words "except" or "all but" were also infrequent (four Ss on the pictorial form).[2] For the most part, Ss described set unions by compounding conjunctions, e.g., "all black not-birds and all birds," "black and not-black birds and not-black not-birds," "things that are not alive, are, and fly," "things that fly, are alive, not alive, and don't fly." The format of these descriptions suggests that S has, in effect, a program for processing information that consists of two basic operations which are applied in series: casting into standard form (e.g., birds and not-birds) and scanning for properties. Thus, for example, in dealing with $\bar{A}$ or B, after casting it into standard form, S scans for a property such as birdness, then for the second property (blackness), and reads out a summary of all included instances: all black birds and not-birds and all not-black not-birds. A very similar process appears to occur when S is given a description and must circle all included instances. The more operations the program includes the greater the likelihood of error, and error generally takes the form of stopping too soon, i.e., with an incomplete set of components, such as $\bar{A}$, B, $\bar{A}$ and B, A and B, etc. Such an analysis is compatible with the error data of both the present and previous experiments.

Descriptions produced by the processing program outlined above are not only cumbersome but also ambiguous; anyone faced with the need for going through the process very often would be well advised to devise a more efficient and economical system, such as a system for dealing with unions as an identifiable entity. Apparently, late adolescents and adults have achieved such a system. But why should development of processing programs follow an apparent age-dependent sequence? One possible explanation is derivable from Piaget's treatment of cognitive development or variants of it (e.g., Neimark, 1970). Identification of properties is a development of early childhood (and is probably intimately related to language development); classification with respect to properties and even intersection of property classes is a concrete operation that is perfected during the 7-10 age range. Thus, it is not surprising that identification of sets appears first, followed by ability to deal with intersection of sets. When confronted with more complex tasks, such as dealing with disjunction, or set union, the child should employ operations already in his repertoire (such as constructing intersects of sets and set intersects). Ability to deal with more complex structures implies an ability to deal with all 16 binary combinations of classes; this is a formal operation and an attainment of adolescence. Thus, it is not surprising to find that (1) understanding of "or" develops over the high school age range and (2) errors in dealing with "or" are largely attributable to application of concrete operations which, in turn, are inadequate for set unions.

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NOTES

1. Due to a misprint on Question 9 of the standard verbal form, it was necessary to omit Items 9-12 of this form from further analysis.

2. One S, on the pictorial form, tried to get around the problem of appropriate connective by varying the quantifier, i.e., using "some" rather than "all" for set union descriptions.

The effect of starting pattern on descriptions of perceived temporal patterns*

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Ss listened to and then described continually repeating sequences of nine tones presented at the rate of three tones/second. Each tone was either 275 Hz (high) or 250 Hz (low). The major independent variable was starting pattern (where E began the continually repeating sequence). The major dependent variable was S's description. The results showed that the "better" the starting pattern, the more often it was accepted and used as the description. "Better" starting patterns were also learned more quickly.

The temporal patterns used in the present study were fixed-length sequences of dichotomous tones (high vs low). When one of these patterns is continuously repeated to form a single ongoing sequence, we can distinguish between the starting pattern and the response or description pattern chosen by S. For instance, the continuing sequence

H(high)L(low)HHHLLLLHLHHH

LLLLHLHHHLL . . .

can be correctly described beginning at any point in the sequence, as HLHHHLLLL, LHHHLLLLH, HHHLLLLHL, etc., even though the starting pattern was HLHHHLLLL.

Two previous experiments have investigated the effects of starting pattern on S's pattern description. Royer & Garner (1966) presented their Ss with continually repeating sequences of eight tones at the rate of two tones/second. They used all eight possible starting patterns. Their results showed only a negligible effect of starting pattern on pattern description. Garner & Gottwald (1968) used patterns of eight tones or lights at rates of presentation from 0.8 to 8.0 events/second. Their results showed that the starting pattern was used as the response pattern if it provided a preferred, or frequently used, pattern description but was seldom used if the starting patterns provided a nonpreferred pattern description. This conclusion is limited, however, since for any given pattern only two of the eight possible starting patterns were used.

It is now known that Ss will describe a perceived temporal pattern with only those response patterns which do not break runs of identical tones (Royer & Garner, 1970). For instance, the pattern HLHHHLLLL . . . will only be described as (coded in terms of run lengths) 1134, 1341, 3411, or 4113. Therefore, the present study used only those starting patterns which did not break a run. This selection yields, for four-run patterns, four starting patterns instead of the two or eight previously used. Further, these four starting patterns can be ordered in terms of

*This research was supported by Grant MH 14229 from the National Institute of Mental Health to Yale University. The authors wish to thank Elinor Garner for her help in data collection and tabulation.

Table 1
The Effect of Starting Pattern on Final Pattern Description. (Both starting patterns and descriptions are indicated as their rank preference based on theoretical factors. See Note 1.)

		Starting Pattern				
		1	2	3	4	Total
Description	1	117	16	21	30	184
	2	9	102	20	24	155
	3	5	4	86	10	105
	4	0	11	3	68	82

Note–Entries represent number of descriptions.

preference for use as a response pattern by principles developed by Preusser, Garner, & Gottwald (1970).[1]

The purpose of the present study was to investigate systematically the effect of starting pattern on pattern description as a function of preference for starting pattern, using only those starting patterns which did not break runs.

METHOD

A tape reader and associated electronic equipment were used to produce square-wave tones of 275 Hz (H) and 250 Hz (L) at 63-dB sound-pressure level. The presentation rate was three tones/second with a 50% duty cycle.

The Ss were 28 male and female undergraduates from the New Haven, Conn., area. Each participated for 1 h and was paid $1.50. S sat at a table in a soundproof room with a single speaker, mounted on a vertical board, directly in front of him (approximately 2.0 ft away). His task was to listen to the sequence of tones, press a footswitch when he knew what the pattern was (thereby stopping the sequence), and then verbally describe the pattern. An intercom provided two-way communication with the E outside and the call buzzer of the intercom was used to alert the S for the next pattern. The verbal description and delay (number of tones presented before S stopped the pattern) were recorded.

All possible four-run, nine-tone patterns were used. They are: 1116, 2115, 5112, 1215, 3114, 4113, 1314, 2214, 4122, 2124, 3213, 3123, 3132, and 2223. The nine-tone patterns provided a greater range of four-run patterns than the eight-tone patterns previously used. Each S heard each pattern and its complement (tones reversed as HLHLLLLL and LHLHHHHHH) for a total of 28 trials. All four starting patterns were used equally often and counterbalanced across all Ss. Across all complements and Ss, there were 14 responses/pattern/starting pattern. Order of presentation of patterns was counterbalanced across Ss.

RESULTS

The results of this research showed that the starting pattern greatly influenced pattern description. Of the 784 total responses, 526 were correct, 242 were errors, and 16 were technically correct but broke a run. Table 1 shows the distribution of correct responses, summed across all patterns, as a function of the ranked preference for the starting pattern. This rank preference was derived from theoretical principles developed by Preusser, Garner, & Gottwald (1970). (See Note 1.)

The diagonal of Table 1 reflects the large starting-pattern effect (117, 102, 86, 68). For all four rank preferences, Ss were more likely to use the starting pattern as the description than any of the other possible descriptions. Of more importance, however, is that the effect decreased monotonically with decreasing rank preference. A 2 by 4 table, On- vs Off-Diagonal by Rank Preference, showed this decrease to be reliable ($\chi^2 = 49.72$, $p < .001$, $df = 3$). The better a starting pattern was, the more willing S was to use it.

It can also be seen in Table 1 that when S does not use the starting pattern as his description, he is most likely to use the most preferred remaining description. There are a total of 153 off-diagonal entries, 76 at the most preferred remaining description, 53 at the second preference, and only 24 at the remaining description. This effect is also reliable ($\chi^2 = 26.63$, $p < .001$, $df = 2$).

The actual magnitude of the starting pattern effect was 71%, in that 71% of the pattern descriptions were the same as the starting pattern (chance being 25%). The reason for this percentage being so high, at least in terms of previous research, is that only high-frequency descriptions (nonrun-breaking) were used as starting patterns. One result of such a large effect is that the distribution of descriptions for any single pattern tends to be relatively flat. Nevertheless, the coefficient of concordance (W) between rank-preferred description in the present study and rank-preferred description found by Royer & Garner (1970) for the same patterns was .50 ($p < .01$ for $N = 4$, $K = 14$). A slightly higher value of W ($W = .58$, $p < .01$ for $N = 4$, $K = 14$) was found between the present results and rank-preferred description theoretically derived from Preusser, Garner, & Gottwald (1970). Therefore, the theoretical ranks provided the best available independent ranking for the current data.

Previous research has also used error rate and delay in studying temporal pattern perception. Across the patterns in the current study, total errors were rank correlated .61 ($p < .05$ for $N = 14$) with mean delay (confirming Royer & Garner, 1966). Within patterns, there was no effect of starting pattern on error rate. There was, however, an effect of starting pattern on delay. If the starting patterns are ranked by theoretical preference and delays are averaged across patterns, in order of preference, 67.4, 80.8, 84.8, and 83.5 mean number of tones were heard before S stopped the sequence. Therefore, the most preferred starting patterns have the shortest delays [$F(3,39) = 4.84$, $p < .01$].

CONCLUSION

Temporal pattern perception has been measured on the basis of pattern descriptions, i.e., phenomenal reports. This method has provided considerable valid differentiation between different pattern sequences but has not provided validation of differences obtained between alternative descriptions within a given sequence. The present research has provided such manipulation in that Ss tend to describe patterns as they are started. However, failures of Ss always to describe patterns as started provides additional information about the alternative descriptions. The greater the frequency of use of a pattern as a description, the more often will it be accepted as a description when started that way. Furthermore, if a pattern is not described as presented, then S is more apt to shift to a frequently used description than to an infrequently used one. Thus, previous conclusions about preferences for alternative descriptions of a given sequence, based primarily on total frequencies of descriptions, are validated by the present research.

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NOTE

1. See Preusser, Garner, & Gottwald (1970) for a more complete description of the theoretical principles. These principles are based on a view that one tone represents the "figure" and the other tone the "ground." Within the figure element the patterns are described starting with the longest run and/or ending with the longest gap. For the present research we have assumed that when the principles are in conflict and are equally "strong," the "gap" principle is stronger.