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Chaper VI

ORGANIZATIONAL PROCESSES IN MUSIC

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In this paper we shall examine musical organization from several points of view. First we shall consider how the listener sorts the components of a musical configuration into separate groupings. Next we shall discuss some issues involving the formation of musical abstractions so as to lead to perceptual equivalences and similarities. And finally, hierarchical organization in music will be considered.

Basically there are two issues involved in examining grouping mechanisms. First we may enquire into the nature of the stimulus attributes with respect to which grouping principles operate. When presented with a musical configuration, our auditory system may form groupings according to some rule based on the frequencies of its components, on their amplitudes, on the spatial locations from which they emanate, or on the basis of some complex attribute such as timbre. All these attributes can indeed function as bases for grouping, depending on the type of configuration presented.

Second, assuming that organization takes place on the basis of some dimension, what are the rules governing grouping along this dimension? The Gestalt psychologists proposed that we form groupings on the basis of various simple principles. One is the principle of Proximity, which states that groupings are formed out of elements that are close together in preference to those that are spaced further apart. In Figure 1a, for example, the closer dots appear to be grouped together in pairs. Another Gestalt principle is that of Similarity, which states that configurations are formed out of like elements. For example, in Figure 1b, we perceive one set of vertical rows formed by the filled circles and another set formed by the unfilled circles. A third principle is that of Good Continuation. As illustrated on Figure 1c, elements that follow each other in a given direction tend to be perceived together: in this case the dots are perceptually grouped so as to form the two lines AB and CD. Fourth, the principle of Common Fate states that elements which move in the same direction are perceptually linked together (Wertheimer, 1923). It seems reasonable to

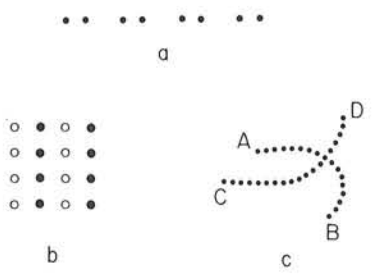

Fig. 1. Configurations illustrating the Gestalt principles of Proximity, Similarity and Good Continuation.

suppose that grouping in conformity with such principles enables us to interpret our environment most effectively (Bregman, 1978; Gregory, 1970; Hochberg, 1974; Sutherland, 1973). For example, in the case of vision, proximal elements are more likely to be part of the same object than more distal elements. Analogously, similar elements are more likely to belong to the same object than dissimilar ones. In the case of hearing, similar sounds are likely to be coming from the same source and different sounds from different sources. A sequence that changes smoothly in frequency is likely to be coming from a single source. Components of a complex sound spectrum that rise and fall synchronously are also likely to be coming from a single source.

A further point should here be made. When we hear a tone, we attribute to it a fundamental pitch, a loudness, a timbre, and a spatial location. So each tonal percept may be described as a bundle of attribute values. If our percept is veridical, this bundle reflects the location and characteristics of the tone presented. But in situations where more than one tone is simultaneously presented, these bundles of attribute values may fragment and recombine in different ways so as to give rise to illusory percepts. So perceptual grouping in music is not simply a matter of forming linkages between different groups of stimuli; rather it involves an initial process in which these stimuli are fragmented into their different attributes, followed by a later process of synthesis in which the values of these attributes are recombined.

The two-channel listening technique involves presenting two sets of auditory stimuli in parallel, either through earphones or through spatially separated loudspeakers. This technique is particularly useful for studying organizational mechanisms in music, since it enables the experimenter to set different attributes in opposition to each other as bases for grouping. Thus, grouping by spatial location may be opposed to grouping by amplitude or by frequency. At the same time, various principles governing grouping along a given dimension may be opposed to each other; for instance the principle of Proximity may be set out in opposition to the principle of Good Continuation.

In one experiment employing this technique, I presented listeners with the two part pattern shown on Figure 2a. It can be seen that this consisted of a major scale, played simultaneously in both ascending and descending form. The sequence was presented through earphones, such that when a tone from the ascending scale was in the right ear, a tone from the descending scale was in the left ear, and successive tones in each scale alternated from ear to ear. This pattern was presented ten times without pause (Deutsch, 1975a, 1975b). The most common percept is illustrated on Figure 2b. It can be seen that this consisted of two melodies, one formed by the higher tones and the other by the lower tones. The higher tones all appeared to be emanating from one earphone and the lower tones from the other. Thus grouping by frequency proximity was here so strong as to cause the tones in one frequency range to be mislocalized to one side of space, and tones in another frequency range to be mislocalized to the other side.

Recently, Butler (1979a) has extended these findings to a broad range of musical situations. He presented this sequence through spatially-separated loudspeakers in a free sound-field environment. The subjects, who were music students, notated separately the sequence that they heard as coming from the speaker on the right and the sequence that they heard as coming from the speaker on the left. In some conditions piano tones were used as stimuli. In addition, difference in timbre and loudness were sometimes introduced between the sounds presented through the different speakers. Regardless of these variations, almost all responses demonstrated grouping by frequency proximity, so that higher and lower melodic lines were heard, each apparently coming from a different speaker. Further, when differences in timbre were introduced between the stimuli presented through the two speakers, the listeners perceived new tone quality, but as though coming simultaneously from both speakers. Thus not only was there a perceptual rearrangement of the spatial locations of tones, but there was also a perceptual rearrangement of their timbres.

In order to find out where these phenomena generalize to other melodic configurations, Butler presented subjects with further two-part contrapuntal patterns. He found that again, virtually all responses reflected grouping by frequency proximity. In each configuration the two simultaneous sequences were perceptually reorganized so that a melody corresponding to the higher

a. STIMULUS

b. PERCEPT

Fig. 2a. Stimulus pattern producing the scale illusion.
Fig. 2b The illusion most commonly obtained.

on Figure 4, and each was generated under the four different conditions shown on Figure 5. The error rates in each condition are also shown on Figure 5. In Condition A the melody was presented to both ears simultaneously. As can be seen, identification performance was here very high. In Condition B the component tones of the melody were distributed in quasi-random fashion between the ears, and here identification performance was in contrast very poor. Subjectively one feels compelled in this condition to listen to the pattern coming either from one earphone or from the other, and it is very difficult to integrate the two patterns into a single perceptual stream. Condition C was exactly as Condition B, except that the melody was accompanied by a drone. Whenever a tone from the melody was in the right ear the drone was in the left ear, and whenever a tone from the melody was in the left ear the drone was in the right ear. So both ears always received input simultaneously, even though the components of the melody were still switching from ear to ear exactly as in Condition B. It can be seen that identification of the melody was greatly improved in this condition, and subjectively the difficulty in integrating the two streams essentially disappers. In Condition D a drone again accompanied the melody, but now it was always presented to the same ear as the melody component. This meant that input was again to only one ear at a time, just as in Condition B. And as can be seen, identification performance was again very poor.

This experiment shows that with signals delivered to two spatial locations, temporal relationships between these signals are important determinants of grouping. When the two ears were stimulated simultaneously, grouping by frequency range was easy, so that identification of the melody was readily achieved. However when the inputs to the two ears were clearly separated in time, grouping by spatial location was so powerful as to virtually obliterate the listener's ability to integrate the signals arriving at the two ears into a single perceptual stream.

What happens in the intermediate case, where the signals arriving at the two ears are not strictly simultaneous, but rather overlapping in time? To find out, I investigated the effects of onset-offset asynchronies between the components of the melody and the contralateral drone. This intermediate case found to produce intermediate results. Identification of the melody in the presence of the contralateral drone where the two were

Fig. 4. Basic patterns used in experiment to study melody identification when the component tones switch between ears. Each pattern was repetitively presented ten times without pause (from Deutsch, 1979).

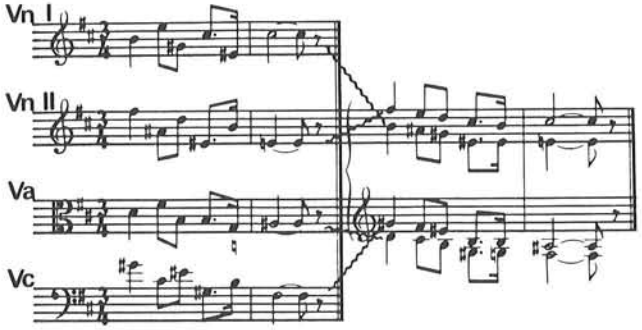

Fig. 3. Passage from the final movement of Tchaikowsky's Sixth Symphony. The combination of the Violin I and Violin II parts gives rise to the percept shown on the upper right. The combination of the viola and violincello parts gives rise to the percept shown on the lower right (from Butler, 1979b).

tones appeared to be coming from one speaker, and a melody corresponding to the lower tones from the other.

In another paper, Butler (1979b) drew attention to a passage from the final movement of Tschaikowsky's sixth symphony. As illustrated on Figure 3, the theme and accompaniment are both distributed between the two violin parts. Yet, the theme is heard as coming from one set of violins and the accompaniment as from the other. This phenomenon is very striking even with the instruments arranged in nineteenth century fashion, with the first violins on one side of the orchestra and the second violins on the other side.

Such localization illusions may be explained as follows. Given the complexity of our auditory environment, particularly the presence of echoes and reverberation, when a sound mixture is presented such that both ears are stimulated simultaneously, it is not evident from first-order localization cues alone which components of the total spectrum should be assigned to which source. Other cues must also provide information concerning the sources of these different sounds. One such cue is similarity of frequency spectrum. As described above, similar sounds are likely to be coming from the same source and different sounds from different sources. So with these musical examples it becomes plausible to suppose that tones in one frequency range are coming from one source, and tones in a different frequency range from another source. The listener therefore reorganizes the tones perceptually on the basis of this supposition (Deutsch, 1975b). The general notion of 'unconscious inference' as a basis for perceptual illusions was proposed in the last century by Helmholtz.

In these experiments the signals arriving at the two ears or from the two locations were simultaneous. What happens when this isn't so? To examine this issue, I performed an experiment in which subjects were presented with two simple melodic patterns, and they identified on each trial which one they had heard (Deutsch, 1979). The two patterns are shown

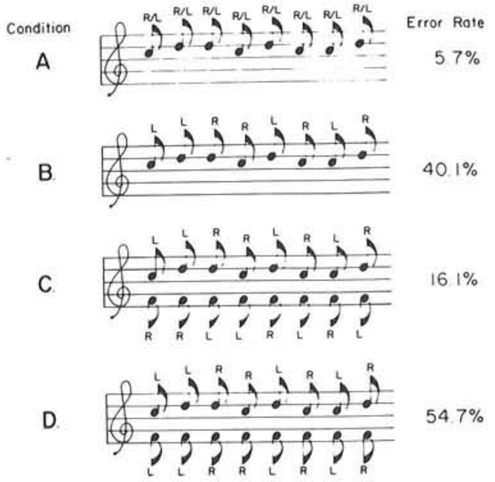

Fig. 5. Examples of distributions between ears of melody and drone in the different conditions of the experiment, together with error rates in each condition (from Deutsch, 1979).

asynchronous was better than where input was to only one ear at a time, but worse than where the melody and drone were strictly synchronous.

How do we explain these findings? The relationships between waveform envelopes of sound signals are important indicators of whether these signals are coming from the same source or from different sources (following the principle of Common Fate). We should therefore expect that the more clearly the signals arriving at the two ears are separated in time, the greater should be the tendency to treat these signals as emanating from separate sources, and so the greater the tendency to group them by spatial location. If such grouping is powerful enough it should prevent us from forming perceptual linkages between the signals emanating from different sources. Obviously it is necessary, in performing auditory shape analyses, that we not link together the components of different signals, or we would end up with nonsensical percepts (see also Bregman, 1978).

Other experiments on grouping in music have used the technique of presenting a single stream of tones in rapid succession. Much of this work has emphasized the importance of frequency proximity as an organizing factor. For example, when tones in a rapid sequence are drawn from two different frequency ranges the listener perceives, not a single stream of tones but two parallel streams. This perceptual phenomenon forms the basis of the technique of pseudo-polyphony. A sequence of tones which are drawn from two different frequency ranges is played in rapid succession, with the result that the listener hears two melodic lines in parallel.

Now, such rapid sequences of tones have several interesting properties. For example, they are poorly organized in the temporal domain. Temporal relationships are easily perceived between tones in the same frequency range, but are poorly perceived between tones in different frequency ranges. This is manifest in several different ways. For example if one presents a sequence of tones drawn from two different frequency ranges in rapid succession (i.e., at a rate of about 10 per second) perception of the orders of these tones can be very difficult (Bregman and Campbell, 1971). When the presentation rate is slowed down, so that order perception is readily accomplished, there is still a gradual breakdown in temporal resolution with an increase in the frequency disparity between two alternating tones. For instance, a rhythmic irregularity in such a pattern of tones becomes difficult to detect (Van Noorden, 1975).

Another consequence of channeling by frequency proximity was demonstrated by Dowling (1973). He presented two well-known melodies, with their component tones alternating at a rapid rate. He found that when the frequency ranges of these melodies overlapped, recognition was difficult, since their components were perceptually combined into a single stream. But as one of the alternating melodies was gradually transposed, so that their frequency ranges diverged, recognition performance increased.

Another principle by which musical configurations are organized is that of Good Continuation. It has been shown, for instance, that when presented with a rapid sequence of tones, listeners can identify their orders better when they follow a unidirectional frequency change than when they do not (Divenyi and Hirsh, 1974; McNally and Handel, 1977; Nickerson and Freeman, 1974: Warren and Byrnes, 1975).

A further organizing principle is that of Similarity, which is manifest in grouping on the basis of timbre. In classical music, timbre is often used as a marker of sequential configurations (Erickson, 1975). Adjacent phrases are often played by different instruments, to enhance their distinctiveness. Overlaps in frequency range between figure and ground are far more common where different instruments are involved. This reflects the greater perceptual distinctiveness provided by difference in timbre.

Grouping by timbre is reflected in the finding that listeners have extreme difficulty in identifying the orders of rapid sequences of unrelated sounds. This was first demonstrated by Warren, Obsuek, Farmer and Warren (1969). They generated repeating sequences of four unrelated sounds: a high tone, a hiss, a low tone and a buzz. Each sound was 200 msec in duration, and the sounds followed each other without pause. Listeners were found to be quite unable to name the order of the sounds in these repeating sequences. To achieve correct naming, the duration of each sound had to be increased to over half a second.

We next turn to an examination of the types of abstraction that are performed on musical information so as to lead to perceptual equivalences and similarities. The Gestalt psychologists first emphasized that configurations may be perceived as equivalent even when they are composed of entirely different elements, provided that certain relationships between these elements are preserved. A visual shape for example will retain its perceptual identity when it is translated to a different location in the visual field, altered in size, and in some conditions rotated or turned into its mirror image.

Interestingly, one of the first examples given of perceptual equivalence under transformation was a musical one. Von Ehrenfels (1890) pointed out that a melody when transposed retains its essential form, provided that the relations between the individual tones are not changed. In this respect, he claimed, melodies are similar to visual shapes. He was therefore implying an inter-modal analogy where one dimension of visual space is mapped into pitch and the other dimension into time. On this analogy, transposing a melody is like translating a shape to a different location in the visual field.

This leads us to ask whether further equivalences can be demonstrated for musical shapes that are analogous to those for shapes in vision. Schoenberg (1951) argued that transformations similar to rotation and mirror-image reversal in vision result in perceptual equivalences in music also. He proposed on this basis that a row of tones may be recognized as equivalent when it is transformed such that all descending intervals become ascending intervals and vice versa ('inversion'); when it is presented with the order of the tones reversed ('retrogression') or when it is transformed by both these operations ('retrograde-inversion'). Examples of such transformations, together with their visuospatial counterparts are shown on Figure 6.

Whether such transformations do indeed result in perceptual equivalences is a thorny issue. In experiments by Dowling and Fujitani (1971) and White (1960) subjects had considerable difficulty in recognizing certain melodic patterns in retrogression or inversion. However, considerably more experimental work needs to be done before this issue can be properly understood. First, such operations may occur readily, provided that the processing load is not too heavy. Second, it appears from consideration of tonal music that inversion is an operation that may be accomplished readily with respect to highly overlearned pitch alphabets, such as the arpeggiation of a triad, or a diatonic scale; without regard to interval size (Deutsch and Feroe, in preparation).

Another assumption of importance is that of octave equivalence. It is clear from a large amount of general evidence that there is a strong perceptual similarity between tones that are separated by octaves. For this reason it has been suggested that pitch should be regarded as a bidimensional attribute; the first dimension representing overall pitch level, and the second defining the position of a tone within the octave. Psychologists have referred to these two dimensions as 'tone height' and 'tone chroma' (Bachem, 1948; Meyer, 1904; Revesz, 1913; Ruckmick, 1929; Shepard, 1964), and music theorists make an analogous distinction between 'pitch' and 'pitch class' (Babbitt, 1960; Forte, 1973).

This raises the question of whether the principle of octave equivalence should be treated as a perceptual invariant; that is, whether it holds true for all types of musical processing. For example, what happens when we take a melody and place its component tones in different octaves so that pitch class is preserved but the pitches themselves are altered? Does our perceptual system treat such a transformed melody as equivalent to the original?

In one experiment I investigated this question by playing a well-known tune (it was Yankee Doodle) to groups of listeners, and asking them to give its name (Deutsch, 1972). The tune was generated in several different ways. First it was produced without transformation. Then it was generated such that pitch class was preserved (that is, each tone was in its correct position within the octave) but the choice of octave placement varied randomly between three octaves. And finally it was generated as a series of clicks, so that the pitch information was removed entirely, but the rhythm was retained. This was to determine a baseline for identificaton performance with rhythm as the only clue.

These different versions of the tune were presented to separate groups of subjects, who were given no clues as to its identity. As shown on Figure 7, although the untransformed version was recognized by everyone, recognition of the randomized octaves version was no better than where the pitch information was entirely removed. The subjects were then informed of the identity of the tune, and were again played the randomized octaves version, and found that they could now follow it to a large extent. They were therefore able to confirm the identity of the tune, although they had not been able to recognize it when they had been given no prior information. We would therefore expect that, if the listener is provided with certain clues as to what a tune might be, for instance, if he is given its rhythm, its contour, or its name amongst a small list of alternative; and as a result he forms the right hypothesis, he can then confirm this hypothesis using the tonal information provided. Indeed, other studies have shown that when subjects are given ample opportunity for hypothesis testing, recognition performance is much higher, as would be expected on the present line of reasoning (Deutsch, 1978; Dowling and Hollombe, 1977; House, 1977; Idson and Massaro, 1978).

We may in this context consider the use of octave jumps in traditional music. Given the present line of reasoning, such jumps can be made with impunity provided that the musical setting is such as to make the displaced

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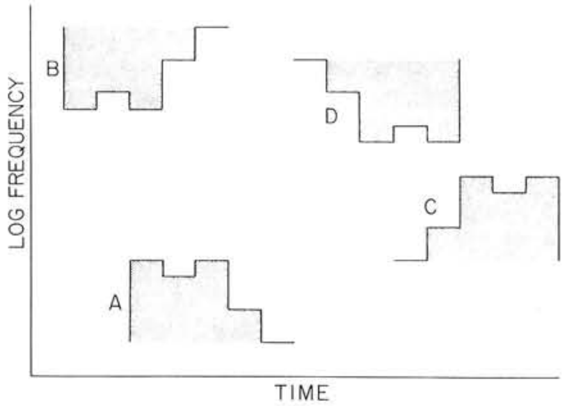

Fig. 6.1 A row of tones presented in prime form (A) inversion (B) retrograde (C) and retrograde-inversion (D).

Fig. 6.2 Visuospatial equivalents.

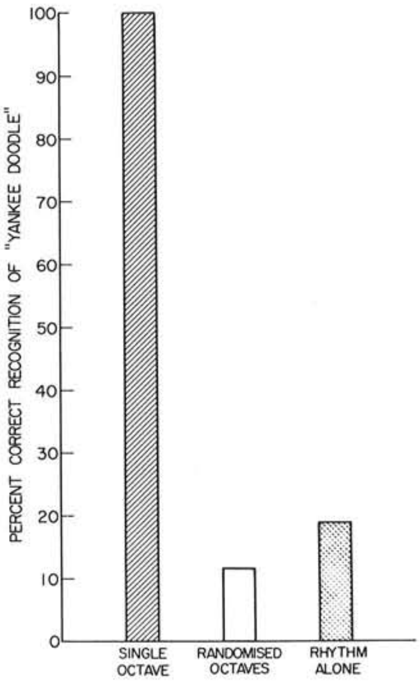

Fig. 7. Percent correct recognition of the tune "Yankee Doodle" under various presentation conditions. See text for details (from Deutsch, 1972).

note highly probable. We should thus expect that octave jumps would tend to occur mostly in such situations. Indeed this appears to be so. In one such situation a melodic line is presented several times without transformation. A clear set of expectations having thus been established, a jump to a different octave occurs. In another such situation, the harmonic structure is clear and unambiguous, with the result that again the displaced notes are highly probable.

Finally I should like to address the issue of hierarchical structure in music from a psychologist's point of view. Music theorists have long recognized that tonal music is organized in hierarchical fashion (Meyer, 1973; Salzer, 1962; Schenker, 1956, 1973). This raises several questions of interest to psychologists. What processing advantages are to be gained by such organization, and why? Under what conditions are tonal hierarchies more apparent to the listener, and under what conditions are they masked?

First we should note that hierarchical structuring of information is a general cognitive phenomenon. The structure of language is a prime example here, but we also readily form hierarchies of rules, of goals in problem solving, and even visual scenes have been shown to be encoded in hierarchical fashion. So hierarchical structuring in music is a manifestation of a general principle of cognitive organization.

Second we should note that when presented with a serial pattern, regardless of the nature of its elements, recall of such a sequence is enhanced if we can divide this information into subsequences or chunks of three of four items each (Estes, 1972; Wickelgren, 1967). In fact, when given the opportunity to do so, we readily group serial patterns into chunks that are retained as units (Bower, 1972).

A third point to be noted from general studies of cognition is that we encode and retain information much more effectively when it is composed of a relatively small alphabet and further that we can handle several such small alphabets at the same time very well, and much better than a single large alphabet which is composed of the same total number of elements (Mandler, 1967).

A fourth point to note is that if different portions of a sequence of elements can be related to each other by some rule, we need only remember an abstraction and the rule, in order to retrieve a considerable amount of information. For example, in order to remember the sequence A B C D B C D E C D E F we need only remember that a higher level sequence traversing the English alphabet acts on a lower level sequence consisting of four steps up this alphabet. Here again, this type of cognitive manipulation occurs with all kinds of information (Restle, 1970: Restle and Brown, 1970; Simon. 1972; Simon and Kotovsky, 1963; Simon and Sumner, 1968; Vitz and Todd, 1969).

Tonal music appears to have evolved in accordance with such principles of cognitive organization. Musical hierarchies involve limited alphabets which may differ from one structural level to another. For example a higher-level subsequence based on a triad may act on a lower-level subsequence based on a diatonic scale. Further, a segment of music tends to be limited to very few items at any one hierarchical level. even though the segment taken in its entirety may be very long. Also, there are often abstract rules governing relationships between subsequences which allow for considerable economy of memory storage. A hierarchical model for the internal representation of pitch sequences in tonal music has recently been advanced (Deutsch and Feroe, in preparation).

In a recent experiment memory for tonal sequences that were hierarchically structured was compared with memory for those that were not (Deutsch, in press). There was a second factor that was also considered. This concerns the influence of temporal segmentation on the ability to utilize such hierarchies. Temporal proximity may act as a very strong grouping principle, and may mask grouping on other principles (Bower and Springston, 1970; Handel, 1973; Restle, 1972). So it was predicted that temporal grouping in accordance with tonal structure would result in somewhat enhanced performance, and that grouping in conflict with such structure would give rise to performance decrements.

In this experiment, four structured sequences were employed, and these are shown on Figure 8a. It can be seen that each consisted of a higher-level subsequence of four elements that acted on a lower-level subsequence of three elements. From each of these, another sequence was constructed, which consisted of the identical set of tones, but arranged in haphazard fashion. These are shown on Figure 8b. The average interval size formed by adjacent tones in the unstructured sequences was near-identical to the

Fig. 8. Sequences employed to study utilization of structure in recall. The sequences in A can each be described as a higher-order subsequence of four elements that act on a lower-order subsequence of three elements. The sequences in B are unstructured (from Deutsch, in press).

average interval size formed by adjacent tones in the structured sequences.

These eight sequences were each presented in three temporal configurations. In the first, the tones were spaced at equal intervals; in the second they occurred in four groups of three; and in the third they occurred in three groups of four.

There were therefore six conditions in the experiment. Figure 9 displays the percentages of tones correctly recalled at each serial position in these different conditions. It can be seen that large effects of both tonal structure and temporal segmentation were obtained. For structured sequences that were segmented in accordance with structure the performance level was extremely high. For structured sequences with no temporal segmentation the performance level was again very high, though slightly lower. But, for structured sequences that were segmented in conflict with structure, the performance level was considerably reduced. For unstructured sequences performance levels were considerably lower than for structured sequences that were either not segmented or that were segmented in accordance with structure.

Examining the serial position curves further, we may note that typical bow-shaped curves are apparent, and that in addition discontinuities appear at boundaries between temporal groups. This type of configuration, which is

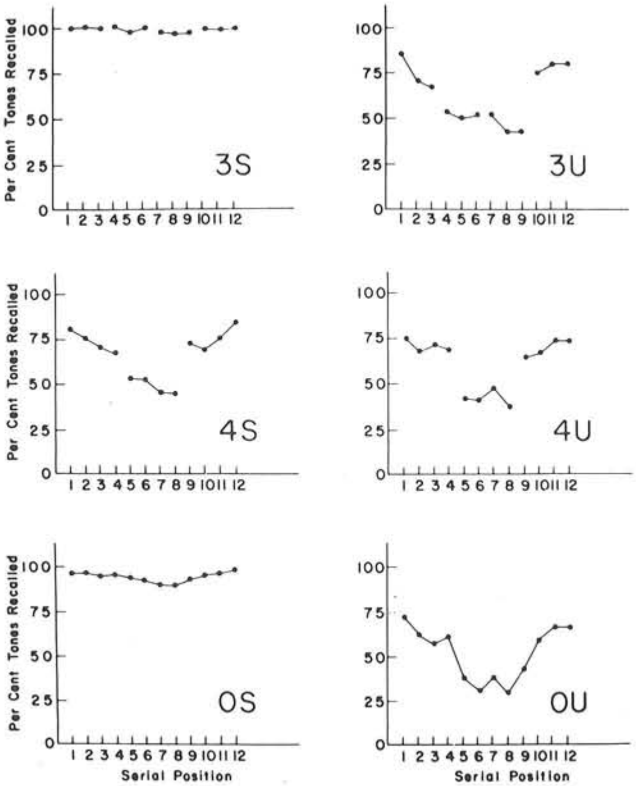

Fig. 9. Serial position curves for the different conditions of the experiment. 3s: structured sequences segmented in temporal groups of three; 4s: structured sequences segmented in temporal groups of four; OS: structured sequences with no temporal segmentation; 3U unstructured sequences segmented in temporal groups of three; 4U: unstructured sequences segmented in temporal groups of four; OU: unstructured sequences with no temporal segmentation.

very similar to that obtained by Bower and Winzenz (1969) with verbal materials, implies that temporal groups tend to be coded as units or chunks, and to be retained or lost independently. A further measure of interitem association is the transition shift probability (or TSP), defined as the joint probability of either a correct response following an error on the previous item, or of an error following a correct response on the previous item. If groups of elements tend to be retained or lost as chunks, then the TSP values should be smaller for transitions within a chunk, and larger for the transition into the first element of a chunk. Figure 10 displays the TSP values for sequences segmented in temporal groups of three and four respectively. The TSP after each pause is shown by shading. It can be seen that the TSPs are larger on the first element of each temporal group than on

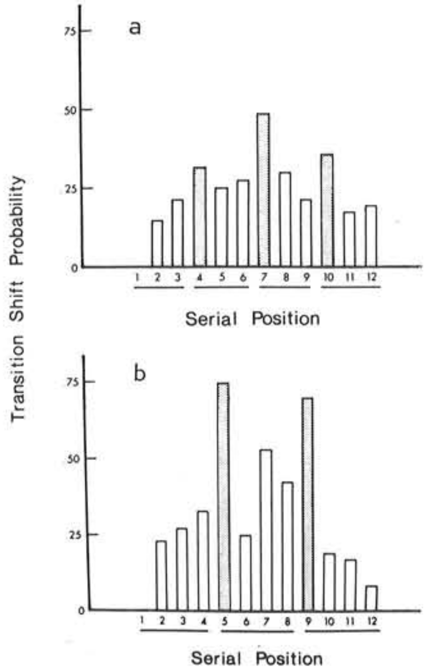

Fig. 10. Transition shift probabilities for sequences segmented in temporal groups of three (a) and temporal groups of four (b).

the other elements. This is as expected on the assumption that pauses define subjective chunks that tend to be retained or lost independently; and these results are again very similar to those obtained by others with verbal materials (Bower and Springston, 1970).

This experiment entails several conclusions. First, it demonstrates that listeners perceive hierarchical structures that are present in tonal sequences and can utilize these structures in recall. For the structured sequences employed in this study, the listener need only retain two chunks of three or four items each; however, for the unstructured sequences, no such parsimonious encoding was possible. The unstructured sequences therefore imposed a much heavier memory load, with resultant performance decrements. Second, the experiments demonstrate that temporal segmentation has a profound effect on perceived structure, as has been noted by others with the use of different materials. Temporal segmentation in accordance with structure resulted in somewhat enhanced performance; temporal segmentation in conflict with structure led to severe performance decrements. On our present line of reasoning, when temporal grouping is in conflict with tonal structure, there results a less parsimonious representation, which in turn leads to decrements in recall. Such findings are in accordance with musical practice, in which groupings based on tonal structure tend to coincide with groupings based on temporal structure.

In this review, musical organization has been considered at several levels: from the mechanisms involved in separating out the components of a complex sound spectrum so that multiple streams of tones are perceived, to those underlying the generation of tonal hierarchies. The system involved is clearly very complex, but an understanding of how we organize musical information is beginning to emerge.

SUMMARY

The organization of musical information is examined at several levels. Grouping mechanisms are first considered. When presented with a complex musical configuration, our auditory system forms groupings according to some rule based on the frequencies of its components, on their amplitudes, on the spatial locations from which they emanate, or on the basis of some complex attribute, such as timbre. The decision as to which attribute is used as a basis for grouping depends on the characteristics of the configuration presented. The principles governing grouping along any given dimension are examined. These include various Gestalt principles, such as Proximity, Similarity and Good Continuation. Some issues involving the formation of higher-order abstractions in music are next considered. Finally, hierarchical structure in music is considered, together with the interaction between tonal structure and temporal segmentation.

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