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THE REINFORCING PROPERTY OF AN AVERSIVE STIMULUS.

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THE REINFORCING PROPERTY OF AN
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A Dissertation

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by

James D. Phillips, Jr.
B.A., University of Arizona, 1956
M.S., Florida State University, 1962
August, 1963
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# TABLE OF CONTENTS

| TITLE PAGE | 1 |
| ACKNOWLEDGMENT | ii |
| LIST OF TABLES | iv |
| LIST OF FIGURES | v |
| ABSTRACT | vi |
| INTRODUCTION | 1 |
| METHOD | 8 |
| Apparatus | 8 |
| Subjects | 9 |
| Design | 9 |
| Procedure | 10 |
| RESULTS | 13 |
| DISCUSSION | 23 |
| SUMMARY | 32 |
| REFERENCES | 35 |
| VITA | 42 |

---

iii
LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Experimental Groups</td>
<td>11</td>
</tr>
<tr>
<td>2 Summary Table for the Analysis of Variance of Groups .00 Through 1.00 During the <strong>First</strong> 20 Minutes</td>
<td>15</td>
</tr>
<tr>
<td>3 Summary Table for the Analysis of Variance of Groups .00 Through 1.00 During the <strong>Second</strong> 20 Minutes</td>
<td>16</td>
</tr>
<tr>
<td>4 Summary Table for the Analysis of Variance of Groups .00, .15-40, and .30-40 During the <strong>First</strong> 20 Minutes</td>
<td>20</td>
</tr>
<tr>
<td>5 Summary Table for the Analysis of Variance of Groups .00, .15-40, and .30-40 During the <strong>Second</strong> 20 Minutes</td>
<td>22</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

FIGURE                        PAGE
1  The Mean Number of Responses at the Shock
   End of the Box for Successive 2 Minute Intervals 14
2  The Mean Number of Responses per Groups .00–
   1.00 During the Shock Period at the Shock
   End of the Box as a Function of the Shock
   Intensity  18
ABSTRACT

The purpose of this investigation was to determine the reinforcing effect of different intensities and durations of presentation of electric shock upon exploratory behavior of white rats. The attempt to use electric shock as anything other than an aversive stimulus has been rather limited. Consequently, very little is known concerning the positive reinforcing characteristics of this stimulus. That electricity can function at all in a nonaversive manner suggests that perhaps all stimuli can be either positive or negative reinforcers depending upon their intensity and duration of presentation.

The subjects for this experiment were 80 Sprague-Dawley albino rats, 120 to 150 days old. The animals were divided into eight equal groups matched on the basis of sex and activity level.

The animals were placed individually in a modified operant box for a period of 40 minutes. The box had the bar removed and had been rendered devoid of any distinctive cues. During the experimental period the amount of activity at the two ends of the box was measured by photocells connected to an event recorder. After a period of 20 minutes, five of the groups received an A.C. shock of either 0.10, 0.15, 0.20, 0.30, or 1.00 ma. through the grid for a duration of one
second each time the photocell beam at one end of the box was interrupted by the animal. The sixth group received no shock for the entire 40 minutes. The remaining two groups received a one second 0.15 and 0.30 ma. shock respectively, with each interruption of the photocell beam at one end of the box for the entire 40-minute experimental period. A three-way classification analysis of variance was applied to the frequency of photocell beam interruptions in successive two-minute intervals.

No significant differences were observed between the groups receiving no shock for the first 20-minute period. However, during the second 20-minute experimental period a significant difference between the groups was obtained. A graphic representation of the data indicated that a systematic change in the number of responses had occurred. Low intensity electrical shock increased the number of approach responses to the shock end of the box and high levels of shock resulted in immediate avoidance responses. Behaviorally, a shock of 0.15 ma. produced maximum seeking and a shock of 1.00 ma. produced maximum withdrawal. To all shock intensities below 1.00 ma. an immediate orientation response was produced. This orientation toward the stimulus was followed promptly by withdrawal in the groups receiving 0.20 and 0.30 ma. shock. The animals receiving shock for the entire 40-minute period showed a significant decrease in the number of exploratory approach responses.
These results indicate that the aversive character of electric shock is a function of the shock intensity and duration of presentation. Under certain conditions shock may be used as a positive reinforcer. The data are in support of the view that all stimuli may be either positive or negative reinforcers depending upon the conditions under which they are applied.
INTRODUCTION

Today, probably more so than at any other time in the past of Psychology, a re-examination of certain issues is taking place. One such issue is that concerning the role of reinforcement and the reduction of primary drives in the acquisition, maintenance and control of behavior. Dember (1960) feels that the commitment is so strong on the part of the learning psychologist to the primary drives and to the commodities that reduce them, that it has been taken for granted that animals themselves are also interested exclusively in primary rewards or their derivatives. Recently, however, the drive reduction view of reinforcement has been challenged. Skinner (1951) has maintained that any change in stimulation, such as light or sound, could serve as a reinforcer for an instrumental response. Hebb (1955) has taken the position that stimulation in itself may be reinforcing and that under appropriate conditions almost any stimulus may have either positive or negative reinforcing characteristics. Kish (1955) has suggested that any perceptible environmental change, even though unrelated to such need states as hunger and thirst, will reinforce any response that it follows. Roberts, Marx, and Collier (1958) are of the opinion that perhaps there are no nonreinforcers. Pereboom (1962) believes that lawful changes in behavior may be produced by a novel environment alone in the absence
of visceral drives and tangible rewards. Perhaps the changing view of reinforcement is best represented by Kimble (1961) in his text reviewing the literature on conditioning and learning. He defines a reinforcer as any event which, employed appropriately, increases the probability of occurrence of a response in a learning situation. It is now well documented in fact by the studies of Barnes and Baron (1961), Barnes and Kish (1958, 1961), Barnes, Kish, and Wood (1959), Baron and Kish (1962), Girdner (1953), Hurwitz (1956), Kish (1955), Marx, Henderson, and Roberts (1955), Moon and Lodahl (1956), Roberts, Marx, and Collier (1958), Robinson (1961), and Thomson (1955) that the momentary onset or an increment in a light or sound will reinforce the bar-pressing response in animals.

A particular class of behavior which has contributed to the controversy over the role of drive reduction and reinforcement has been that of the free operant responses of exploration and curiosity which seem to have no known primary drive. Dember and Earl (1957) have made the assertion that exploratory, manipulatory and curiosity behavior belong to a general class of behavior called "attention." They consider attention to mean any behavior, motor or perceptual, which has as its end state contact between the organism and selected portions of the environment. Functionally, attending serves to orient or bring the organism into contact with certain stimuli in the environment. In an animal, attending
may involve locomotor activity in order to attain contact with a particular aspect of the environment. Dember and Earl have been primarily concerned with the selection of goal stimuli. Goal stimuli are defined as those stimuli which are the object of attention.

Berlyne (1960), in a book reviewing the literature on exploratory and curiosity behaviors, examines the matter of which stimuli in a complex environment an organism will react to and what aspects of the environment will occupy the attention of the organism. Exploratory responses, he believes, aid attention by maximizing certain stimuli and minimizing others in the stimulus field. Exploration affords access to environmental information which was not previously available to the organism. In addition, exploration reduces uncertainty about stimulus properties in the field by bringing more receptors into contact with the stimuli. He feels that exploratory responses have biological utility for the organism and that they become strengthened when some primary drive reduction ensues. According to Berlyne, exploratory behavior may be classified as being one of three kinds: orienting responses, locomotor exploration, and investigatory responses. Orienting responses involve changes in posture or in the state of sense organs. These responses occur with the first onset of a stimulus but adapt readily if the stimulus eliciting them is repeatedly presented. Locomotor exploration consists of orienting
responses which involve locomotion. These may be akin to extrinsic exploratory responses or the observing responses described by Wyckoff (1952). Investigatory responses are those responses directed toward a particular object or event and which effect changes in external objects. These responses are often called manipulatory behavior.

Of the factors which are known determinants of selective orienting responses and locomotor exploration, stimulus intensity has been of primary concern. Schneirla (1957) is of the opinion that stimulation energy fundamentally dominates the approach and withdrawal responses of all animals. According to Maier and Schneirla (1937) and Schneirla (1957), locomotor activity is either toward or away from a stimulus source. The direction of reaction is determined by the intensity of the stimulation and thereby exerts a selective effect on what conditions generally affect the organism. Low intensities of stimulation tend to evoke approach responses, and high intensities evoke withdrawal reactions.

The stimulation consequences of various intensities of illumination have been investigated by Henderson (1953) and Levin and Forgays (1959). The different intensities of light were used as a reinforcer in a bar-pressing situation with rats. It was found that the effectiveness of reinforcement as a function of light intensity was described by an inverted U-shaped curve, i.e., reinforcement was minimal for very weak and very intense levels of illumination.
Barnes and Kish (1957) found that white mice would approach a platform whose depression turned off an intense noise and would avoid a platform whose depression would turn on an intense noise. Kish and Antonitis (1956) reported that mice would spend approximately 40 per cent of the time on the one of four platforms which produced a mild clicking noise when depressed, whereas chance would dictate that the animals spend only 25 per cent of the time on one platform.

It would appear that many non-primary or so-called "neutral" stimuli do, in fact, increase the probability of a response, and there is indication that the reinforcing properties of a neutral stimulus are, at least in part, due to the intensity dimension. Hebb (1955) has intimated that a discrepancy in an animal's expectation of a stimulus is also a variable influencing the reinforcing characteristics of a stimulus and that any stimulus may have either positive or negative reinforcing properties. Furthermore, there are implications that non-need-related exploratory behavior is a function of both stimulus intensity and stimulus novelty. Discussion of all of these factors in the past has been centered around the positive reinforcing stimuli. But what about the so-called primary "aversive" stimuli? Are there actually two kinds of stimuli? Are there positive reinforcers, not necessarily grounded in survival or reproduction, and negative reinforcers which threaten existence? Or is there a continuum with all stimuli, both positive and
negative, depending upon intensity level and duration of presentation? It is to these questions that the present study is directed.

The use of electric shock as a primary aversive stimulus is well known. However, until recently very little use has been made of electricity in the role of a positive reinforcer. Harrington and Linder (1962) substituted one of four different intensities of shock for a light reinforcement which was contingent upon a bar-touch response. The electric shock was found to have positive reinforcing effects which appeared to be a positively accelerated function of intensity up to the aversion threshold. Values for the aversion threshold have been determined by Kimble (1955) and Campbell and Teghtsoonian (1958). Kimble applied a psychophysical method of limits technique by way of a grid to rats over a stimulus range of 0 to .90 milliamperes (ma.). The stimuli were presented in successive .10 ma. steps which had a duration of one second. Up to an intensity of about .30 ma. the animals exhibited a reaction of freezing, crouching, or sniffing. Above that intensity, an avoidance reaction in the form of a jump response occurred. Using a constant impedance shock source, Campbell and Teghtsoonian determined the aversion threshold of a rat on a grid to be about .15 ma.

In order to reveal further information on the role of a primary aversive stimulus serving as a positive reinforcer,
and to elaborate upon the function of intensity and duration of presentation of the stimulus, the present study was designed. It has already been pointed out that in the Harrington and Linder (1962) study the reinforced response had been partially established using light as the reinforcer. One of four shock intensities was then substituted for the light. In this study, however, no stimulus substitution was made. Rather, one of five different shock intensities within the ranges studied by Kimble (1955) and Campbell and Teghtsoonian (1956) was introduced following an approach response to one end of an operant box.
METHOD

Apparatus

The objective measurement of an animal's exploratory behavior took place within a modified operant box. The box measured 8 in. high, 8 in. wide, and 10 in. long. The sides and hinged top of the box were constructed of 1/4 in. clear plexiglass. The ends were made of plain tempered aluminum, and the floor consisted of a stainless steel grid. The box was placed inside a semi-soundproofed enclosure containing a one-way glass through which the animal could be observed. The inside of the enclosure was lighted by two 40-watt fluorescent bulbs. An air blower attached to the enclosure provided fresh air and a masking noise at all times during experimentation.

A Clairex Cl-3 photocell inserted in a one-hole rubber stopper was mounted at each end of the box. The photocells were located 6 in. from the side of the box, 1.50 in. above the grid floor, and 1.25 in. in from the end of the box. The light source for the photocells consisted of two 15-watt incandescent bulbs located 6 in. from the opposite side of the box. Each photocell operated a relay connected to a separate pen on an Esterline-Angus event recorder. In addition, each photocell relay operated an electric Mercury
A cam timer provided a time marker via a third pen on the Esterline-Angus recorder.

A Wyckoff and Page (1954) shock source and grid-shock scrambler provided the A.C. electrical stimulus. The current was monitored across a 1K resistor in series with the grid by a Heath-kit vacuum tube voltmeter. Shock duration was controlled by a Hunter decade timer.

The entire apparatus was maintained in a darkened, air-conditioned animal laboratory at Louisiana State University.

Subjects

Eighty naive Sprague-Dawley (56 male and 24 female) rats, 120-150 days of age, were the subjects for this experiment. The subjects were obtained from the Louisiana State University Psychology Department animal colony. All of these animals had been maintained ad libitum food and water since birth.

Design

The design of this study employed 8 matched groups of 10 animals per group. Matching was accomplished on the basis of sex (7 males and 3 females per group) and on the basis of activity level as determined by the number of traversals of an elevated 12-ft. straight runway made during a 40-min. period (Pereboom, 1962).
Six levels of A.C. shock were used: 0.00, 0.10, 0.15, 0.20, 0.30, and 1.00 ma. Each shock was of a one-sec. duration, the length of time required to sweep the grid once.

The number of responses, i.e., the frequency of photocell beam interruptions at each end of the box were grouped into 20 intervals of 2 min. each. The design thus employed permitted the use of three-way factorial analysis of variance (Lindquist, 1956).

**Procedure**

Each animal was individually removed from his home cage and placed in the operant box for a period of 40 min. The number of exploratory responses, i.e., approach responses, made toward each end of the box were recorded whenever the animal interrupted a photocell beam. During the first 20 min. of the experimental period for Groups .00 through 1.00 an operant level of approach responses was obtained. During the second 20 min. of the experimental period, Groups .00 through 1.00 received respectively .00, .10, .15, .20, .30, and 1.00 ma. of instantaneous A.C. shock each time the photocell beam at one end (shock end) of the box was interrupted. Groups .15-40 and .30-40 received respectively .15 and .30 ma. shock of one second duration each time the beam at the shock end of the box was broken during the entire 40 min. experimental session. A summary of the experimental groups is shown in Table 1.
TABLE 1
Experimental Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Subjects</th>
<th>Shock Intensity</th>
<th>Period of Shock</th>
</tr>
</thead>
<tbody>
<tr>
<td>.00</td>
<td>10</td>
<td>0.00 ma.</td>
<td>Entire 40 minutes</td>
</tr>
<tr>
<td>.10</td>
<td>10</td>
<td>0.10 ma.</td>
<td>Second 20 minutes</td>
</tr>
<tr>
<td>.15</td>
<td>10</td>
<td>0.15 ma.</td>
<td>Second 20 minutes</td>
</tr>
<tr>
<td>.20</td>
<td>10</td>
<td>0.20 ma.</td>
<td>Second 20 minutes</td>
</tr>
<tr>
<td>.30</td>
<td>10</td>
<td>0.30 ma.</td>
<td>Second 20 minutes</td>
</tr>
<tr>
<td>1.00</td>
<td>10</td>
<td>1.00 ma.</td>
<td>Second 20 minutes</td>
</tr>
<tr>
<td>.15-40</td>
<td>10</td>
<td>0.15 ma.</td>
<td>Entire 40 minutes</td>
</tr>
<tr>
<td>.30-40</td>
<td>10</td>
<td>0.30 ma.</td>
<td>Entire 40 minutes</td>
</tr>
</tbody>
</table>
All experimentation was carried out between the hours of 8:00 A.M. and 12:00 noon.
RESULTS

A graphic record of the mean frequency of photocell beam interruptions at the shock end of the box as a function of successive 2 min. intervals is shown in Figure 1. A composite curve of Groups .00 through 1.00 was plotted for the first 20 min. since no significant difference was obtained between the groups during the pre-shock period. The summary table for the analysis of variance of Groups .00 through 1.00 during the first 20 min. is shown in Table 2.

The decline in operant level exploratory behavior with the passage of time is significant (p < .01). This observation is consistent with the adaptation or habituation effect described by Berlyne (1955), Danziger and Mainland (1954), Glanzer (1953), Montgomery (1953), and Pereboom (1958).

The second half of Figure 1 clearly indicates the systematic change in the number of approach reactions toward the shock end of the box as a function of the intensity of the introduced electric shock. This differential was significant (p < .01) as shown in Table 3. The introduction of .10, .15, and .20 ma. of shock increased the number of approach responses to the shock end of the box. Exploratory
### TABLE 2

Summary Table for the Analysis of Variance of Groups .00 Through 1.00 During the First 20 Minutes

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>PROBABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>59</td>
<td>1,685.12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shock (S)</td>
<td>5</td>
<td>91.15</td>
<td>18.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error (B)</td>
<td>54</td>
<td>1,593.97</td>
<td>29.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td>540</td>
<td>8,808.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minutes (M)</td>
<td>9</td>
<td>4,048.00</td>
<td>449.78</td>
<td>47.15</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>M x S</td>
<td>45</td>
<td>122.17</td>
<td>2.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error (W)</td>
<td>486</td>
<td>4,638.33</td>
<td>9.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>599</td>
<td>10,493.62</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 3

**Summary Table for the Analysis of Variance of Groups**

*0.00 Through 1.00 During the **Second** 20 Minutes*

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>PROBABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>59</td>
<td>3,189.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shock (S)</td>
<td>5</td>
<td>1,705.05</td>
<td>341.01</td>
<td>12.41</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>Error (B)</td>
<td>54</td>
<td>1,483.98</td>
<td>27.48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td>540</td>
<td>5,126.80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minutes (M)</td>
<td>9</td>
<td>446.00</td>
<td>49.56</td>
<td>5.74</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>M x T</td>
<td>45</td>
<td>481.18</td>
<td>10.69</td>
<td>1.24</td>
<td></td>
</tr>
<tr>
<td>Error (W)</td>
<td>466</td>
<td>4,199.62</td>
<td>8.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>599</td>
<td>8,315.83</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
behavior, in general, was increased in groups .10, .15, and .20. However, the exploratory activity tended to be confined more to the shock end of the box, i.e. the area in which the shock was received. The maximum seeking response was produced by a .15 ma. shock as shown in Figure 2. A typical reaction to the first shock at this intensity was either freezing or an immediate orientation of the nose to the grid at the hind feet. Another common reaction was simply turning around and profusely sniffing the grid. Continuing to search, the animal would begin to make a closer inspection of the wall at the end of the box, particularly at the corners. This behavior usually produced another shock and the whole response sequence would be repeated. After a number of repetitions of the stimulus the animal would carry the search to the other end of the box. This can be seen as a depression in the curves occurring between minutes 24 to 30. The animal would then return to the shock end of the box and seek the source of stimulation once again. As the exploratory activity of the animal declined he would often tend to engage in grooming behavior. A similar observation has been reported by Berlyne (1960).

Group .10, receiving .10 ma. shock, behaved similarly to Group .15 though with decreased fervor. These animals, however, did not respond at all to some of the stimulations. The third group also behaved in a similar manner to the second group except that their approach response was less
persistent and on some occasions the stimulus elicited a withdrawal response which was usually preceded by a jump reaction. This latter observation has also been reported by Kimble (1955). Group .30 animals, receiving a .30 ma. shock, revealed a more pronounced jump reaction. These animals would, following the first shock, either make an immediate orientation response to the grid or move to the opposite end of the box and make a cautious approach back toward the shock end. The repetition of several shocks was usually sufficient to elicit withdrawal from and avoidance of the shock end of the box in this group of animals.

As the curve for Group 1.00 clearly indicates, a shock of 1.00 ma. results in an immediate withdrawal. A shock of this intensity elicited a very evident jump and usually some defecating and squealing behavior. In addition to further avoidance of the shock end of the box, an over-all decrement in activity was produced by this intensity shock.

Unlike the increased approach responding produced by the addition of mild shock to the environment, the continuous presence of .15 and .30 ma. shock yielded a rapid decrement in responding. This effect is evident from the curves for Groups .15–40 and .30–40. A comparison between these groups and the no-shock control group was significant (p < .01) as shown in Table 4. Avoidance developed early in these two experimental groups and persisted for the remainder of the experimental session. The seeking of the
**Summary Table for the Analysis of Variance of Groups**

**.00, .15-40, and .30-40 During the**

**First 20 Minutes**

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>PROBABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>29</td>
<td>1,420.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shock (S)</td>
<td>2</td>
<td>1,112.01</td>
<td>556.00</td>
<td>48.69</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>Error (B)</td>
<td>27</td>
<td>308.49</td>
<td>11.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td>270</td>
<td>4,241.30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minutes (M)</td>
<td>9</td>
<td>2,243.03</td>
<td>249.22</td>
<td>33.27</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>M x S</td>
<td>18</td>
<td>177.66</td>
<td>9.87</td>
<td>1.32</td>
<td></td>
</tr>
<tr>
<td>Error (W)</td>
<td>243</td>
<td>1,820.61</td>
<td>7.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>299</td>
<td>5,661.80</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
stimulus source which occurred in Groups .10, .15, and .30 did not occur. The avoidance effect was much greater in the 0.30 ma. group and responding was depressed to a zero level during the second 20 min. period. This shock effect was significant (p < .01) as revealed by the statistical comparison of Groups .00, .15–40, and .30–40 in Table 5.
### TABLE 5

Summary Table for the Analysis of Variance of Groups .00, .15–40, and .30–40 During the Second 20 Minutes

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>PROBABILITY</th>
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</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>29</td>
<td>167.83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shock (S)</td>
<td>2</td>
<td>110.06</td>
<td>55.03</td>
<td>25.71</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>Error (B)</td>
<td>27</td>
<td>57.77</td>
<td>2.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td>270</td>
<td>533.30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minutes (M)</td>
<td>9</td>
<td>22.43</td>
<td>2.49</td>
<td>1.30</td>
<td></td>
</tr>
<tr>
<td>M x S</td>
<td>18</td>
<td>46.14</td>
<td>2.56</td>
<td>1.34</td>
<td></td>
</tr>
<tr>
<td>Error (W)</td>
<td>243</td>
<td>464.73</td>
<td>1.91</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>299</td>
<td>701.13</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DISCUSSION

The systematic change in the number of approach responses toward the shock end of the box as a function of the intensity of the introduced electric shock clearly suggests that electricity may be used in a capacity similar to that of any other stimulus, i.e. energy change, as in the studies of Barnes and Baron (1961), Barnes and Kish (1958), Girdner (1953), Harrington and Linder (1962), Henderson (1953), Hurwitz (1956), Kish (1955), Kish and Antonitis (1956), Roberts, Marx, and Collier (1958), and Schoenfeld, Antonitis, and Bersh (1950). Such a view, however, requires qualification. This study indicates that an optimum level of approach may be elicited from a rat when the shock has a magnitude of approximately .15 ma. and that shock intensities close to this optimum value, yet lying on either side of it, are less effective in reinforcing approach behavior under the conditions of this particular experimental environment. However, the data also indicate that approach, exploration, or reinforcement occur only when the shock is added to the familiar environment. If the shock is part of the milieu of background stimuli present in the new environment, it appears to have the effect of depressing the exploratory or approach responses in that environment, as can be seen with Groups .15-40 and .30-40. In this latter situation
electric shock seems to perform as in its usual application for the production of withdrawal and avoidance behavior.

The fact that shock under any circumstances will elicit an approach response is unique and constitutes a point for further consideration. Only one other study in the literature (Harrington and Linder, 1962) has attempted to use electric shock as a positive reinforcer and reported some measure of success in doing so. In that study, however, the shock had been substituted for a light reinforcer, while in the current investigation no stimulus substitution per se was made. Rather, in the current study, the shock was introduced following a period during which the animal had become familiar with the environment, and hence the electrical stimulus may be considered similar to an energy change such as light or sound.

Several alternative ways of looking at this reinforcement effect may be considered. For convenience the viewpoints may be categorized as either being due to stimulus properties or to organismic function.

Considering first the stimulus characteristics, the addition of shock may constitute what Berlyne (1960) has termed a "novel" stimulus. He views novelty as being one of the determinants of selective orienting responses. Novelty involves stimulus distinctiveness, unfamiliarity, something new in experience, an unrecognized stimulus, or uncertainty. It may also involve surprise. That is, the
novel stimulus may differ from what preceded it, be unexpected or not anticipated, i.e., when there is a disparity between an organism's expectancy and his experience. Moreover, Berlyne (1950) believes that novelty is a matter of degree; that the maximum response from an organism will be elicited by a stimulus of intermediate novelty. A stimulus of moderate novelty would be similar to something well known, yet somewhat different. Similarity he considers to be a function of stimulus generalization. Moderate novelty is thought to elicit approach behavior, whereas extreme novelty is thought to bring about avoidance responses. If the stimuli are weak or indistinct, then he feels that exploration is necessary for identification of them. According to Berlyne's definition, the electricity would constitute a novel stimulus; it is unfamiliar to the organism, it is something new in his experience, it is unexpected, and it differs from the stimuli preceding it. A shock of .15 ma. in the present study would thus apparently constitute a stimulus of intermediate novelty. That weak or indistinct stimuli will bring about exploration for identification seems to be indicated in the study by Hudson (1950) in which rats were given a mild shock in the presence of a cue previously associated with food.

Another point of view is expressed in terms of the stimulus effects on the organism, or as the shock intensity changes, the receptor effects change accordingly. This view
considers that the organism has no specialized anatomical receptors for an electrical stimulus which may be oriented toward the stimulus source and that electricity may be an adequate stimulus for any receptor. The effect of electric shock is uncommon in the organism's experience and as such is a novel stimulus. A mild electric shock may be akin to a tactual stimulus to the feet, whereas an intense shock may induce brief tetany and spasmodic kinesthetic discharge in combination with cutaneous stimulation including touch, pressure, and pain. A tactual component alone may elicit approach reactions, while the combination of effects may be aversive and produce withdrawal. The only way in which the novelty of the shock stimulus could be perceived by the organism is by way of his somesthetic receptors. However, the sensation of touch elicited by electricity is certainly not the same as that elicited by mechanical stimulation with a feather. Hence .15 ma. is similar to something well known yet somewhat different. Berlyne (1960) acknowledges that a tactual stimulus will elicit an exploratory response. An electrical stimulus of greater than .30 ma. would tend to bring on discharge from all the cutaneous receptors in addition to the deeper lying structures. It may be that the extreme novelty characterized by the complexity of sensation is unpleasant to the organism, or it may be that exceeding the pain threshold alone is sufficient to bring about withdrawal and avoidance.
A third point of view concerns organismic reaction involving the stimulus arousal potential of Berlyne (1960). Arousal potential consists of the properties of stimuli whose intensification appears to entail a rise in arousal. Arousal of an organism tends to be maintained at a level above an extreme of sleep and below a maximum of high drive or anxiety. He calls this level "arousal tonus" and thinks of it as the minimum level of arousal that the organism is capable of at a particular time over a wide range of conditions. The actual location of the tonus level depends upon the pattern of cortico-reticular interaction. This in turn depends upon internal regulatory factors and external environmental factors. To be maintained the arousal tonus requires a particular rate of influx of arousal potential. Should the rate of influx of arousal potential increase or decrease, arousal will rise above the tonus level and hence increase drive. A return to the tonus level would then be rewarding and those responses aiding that return will be reinforced. For an individual organism at a particular time there will be an optimum arousal level, and a deviation from it in either an upward or downward direction will be drive-inducing or aversive. Thus an animal will strive to maintain an intermediate arousal level. Maintenance of an intermediate arousal potential would be enhanced by stimuli of moderate intensity. Stimuli of medium intensity would be pleasant to the animal and would
become unpleasant as the intensity increases. Such a relationship, he feels, could be described by Wundt’s inverted U-shaped curve representing hedonic tone as a function of stimulus intensity. A similar position to that of Berlyne has been presented by Dember and Earl (1957), Glanzer (1958), Hebb (1955), and Leuba (1955).

There is little question concerning the arousal characteristics of stimuli along the intensity dimension (Davis, 1930; Hovland and Riesen, 1940; Lubow and Tighe, 1957; and Sokolov, 1958). The arousal effect on the reticular activating system of incoming stimuli has been demonstrated by the work of Hernandez-Peon (1955), Jasper (1954), and Lindsley (1957), and the integral relationship between arousal and drive has been discussed by Hebb (1955), Lindsley (1957), Malmo (1958), and Morgan (1957). A demonstration of the relationship that arousal increases with the novelty of a stimulus has been presented by Sharpless and Jasper (1956). Habituation of the arousal effects with repeated presentation of the stimulus has been shown to occur by Popov (1953), Seward and Seward (1934), and Wilson and Wilson (1959). The hypothesis that an animal strives to maintain an optimum level of sensory input and hence, arousal, is supported by light reinforcement studies of Barnes and Baron (1961), Barnes and Kish (1958), Girdner (1953), Henderson (1953), Hurwitz (1956), Kish (1955), Roberts, Marx and Collier (1958), and Robinson (1961); sound
reinforcement studies of Barnes and Kish (1957), Girdner (1953), Kish and Antonitis (1956); tactual and kinesthetic stimulation is a study of Schoenfeld, Antonitis, and Bersh (1950); and an electricity reinforcement experiment by Harrington and Linder (1962). In the case of light reinforcement an optimum level of stimulation and an inverted U-shaped function for intensity was demonstrated by Henderson (1953). For sound reinforcement a similar relationship has been shown by Barnes and Kish (1958). The same type of function using an electrical stimulus was shown to exist in the present study.

A fourth possible explanation concerns the observation that an animal when placed in a new environment will explore less with the passage of time spent in that environment (Berlyne, 1955; Glanzer, 1953; Montgomery, 1952; and Pereboom, 1962). If one assumes that exploratory behavior is a high operant response having been reinforced in the animal's past history, then it is conceivable that the exponential decline of exploratory behavior during the first 20 min. of this study represents the extinction of exploratory responses. The introduction of electricity into the environment (or for that matter, any perceptible novel stimulus change) would elicit disinhibition and consequently the resumption of exploratory responses. A position similar to this has been taken by Pereboom (1962).

If an organism does strive to maintain an optimum level
of stimulus input, or arousal, then it follows that after habituation has occurred, the introduction of shock could serve as a disinhibiting stimulus by raising the level of functioning of the reticular activating system. This in turn would yield heightened arousal and a return of the exploratory activity of the animal. It may be further pointed out that a disinhibiting stimulus does not bring about a return to the original level of responding, nor does it retain its effectiveness indefinitely. Rather, an increment in responding is elicited and repeated application of the disinhibiting stimulus results in habituation to that stimulus. The habituation effect to shock can be seen to occur during the latter part of the shock period in Figure 1.

The data of this study are in accord with the views of Berlyne (1960), Dember and Earl (1957), and Pereboom (1962) regarding the role of novelty in reinforcement. As we have seen, the effectiveness of shock as a positive reinforcer only occurs when there is a temporal change in stimulation. Agreement is also maintained with the view of Maier and Schneirla (1937) that approach and withdrawal are a function of stimulus intensity. Further support is also offered to the position taken by Hebb (1955), Kish (1955), and Skinner (1951), that any perceptible stimulus change constitutes a reinforcement, and reaffirms the position of Roberts, Marx, and Collier (1958) that perhaps there are no nonreinforcers.
The results confirm the observation of Harrington and Linder (1962) that shock can be used as a positive reinforcer and reveal that the aversion threshold is in the approximate intensity range found by Campbell and Teghtsoonian (1958) and Kimble (1955).

The study suggests that further research needs to be done considering the recovery of arousal effects of electrical stimuli as compared with other stimuli; what role the shock duration played in providing a novel stimulus; and whether in a two-choice situation shock could be used as an incentive.

In conclusion, it is the opinion of the writer that there are not two types of reinforcers, positive and negative, but that all stimuli lie along a continuum. The reinforcing characteristics of any stimulus are dependent upon the intensity and the duration of presentation of the stimulus. Thus it was demonstrated in this study that intermediate intensities of electric shock, when introduced into a familiar environment, will reinforce an approach response and are hence nonaversive. But when electric shock is a part of the background stimuli in a new environment or when the shock is of high intensity, it tends to produce avoidance, and is aversive.
SUMMARY

Recent evidence on the reinforcing characteristics of neutral stimuli has challenged the drive-reduction of reinforcement, and suggested that any stimulus change may serve as a reinforcer. The effectiveness of the neutral stimulus as a reinforcer appears to be a function of the intensity and duration of presentation of the stimulus. In addition, some question remains concerning whether there is a reinforcement continuum for all stimuli or whether there are actually positive and negative reinforcers. The present study was designed to provide further information on the question of a reinforcement continuum for stimuli when the intensity and duration of presentation of a so-called primary aversive stimulus are varied.

Eighty Sprague-Dawley albino rats, 120 to 150 days old, were divided into eight equal groups. Each group was matched on the basis of sex and activity level. The animals were placed individually in a modified operant box for a period of forty minutes. The box had the bar removed and had been rendered devoid of any distinctive cues. During the experimental period the amount of activity at the two ends of the box was measured by photocells connected to an event recorder. After a period of twenty minutes, five of the groups received an A.C. shock of either .10, .15, .20, .30, or 1.00
ma. through the grid for a duration of one second each time the photocell beam at one end of the box was interrupted by the animal. The sixth group received no shock for the entire forty minutes. The remaining two groups received a one second .15 and .30 ma. shock respectively, with each interruption of the photocell beam at one end of the box for the entire forty minute experimental period. A three-way factorial analysis of variance was applied to the frequency of photocell beam interruptions in successive two-minute intervals.

No significant differences were observed between the groups receiving no shock for the first twenty-minute period. However, during the second twenty-minute experimental period a significant difference between the groups was obtained. A graphic representation of the data indicated that a systematic change in the number of approach responses to the shock end of the box had occurred. Low intensity electrical shock increased the number of approach responses to the shock end of the box, whereas high levels of shock resulted in immediate avoidance responses. Behaviorally, a shock of .15 ma. produced maximum seeking and a shock of 1.00 ma. produced maximum withdrawal. To all shock intensities below 1.00 ma. an immediate orientation response was produced. This orientation toward the stimulus was followed promptly by withdrawal in the groups receiving .20 and .30 ma. shock. The groups receiving shock for the entire forty
minutes showed a significant decrease in the number of exploratory approach responses.

These data suggest that the aversive quality of an electrical stimulus is a function of the shock intensity and the duration of presentation. An approach response to an electrical stimulus may be elicited if the shock intensity is below the aversion threshold and when that shock is introduced unexpectedly into a familiar environment.
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VITA

James Dickens Phillips, Jr. was born in Pittsburgh, Pennsylvania on December 18, 1932. He is the second eldest of three children by James D. and Gertrude Anderson Phillips. He was graduated from Baldwin High School in Pittsburgh in 1951, after which he enrolled in Pennsylvania State College. The following year he transferred to the University of Arizona where he received Bachelor of Arts degrees in Chemistry and Psychology in 1956. He then attended Florida State University where he obtained his Master of Science degree. In 1959 he enrolled in the graduate school of Louisiana State University where he became a candidate for the degree of Doctor of Philosophy. Presently he is an Assistant Professor of Psychology at Arlington State College, Arlington, Texas.
EXAMINATION AND THESIS REPORT

Candidate: James D. Phillips, Jr.

Major Field: Psychology

Title of Thesis: THE REINFORCING PROPERTY OF AN AVERSIVE STIMULUS

Approved:

[Signatures of Major Professor and Chairman, Dean of the Graduate School, and other members of the Examining Committee]

EXAMINING COMMITTEE:

[Signatures of committee members]

Date of Examination: 1 July 1963

[Signature of Major Professor and Chairman]