Perception & Psychophysics
1973, Vol. 14, No. 1, 37-40

Rhythmic groups and subjective chunks in memory for melodies*

W. J. DOWLING
University of California, Los Angeles, California 90024

Memory for brief melodic phrases was tested using a short-term recognition-memory paradigm. The five-note phrases were rhythmically separated from each other and presented in lists four phrases in length. A single five-note test item followed each list and either corresponded rhythmically to one of the phrases as presented in the list (within items) or to the last three notes of one phrase and the first two notes of the next (across items). Within items were easier than across items. Slow presentation (3 notes/sec) was slightly easier than fast (6 notes/sec). The J-shaped serial position curve typical of short-term memory for verbal material was obtained. The results support the position that rhythmic grouping of input determines subjective chunking and memory storage, facilitating the recognition of test items chunked in the same way as list items.

Miller (1956) suggested that one way the human processes and remembers information from a complex environment is by imposing some organization on it by creating subjective "chunks." Each chunk would subsume a number of to-be-remembered stimuli and would function as a single unit in memory. A few chunks, while taking up little space in short-term memory, would encode much information provided S knows rules for retrieving the original material out of the chunks.

Bower and Winzenz (1969; Bower, 1970; Winzenz, 1972) have demonstrated that grouping of verbal materials into phrases affects the way in which they are remembered. For example, if a five-digit number is presented to Ss grouped as "17-348" ("seventeen, three hundred forty-eight"), then it is more likely to be recognized on a second presentation if that presentation preserves the grouping of the original (17-348 vs 173-48). Bower attributes this result to what he calls the "reallocation hypothesis." According to that explanation the grouping of the original string determines the form of the chunks stored in memory. Chunks of similar form are stored together. When the test item is presented for recognition, its form is coded and a memory search is instituted for previous items of the same form. Hence, similar grouping of input on repeated presentation facilitates recognition.

One problem with the explanation just given is that the observed effect may be due to disparity of phonemic (verbal) encodings of the differently grouped numbers rather than the form of the groupings themselves. That is, 173-48 is harder to recognize because of the great verbal disparity between "one hundred seventy-three, forty-eight" and "seventeen, three hundred forty-eight." Bower and Winzenz (1969, Experiment III) attacked this problem with a recall experiment in which the grouping was more strictly rhythmically based and not as dependent on phonemic patterning. In that experiment, the item 17-348 (for example) was read "one seven . . . three four eight." They found the same kind of result, namely that repetitions with the same grouping improved recall while repetitions with different grouping did not. They point out, however, the possibility that Ss may have been tacitly reimposing the phonemic coding ("seventeen," etc.) on the items. Therefore, the phonemic-coding hypothesis is not conclusively ruled out.

The present experiment aims at demonstrating the effects of rhythmic grouping on chunking and memory for nonverbal materials, namely brief melodies. If similarity of rhythmic grouping facilitates recognition of melodies, that would provide support for Bower's reallocation hypothesis with materials not readily subject to verbal recording. To accomplish this, "lists" of rhythmically grouped brief melodies were presented, followed by test items which corresponded either to one of the rhythmic groups (within items) or to the end of one group and the beginning of the next (across items). According to the hypothesis, recognition of the within items should be superior to recognition of the across items.

The present experiment was also designed to demonstrate the recency effect with its J-shaped serial position curve typically found in short-term memory experiments with verbal material (Waugh & Norman, 1965) but not previously demonstrated with melodies. To test the serial position effect, the lists each consisted of four brief melodies and each list position was tested equally often. The experiment was carried out at two rates of presentation to test for the possibilities that (1) fast presentation might be easier because the faster groups would form more cohesive patterns ("Gestalts") and thus be easier to remember, or (2) slower patterns

*This study was supported by a grant from the UCLA Academic Senate. Computing time was provided by the Department of Psychology, UCLA. I thank Desda Metropole for organizing the sessions and collecting the data, and Dane Harwood, Roberta Greer, and Kelyn Roberts for helpful suggestions.

might be easier to remember because of the longer time allowed for assimilation of information ("encoding" and "rehearsal").

METHOD

Procedure

On each trial of the experiment, S heard a sequence of 20 tones grouped rhythmically into four phrases of five tones each. A Morse-code-type representation of the rhythmic grouping would be: (•••• — •••• — •••• — •••• —). This sequence of 20 tones, called the "list," was followed by a 2-sec pause. After the pause, S heard a five-tone sequence (called the "test"). S's task was to say whether the test sequence was contained in the immediately preceding list. S had 10 sec in which to respond. A warning beep (1,000 Hz) preceded the onset of the next trial by 2 sec. There were 60 trials in the session. On 38 of the trials, the test actually was contained in the list; on 32, it was not. The latter are called "noise" trials. On 31 trials, the test used the same rhythmic grouping as the phrases of the list: (•••• —). These are called "within" trials since the five notes being tested fell within a rhythmic phrase of the list during its initial presentation. On 29 trials, the rhythmic grouping cut across phrase boundaries in the initial list, corresponding to the last three notes of one phrase and the first two notes of the next: (•• — ••). These are called "across" trials.

Since there were four rhythmic phrases of five notes each in the lists, there were four possible positions for the within tests. The start of the first list item and the end of the fourth list item could not be used in an across test item, so that there were three possible positions for across tests: end-of-1 plus beginning-of-2, 2-3, and 3-4. In order to keep the proportions of within and across test items nearly equal in the session as a whole, there were five tests of each of the four within positions plus 11 noise trials having the within rhythmic grouping—31 trials in all. There were six tests each of the three across positions plus 11 noise trials with the across rhythmic grouping—29 trials in all, adding up to 60 trials in the session. The near equality of within and across trials was desirable to discourage Ss from trying to improve their performance by concentrating on one type of trial at the expense of the other. Sixty trials had been found in previous studies of this sort to be long enough to obtain stable performance from Ss without encountering fatigue problems.

Two different groups of Ss performed the task at two different rates of presentation. For the fast condition, the presentation rate of the short notes (••••) was 6 tones/sec; for the slow condition, it was 3 tones/sec. For both conditions, the gaps after short notes were of the order of 10 msec. The long tone (—) at the end of each rhythmic phrase was 1.5 times as long as a short tone. A rest of .5 of a short tone separated the phrases. In musical notation, the short notes could be represented as quarter notes and the long notes as dotted quarters followed by an eighth rest. The order of the 60 trials was randomized separately for the two conditions.

The session was introduced by thorough instructions on the meaning of "contained in" for both within and across test items—that the exact sequence of five notes must have occurred somewhere in the list. Six examples, three of each type, were presented and discussed. At the close of the session, Ss completed a musical biography listing their experiences in groups and with music lessons.

Ss responded by marking specially prepared IBM cards with a pencil, using four confidence-level categories: "sure yes" (the test item was contained in the list), "yes," "no," and "sure no." Ss received no feedback. These responses were used to compute areas under the memory-operating characteristic (MOC) for each S for each test type and list position. (See Norman & Wickelgren, 1965, for details of a similar procedure.) The area under the MOC was taken as an estimate of the probability of correct response in a forced-choice procedure with a chance level of .50.

Subjects

Forty-four UCLA undergraduates served in group sessions of one to six Ss each for course credit. There were 22 Ss in each of the conditions, fast and slow. Ss had a mean of 2.85 years of musical training, including playing in an ensemble and lessons on an instrument or voice, but not including singing in choirs or music appreciation classes. Median years of musical training was approximately 1.0. Ss were assigned to conditions blindly, and the two conditions were within 0.1 year of each other in mean training.

Stimuli

A Hewlett-Packard 2116B computer generated the stimuli through a digital-to-analog converter with a sample rate of 3,000 Hz. Due to a not-yet-perfected filter system, the sine-wave stimuli contained some noise in the 1,500-Hz region. Stimuli were recorded on tape and played to Ss over high-quality reproduction equipment through loudspeakers. The computer performed all randomizations and timing of presentation.

The computer constructed a new list for each trial. The list was constructed in four phrases of five tones each. Each of the phrases in a given list had a different contour or pattern of ups and downs (see Dowling & Fujitani, 1971, for details). If the test was a noise item not contained in the list, it had a contour different from any phrase in the list. [Across noise tests had contours different from any contour pattern extending across list phrases in the (•• — ••) rhythmic grouping.] The set of four list contours was chosen randomly from the 16 possible contours of a five-note phrase (up-up-up-up, up-up-up-down, up-up-down-up, etc.).

Each phrase began on middle C (262 Hz). Pilot studies showed that letting the phrases begin on randomly selected tones increased the task difficulty beyond what was tractable for these Ss. Thus, the phrasing was marked not only by rhythm but also by a return to middle C, which functioned as a kind of "tonal center." Succeeding notes in each phrase were selected with the following probabilities of intervals between successive notes: $P(\pm 1 \text{ semitone}) = .5$; $P(\pm 2 \text{ semitone}) = P(\pm 3 \text{ semitone}) = .25$. The first note of every within test and the fourth note of every across test (noise or list item) was middle C. Noise items were generated under the same constraints as the phrases of the list. Across-noise tests were constituted of the ending and beginning of two newly constructed phrases not in the list.

RESULTS

Figure 1 shows mean areas under the MOC for the various list positions of the within and across test items. A two-way analysis of variance was performed on the 2 rates by 7 positions. The slow condition was slightly easier than the fast, overall [$F(1,42) = 5.01$, $p < .05$]. The effect of position was significant [$F(2,252) = 15.92$, $p < .01$], with later items generally easier. A planned comparison showed within items to be significantly easier than across items [$F(1,252) = 34.67$, $p < .01$]. No other effects approached statistical significance.

Correlation coefficients between years of musical experience and mean area under the MOC were .31 for the fast condition and −.48 for the slow.

DISCUSSION

These results provide a clear demonstration that rhythmic grouping functions in memory for tonal sequences in much the same way as in memory for verbal materials. The results strongly support the theoretical position of Bower (1970; Bower & Winzenz, 1971), which holds that rhythmic grouping of the list determines the form of subjective chunks, and that chunk contents in turn determine how the list items are stored. When a test item is presented, the ensuing memory search is facilitated if the test item is similar in form to the original subjective chunks of the list. This experiment contributes to the evidence for that theoretical position by providing a demonstration of the effects of subjective chunking on memory which is free from the peculiarities of verbal materials.

This experiment also demonstrates the type of recency effect typically found in analogous short-term memory tasks with verbal materials (see, for example, Waugh & Norman, 1965). Memory for Within Test Position 4 is still not as good as it would be without the previous three list items being present. Dowling and Fujitani (1971), in a task nearly the same as the present fast condition but with only one list item presented per trial, found a mean area under the MOC of .98 (vs .81 here).

Several factors affect the relative difficulty of the present task as contrasted with other melodic-memory tasks. The fact that each phrase of the list had a different contour (pattern of ups and downs) tended to make the task easier, since similarity of contour has been shown to lead to confusion among melodies (Dowling & Fujitani, 1971). Another factor making the task easier was that test items started on the same note as corresponding list items rather than being transposed (Dowling & Fujitani, 1971; Francès, 1958). Two related factors tended to make the task harder. First, the items were not in a common western tonality or "key." Francès (1958) and Zenatti (1969) have shown that short-term memory for tonal melodies is better than for atonal ones. This is presumably because the typical musical scales of a culture serve as overlearned perceptual "frameworks" in terms of which melodies are encoded (cf. Attneave & Olson, 1971; Miller & Cuddy, 1972). Second, far from being in a key, the present stimuli use mainly chromatic (one semitone) intervals and this increases the difficulty over that for diatonic melodies (Teplov, 1966).

The slight superiority of the slow condition to the fast suggests that "encoding" or "rehearsal" time may be important in memory for melodies as it is in memory for verbal material (Aaronson, 1967). The fact that musical experience is more aid in the fast condition than in the slow supports this interpretation, since among other things such experience could be expected to provide practice in rapid encoding of musical materials. I also want to mention a striking adaptation effect of presentation rate which E reported experiencing through the course of running the several sessions. The first couple of sessions happened (through random selection)

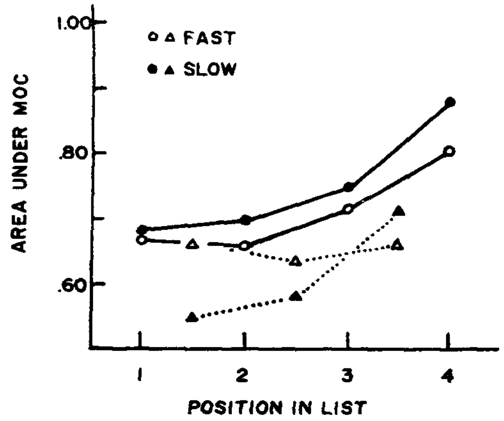

Fig. 1. Area under the MOC as a function of list position for within (circles) and across (triangles) items. Separate groups of Ss (N=22) provided data on two presentation rates: fast (open symbols) and slow (filled symbols).

to be slow, and after some trouble in the beginning trials E began to feel confident that she recognized some of the test items as having appeared in the list. At the first fast session, however, she again experienced difficulty. After two fast sessions, she again felt confident of her recognitions. The surprising thing is that she reports again experiencing difficulty when returning to the slow condition. Further experiments should be constructed to test this adaptation to rate of presentation. If it proves to be a durable phenomenon, it would suggest (as does the good fast-condition performance of musical Ss) that experience with materials of various rates leads to the learning of encoding strategies appropriate to those rates.

REFERENCES

Aaronson, D. Temporal factors in perception and short-term memory. Psychological Bulletin, 1967, 67, 130-144.

Attneave, F., & Olson, R. K. Pitch as a medium: A new approach to psychophysical scaling. American Journal of Psychology, 1971, 84, 147-166.

Bower, G. Organizational factors in memory. Cognitive Psychology, 1970, 1, 18-46.

Bower, G., & Winzenz, D. Group structure, coding, and memory for digit series. Journal of Experimental Psychology Monographs, 1969, 80, No. 2, Part 2, 1-17.

Dowling, W. J., & Fujitani, D. S. Contour, interval, and pitch recognition in memory for melodies. Journal of the Acoustical Society of America, 1971, 49, 524-531.

Francès, R. *La perception de la musique.* Paris: Vrin, 1958.

Miller, G. A. The magic number seven, plus or minus two: Some limits on our capacity for processing information. Psychological Review, 1956, 63, 81-97.

Miller, J., & Cuddy, L. L. Tonality as a cue for melody recognition. Experimental Report 72-1, Queen's University, Kingston, Ontario, 1972.

Norman, D. A., & Wickelgren, W. A. Short term recognition memory for digits and pairs of digits. Journal of Experimental Psychology, 1965, 70, 479-489.

Restle, F. Theory of serial pattern learning: Structural trees. Psychological Review, 1970, 77, 481-495.

Restle, F. Serial patterns: The role of phrasing. Journal of Experimental Psychology, 1972, 92, 385-390.

Restle, F., & Brown, E. Organization of serial pattern learning.

In G. H. Bower (Ed.). *Psychology of learning and motivation.* New York: Academic Press. 1970.
Teplov, B. *Psychologie des aptitudes musicales.* Paris: Presses Universitaires de France. 1966.
Waugh, N., & Norman, D. A. Primary memory. Psychological Review, 1965, 72, 89-104.
Winzenz, D. Group structure and coding in serial learning. Journal of Experimental Psychology, 1972, 92, 8-19.
Zenatti, A. Le développement génétique de la perception musicale. Monographies Françaises de Psychologie, 1969, No. 17, 1-110.

(Received for publication August 28, 1972;
accepted March 9, 1973.)