The Behavioral Specificity of Stimulation:
A Systems Approach to Procedural
Distinctions of Classical and Instrumental
Conditioning

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Abstract—This paper presents a new methodological approach to classical Pavlovian investigations. Using a yoked group for stimulus pairing trial pacing, behavioral occurrence frequencies, sequential behavior patterns, and behavioral change dynamics are analyzed for rats in both a non-discriminative and a general setting discrimination paradigm. Theoretical issues addressed by a variety of new dependent measures are discussed, and a special emphasis is placed on comparing instrumental and classical procedures as viewed from the behavioral perspective of the subject.

In current papers we present a general systems view of behavior. In these we detail illustrative investigations of ecological applications (Ray and Ray, in preparation) and laboratory analyses where traditionally independent variables were treated also as dependent variables for descriptive analysis in a discriminative operant paradigm (Ray and Brown, 1975). In these papers we emphasize the importance of describing organismic-environmental interactions as continuous and integrated events occurring within contextual setting conditions. This perspective on "interbehavioral" (Kantor, 1959) continuity resulted in several new measures of behavioral adaptation dynamics and a revision of traditional conceptions of learning. The present investigation applies the same methodology to the quantification of various systems of behavioral and environmental elements defining adaptational dynamics in a classical Pavlovian environmental arrangement. Also,

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we suggest some selected theoretical revisions pertaining to distinctions of classical and instrumental learning.

Many criteria for distinguishing between these two forms of learning have been discussed (e.g., Kimble, 1961), but in our view the primary compelling argument has focused on procedural elements of the two experimental operations. Distinctions of response contingent vs. stimulus contingent reinforcement presentations strongly emphasize the decision-making processes of the experimenter, and they rely heavily on whether the animal is or is not an integral participant in the reinforcement process. If the animal is an integral participant, then its behavior is a criterion for the experimenter’s manipulations, thus making this “independent” variable manipulation dependent upon the organism as well as the experimenter. If the animal is not, then the experimenter appears to be the sole and independent operator. But such procedural distinctions largely ignore the broader behavioral context of organismic existence in the experimental situation, and thus they ignore an alternative and potentially unifying factor for the analysis of learning procedures. In this paper we present experimental data which illustrate some possible alterations in existent views of the interactive processes between animal and environment.

Subjects in our investigation were yoked to experimental subjects in the discriminative operant investigation (Ray and Brown, in 1975). By this procedure we were able to develop a modified Pavlovian arrangement whereby the yoked group had no instrumental behaviors contingently specified for water reinforcement presentations (UCS), but dipper excursion noise (CS) was always .5 seconds prior to water. Two unique aspects of our “yoked” approach to classical paradigms involved: (1) other-animal pacing of CS-UCS pairing trials (since the dipper was controlled by the bar press of the other group); and (2) general contextual setting conditions having differential compound CS functions. Since the precise details of our present methods and procedures are given in the report of the bar press group, we only summarize them here.

Methods and Materials

Subjects

Six male, Long Evans, hooded rats were randomly selected and assigned to either response contingent (bar press) or yoked-to-response-contingent (stimulus contingent, or classical conditioning) groups of equal size. A seventh animal was selected for use in daily scoring reliability sessions. This reliability animal was under bar press experimental conditions. All subjects (Ss) were approximately 130 days old at the start of the experiment.
Procedures

Ss were paired in two separate but yoked standard operant conditioning chambers equipped for water reinforcement. Reinforcement on a constant reinforcement schedule was under the control of the bar pressing animals such that water was delivered to both animals only when the response contingent animals pressed during a bright (S^D)-dim (S^A) light discrimination situation. Ss were exposed to a rather lengthy and complex series of experimental conditions, of which only adaptation, acquisition, and maintenance functions were relevant for present discussion purposes.

Each chamber was contained in separate sound attenuated environmental boxes. Each environmental box was housed in a separate observation room. Light conditions (each with durational $\bar{X} = \text{approx. 19 sec}$) and reinforcements were controlled by a solid state and relay programming apparatus in a room adjacent to the observation rooms. As stated, all Ss were observed during those conditions to be reported, which included adaptation to the conditioning chamber while on ad lib water (Adaptation Satiated) and 23½ hour water deprived (Adaptation Deprived), in that order. All experimental conditions included four separate sessions of 15 minutes each. Adaptation sessions were followed by conditions of bar pressing of the instrumental Ss (BPS) and bar press stabilization maintenance (BPM), S^D/S^A shaping and maintenance (S^D/S^M), and two blocks of four sessions each of S^D conditions late in discriminative training when discrimination had fully stabilized (LS^D). Eleven possible isolate behaviors were defined prior to the experiment (see Table 1 for categories and definitions). Behavioral observations were made by two observers (one for each group) through one-way glass. A 5 sec observation, 15 sec recording time sample schedule was used. Inter-observer reliability was checked and maintained at .98+ through daily simultaneous observation of the seventh animal by both observers. Observations included behavioral antecedents (S^D/S^A conditions and dipper events), behaviors, and behavioral consequences (water). Thus interbehavioral functions are analyzed as behavioral-environmental sequential phenomena.

Results and Discussion

As stated, only the yoked group's results are presented in the present paper, since this group serves as the traditional Pavlovian stimulus pairing (dipper noise CS and water UCS with .5 sec inter-stimulus interval) procedure. The instrumental group is reported in the paper previously cited (Ray and Brown, 1975). For present experimental comparative purposes, data baselines are established by the adaptation conditions. Discussion of results will be presented
<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar Press</td>
<td>A bar press is defined as pressing the bar sufficiently enough to effect a switch closure. Any behavior involving the bar which does not summate in a switch closure is scored as object manipulation. The manner of bar pressing is not relevant, therefore an accidental bar press is still scored as a bar press. A bar press is also independent of whether or not a reinforcement is delivered.</td>
</tr>
<tr>
<td>Freezing</td>
<td>Motionless attentiveness.</td>
</tr>
<tr>
<td>Resting</td>
<td>Motionless, unattentive, animal is usually in reclined position with eyes closed.</td>
</tr>
<tr>
<td>Head Exploration</td>
<td>Animal is fully attentive, body may move, and forepaws may move. <em>Hind paws do not move!</em> This category includes rearing, sniffing, pawing, or licking non-significant objects. Climbing with forepaws is also included as long as hind paws do not move.</td>
</tr>
<tr>
<td>Movement</td>
<td>This category includes all movement involving the hind feet with the exception of scratching.</td>
</tr>
<tr>
<td>Grooming</td>
<td>Grooming includes all forms of grooming except scratching. It may include licking, chewing, and scratching (with forepaws only) at any and all parts of the body. Momentary pauses of less than one second during this behavior do not constitute a break in the behavior.</td>
</tr>
<tr>
<td>Object Manipulation</td>
<td>Sniffing, pawing, licking, or chewing any significant object in the experimental space is called object manipulation. Significant objects are defined by the particular experiment and apparatus used. In this study they were defined as the bar, water dipper, food box, and the light above the bar. Novel objects introduced for experimental purposes are considered significant. Licking the water dipper when water is not available is scored as object manipulation in this study.</td>
</tr>
<tr>
<td>Carrying</td>
<td>This category includes transporting any moveable object from one point to another by dragging or pulling with the teeth or paws or carrying an object with the forepaws.</td>
</tr>
<tr>
<td>Drinking</td>
<td>Drinking is self-explanatory. Duration is restricted to 5 secs. in this study.</td>
</tr>
<tr>
<td>Eating</td>
<td>Eating is self-explanatory.</td>
</tr>
<tr>
<td>Scratching</td>
<td>This includes scratching at various parts of the body with one or the other hind paw. It also includes chewing or licking the feet immediately after scratching.</td>
</tr>
</tbody>
</table>

in sections corresponding to each form of measurement obtained from the contingency analysis approach.

**Behavioral Occurrence**

Our measure of behavioral occurrence is total seconds accumulated per minute. This accounts for initiation frequencies and
durations simultaneously in a confounded measure. Figure 1 illustrates that deprivation vs satiation made little overall difference in behavioral occurrences during adaptation. Initial introduction of a constant compound CS+ (\(S^D\)) along with dipper presentations created a context-event situation which first resulted in an increase in freezing and licking-drinking (BPS sessions) compensated by declines in other behaviors. The second block of four sessions of CS+ and dipper-water (BPM) brought a second increase in drinking and disappearance of freezing. This indicates both an acquisition of dipper-water association resulting in longer licking/drinking durations and simultaneous habituation of freezing to the rather loud CS noise made by the dipper excursions. The Ss were observed spending a great deal of time in perseverative licking at the dipper whether water was present or not. Thus Ss were quite likely to be at the dipper when water was presented and few other behaviors occurred between presentations. Such a result goes somewhat beyond a short lived reflex-elicitation phenomenon and suggests that similar but interim behaviors are also being brought under situational control. This argument is related to discussions of operant superstitious behaviors (Staddon and Simmelhag, 1971), and it suggests that behavioral results of Pavlovian pairings may involve integrations as well as frequencies. We will present further data on this point shortly. This perseverative licking/drinking also serves to illustrate the difficulty in choosing whether a behavior is elicited by a stimulus or whether it instrumentally precedes a stimulus. Since this behavior is initially elicited but remains continuous until the next stimulus, it is both in this instance. This points to the rather arbitrary nature of choice in viewing behavior as isolated phenomena rather than integrated and continuous events.

Addition of differential setting conditions (\(S^D = \text{compound CS+; } S^A \text{ compound CS-}\)) eventually brings the animals back to adaptation-satiated normalcy in \(S^A\). Possible exceptions are an increased licking/drinking carry-over from the last \(S^D\) water available, and a slight increase in eating now that some amount of water has been consumed. Behavioral occurrences in \(S^D\) are generally equivalent to early dipper training sessions (BPS). Most marked in the overall results is a sharp decline in perseverative licking within \(S^A\) conditions across training sessions. This reflects a general discriminative control over the animals' behaviors exerted by the addition of a general setting stimulus.

**Behavioral Patterning**

Use of inclusive multiple behavior categories and somewhat continuous recording allows us to chart sequencing from one type of behavior to another, and thus to analyze sequential behavioral patterning and associated occurrence probabilities.
Experimental Condition

Fig. 1. Average cumulative seconds per minute spent in each behavior across four sessions in each experimental condition, including Adaptation Satiated (AS), Adaptation Deprived (AD), Bar Press Shaping (BPS) of the yoked group, Bar Press Maintenance (BPM) in the yoked group, Stimulus Discrimination Shaping (SDS), Stimulus Discrimination Maintenance (SPM), and two consecutive blocks of Late Discrimination Maintenance (LSD).

Behavioral patterns were analyzed for $S^D$ and $S^a$ during Adaptation Satiated and Adaptation Deprived conditions, and probabilities were virtually the same in all settings. Thus Figure 2 is representative of behavioral patterns and associated probabilities of occurrence in all observed adaptation conditions. The most frequently observed behavior was head exploration, which then sequenced most frequently into movement and object manipulation, both of which had a high frequency of sequencing back into head exploration.
Fig. 2. Behavioral sequencing patterns during: (a) all of the Adaptation conditions combined; (b) Bar Press Maintenance sessions; and (c) $S^D$ and $S^A$ periods of Late Discrimination Maintenance conditions. The connecting arrows have proportional width depicting probability of occurrence of each type of sequence.
Introduction of the dipper noise plus water presentations would be expected to alter both behavioral patterning and probabilities, as well as general behavior rates. Figure 2 illustrates changes in behavioral integration brought about by stimulus pairings in the early “maintenance” sessions. Since dipper excursions were recorded along with the behavior, the possibility of drinking continuing perseveratively through from one trial presentation to the next makes possible a drinking-to-drinking sequence interrupted only by a stimulus event. As Figure 2 illustrates, this is the most frequent of all possible behavior occurrence sequences and occurred with a .88 probability. As suggested in the data, this depicts an organism spending nearly all of its time either drinking water or perseveratively licking a dry water dipper. Thus if there is an “instrumental” behavior pattern in these data, licking/drinking is the most predominant response being acquired. But that is also the very pattern “elicited” by the water UCS. Other behavior patterns are infrequent, but once initiated they tend to perseverate away from the dipper as seen by Head Exploration sequencing most frequently into Gross Motor Movement which then sequences most frequently back to Head Exploration. In fact, these patterns bear strong resemblance to patterns observed in Adaptation sessions, suggesting that some integrated patterns are being transferred intact, but are being displaced by new and differentially integrated patterns elicited by the dipper and water.

Analysis of discrimination data based on later maintenance sessions suggests that perseverative drinking patterns of the early sessions are becoming even more strongly entrenched with fewer side excursions into long-lasting exploratory patterns. On the other hand, S₄ conditions reflect patterns almost identical to Adaptation sessions, suggesting a nearly perfect setting control over discriminative integrated behavior patterns. Thus not only did normal behavioral rates return in S₄, but so did the normal integrations return.

**Interbehavioral Sensitivity**

Sequential behavior events may also be analyzed around specific stimulus change events as well as constant setting conditions. Such analysis will supply considerably more information than those previously discussed, since both stimulus elicited behavioral changes and stimulus elicitation failures will be represented. In addition, specific behaviors being intercepted by stimuli (base behaviors) are accounted for. Behaviors which “sequence” onto themselves given stimulus intrusion (i.e., those that do not change due to the stimulus event) may be compared to behaviors which sequence into some other behavior, thus rendering an overall proportional measure of sensitivity of animals to stimulus-induced behavioral
change under given experimental and behavioral situations. A simple proportion based on total number of behavior type changes divided by the total event presentations gives an index of general "combined" behavioral elicitation sensitivity relative to any given stimulus event upon which a behavioral sequence analysis is based. In this report we shall investigate only the "$S^D$ onset" and "dipper-noise" event elicitations.

Behavioral sensitivity measure for all behaviors combined gives a general picture of the degree to which an organism is sensitized or attends (more specifically: is likely to alter his behavior) to given environmental events. However, a more detailed and explicit analysis may be added by calculating elicitation likelihood separately for each ongoing behavior occurring at time of stimulation (base behaviors). Individual and combined sensitivity measures for AS, AD, and the combined Late $S^D$ conditions are given in Table 2. These conditions were respectively chosen as representative of baseline (satiated), motivational-organismic setting conditions (water deprivation), and learned environmental setting conditions ($S^D - S^A$).

From Table 2 it appears that water deprivation had a sensitizing effect. The combined index increased approximately 78 per cent over baseline sensitivity by changing from 23 per cent elicitation to 41 per cent. This is especially important considering that occurrence and pattern data reflected no changes whatsoever in these two conditions. Perhaps most significant is the fact that all behaviors share in this sensitivity increase to some extent, except for freezing which we shall presently see was affected only as a sequential, or elicited, behavior. Freezing was never observed to sequence into another form of behavior as the result of light onsets, but rather remained as a continuation of freezing. This would appear to have face validity since there would be some survival value in remaining frozen in an uncertain and shifting environment; especially if quarters were small and precluded flight. It is also relevant to note the added effects of discriminative setting conditions and their contributions (Table 2, column three). Note that behaviors do not attain equal final sensitivities. Some become highly sensitive, or likely to sequence to $S^D$ onsets, while others remain less sensitive. Thus even learned discriminations appear to exist on a continuum, with sequential probabilities differing among the various behavior categories. This means that learned stimulus onset functions will vary depending upon which behavior is active during the event's presentation. The account of variance in general conditional responding by such an analysis should be rather significant. Implications are such that preceding behaviors prior to classical stimulus pairing trials may modify the functional relations and their generalizations derived from classical study techniques.
TABLE 2. Proportion of SD Presentations Which Induced Behavioral Change With Each Specific Behavior Category Across Conditions of Adaptation Satiated, Adaptation Deprived, and Late SD Maintenance.*

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Adaptation Satiated</th>
<th>Adaptation Deprived</th>
<th>Late SD Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freezing</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Movement</td>
<td>.75</td>
<td>—</td>
<td>1.00</td>
</tr>
<tr>
<td>Exploration</td>
<td>.33</td>
<td>.46</td>
<td>.84</td>
</tr>
<tr>
<td>Grooming</td>
<td>0.00</td>
<td>.33</td>
<td>.42</td>
</tr>
<tr>
<td>Scratching</td>
<td>0.00</td>
<td>.57</td>
<td>.53</td>
</tr>
<tr>
<td>Object Manipulation</td>
<td>.30</td>
<td>.50</td>
<td>1.00</td>
</tr>
<tr>
<td>Drinking</td>
<td>—</td>
<td>—</td>
<td>0.00</td>
</tr>
<tr>
<td>Eating</td>
<td>0.00</td>
<td>.40</td>
<td>.17</td>
</tr>
<tr>
<td>Combined</td>
<td>.23</td>
<td>.41</td>
<td>.55</td>
</tr>
</tbody>
</table>

* Also depicted is overall proportion of successful elicitations for all behaviors and SD presentations combined.

Freezing remains totally insensitive even during learning and it should be noted that eating has become less sensitive now that water is being ingested (i.e., less thirsty animals are more likely to continue eating even in the face of stimulus change cues than are more thirsty animals).

Elicited Behaviors

Once the question of behavioral sequencing has been raised, it is not only possible to address the specific and general likelihoods of initial behaviors altering in form and frequency, but also to ask what forms the sequential, or elicited behaviors take. Such an analysis looks at behaviors being elicited by environmental events, and thus parallels the more traditional measures of classical theory.

This report focuses on only the three elicited behaviors which demonstrate the most consistent and illustrative modification due to stimulus pairings. Behaviors elicited by both SD onsets (differential compound CS) and by dipper noises (CS) were analyzed and are presented in Figure 3. As suggested previously by elicitation sensitivity data, deprivation created a much more sensitive organism as also reflected in the fact that freezing was elicited much more frequently by onsets. During constant SD conditions existing during BPS and BPM, the dipper elicited some freezing as well, even though water was being presented with each excursion. These data illustrate what is traditionally referred to as a competing Pavlovian orienting reaction (OR). The decline of this response across sessions illustrates OR habituation. It is interesting to compare freezing to graphs illustrating acquisition of other elicited behaviors, since OR habituation and CR acquisition are being simultaneously modified. It should also be noted that dipper-freezing habituation
Fig. 3. Behaviors elicited by $S_D$ onsets and dipper presentations during each experimental condition, including Adaptation Satiated (AS), Adaptation Deprived (AD), Bar Press Shaping (BPS) of the yoked group, Bar Press Maintenance (BPM) in the yoked group, Stimulus Discrimination Shaping ($S_{DS}$), Stimulus Discrimination Maintenance ($S_{DM}$), and two consecutive blocks of Late Discrimination Maintenance ($LS^{D}$).

did not transfer to $S_D$ onset elicitations, which had to be habituated separately after being added.

The graph for licking/drinking illustrates establishment of a traditional consummatory-motor CR across sessions. The dipper event (CS) elicits licking/drinking behavior increasingly as learning progresses. As this response was acquired animals were often observed licking at the open hole while the dipper made its excursion into the reservoir. As suggested by the $S_D$ graph, the $S_D$ onset also frequently started this anticipatory licking, often many seconds prior to any dipper activity. This elicitation slowly developed simultaneously with declines in perseverative licking occurrences in $S_A$. Before this occurs, such elicitations are not physically possible. Such $S_D$ elicited licking is only possible, however, if animals are in the physical vicinity of the dipper. If further away, the licking would have to be preceded by movement. Thus gross spatial movement, while not often thought of as "reflexively elicited," should be included for a more complete analysis.

Movement elicited by the dipper is generally evoked during earlier conditioning sessions. The decline of this behavioral elicitation in later sessions is a product of the simultaneous increase in movement elicited by $S_D$ onsets (which preclude the necessity of going to the dipper during excursions). Observations in support of this analysis indicate that when the light comes on, the animal runs to the dipper, which often is beginning its first excursion, resulting in a dipper elicited licking. Thus the opportunity to run at the sound of the dipper is eliminated by an anticipatory run before the dipper excursion, leaving only licking/drinking to be elicited. In the event that the $S_D$ fails to elicit the movement, the dipper usually will, but has fewer opportunities to do so. Thus several CR sequences are learned as elicited patterns of activity appropriate for obtaining water under a variety of appropriate setting situations. These replace other less-successful and habituating patterns of
elicitations such as freezing. Such an analysis suggests a very complex interplay between elicitation functions and instrumental reward functions of stimuli which serve to reintegrate and redirect behaviors for appropriate situational adaptation. In fact, such dichotomous terminology may represent more of a focusing bias on pre vs post stimulation behavioral events than stimulus events. If this is the case then reinforcement must be totally reanalyzed as we have suggested elsewhere (Ray and Brown, 1975). The next question is how the existing behavioral integrations serve to facilitate and/or hinder this stimulus control process.

**Elicited Behavioral Bases**

After accomplishing assessments of varying behavioral sensitivities through elicitation probabilities and analyses of which behaviors come to be elicited, a further analysis was conducted of the proportion of elicited behavior changes accounted for by each specific initial behavior.

An analysis of elicited drinking and the initial behaviors which served as its base for elicitation will be discussed, but first several considerations are important as background for the significance of this measure.

(A) Since not all behaviors share equal probabilities for sequencing as the result of a given stimulus event, behaviors are likely to play differing roles in the learning process. That is, some initial behaviors will be quite likely to sequence given certain stimulus elicitors. They may also be more likely to sequence into certain types of behaviors, and the right combination of sequential probability and elicitation probability will result in very rapid CR acquisition if the specific initial behavior is in progress at the time of the CS. Thus the CR elicitation may be associated easily to some behaviors, while other behaviors, such as freezing and eating (when not totally deprived of water), may be difficult, if not close to impossible, to associate with the desired elicitation. This point shares some commonalities with Seligman’s (1970) suggestions of a behavioral preparedness for learning, except that Seligman’s emphasis is primarily on the elicited behavior, not the base-elicitation combination. Bolles (1970) species-specific defense analysis perhaps comes closer to the present analysis, but since not all behaviors share an equal sequential pattern probability initially, and since intentions of the learning operation may be on changing patterns rather than elicitations (or even both), proper analysis of learning generalities becomes considerably more complex than either Bolles’ or Seligman’s approach would suggest. One must, at least, consider initial behavioral sensitivity, behavioral elicitation values, sequential patterning, and the type of interbehavioral change intended by the learning operation.
(B) Associated with, and derived from, this first consideration is the fact that learning may come fully under one or more initial behavioral conditions, only partially with others, and perhaps never with others; and unless the partially or non-associated behaviors are eliminated by experimental manipulations such as setting modifications, habituation, suppression, or even processes yet to be investigated, then performance may never be precisely predictable (as the continued problem of "random" variance in psychology attests).

(C) Implicit in (B) is the fact that behavioral occurrences will also be associated with defining individual contributions to the elicited behavior's base. Thus, if stimulus contingent learning is complete, a general analysis of a given elicited behavior should show each behavior contributing in proportions equal to its proportional rate of occurrence. For instance, assume that five behaviors contribute to a behavior's elicitation as initial behavior bases. If they are of equal rates and are equally associated with the elicited behavior, they should each contribute 1/5 or 20 per cent as bases for that behavior's elicitation. However, since initial rates will probably be unequal, their ideal proportionate contribution will be unequal. More frequent behaviors will be available more often and will thus account for a higher proportion of the elicitation base. It is thus necessary to calculate both the number of behaviors contributing as bases and their relative proportion to one another. Such a calculation will give the proportional value, based on occurrences, which would be expected given elicitation learning distribution equilibrium among the contributing initial behaviors. Proportions in excess of that ideal proportional rate indicate easily learned base-behavior-CR connections around the eliciting stimulus event, and proportions under the ideal proportion imply difficult or slow acquisition. The order in which behaviors reach or exceed this value marks their relative ease of learning, or preparedness as bases for elicitation. We might note in passing that reward properties of the stimulus would likely alter this arrangement during the experiment.

(D) Fixed locality may define a behavior's occurrence (i.e., eating or drinking) such that it is impossible to associate with other environment-bound behaviors which are separated spatially.

Figure 4 illustrates the five prominent contributors to elicited drinking, their proportionate contribution by experimental condition, and their ideal proportional level of contribution based on SP behavioral rates in the combined final SP-SA conditions (details in Table 3). Whether new pattern learning is involved is not addressed by the present study, since no adaptation sessions with water available were included. Such a condition would be necessary to deter-
Fig. 4. Proportional contribution of each behavior serving as a behavioral base for $S^D$ onset induced behavior changes and dipper induced behavior changes during each experimental condition, including Bar Press Shaping (BPS) of the yoked group, Bar Press Maintenance (BPM) in the yoked group, Stimulus Discrimination Shaping ($S^D$PS), Stimulus Discrimination Maintenance ($S^D$DM), and two consecutive blocks of Late Discrimination Maintenance ($LSD^D$). Also shown is the average proportional occurrence of each of these behaviors during all combined $S^A$ periods in Late Discrimination Maintenance ($LSD^D$).

mine whether behaviors sequencing normally into drinking have been significantly altered, merely shifted to specific stimulus elicitation control, or both. It is clear that at least pattern association to environmental cue elicitation is involved, since the elicitation values of behaviors were specifically altered across discrimination training sessions.
TABLE 3. General Frequency of Each Behavior’s Occurrence in Cumulative Seconds Per Minute and Associated Proportional Occurrence for Comparing the “Expected” versus the “Observed” Participation as Base Behaviors for $S^D$ and Dipper Induced Behavior Change.

<table>
<thead>
<tr>
<th>Behavior</th>
<th>$\bar{X}$ Rate During Late $S^D$ Maintenance</th>
<th>Proportional Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration</td>
<td>14.5</td>
<td>.337</td>
</tr>
<tr>
<td>Movement</td>
<td>4.0</td>
<td>.093</td>
</tr>
<tr>
<td>Grooming</td>
<td>5.0</td>
<td>.116</td>
</tr>
<tr>
<td>Scratching</td>
<td>9.0</td>
<td>.209</td>
</tr>
<tr>
<td>Eating</td>
<td>10.5</td>
<td>.244</td>
</tr>
<tr>
<td>Total</td>
<td>43.0</td>
<td>1.000</td>
</tr>
</tbody>
</table>

From Figure 4 it is clear that Head Exploration was the most easily associated with the drinking, since in early sessions it accounted for the greatest proportion of behavioral sequencing into drinking. Next acquired was movement, grooming, scratching, and eating, in that order. In fact eating has not yet reached its expected proportional contribution. While this ordering does not match the rank-order of occurrence frequencies, thus ruling out simple number of pairings explanations, this ordering of acquisition does bear remarkable resemblance to the ordering of sequential behavioral patterning probabilities. This suggests the possibility of additional types of analyses relating initial behavioral patterns to the specific altered pattern desired. We have reported similar results relative to the discriminative control exerted over the bar presses of the response contingent group (Ray and Brown, 1975), which further argues for the generality of this phenomenon. Operant psychologists have long known of this problem on an informal basis in their use of successive approximations for behavioral pattern shaping in relation to environmental outcomes and effects. The fact that shaping might be applied to Pavlovian stimulus pairing and behavioral elicitation has been ignored due to the assumption that all elicitations share a common probability and are not dependent upon what the animal is doing when the stimulus is presented. However, most experimenters know at the informal level that you must first restrain and habituate the animal in order to maximize the attention-getting properties of the stimuli to be used experimentally. It now appears possible to accomplish a much more systematic analysis of these variables.

**Behavioral Flow**

Interbehavioral contingency analysis places a great deal of emphasis on total situational interactions. One indicant of the degree of this interaction is the total number of behavioral changes
occurring within the time span of a given constant setting. Such a measure accounts for the rate of flow from one type of behavior to another. Technically the measure is calculated by dividing the total number of behavioral sequences by a given time period relative to a given setting. Behavioral flow calculations for the $S^D$ and the $S^A$ settings are given in Figure 5. Flow rate increases as a result of conditioning, but not as a result of deprivation. It should be noted that flow rate is elevated in $S^A$ as well as $S^D$, despite the fact that overall combined time spent in each behavior (rates) and the behavioral patterns are similar between adaptation and the late $S^D$ conditions. This means that individual durations of each behavioral occurrence is shortened, but that the total cumulative time per minute spent within each category remains the same (i.e., initiation frequencies are up).

**Behavioral Pattern Variability**

Behavioral flow rates indiscriminately analyze total changes from behavior to behavior in a given time period and setting. If one were to further analyze for total number of different specific kinds of behavior changes, information relative to the number of variations in patterns would be gained.

Figure 6 illustrates measures of pattern variability during $S^D$ and $S^A$. Of particular interest is the rather sharp increase in $S^A$ during Late $S^D$ experimental conditions. Like the results of the flow rate analysis, flow variation analysis suggests that $S$s are quite different in $S^A$ during these sessions than in Adaptation conditions, even though situational contingencies are equivalent except for surrounding settings ($S^D$-stimulus pairings) and durational characteristics. The variability increase indicates the animals' reliance
FIG. 6. Average number of different kinds of behavioral sequence patterns occurring in each experimental condition, including Adaptation Satiated (AS), Adaptation Deprived (AD), Bar Press Shaping (BPS) of the yoked group, Bar Press Maintenance (BPM) in the yoked group, Stimulus Discrimination Shaping (SDS), Stimulus Discrimination Maintenance (SDM), and two consecutive blocks of Late Discrimination Maintenance (LSM).

on a much greater variety of different behavioral sequence patterns and the flow data suggest this sequencing is occurring at a much faster rate.

Flow rate and variation data taken together are suggestive of the importance of contextual setting conditions for behavioral analysis, and the temporal pacing of such settings has been demonstrated a highly significant variable for these measures (Ray, Brown and Greenspan, 1974).

Discussion

By now it is clear that all stimulus events, when interfaced with the behavioral stream, meet our present definition of eliciting stimuli. This would also have to include stimulus classes normally defined as instrumental reinforcing stimuli. In fact, we suspect that future research may reveal that stimulus elicitation values are perhaps synonymous with reinforcement values or potentials. Suggestions and evidence to this effect have been discussed by Denny and Adelman (1955), and present methods could add significantly to a systematic analysis of this approach.

But we are still faced with the dilemma of explaining differences in experimental operations which have traditionally led to distinctions between various stimulus and behavioral functions (i.e., Pavlovian and Instrumental). Considering the number of different elicited behavior bases serving in the present study, it would appear that a much larger variety is serving here than would be found in an instrumental conditioning situation. In an instrumental paradigm, normally only one behavior is defined as the desired elicitation base, except perhaps during successive approximation training. Thus, the selected “instrumental” behavior is always the base behavior for the presentation of the “reinforcement” stimulus. Reinforcing stimulus delivery then most frequently elicits a behavioral
change (e.g., consumption) which starts a new pattern of events that increasingly (upon successful "learning") return back to the instrumental behavior-reinforcement stimulus sequence. But when analyzed, actually all of the behavioral measures we have discussed are changed to some extent by this "instrumental" process. Thus it makes little sense to look only at the pre-stimulus behavior changes (i.e., instrumental responses) or only at the post stimulus behavior changes (i.e., classical elicitations). As we have noted, this is even a dubious distinction in some classical situations.

On the other hand, in the most theoretical sense of the traditional Pavlovian paradigm, stimuli are delivered to the animal without regard to the base behaviors in progress. We point to the theoretical nature of this procedure because in practice many behaviors are systematically eliminated by physical restraint or harnessing in order to "maximize" certain elicitation acquisition effects by minimizing certain "interference" forms of base behaviors available to the organism. When analyzed, these base behaviors that have been eliminated may turn out to be highly insensitive to stimulus elicitation (i.e., have low elicited sequencing probabilities and are difficult to increase in probability). Thus from our previous examples, we can see that virtually all remaining, or situationally possible, behaviors are post factum serving quite randomly as base criteria in the delivery of stimuli. Put another way, this is a statement that ecologically determined proportional distributions of behavioral occurrences are used to specify the behavioral interface with some probability of stimulus occurrence remaining unspecified. Where certain regularities in temporal elements are included in the paradigm, it is immediately recognizable as the "temporal classical conditioning" or "superstitious operant conditioning" paradigm; and it is well known that such paradigms have very complex between-stimulus effects on behavioral flow dynamics (e.g., Staddon and Simmelhag, 1971; Schoenfeld and Cole, 1972).

To summarize, it would appear that one potential difference defining the separation of instrumental vs Pavlovian procedures is the specificity of environmental-stimulus presentation bases required by the paradigm. This distinction is normally referred to as a "contingent" vs a "non-contingent" interface, where a single base specification means contingent, and a multiple, random, or all-inclusive base specification means non-contingent.

Since there is a very wide use of either single, pre-specified behavioral criteria for delivering reinforcement (instrumental paradigm) and of random distribution-unspecified behavioral criteria (classical paradigm), it would appear that dichotomies of this type have been somewhat artificially maintained by an incomplete analysis of behavior change processes. Our analysis suggests
that many other forms of criteria selection might exist which fall somewhere between these two extremes. For instance, we could select any collective number (but not all) of specific base behaviors and make any one of them probabilistically sufficient for reinforcement delivery. Thus the animal might learn that several alternative behaviors are equally satisfactory for obtaining reward. Put more succinctly, by merely manipulating the range of 0 to 1.0 probabilities of stimulus delivery upon each of these non-inclusive behavioral categories independently, we could approximate a paradigm which appears to randomly specify one set of behaviors while systematically excluding another set. This paradigm appears to be some combination of a traditional classical paradigm and an instrumental "omission" contingency.

Thus we suggest that learning procedures actually represent a parametric continuum of related procedures comprised of the specification of a certain number and type of behavioral events (ranging from zero behaviors, or extinction, through one behavior, or instrumental, up to and including all behaviors, or classical) which will be sufficient for serving as "base behaviors" for probabilistic stimulus deliveries. These stimulus deliveries then determine the nature of many alterations in behavioral flow dynamics as previously discussed. Thus three major parameters seem appropriate for determining a paradigm statement: (1) the specific number and (2) the specific type of behavioral categories included in the behavioral specification for stimulus delivery, and (3) the probability of the stimulus' occurrence given each specific type of prerequisite behavioral occurrence. Behavioral type is critical in terms of the normal sequential and distributional probability properties relative to other behaviors included or excluded in the stimulus event list. Each of these quantifiable dimensions, including the stimulus probability dimension is free to be independently manipulated in a paradigm specification.

A consideration of operant definitions of multiple behavior specification in the form of chaining suggests still another level of consideration. Sequential behavior patterns occurring prior to the reinforcing-eliciting stimulus may also be experimentally specified, thus changing the elicitation matrix into a multiple-matrix series where behavioral patterning sequences are selectively specified as required prior to eliciting stimulus presentation. This merely transforms the base behavior delimiters into multiple behavioral-sequence requirements instead of singular behavioral requirements. Such a compound event could also be developed on a random basis (i.e., in a Pavlovian paradigm). Under truly random Pavlovian procedures these conditions would exist by definition, but we know of no existing analysis of such pre-UCS response chains.
Variations on this theme might exist however. For instance, it may be that with conditions of very long CS-UCS inter-stimulus intervals, a situation is inadvertently established where multiple behavior sequences are likely to occur after the CS onset elicitation, but prior to the UCS elicitation. Such complexities would increase greatly the number of behavioral patterns potentially serving either as the UCR or the CR elicitation base, and would be expected to retard conditioning using behavioral systems with naturally high flow rates (e.g., various motor systems), but would not so greatly affect those systems where slower flow rates exist (i.e., various autonomic systems). This may help explain the long existent inconsistencies in the inter-stimulus interval research; the results of which, to our knowledge, fit the predictions of the present model relatively well. This multiple response analysis bears some resemblance to a discussion by Lynch and Kakigi (1968) relative to generalized vs conditional responding early in long inter-stimulus intervals.

When compound stimulus events are added to the elements just discussed, experimental interface procedures become more context-specific in the sense that stimulus event requirements may or may not be included in specifying the “reinforcement” stimulus and CS-UCS deliveries. Thus a specific interbehavioral sequence (i.e., a behavior-stimulus-behavior interaction) may become the criterion for delivering reinforcement. The simple example of this is a bar press or key peck. That is, any instrumental response which is environmentally interactive or effective becomes a response-stimulus-response-reinforcement sequence of events. But such cases naturally increase the kinds of possibilities for experimental-procedural specification. For instance, the first stimulus (e.g., a CS or $S^P$) may be made “instrumental” (i.e., contingently specified relative to specific behaviors), but the second stimulus (reinforcement) may only be contingent on the delivery of the first stimulus (and thus random relative to behavioral category interface). Such a paradigm would allow for a response-contingent, or instrumental, delivery of a traditional Pavlovian stimulus pairing. Just such a procedure is still used in Pavlov’s original laboratories and is known as the “Kupalov place reflex” or “situational reflex” (Cole and Maltzman, 1969; Giurgea, 1974). This is an example of a paradigm where one behavior is specified for the first stimulus’ delivery (either a CS+ or a CS−) and then the delivery of a second stimulus (UCS) occurs contingently only upon that base-behavior–CS+ sequence occurrence. We can also envision a randomly sufficient behavioral criteria for delivery of the first signal, but then a specific qualification of the sufficient behavior for the second signal (this paradigm fits the widely used discriminative operant definition). Many other
permutations and combinations of possibilities exist which qualify stimulus deliveries upon the basis of multiple behavioral, stimulus, and interbehavioral choices and specifications. When probabilistic functions related to stimulus delivery-event specification relations are added, the possibilities become even greater. Most of the possibilities have no known research pertinent to their special qualities.

Further experimental assessment is the only means of truly evaluating the merits of elevating specificity and contiguity of stimulus-behavior occurrence to this level of importance, but certainly many unique paradigms are suggested by such an analysis. Only future assessments of the adequacy of the various parametric procedures suggested can determine for certain, but we suspect that eventually we will find that classical-instrumental distinctions of any type will reduce to parametric extremes rather than generic differences.

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References


