extent to which concurrent behaviors are used to explain schedule-controlled behavior (Blackman, 1968; Davis & Iriye, 1973; Glazer & Singh, 1971; Kelly, 1974; Stein & Flanagan, 1974; Stein & Landis, 1973) and schedule-controlled behavior is used to explain the development of concurrent behaviors (Davis, Hubbard, & Reberg, 1973; Falk, 1966b, 1971; Herrnstein, 1966; Iverson, 1976). Careful attention to the experimental procedures necessary to distinguish the "true" nature of these concurrent behaviors is essential.

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