Shock duration and adhesion in the planaria, *Phagocata gracilis*¹

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Planaria, *Phagocata gracilis*, were assigned to five shock duration conditions. Shocks were continued every 18 sec. until Ss no longer responded by moving freely but adhered firmly to the trough. Trials to adhesion was found to be an inverse function of shock duration; total shock required for adhesion was a direct function of shock duration. The results are discussed in terms of morphological characteristics of planaria.

Electric shock may selectively produce several behavioral effects in planaria depending on the parameters of shock used (Halas, Mulry, & DeBoer, 1962; Barnes & Katzung, 1963). An unconditioned behavioral consequence of repeated noxious stimulation is a reduction in responsiveness and locomotion. Such reduction has some generality as it has been observed when the aversive stimulus was removal of water (Best & Rubenstein, 1962) and shock (Pearl, 1903). The present study investigates the effects of shock duration on locomotion in planaria.

Subjects

The Ss were 40 planaria, *Phagocata gracilis*, 7-11 mm. long, which were originally obtained from a creek located outside the city limits of Bloomington, Indiana. All Ss were selected from a larger colony of *P. gracilis* which was maintained at all times in opaque, milk glass bowls containing aged tap water. Water was changed once a week, immediately after the weekly feeding of beef liver.

Apparatus

The experimental apparatus consisted of a circular, V-shaped, plastic trough 1/2 in. wide, 3/8 in. deep and 24.7 in. in circumference. This trough formed the recessed perimeter of a solid circle which was mounted, at its midpoint, on a plastic base. A graphite and oil lubricant between the two surfaces permitted manual rotation of the trough. Two silver electrodes, mounted on the base and extending into the trough, formed a fixed diameter of 7-7/8 in. A dc shock source supplied 6 volts through the electrodes which was sufficient to reliably elicit a vigorous contraction. Trough and base rested on a large wooden surface painted flat black and were centered between two identical 100 watt light bulbs located 15 in. apart and 6 in. above the trough. Suspended below each light bulb was a heat filter containing 2 in. of water. A variable transformer controlled light intensity which was adjusted to be approximately 5 ft.-c incident light as measured by a Gossen Lunasix light meter. Temperature in the experimental room was maintained at $68^{\circ} \pm 2^{\circ}\text{F}$. Prior to an experimental

period, the trough was filled with aged tap water at room temperature.

Procedure

Each S was assigned to one of five shock duration conditions and tested individually according to a random, predetermined order. A pipette was used to transfer planaria from the colony bowl to the trough. All Ss were free-moving in the trough at the onset of training. Each planarian was individually centered between the electrodes and the relative position of each S in relation to the electrodes was maintained by manual rotation of the trough. When an S turned around in the trough, a switch permitted the polarity of the electrodes to be reversed. Each S received either .5, 1, 2.5, 5 or 10 sec. duration of anodal (Ss head nearer anode), dc shock on each trial. An intertrial interval of 18 sec. was used throughout. Shock trials were continued until S was no longer free-moving and had firmly adhered to the side of the trough for 10 consecutive seconds.

Results

The mean number of trials to adhesion for the five shock duration groups was compared. These results are summarized in Fig. 1. It is apparent that with the longer shock durations, fewer trials were required for an S to stop moving and adhere to the trough. This relationship was confirmed by analysis of variance ($F = 20.66$; $df = 4/35$; $p < .001$). Further comparisons indicated that shock durations of 2.5, 5 and 10 sec. yielded adhesion in significantly fewer trials than either shock durations of .5 or 1 sec. In addition, adhesion occurred more rapidly when the shock duration

Fig. 1. Mean shock trials required for adhesion for five shock duration conditions.

was 10 sec. than when it was 2.5 sec.

The mean total shock required to yield adhesion for the five shock duration groups was also compared. These results are summarized in Fig. 2. It is apparent that there is a direct relationship between shock duration and total shock required for adhesion. This was confirmed by analysis of variance ($F=26.9$; $df=4/35$; $p<.001$). Further comparisons indicated that shocks of 2.5 sec. duration or longer required a greater total amount of shock than shocks of .5 sec. duration, that shocks of 5 sec. duration or longer required a greater total amount of shock than shocks of 1 sec. duration, and finally, shocks of 10 sec. duration required a greater total amount of shock than shocks of 2.5 sec. duration.

One could argue that the reported effects are due to the fact that Ss receiving 10 sec. of shock on each trial are also spending a greater amount of time per trial in the trough than Ss receiving lesser durations of shock. That an analysis of variance for total time in the trough was highly significant ($F=10.97$; $df=4/35$; $p<.001$) considerably weakens such an argument.

Discussion

The observed effect, i.e., that repeated shock stimulation results in non-locomotion and adhesion to the trough, is consistent with morphological characteristics of *P. gracilis*. Although the family Planariidae, to which *P. gracilis* belongs, is distinguished because they lack adhesive organs (i.e., have neither glandulo-muscular adhesive organs nor a true sucker), members of the

class Turbellaria, including *P. gracilis*, are supplied with glands having adhesive functions (glandulo-epidermal adhesive organs); there are eosinophilous glands which encircle the ventral surface near the margin forming a marginal adhesive zone (Hyman, 1951). It may not be entirely accurate to identify the non-locomotion we have observed as being due exclusively to adhesion; Pearl (1903) reports that dc current quickly paralyzes planaria and non-locomotion in the present study may represent the joint effects of paralysis and adhesion. Regardless, the resultant non-locomotion is an important behavioral change as a number of behaviors (e.g., gliding, crawling, etc.) have been eliminated, thereby limiting the behavioral repertoire of each S.

Our observations indicate that adhesion can occur reasonably rapidly when successive shocks are received and that an S adheres primarily marginally and posteriorly, which permits S to turn right or left but to do little else. This limits the behavioral repertoire of each S by eliminating those competing behaviors which predominated prior to adhesion. In this connection, Jensen (1965) has pointed out some of the inherent difficulties in the use of shock as a US in learning experiments. The results of the present experiment support this and cast doubt upon the continual efficacy of shock as a US in planaria research. The limiting behavioral consequences of shock-induced-adhesion represents a profound behavioral change which must be considered in the interpretation of experiments which use shock in attempting to demonstrate learning in planaria.

References

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Note

1. This research was supported by Public Health Service post-doctoral fellowship MH-20, 660-01 from the National Institute of Mental Health.

Fig. 2. Mean total shock in sec. required for adhesion for five shock duration conditions.