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Fundamental Factors of Music Comprehension

Introduction

The Psychology of Music, since it has emerged in the last decades of the nineteenth century, is focussed on two main problems: finding out which abilities distinguish between musical and non-musical persons, and describing how the mind works while listening to music. Since it has become clear that it is impossible to devise a culture-free test (beyond the pure measurement of sensory acuity) the interest in research on musical ability decreases, whereas problems of information-processing during listening periods increasingly stimulate scientific thinking. In the field of cognitive psychology a lot of work has been done in the last ten years – opening a no-man's-land full of open questions.

For American and English scientists, the cognitive psychology of music seems to be a very young discipline, unknown prior to the influential book of Ulric Neisser. But is it really a new branch of psychology? The psychology of music started as a discipline concentrating on cognitive operations. The purpose of Carl Stumpf, using for the first time the title »Tonpsychologie« for a book (1883/1890), was to explain how the musical mind works. Stumpf tried to find out whether cognition of music follows any of the rules which music theoreticians have assumed to be inherent in musical structure.

At present, many American and fewer English psychologists refer to the Schenker theory. Perhaps it is better to say they refer to the Schenker adherents, especially Salzer and Forte, as there exists no very good translation of the original Schenkerian writings. Stumpf referred to the theory of Hugo Riemann, a theory which is less speculative and more practical for musical analysis and, last not least, inspired by psychological thinking. The fruitful cooperation between Stumpf and Riemann endend in 1911 with a severe disappointment. Indeed, Stumpf was shown that the rules explained by music theory are the implicit knowledge of the listener. How correctly the listener uses these rules depends on his musical training. However, Stumpf has also rejected the idea there should be some cross-cultural universals. He believed the auditory system and the musical mind to be so flexible that it would be impossible to imagine any universal features (except for some psycho-physical limitations, for instance the just noticeable difference, and so on). His was a more radical point of view than that of his students, the famous gestalt-theorists who believed in innate ideas.

Today, listening, memorizing, and representation of music, are mainly looked upon as acquired skills. By the same token, music comprehension is treated as a learned activity. And the books on "cognitive psychology of music," or on "musical structure and cognition", or on "music and cognition" stress this aspect by examples of non-western music. Nobody would want to have such a closed mind as to believe the categories of tonal western music could be inherent in any music. However, curiously enough, all these books devote the last pages to a resumee about cross-cultural music universals. In the closing pages they present conclusions yet do not discuss the problem. There are hardly any questions.

Let me mention some of the universals I have found in every psychology of music book published in the last 5 years: For instance the phenomenon of the octave, the division of the octave into discrete pitches, the organization of pitches into a hierarchic structure. Last not least, small melodic intervals, as well as regular time grouping, are conceived as constraints imposed on musical systems by our processing mechanisms. Whilst cognitive psychologists stress learning, they also argue innate ideas, or inherited human characteristics, as a universal cognitive basis of music transcending individual cultures. Chomsky emphasized such ideas for the system of language. However, why should psychologists follow his ideas? Returning to the above-mentioned examples, I ask what meaning there is in an universal *qua* division of an octave into separate pitches in regard to the compositions with an ultrachromatic continuum? What does the phenomenon octave mean in respect to a relationship based on 1:5 instead of 1:2 as used by Stockhausen for his Elektronische Studie II? And all the weighted hierarchically ordered scales – what is their relationship in respect to the scales of the Arnold Schönberg School, using scales without fixed reference pitches? Our own culture shows us that there can be no structural universals in music. Musical structure is therefore quite different from the syntax of language, which has transcultural features. Possibly, contrary to language, music shows a paradoxical relationship as regards syntactic and semantic aspects since the emotional factors of music, which are responsible mainly for semantic aspects, are limited by inherited universals, whereas the structural aspects are flexible in many ways. Language by contrast has a fixed syntactical structure and no limitation as to meaning.

I mentioned Carl Stumpf on purpose. He expressed his convictions in the years when modern music emerged to demonstrate the unlimited possibilities of human thought. At the beginning of our century, he looked into an unknown future that would confirm his ideas. At the end of this century, there are some scientists who are looking so far back into the past that they overlook the closer present which shows that there are no universal features for the comprehension of music. Please keep in mind this first conclusion of mine whilst I speak next about some of the fundamental mechanisms of acoustical information-processing. Afterwards, I will try to clarify the relationship of these fundamental mechanisms to the idea of universals.

Reduction of information seems to be a fundamental principle for dealing with acoustical input. Instead of the 340 000 tones which it is possible to differentiate by ear we hear only 12 pitches and five degrees of intensity. When there are several alternatives for the interpretation of acoustical information we take the simplest. This law of parsimony can be easily demonstrated by thinking over the relationship between the frequency 4:5. Spontaneously assessed, it seems to be minor third and not half tone. Information is reduced by gathering stimuli and focussing attention on them in such a way that they are distinct from a more diffuse environment, or vague background. Such a differentiation of figure and ground demonstrates the well-known cocktail party phenomenon, i.e. we sum up acoustical stimuli coming from the same source. Thus we are able to listen to one speaker in the humbug of voices. Real understanding is possible if the collected stimuli conform with categories already existing in our mind. In general, perception is governed by spontaneous, automatic principles of grouping. Many of them are detected and described by the Gestaltists. For pitch grouping, a principle of similarity is as important as sound location. The "scale illusion," as well as the phenomenon of perceptual streaming demonstrate a tendency to sum up pitches with similar frequencies and to form out of them a special coherent line. Did composers of traditional music use such an auditory mechanism when they formed coherent melodic lines? In any case, difficulties of comprehension arise when melodic contours are broken by splitting pitches over several octaves. But what about such outstanding intervals as the major 6th or, even more expressively, the minor 7th. Mozart used them both for his famous aria "Dies Bildnis ...". Looking more precisely at music, we often find wonderful tunes outside the simple mechanisms of acoustical comprehension. The most beautiful melodies have many jumps, and for the music listener the phenomenon of perceptual streaming is seldom invoked. It is based on highly artificial techniques in music. Models of information-processing that have been develoed for acoustic phenomena often have little musical relevance. That is why books on the psychology of music are always citing the same examples as if there were no others. The main reason for this gap between experimental findings and musical experience is the difference between acoustical and musical material. A single pitch rarely has any musical significance. First of all, pitch is an acoustical phenomenon deriving musical meaning mostly by contextual features. How about studying the effects of interaction rather than studying isolated parameters in order to explain musical cognition?

I wonder why there are so few rhythm studies even though rhythm is forming the flow of musical information in more easily comprehensible units. Probably rhythmic information is more fundamental to music cognition than is pitch information. In traditional music, the metric weights of the bars are the base of a hierarchically conceived syntax defined by harmonic progressions. Notably Monahan (1984) has shown, in a multidimensional task, that rhythm is the major first-ordered dimension of musical perception. An experiment I made in the 'sixties showed by way of contrast that a melodic rather than a rhythmic mistake may be rather discovered in an Adagio than in an Allegro. It is not possible to re-examine the data. But, adding to my former interpretation *re* focussing attention, I think today that exact pitch-information processing is progressing slowly, and a melodic mistake will be more readily noticed at a slower tempo. The effort of comprehending rhythms can be less because the metric structure already divides music into meaningful units. Given a meter or a modus music can readily be grouped into a repeated-beat pattern which works as a perceptual (stimulated by physical cues) as well as a conceptual (due to learned categories) chunk. There are only a few music examples where such grouping into equal patterns is absent. I have tested the hypothesis that this grouping of temporal qualities is fundamental for musical cognition, regardless of pitch information, even though of course pitch-grouping mechanisms can further enhance comprehension.

Experimental Findings

Purpose

The preceding analysis raises two main problems:

1. Are there constraints imposed on musical systems by our processing mechanisms? Normally, psychologists argue that small melodic intervals are processed more effectively. This law of proximity is conceived as a cross-cultural universal. Likewise a regular time grouping is viewed as an obliging musical rule, even though researchers have seldom focussed on such time grouping effects in the last ten years.
2. How do these two mechanisms interact? I suggest the hypothesis that time grouping is more significant to easy comprehension than melodic contour.

Method

A Spanish folk tune (not known in Germany) with 12 pitches (example 7) and a monophonic section (example 4) from the "Structures" of Boulez were selected for this experiment. The tonal example has a melodic contour with small intervals and a four-four beat. The intervals of the serial example are widely spread over several octaves; the complicated rhythmic structure is subject to the same rules as the order of tones is. (For additional information see the analysis published by Boulez himself in the American magazine "Transform" in 1952 and the analysis of Ligeti in the "Darmstädter Beiträge" 1956.) In addition to the original folksong, three further versions (examples 5, 9, 3) were constructed. One by shifting pitches in the octave range of the Boulez example (5), one by transforming the rhythmical structure in the way of the serial piece (9), and one by combining the two parameters (3). The Boulez example was treated in the same way (examples 8, 2, 6). As the octave range was shifted in the manner of the folksong the rhythm was simplified, and both parameters were combined.

30 graduate students of musicology (this means trained in tonal music) were subjects. The eight examples were presented to them in a random order, and to small groups of listeners. I had to give up my first idea that the students should write down the examples so that it would be possible to count the mistakes. This task was too difficult. Each music example was played twice, and the students had to judge whether the second version was the same or not the same, or whether they didn't recognize it.

Results

The table 1 shows the frequencies of correct and incorrect assessments. The original version of the folk tune was easily recognized. However, there is a drastic decrease of correct responses (only 6) if melodic contour is destroyed by shifting tones into another octave range. 21 subjects believed they were listening to another piece.

The transformation of the folk tune into a complicated rhythm which inhibits the process of chunking makes recognition also more difficult. The difference between the distribution for the contourless version and the beatless version is not significant. And the same result is obtained if both parameters are combined. The four versions of the Boulez example provided more clear-cut results. It seems to be impossible to perceive the original version if it is played a second time. It is not surprising that people believe they are hearing something else if this piece – maybe the most complicated one in our history of music – is played a second time. Nobody should be prevented from hearing a piece more than twice!

But it didn't help the listener to put the serial example into the range of only one octave even though this example then has a melodic contour with small intervals. It is surprising to see the effect of simple rhythmic structure. In a four-four beat the highly complicated series of pitches is recognized as easily as the folktune. Again it is more difficult to recognize this musical example when the simple rhythm is combined with a small octave range.

Discussion

Our experimental results indicate that in the case of a tonal example the destruction of the melodic contour as well as the metric structure confuses the listener. But for a very complex series of pitches, simple time-grouping increases perception more than melodic contour. Thus recognition patterning on a rhythmic level seems to be more important than on a melodic level. It facilitates the fundamental process of chunking and therefore easier perception.

The idea of different types of information processing – some of them more fundamental than others – seems to be a good hypothesis for further research.

The result obtained with the Boulez example which has the contour and the rhythm of the folktune, suggests another basic mechanism working in rhythmic and melodic organization. At first glance, I was really disturbed that listeners could not recognize this version when it was played the second time. I repeated the experiment, and I found the same result. I carefully interviewed the subjects who mainly mentioned the lack of any sense plus the impossibility to pick up this serie of tones which conflicted with their perceptual categories. Indeed, this example suggests d-flat minor at the beginning as much by a rhythmic as by a melodic gesture. However, this impression seems to be totally wrong after the e and f sharp key has appeared. This example doesn't reveal a harmonic problem alone. It shows more generally the tendency of our mind to pick up larger units while listening and to analyse the detail afterwards. It is possible to influence this process by an external memory which allows us to conceive smaller units at a lower level of comprehension. I undertook a further experiment in which subjects had the possibility of reading four annotated examples while listening. Three of these annotations had melodic or rhythmic mistakes, one of them was the right one. The correct choice was very easy. Apparently in a reading task it is easy to break down the large units into their intervallic semi-quaver structure and to follow them pitch by pitch. It is even not necessary to memorize exactly a preceding pitch to discover the meaning of the one following, because of the annotation. Without this external memory, the listener has to pick up larger units (I avoid the term "Gestalt" for its ideological implications) and to state the exact details by an additional analysis. Forming these units is not independent of the structural organization of music. But these units have a lot to do with the categorical system of the listener. Partly he imposes this categorical system on incoming information, more or less with success. Piaget called this a process of "assimilation". Considering all of our tunes (but especially examples 2 and 6) I suppose that at a very low level of perception, a stylistic scheme is working. This scheme need not be a tonal one (eventhough it was a tonal one for example 6). It is a perceptual set (in the sense of the theory of Bruner and Postman) working as a hypothesis for the listener who has lost his orientation through disapproving of it by reason of conflict with the incoming information. In the case of example 6 such a conflict arose, but not in the case of the non-tonal series example (it seems also that such a conflict arose in example 5). The idea that implicit acquired knowledge (a stylistic schema) can be more important than structural organization – even sometimes inhibiting the recognition of "Gestalt" principles – explains partly the different findings on recognition of distorted melodies.

Retrograde variations were particularly destructive of the recognition of familiar tonal melodies because they hurt the stylistic schema. These effects were weaker when the melodies were non-tonal. To assume that a stylistic judgement is automatically a basic process of perception is also confirmed by everyday experiences which show that listeners use such stylistic schemas. When listening to radio music, they move from one broadcasting station to another quickly if the style of music is incompatible with their categorical system.

Conclusion

The ease or difficulty with which subjects conceive music depends on the level of complexity inherent in the structural organization. Simple time-grouping enhances comprehension especially well. However, art isn't subject to limitations by simple structure. The ease or difficulty with which subjects conceive music depends on the possibility of relating music to a stylistic category. Such categories are learned. The history of music shows a broad range of musical styles, and if we hope that art in future will still be innovative we must expect new styles and new forms of music.

It is possible that the stylistic categories will overcome the fundamental principles of melodic and rhythmic organization, of "chunking," and proximity. Instead of seeking universals to confirm their own stylistic prejudice, psychologists should try to develop methods on how a listener can enlarge his perceptual sets. For a rich mind it can be a pleasure to listen to complex music where the simple rules, helpful for the processing of everyday events, are replaced by luxurious surprises.

Abstract

The ease or difficulty with which subjects conceive music depends on the level of complexity inherent in the structural organization. An unknown Spanish folk tune and a monophonic section from the "Structures" of Boulez were selected for an experiment. In addition to the original versions six further versions were constructed by shifting pitches into another octave range and by transforming the rhythmical structure. Each musical example was played twice, and 30 graduate students of musicology had to judge whether the second version was the same or not the same, or whether they didn't recognize it. Simple time-grouping enhances comprehension especially well. But the possibility of relating music to a stylistic category is more important than simplicity of musical structure.

References

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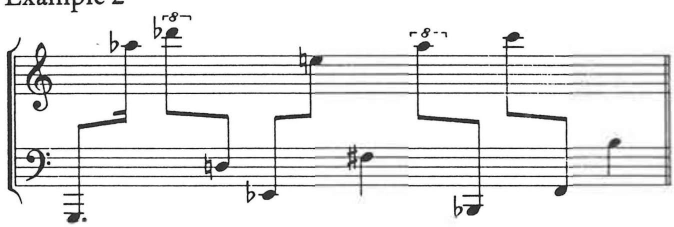
Table 1: Number of correct (+) and incorrect (–, 0) answers

Subjects: 30
male: 17
female: 10
unclassified: 3

musical example	male			female			unclassified			total			
	+	–	0	+	–	0	+	–	0	+	–	0	
7	14	3	–	6	4	–	2	1	–	22	8	–	
5	2	15	–	2	5	3	2	1	–	6	21	3	} $\chi^2 = 4{,}8$
9	5	7	5	5	5	–	–	1	2	11	14	5	
3	6	10	1	3	7	–	–	3	–	12	17	1	
4	7	7	3	1	8	–	–	1	2	9	17	4	
8	4	11	2	4	6	–	2	1	–	10	18	2	
2	13	4	–	9	1	–	2	1	–	24	6	–	
6	6	11	–	2	8	–	1	2	–	9	21	–	

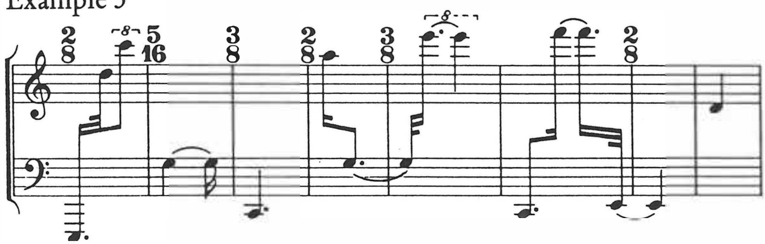
+ = same – = not the same 0 = don't know it

Example 2



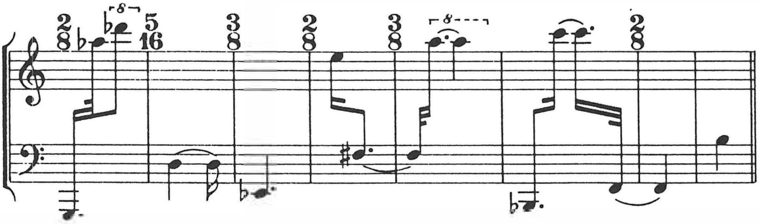
Boulez rhythm folk tune

Example 3



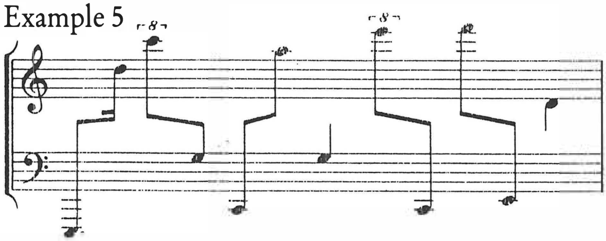
Folk tune rhythm and octave range Boulez

Example 4



Boulez "Structures"

Example 5

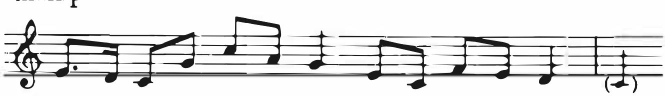


Folk tune with octave range Boulez

Example 6

Boulez rhythm and octave range folk tune

Example 7

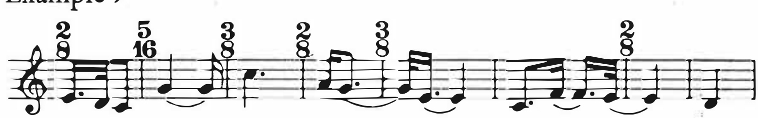


Folk tune

Example 8

Boulez with octave range folk tune

Example 9



Folk tune rhythm Boulez