Stimulus control of the prey attack response in naive garter snakes[1]

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Newborn garter snakes without prior feeding experience were found to selectively respond with attack behavior to water extracts of organisms normally eaten in captivity and not to respond to extracts of other organisms and controls. Differences were noted in the frequency and latency of responding to the effective stimuli. This response to chemical stimulation did not easily habituate. Visual stimuli may cause the S to orient toward and "explore" a potential food object, particularly if moving; but it is concluded that the basic somatic movements involved in the attack of prey are present at birth and that this behavior can only be elicited by certain chemical stimuli in naive Ss.

Chemical stimulation is generally considered as being of great importance in the feeding and social behavior of many snakes (Noble, 1937), but no work has been done on the responses of newborn young to isolated sensory cues. When a litter of newborn garter snakes became available it was decided to investigate the stimuli necessary to elicit the prey attack response before learning could be a factor. This response has been shown to be under control of the vomeronasal portion of the olfactory system which is unusually well developed in snakes (Wilde, 1938).

Subjects

The Ss were 24 garter snakes produced in a litter by a gravid female *Thamnophis s. sirtalis* collected near Valparaiso, Indiana.[2] The day following their birth, the Ss were transferred to individual glass 6 quart tanks measuring 23 x 14 x 17 cm. Each S was visually isolated from its neighbors by cardboard partitions. The aquaria contained 2 cm of sand which was sprinkled with water twice daily. The Ss were allowed one day to adapt to the tanks before the experiments commenced. The temperature ranged between 26 - 32°C.

Method and Results

The first experiment was designed to determine whether the ingestively naive S will respond to a chemical stimulus alone with the characteristic prey attack response or whether an association or reinforcement contingency is involved.

Extracts of 4 animals were used: redwords (*Eisenia foetida*), mealworms (*Tenebrio molitor* larvae), minnows (*Notropis atherinoides acutus*), and horsemeat. Worms and fish are readily taken in captivity by these garter snakes but insects and meat are not. The method of extraction was modified from Wilde (1938). Three grams of each item were washed in distilled water (except for the ground meat), dried on absorbent paper, and dropped into 20 cc of distilled water at 60°C. The instantly killed animals were stirred slowly for 1 min. and then removed. The solution was filtered through Whatman No. 54 filter paper and the filtrate was clear and colorless and refrigerated in sealed glass vials until use.

The extracts were presented to the Ss with commercial cotton swabs on 15 cm wooden sticks. The tip of the swab was dipped in the extract and the excess removed with a quick shake. The swab was slowly moved toward the head of the S and kept about 1 cm away. If no response was made within 0.30 min. the swab was moved closer to the S until it lightly touched its lips. The S was given a total of 1 min. to respond. If it did respond the elapsed time was recorded to 0.01 min. Ten min. before and after the test stimulus, a distilled water control swab was presented in an identical fashion. Twenty Ss were run on the 4 stimuli. Four variations of the order of presentation were used with 5 Ss per sequence; each S was tested only once with each stimulus. The first two stimuli were presented on the third day after birth and the second two the following day at the same time.

No response except tongue flicking was elicited by the control swab or by the horsemeat and mealworm extracts. All 20 of the Ss responded with the attack response to the redworm extract and 13 responded to the minnow extract (this difference is significant: $\chi^2 = 6.23$, $df = 1$, $p < .02$). There was also a difference in the mean latency; that to redworm extract averaged 0.202 min. and that to minnow averaged 0.249 min. No significant order effects were apparent in the data.

The response to an effective stimulus was very clear-cut. The S increased its rate of tongue flicking and then lunged forward at the swab with its jaws open wide at about a 45° angle. To prevent the snake from entangling his teeth in the cotton, the swab was removed at the moment of the strike. This response was identical with that seen toward live redworms and small fish (guppies, *Lebistes reticulatus*) given to two young not involved in the above tests but previously unfed. They refused the horsemeat and live mealworms, but would attack and eat horsemeat dipped in the worm extract.

The second experiment dealt with the stability of the response to chemical stimulation. Two Ss neither previously fed nor involved in the chemical tests above, were presented with the worm extract at 5 min. intervals for 20 trials. Since the specificity of the response had already been demonstrated the control swab was presented only before the 1st test, after the 10th, and after the last trial. The results are shown in graph

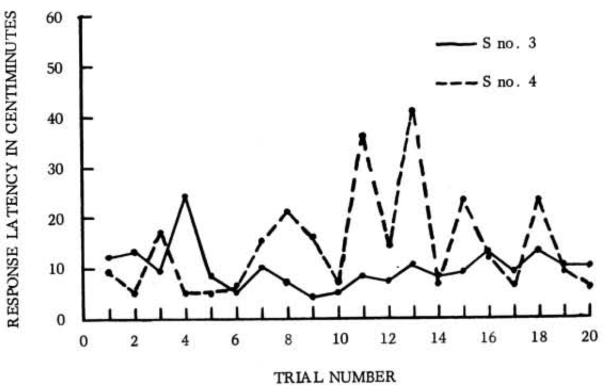

Fig. 1. Latency of prey attack response to swabs dipped in redworm extract and presented at 5 min. intervals.

form in Fig. 1. Both Ss responded on every trial and there was no gradual lengthening of the response latency. It should be noted that S No. 4 displayed more variation than S No. 3 and this appeared due to its greater "nervousness" or initial flight as the E began to introduce the swab.

The 20 Ss used in the chemical tests were utilized in experiments on visual stimuli performed on the 5th day after birth. Ten Ss were presented with a 5 dram glass, plastic stoppered vial containing water and 3 guppies; the control vial contained the same amount of water. Five Ss were presented with a vial containing 3 redworms and 5 with a vial containing 5 mealworms. The control vial was placed lengthwise in the sand in front of the tank and after 1 min. was removed. Ten min. later the test vial was introduced which was also removed after 1 min. Any behavior directed toward the vial was recorded as well as the latency of the response. The 10 Ss not presented with live guppies were tested on dead guppies in water the following day.

The first thing to be noted about the results is that in no case did the visual stimulus of living prey elicit the attack response. However, a definite pattern of behavior was often noted that differed from the controls. This behavior was an orientation towards the vial, increased tongue flicking, and approach. Four of the 5 Ss responded to the redworms but with a reaction so weak that no meaningful latency measure could be recorded. The same number responded to the faster moving mealworms but with a more marked response and a mean latency of 0.24 min. Six of the Ss reacted to the quickly swimming fish with a mean latency of 0.06 min. There was no overlap in the latencies for the three stimuli. The strength of this visual response seemed strongly correlated with the amount of movement of the animals in the vials, though, of course, the three species also differed in their external morphology and mode of locomotion. That the critical factor was movement seems substantiated in that the response was directed to that part of the vial where there was movement, and the 10 Ss given dead guppies showed no response. This visually released behavior soon habituated and reintroduction of the vial shortly afterwards led to either little or no response.

Discussion

These preliminary experiments clearly indicate the importance of chemical stimulation in the feeding behavior of newborn garter snakes. Being presented on cotton swabs, there was, of course, a visual factor which undoubtedly aided in the directing of the response, though not in its elicitation. It would appear that we are here dealing with an innate behavior pattern critically dependent upon specific chemical stimuli. Environmental events later in ontogeny may, of course, influence subsequent behavior to chemical and visual stimuli.

It is possible that imprinting may play a role in determining which chemical stimuli are most effective in the adult snake. Previous work has shown that in turtles food preferences can be differentially modified due to early experience (Burghardt & Hess, 1966). It seems most likely that if food imprinting is present in snakes the imprinting is actually to the specific chemicals involved. The differences in the parameters of the response to the worm and fish extracts suggest that a different active substance(s) is critical in each case.

In the light of these results it appears possible that snakes could prove very useful organisms in the study of chemical sensory mechanisms due to their dependence upon them and the stereotypy of the responses.

References

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Notes

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2. Thanks are due Erich Klinghammer and Gitta who found the snake.