Further study of avoidance conditioning in toads

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Acquisition and extinction of shuttle avoidance learning in *Scaphiopus hammondi* and *Bufo woodhousei* was studied. Five toads of each genera were given 20 training trials each day for 5 days, then 2 days of extinction. A buzzer-door lift CS compound was followed by shock onset 5.0 sec later during training. Five additional toads of each genera served as sensitization controls, and received the same number of CSs and USs, only noncontiguously. Both types of toads showed reliable acquisition of the shuttle response, but neither evidenced any resistance to extinction. The results were compared to a previous report of unsuccessful conditioning of *S. hammondi*. Van Bergeijk's notion of behavioral passivity was discussed.

Van Bergeijk (1967) suggested that behavioral passivity (little or no active foraging) in some salientians may be responsible for poor performance in conditioning situations where a more or less arbitrary preparation is employed. For example, frogs clearly display learning when the reference behavior is a "natural" one, such as forming feeding aggregations (Van Bergeijk, 1967), but not when the target behavior is arbitrarily selected by the investigator (e.g., the eyeblink CR studied by Yaremko, Boice, & Thompson, 1969).

Boice (1970) investigated this notion vis-à-vis the acquisition of shuttle avoidance conditioning in active and passive frogs and toads. *Bufo woodhousei*, an active toad, showed reliable avoidance learning; *Rana clamitans*, an active frog, demonstrated some tendency to avoid shock; and passive frogs (*R. pipiens*) and toads (*Scaphiopus hammondi*) never learned the avoidance response.

While this outcome is certainly consistent with the behavioral passivity hypothesis, pilot data from our laboratory indicated that even passive spadefoot toads (*S. hammondi*) could acquire the shuttle avoidance response. The present study reexamined avoidance learning in spadefoot and Woodhouse toads (*B. woodhousei*) where the CS was a clearly audible signal (in addition to the visual CS of door opening), and where the apparatus was proportioned to the size of the animal (Crawford & Langdon, 1966). Another purpose was to examine performance during extinction as an additional index of conditionability.

METHOD

Subjects and Apparatus

Ten spadefoot toads were gathered in the vicinity of San Diego, California, and 10 Woodhouse toads were obtained commercially. They were housed in two 10-gal terraria containing about 2 in. of moist sand and moss. Mealworms were available ad lib.

Two one-way shuttle avoidance boxes were constructed of ¼-in. unpainted plywood. The inside dimensions were 9.5 x 3.5 x 5.5 in. deep for spadefoot toads, and 14 x 5 x 8 in. deep for Woodhouse toads. Guillotine doors divided the boxes into equal sized safe and shock compartments. The floor of the safe side was plywood covered with wet paper towels. The grid floor of the shock side was formed of 1/16-in. brass rods spaced 3/32 in. apart for spadefoot toads, and 3/16 in. apart for Woodhouse toads. The grid was wired in series with a shock source which delivered approximately 0.75 mA ac. An auditory/vibratory CS was produced by a 6-V dc buzzer located on the outside wall of the box near the door. Hunter timers controlled these stimulus events, and a Lafayette clutch clock measured response latencies. A mirror above each box facilitated observation of the toad. A holding box of individual 3 x 5 x 5 in. deep compartments maintained the animals during each day's session.

Procedure

The two types of toads were each randomly divided into avoidance training and control groups. Before each day's session, the toads were rinsed and placed in their holding boxes. For toads assigned to the avoidance training condition, the animal was placed on the shock grid about 2.0 cm from the door. Trials were initiated only when the toad was stationary and facing the door. Buzzer onset coincided with raising the door, shock onset occurred 5.0 sec later, and both stimuli were terminated 7.0 sec after that. Movement to the safe side immediately terminated the CS (and US), and the toad was allowed to rest in the safe side for several seconds before being returned to the holding box for the remainder of the 30-sec intertrial interval. These toads received 20 training trials each day for 5 consecutive days. The control toads received the same number of buzzer and shock trials each day, but the stimuli were delivered in a noncontingent fashion where the sequence of tones and shocks was randomly ordered. The overall duration of the session was equated by shortening the intertrial interval to 15 sec for control toads. All toads then received 20 extinction (buzzer alone) trials each day for 2 consecutive days.

RESULTS

For both acquisition and extinction, a successful avoidance response was defined as the removal of all four appendages to the safe side with a latency of less than 5.0 sec. The dependent variable was the percent of each day's trials in which a toad demonstrated an avoidance response. Figure 1 (left plate) shows that Woodhouse toads receiving contingent buzzer-shock trials consistently outavoided their noncontingent
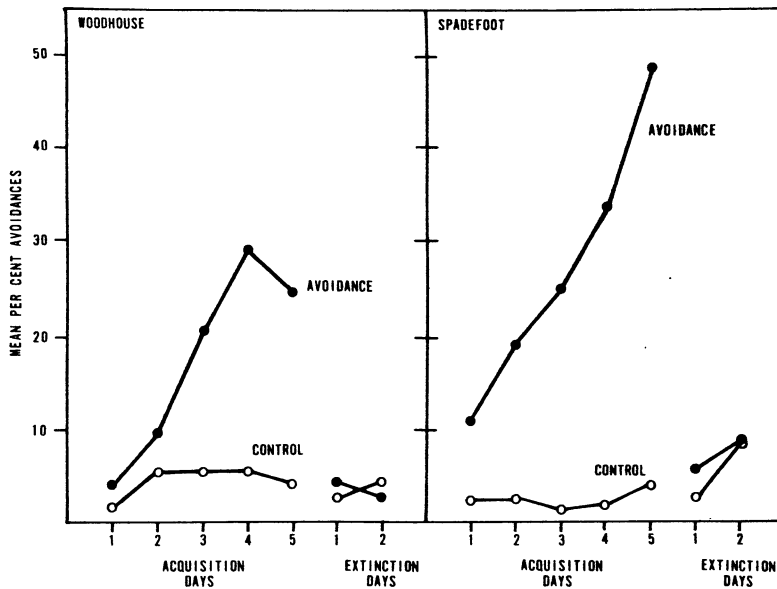
Fig. 1. Avoidance behavior of *S. hammondi* (spadefoot) and *B. woodhousei* (Woodhouse) over training and extinction sessions (N = 5/group).

controls. Spadefoot toads (right plate) showed an even more dramatic acceleration of avoidance behavior, and indicated that the increase might have continued with additional training.

Analysis of variance indicated that in both cases these differences were highly reliable. The overall differences between avoidance groups and their respective control groups were highly significant (for Woodhouse: $F(1/8) = 70.4$, $p < .001$; for spadefoot: $F(1/8) = 68.0$, $p < .001$). Overall changes in responding as a function of training were also significant (for Woodhouse: $F(4/32) = 6.35$, $p < .001$; for spadefoot: $F(4/32) = 5.12$, $p < .005$), as were the interactions of these two variables (for Woodhouse: $F(4/32) = 4.40$, $p < .01$; for spadefoot: $F(4/32) = 4.64$, $p < .005$).

Both types of toads immediately fell to the level of their noncontingent controls on the first day of extinction, and neither type of toad showed an appreciable change in responding on the second day. Further inspection of the first day's extinction data revealed no evidence of a gradual decay in response strength. These uniformly low levels of responding obviated the need for statistical analysis of the extinction data.

DISCUSSION

The acquisition data clearly reflect an increasing tendency to avoid shock in both types of toads studied. While interspecies comparisons of absolute levels of responding are generally uninformative, the present results do provide clear-cut evidence that a so-called passive salientian is capable of acquiring an arbitrarily selected response. The successful acquisition of avoidance by spadefoot toads could be accounted for by one or both of two major differences between this study and that reported by Boice (1970). First, this study employed a more intrusive CS complex (vibrating buzzer and door lift) than did Boice (door lift alone). Second, the adjusted dimensions of the

shuttle box may have modified locomotory responses by restricting lateral movement, even though the amount of forward movement needed to avoid or escape shock was about the same in both studies. At any rate, the results do show that the active-passive distinction is of questionable value in predicting shuttle avoidance in these species.

The total lack of response persistence during extinction, however, raises serious questions regarding the learning processes which presumably underlie performance of the paired groups during acquisition. Since there were highly reliable differences between paired and unpaired groups during training, the avoidance behavior cannot be dismissed as a mere nonassociative performance change resulting from sensitization. Still, the precipitous drop in responding at the beginning of extinction suggests that something other than "true" avoidance learning may have occurred here, or at least that avoidance responding was not well retained from session to session. In this respect, the results are comparable to those of two previous studies. Boice (1970) observed a dramatic loss of responding in Woodhouse toads after a 2-day interruption in avoidance training, and Crawford and Langdon (1966) reported that *B. terrestris* needed daily retraining to maintain the shuttle avoidance response.

Together, the results of these studies indicate that shuttle avoidance learning, although obtainable in a variety of salientians, may be a paradigm of questionable value in studying associative processes in these organisms. Since the available evidence indicates that learning in these organisms is clearly more resilient when biologically salient stimulus events and response requirements are employed (Van Bergeijk, 1967), it could be argued that toads and frogs are unprepared or contraprepared (Seligman, 1970) to acquire the associations needed for efficient shuttle avoidance performance. Regardless of interpretation, these findings certainly call for additional investigation of the problem of "natural" vs arbitrary conditioning preparations.

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Context effects in speeded comprehension and recall of sentences*

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Effects of four types of context on sentence processing time and recall are examined. The results are consistent with Bransford and Johnson's (1972, 1973) view that thematic or referential contexts facilitate comprehension by helping S to gain access to relevant prior knowledge. The results also suggest that context can speed sentence processing without influencing the semantic interpretation of the input.

The present study tests some predictions concerning effects of various context conditions on sentence comprehension time and recall. Bransford and Johnson (1972, 1973) have suggested that thematic or referential contexts facilitate comprehension by providing cues which help S to infer an acceptable interpretation of the input or a suitable organization of his prior knowledge. This view suggests that appropriate referential contexts should generally enable S to comprehend more quickly than in the absence of context, as well as produce greater comprehension and recall. This view also suggests that it may be possible to manipulate comprehension time by varying the amount of inferential activity required to go from the context to an acceptable interpretation of the input. Thus, contexts which only indirectly specify an appropriate theme or referential setting for the material should produce somewhat longer comprehension time than appropriate context, but should also facilitate recall relative to a neutral or no-context condition.

On the other hand, a context which is related to the material in a way which is inconsistent with any acceptable interpretation of it may mislead S into making inappropriate inferences. Such contexts should therefore produce longer comprehension time and should hinder comprehension and recall relative to the neutral condition. Finally, it should be possible to give S a head start on processing (cf. Dooling, 1972) without affecting the extent of comprehension. Thus a context which simply duplicates part of the material without suggesting a theme or referential setting should reduce comprehension time but should not affect recall relative to the neutral condition.

METHOD

Design

Each S experienced all five context conditions in a mixed list design. Context-sentence pairs were presented in blocks of six. Written free recall of the preceding six sentences was required after each block. The last sentence in each block served as a buffer and was not scored.

The S was instructed to carefully read each sentence as it appeared and to press the response button as soon as he felt that he understood it. The recall data in the present study serve the same purpose as error data in conventional RT studies, i.e., they provide a way of setting a constant lower bound on the level of processing across conditions.