Serial pattern learning: Pretraining of runs and trills¹

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In learning a repeating serial pattern of six lights, college students divided the event sequence into recurring subunits such as runs (1 2 3 4) and trills (3 4 3 4). The experiment showed that an ambiguous serial pattern (2 1 2 3 4 3 4 5 6 5) would be organized into runs, 2(1 2 3 4)(3 4 5 6)5, by Ss pretrained on a pattern of runs, and into trills, (2 1 2)(3 4 3 4)(5 6 5), by Ss pretrained on a pattern of trills. The profile of errors and the frequencies of run- and trill-overextension errors were symptomatic of how the test pattern was organized.

A previous study of serial learning of a repeating pattern of six lights (Restle & Brown, 1970) showed that various versions of the same pattern, transposed or inverted, produce very similar learning data. The results were interpreted to mean that college students organize patterns into subunits consisting of runs, e.g., (4 3 2) or trills, e.g., (2 3 2). The symptoms of a subunit are (1) the first element of a subunit is more difficult for S to predict than are its subsequent elements, and (2) the organizing principle of the subunit may be overextended, as when after seeing events (2 3 4), the S next predicts 5 in error.

Several questions regarding this hypothesis about serial pattern learning remained unanswered. First, the earlier results suggested that runs and trills were basic natural subunits, but no direct evidence has been gathered to support this claim. The first purpose of this study was to isolate runs and trills as effective subunits. Second, the previous study did not show whether the error-producing tendencies were fixed, always producing the same errors in the same frequencies, or more flexible and subject to change in character or strength through, for example, transfer of training. The second purpose of this study was to attempt transfer of training. Third, it was not clear from the earlier results whether the error-producing tendencies were specific, depending upon particular events or subunits, or were more abstract. It was shown that transposing or inverting a pattern does not change the data substantially, but it has not been shown that subunits themselves can be

changed. The third purpose of this study was to study transfer between two patterns having only abstract properties in common.

METHOD

The Ss learned repeating sequences of events by the method of anticipation. The events were six lights arranged in a row on a panel and the response alternatives were six push buttons, one beneath each event light. Lights and buttons will be designated from left to right with the numbers 1-6.

The "trills-pretrained" group of Ss was given pretraining on a sequence that divided naturally into trills of Length 3, e.g., (3 4 3). The "runs-pretrained" group was pretrained on a sequence that divided naturally into descending runs of Length 4, e.g., (5 4 3 2). Both groups were then shown the same test sequence. The test sequence was *ambiguous* in that it could be divided into either trill or run subsequences.

Subjects

The Ss were 63 undergraduates from introductory lecture and laboratory courses in psychology at Indiana University, who participated in the experiment as a course requirement. Most Ss were tested in squads of four. The assignment of squads to the two pretraining conditions was prearranged and unsystematic. There were 29 Ss in the trills-pretrained group and 34 Ss in the runs-pretrained group.

Apparatus

The Ss sat side by side in four booths separated by plywood partitions. In front of each S was a slanting panel equipped with six small white lights arranged in a row, a red push button beneath each event light, and a larger amber ready light centered at its top. The events were presented and the responses recorded by a system of timers and relays and an IBM summary card punch located in an adjoining room.

Procedure

The Ss were told that the event lights would come on, one at a time, in a repeating pattern, but they were not told anything about the pattern's characteristics. With each onset of the ready light, they were to predict which event light would come on next by pressing the button beneath that light. At each presentation, the ready lights came on and the Ss had 2 sec to respond. After this 2-sec interval or after all Ss responded (if this occurred sooner), the correct event light came on for 1 sec on each S's panel.

Then, following a 1-sec delay, the ready lights came on again, and the apparatus was ready for the next set of predictions. The procedure was fully automatic, and no E was present in the testing room during the presentation of events.

The pretraining for the trills-pretrained group was 11 repetitions of (5 6 5 3 4 3 3 2 3 1 2 1), which subdivides into four short trills. The pretraining for the runs-pretrained group was 11 repetitions of (6 5 4 3 5 4 3 2 4 3 2 1), which subdivides into three descending (right to left) runs. Both groups were subsequently tested over 29 repetitions of (2 1 2 3 4 3 4 5 6 5), which contains overlapping trill and run subunits. There was no break between successive repetitions (trials) during pretraining and test phases. Although the Ss were not told explicitly that they would be shown two different sequences, the transition from the pretraining to the ambiguous test sequence was marked by the occurrence of six "blank" presentations.

The ambiguous test sequence provides for an efficient test of transfer from trills and runs pretraining. When its pattern is organized by runs, it is 2(1 2 3 4)(3 4 5 6)5. Runs-pretrained Ss should encounter difficulty at the first element of each run (Locations 2 and 6) but find the third element of each run (Locations 4 and 8) quite easy. When the test pattern is organized by trills, it is (2 1 2)(3 4 3 4)(5 6 5). Trills-pretrained Ss should find Locations 2 and 6 relatively easy, since each is with a trill sequence. Locations 4 and 8, on the contrary, should be difficult, since each begins a trill.

RESULTS

Figure 1 shows the mean errors made at each location of the runs-pretraining pattern.² Relatively large numbers of errors were made at the beginning of each run (Locations 1, 5, and 9). The smallest number of errors occurred at the third position of each run (Locations 3, 7, and 11), less than one error on the average.

Fig. 1. Mean total errors at each location (serial position) of the runs-pretraining pattern.

Fig. 2. Mean total errors at each location (serial position) of the trills-pretraining pattern.

Fig. 3. Mean total errors at each location (serial position) of the ambiguous test pattern for the runs- and trills-pretrained groups.

(This includes the first anticipation, made before the pattern had unfolded.)

At Locations 5 and 9, it is possible for S to err by predicting the continuation of the just previous run. At Location 5, S can predict the continuation of (6 5 4 3) by responding "2." This error was most frequent at Location 5, occurring a mean of 3.74 times. No other single error at Location 5 occurred more frequently than a mean of 0.45 times. At Location 9, the run-continuation error is "1," which continues the just previous run (5 4 3 2). This error was most frequent at Location 9, occurring a mean of 2.61 times. The second most frequent error at this location occurred a mean of only 0.87 times. The dominance of run-continuation errors in sequences that divide into runs was previously noted by Restle & Brown (1970).

Figure 2 shows the mean errors made at each location of the trills-pretraining pattern. Relatively larger numbers of errors were made at the beginning of each trill. The drop of errors within the first two trill subsequences, (5 6 5) and (3 4 3), is similar

to the decline in frequency of errors within run subsequences (see Fig. 1). The second two trills, (3 2 3) and (1 2 1), are, apparently, exceptions to this pattern of results. Still, fewer errors were made at the second and third positions of each trill than at the first position.

The experimentally planned comparison between the two pretraining conditions involves Locations 2, 6, 4, and 8 of the test pattern. Recall that Locations 2 and 6 should be hard for runs-pretrained Ss (since each begins a run) but easy for trills-pretrained Ss (since each is within a trill). Locations 4 and 8 should be easy for runs-pretrained Ss (since each is the third element of a run) but hard for trills-pretrained Ss (since each begins a trill). An appropriate index is the total errors made at Locations 2 and 6 minus the total errors made at Locations 4 and 8. As predicted, the runs-pretrained group had the larger value of this index (8.03 vs 1.21) and this difference was significant [$t(61) = 4.38, p < .01$].

Figure 3 displays the differential effects of pretraining in greater detail by showing the mean errors made at each location of the test pattern for the runs- and trills-pretrained groups. The runs-pretrained group shows a progressive decline of errors within both runs, (1 2 3 4) and (3 4 5 6); the trills-pretrained group does not. The error profile for the trills-pretrained group is less definitive. Errors drop sharply within the first trill, (2 1 2), but not within the second and third trills, (3 4 3 4) and (5 6 5). The inconsistencies resemble those observed in the trills-pretraining data.

During transfer, the runs-pretrained Ss made more total run-continuation errors [$t(61) = 2.66, p < .01$] and fewer total trill-continuation errors [$t(61) = 4.02, p < .01$]. As shown in Table 1, the runs-pretrained group made more run errors at each point in the test pattern where this error was possible (Locations 1, 6, and 7). The trills-pretrained group made more trill errors at each point in the test pattern where this error was possible (Locations 1, 4, 5, 8, and 9). Thus, the effects of pretraining are seen, not only in the overall difficulty of certain locations of the test pattern, but also in the particular errors made.

DISCUSSION

The results of this experiment support the earlier conclusion that serial patterns are organized into runs and trills during learning (Restle & Brown, 1970). This conclusion is supported in three ways. First, the error profiles in learning show fewer errors at points within runs and trills than at points where the pattern shifts from one such subunit to another. Second,

Location of Test Pattern	Runs-Pretrained Group	Trills-Pretrained Group
Mean Run Errors		
1	4.65 ^a	1.59a
6	5.32	2.72
7	1.59	0.45
Total	11.56	4.76
Mean Trill Errors		
1	0.38 ^a	1.72a
4	0.41	1.83
5	0.71	1.34
8	0.53	.93
9	0.74	1.21
Total	2.77	7.03

^a These means do not include the first anticipation.

certain high-frequency errors are interpretable as overextensions of the organizing principle of such subunits. Third, run and trill tendencies transfer between two patterns, even when the particular direction or location of the subunits is changed.

Although the tendency to organize a serial pattern by runs appears stronger than the trills tendency, their relative strengths are not immutably fixed. Their relative strengths in organizing the ambiguous test pattern were affected by pretraining on runs and trills.

The test pattern differed in detail from the two pretraining patterns. Run subunits were from left to right in the test pattern but from right to left in the pretraining pattern. Trill subunits were also located and oriented differently in the two patterns. Nevertheless, the differential effects of pretraining were substantial, suggesting that abstract properties of runs and trills, not particular sequences of events, are transferred, i.e., that runs and trills have a rule-like character.

An essential property of any experimental task, if it is to be useful in the study of higher processes of serial integration, is that it be controlled by higher mental processes both of organization and abstraction. The results of this experiment, together with the earlier results (Restle & Brown, 1970), suggest that serial pattern learning meets these criteria.

REFERENCE

RESTLE, F., & BROWN, E. R. Serial pattern learning. *Journal of Experimental Psychology*, 1970, 83, 120-125.

NOTES

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2. The pretraining data of three Ss in each pretraining condition had to be discarded due to failures in the response-recording system.