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Effect of removing background white noise during CS presentation on conditioning in the truly random control procedure

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Truly random sequences of tone CSs and shock USs were given to groups of rats, then conditioned fear to the CS was measured using a conditioned suppression procedure. Subjects exhibited an excitatory CR to the CS following truly random training independently of whether or not a background white noise continued through the presentation of the CS during conditioning and testing. It was concluded that the presence of the white noise during the CS did not block excitatory conditioning to the CS as had been predicted by Rescorla (1972).

Rescorla (1967) has proposed that it is the contingency between a CS and a US rather than their mere temporal contiguity which determines whether or not the CS will acquire conditioned properties. A zero point of conditioning is associated theoretically with the independence of CSs and USs, that is with the equal probability of USs in CS presence and absence. Such a procedure has been suggested by Rescorla as the proper control for both excitatory and inhibitory conditioning procedures and has been labeled the truly random control.

In a more recent consideration of Pavlovian conditioning, Rescorla and Wagner (1972) have incorporated the predictions of this contingency view into a theoretical framework which emphasizes trial-by-trial changes in conditioning which are determined by existing amounts of conditioning to all stimuli present on a given trial. Thus, on a CS trial, changes in the associative strength of the CS will be influenced by the current associative strength of the CS and the current associative strength of the background cues and will be determined by the difference between the asymptotic value of associative strength which may be supported by reinforcement, or nonreinforcement, and the current combined associative strength of all stimuli present.

Within this framework, the truly random control procedure is expected to generate a neutral CS because of the blocking effects of the conditioning of excitation to the background cues. Reinforcement of non-CS trials increases the associative strength of the background cues, and, to the extent that this value approaches the asymptotic amount of conditioning supportable by the US, the increases in associative strength of the CS with reinforcement will be limited. Further, as the combined associative strength of CS and background cues exceeds asymptote, the associative strength of the CS will be decremented, eventually reaching zero. In this regard, it should be noted that while, asymptotically, the truly random control should generate a neutral CS, preasymptotic excitatory conditioning of the CS is possible according to the model. The excitatory conditioning of the background cues must be sufficiently great before a reduction in conditioning to the CS can take place.

Empirical evidence for the neutrality of the truly random control has been reported (Ayres & Quinsey, 1970: Bull & Overmier, 1968; Rescorla, 1968). Other studies, however, have found that truly random training can produce excitatory conditioning (Benedict & Ayres, 1972; Kremer, 1971; Kremer & Kamin, 1971; Quinsey, 1971). Rescorla (1972) has noted that a procedural peculiarity of Quinsey (1971) and Benedict and Ayres (1972) might have contributed to the excitatory conditioning they found. Specifically, a continuous white noise background stimulus was discontinued during the tonal CS. Rescorla suggested that removing this background stimulus—a potential source of blocking—might permit even asymptotic conditioning of fear to the CS.

The following experiment was designed to test this suggestion. Two groups of subjects received truly random training according to a schedule that had produced excitatory conditioning in Benedict and Ayres (1972). For one truly random group, Group TRN, the background white noise continued during the CS—while for a second truly random group, Group TR, the background white noise was discontinued during the CS. It was expected that if Rescorla's suggestion was valid, then excitatory conditioning to the CS should be weaker for Group TRN than for Group TR. However, a second

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Table 1
Order of Events in Truly Random Sequence

CS-US*	US	US	3 CSs
CS-US*	2 CSs	6 CSs	US
CS-US*	CS-US*	CS-US*	4 CSs
CS	US	CS-US-US†	CS-US*
CS-US*	4 CSs	CS-US*	4 CSs
2 CSs	CS-US*	5 CSs	US
CS-US*	3 CSs	CS-US*	CS-US*
4 CSs	CS-US*	3 CSs	3 CSs
US	CS	CS-US*	US
2 CSs	CS-US*	CS	CS
	CS	2 USs	

*Note–In Benedict and Ayres (1972) this sequence was labeled .66-.26-.17P. These numbers denoted, respectively, the probability of CSs, USs, and chance pairings and, when multiplied by 100, the number of CSs, USs, and pairings distributed throughout two 1,000-sec sessions. The table is read from top left down. Not depicted are the time intervals between events. *Denotes that a CS overlaps a US. †Denotes that a CS overlaps two USs.*

mechanism could also be responsible for such a result; namely, the reduced salience of the tone when superimposed on the white noise. To assess this possibility, two "pairings-only" groups, Groups PON and PO, were given only the CS-US pairings which occurred by chance in the truly random sequence. If blocking were the important mechanism, then continuing the white noise during the tone should have a greater effect on the truly random groups than on the pairings-only groups, which experienced no USs alone and hence suffered little blocking. On the other hand, if tone salience was the important mechanism, then superimposing the tone on the white noise should reduce the salience of the tone equally for both truly random and pairings-only groups and weaken conditioning equally in both. Thus the design of the study was a 2 by 2 factorial in which the variables were presence vs. absence of background white noise during CS presentations and pairings only vs. truly random training.

METHOD

Subjects

The subjects were 24 male albino rats, 85-95 days old on arrival from Holtzman Company, Madison, Wisconsin. They were housed individually and fed Purina Lab Chow freely for 1 week. Then, over a 5-day period, they were reduced to 80% of their free-feeding weight and were maintained at 80% throughout the experiment.

Apparatus

Six Gerbrands operant conditioning chambers with left-side dipper feeders and centrally mounted levers were housed in ventilated .61-m cubes of 13-mm plywood lined with acoustical tile. A background white noise of 82 dB was presented continuously, except as described below, through a 10-cm speaker mounted on the lid of each chamber.[1] A 1,000-Hz 84-dB tone presented through a second speaker mounted on the lid of each chamber served as the CS. Scrambled grid shocks provided by six Grason-Stadler shock sources (Models E1064GS and 700) served as the US (1 sec, 2 mA). The baseline response to be suppressed by the CS was barpressing, reinforced with 4-sec presentations of a .1-cc dipper cup containing a 32% (weight/weight) sucrose solution.

Procedure

Preliminary training. During three daily sessions lasting up to ½ h, subjects were shaped to barpress on a continuous schedule of reinforcement. Subjects were required to make a total of 180 responses over the 3 days of shaping, including 90 on the 3rd day. Following this, subjects responded on a VI 1-min schedule of reinforcement in three daily 1,000-sec sessions. The background white noise was introduced at the beginning of VI training and remained on throughout each session.

Pretesting. In each of three 1,000-sec pretest sessions, two presentations of a 1-min 1,000-Hz tonal CS were superimposed on VI responding in Min 8 and 14. For Groups TRN and PON, the background white noise remained on while the CS was presented, while for Groups TR and PO, the white noise was discontinued as long as the CS was present.

Conditioning. Conditioning to the CS took place in two daily 1,000-sec sessions, during which barpressing was prevented by the insertion of a four-walled Masonite insert with vertical 19-mm black and white stripes. The CS was a 20-sec 1,000-Hz tone; the US was a 1-sec 2-mA shock. Subjects in Groups TRN and TR received the truly random sequence presented in Table 1. As in pretesting, the white noise continued throughout the CS for Group TRN while, for Group TR, the white noise was discontinued for the duration of the CS. Groups PON and PO received only the pairings experienced by Groups TRN and TR and did not receive the CSs or USs alone. Again, for Group PON, the white noise remained on during the CS while, for Group PO, the white noise was absent during the CS.

Baseline recovery. Following conditioning, subjects were allowed to recover barpressing on a VI 1-min schedule of reinforcement. Each subject was run in successive 1,000-sec sessions on a single day until it made, during one 1,000-sec session, at least 60% of the responses made in the last pretest session.

Testing. On each of six daily 1,000-sec sessions, one tonal CS was superimposed on VI responding in Min 8. The relationship between the CS and the white noise remained, for each group, as it was during pretesting and conditioning. Shocks were not presented in this phase.

Treatment of data. Conditioned suppression to tone presentations was measured using the Annau-Kamin (1961) suppression ratio, $D/(B + D)$. D denotes the number of responses *during* the CS and B the number in the minute *before* the CS. A ratio of zero indicates strong suppression, or excitatory conditioning, while one of .5 suggests that the CS had no effect. A ratio of 0/0 is mathematically undefined, but there were no such scores in this study.

RESULTS

Figure 1 shows the mean suppression to the tone CS for each group during the three pretest sessions and the six test sessions. It is clear from the figure that the tone had little or no suppressive effects prior to the conditioning treatments but strong suppressive effects in all groups after treatment. Analyses of variance performed separately on the pretest and test data revealed significant trials effects ($ps < .01$) reflecting CS habituation during pretesting and extinction of conditioning during testing. However, the main effect of the between-groups variables and their interactions were not significant ($ps > .10$). It would be expected on the basis of a priori considerations and previous data (Benedict & Ayres, 1972) that the differences between

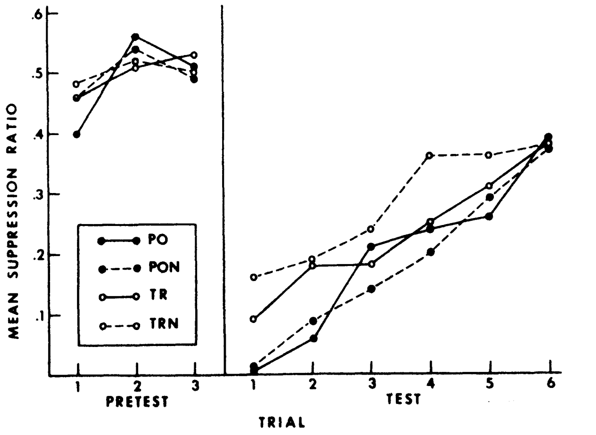

Figure 1. Mean suppression to the CS during pretest and test trials.

groups would be at a maximum early in testing. Accordingly, an analysis of variance was performed on the data from Test Trials 1 and 2 and revealed a significant effect of the pairings-only vs. truly random treatments ($p < .05$) but no significant noise or interaction effects ($ps > .20$); t tests performed on the data from Test Trials 1 and 2 revealed that Groups PON and PO, considered together, suppressed significantly more to the tone than did Groups TRN and TR, considered together ($p < .05$). As might have been expected from the salience notion, Groups PON and TRN tended to suppress less on Test Trials 1 and 2 than Groups PO and TR, but this difference was not reliable, even with a one-tailed test ($ps > .20$); nor was the difference significant when Groups PON and TRN, combined, were contrasted with Groups PO and TR ($p > .20$, one-tailed). During this same period, the average pre-CS response rates of the four groups ranged from 16 to 23 responses per minute and did not differ significantly. It is clear then that the significant differences reported in terms of the suppression ratios are uncomplicated by differences in the pre-CS rates or by differences in suppression to the CS prior to treatment.

DISCUSSION

The main finding of this research is that conditioning to a tonal CS was again demonstrated following administration of a truly random control procedure, even though the background white noise was continued throughout CS presentations. It appears then that the conditioning previously described by Quinsey (1971) and Benedict and Ayres (1972) is not limited to the unusual CS presentation procedure these authors used.

The finding that continuous noise throughout the CS fails to block excitatory conditioning does not strongly support Rescorla's (1972) suggestion about the importance of this variable in earlier work. Yet, at the same time, it is not inconsistent with the importance the Rescorla-Wagner model attaches to blocking in the truly random control. The background white noise is only one of many background cues that might contribute to blocking. In addition, according to this model, conditioning to the CS is blocked to the extent that conditioning occurs faster to the background cues than to the CS. One factor contributing to fast conditioning to the background cues is the occurrence of early US-alone trials. In this regard, it is important to note that the sequences that produced conditioning in Benedict and Ayres (1972) were those in which chance pairings occurred before USs alone (see Benedict, Note 1). In such procedures, blocking effects should be minimized in the short run. That is, the conditioning measured following 2 days of truly random training may be preasymptotic, representing inadequate conditioning of excitation to the background cues. Extended experience with the truly random sequence might generate a neutral CS. Indeed, recent data from this laboratory (Keller, Note 2) support this possibility.

The results also showed stronger excitatory conditioning in groups that received only the chance pairings of a truly random sequence than in groups receiving both the pairings and the CSs and USs alone. This result is consistent both with previous work (e.g., Quinsey, 1971) and with theoretical expectations (Rescorla, 1967; Rescorla & Wagner, 1972).

REFERENCE NOTES

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2. Keller, R. J. Effects of extended exposure to the truly random control procedure. Unpublished masters thesis, University of Massachusetts, 1974.

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NOTE

1. Quinsey (1971) used a background noise of 90 dB and a tonal CS of 84 dB, and Benedict and Ayres (1972) used a background noise of 87 dB and a tonal CS of 84 dB. However, we were concerned that animals might not be able to hear an 84-dB tone when superimposed on an 87-dB or 90-dB noise and hence reduced the noise level to 82 dB for purposes of this study.

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