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Recognition of the Wagnerian Leitmotiv – Experimental Study Based on an Excerpt from »Das Rheingold«

This study is part of a body of work devoted to the *psychological organization of listening to music,* certain parts of which have already been the subject of recent papers and publications (I. Deliège: 1987,1989, 1990, 1991; I. Deliège et al: 1989, 1990). The corpus itself is grounded on what is commonly called a *model of the itinerary of musical information.* This model - described elsewhere - is essentially based on the formation of groupings generated by cues and their imprints. In this study, I will attempt in particular to develop the idea of the cue as internal or external reference to the musical work. I will then describe the aspects of the experiment itself.

Introduction

1. The cue as internal reference to the musical work.

"Any procedure whose goal is to grasp the structure of the surrounding universe must itself construct a certain number of fixed points in that environment. To understand the universe, in fact, it must be possible to consider certain aspects of it as invariable; otherwise, the universe will forever remain a complex and unpredictable set of sensory images and elusive, anarchic and random manifestations" (Richelle, 1985, p. 271). This remark, reminiscent of Tolman's method of *cognitive map* formation (1946), is sufficiently general to be applicable to any perceptual situation, and thus to the perception of music. Indeed, the listener who wishes to grasp the design of a work must first be able to identify fixed points and invariant foundations to build his organization around.

Jérôme Bruner, in an important study entitled "On perceptual readiness" (1957), defined a step he called "primitive categorization", "that results in

the perceptual isolation of an object or an event (...) marked by certain spatio - temporal - qualitative characteristics" (pp. 130, 131). When this stage gives rise to an uncertain definition of the object, more precise markers are sought before the primitive categorization may be *confirmed.* During this stage, "incongruent cues are either normalized or gated out". (p. 131) The process whereby cues are extracted and the "natural selection" among those extracted first in the structuring of listening to music (I. Deliège: 1989) are not far removed from Bruner's assertion. Moreover, it is clear that the psychological processes implicated in the perception of music and all perceptual strategies have a great deal in common.

Similarly, would it not be possible to find certain common ground between the above statements and the notion of the Gestalt figure-background differentiation in the perceptual structuring of the visual environment? "Identifying fixed points", "isolating an object or an event along with its characteristics": such language does seem to designate concepts similar to those enunciated by the Gestalt School.

Such relationships are not absent from the field of auditory perception. It is well-known, for example, that one may pick out a specific piece of information from a tumult of sounds, or a sentence uttered by one particular individual from a number of simultaneous conversations or the soloist of a concerto from the orchestral background, etc. The extraction of cues in listening to music would seem to be an analogous process. Are they not these "fixed points" and "isolated events" which are perceived as "foreground" in the design of the work? Do they not act as "figures" in relation to the musical background and thereby preside over the organization of the listening process? (I. Deliège: 1987, 1989, 1990)

Assuming that this is so, one may then wonder why certain structures rather than others are designated for this purpose and what steps are involved in their memorization. For Leipp, who has hinged a substantial part of his thought on the application of Gestalt to auditory perception, the answer to this question must be framed in terms of emergence criteria: "Man has invented simple tools empirically in order to make effective warning signals since the beginning of time!" (1977, p. 160) This idea may seem rather remote from the problem of musical perception; however, it could simply be that it is situated on a more complex level. Is what the ear distinguishes and isolates as a signal simply what the composer has invented to attract and capture the listener's attention as well as to indicate to him the directions he has taken? From the practical point of view, Leipp demonstrates how the

invention of the sonagraph, which obtains visual images from sounds, has made it possible to observe the emergence of an acoustic event from a sound environment. He lays particular stress on the fact that during data acquisition, a large part of information is lost, with only that which most attracts the listener's attention being retained. These events are then coded, labelled, and transformed into a memorized mental image around which the processes of recognition will be organized. These images, Leipp observes, may then undergo multiple anamorpheses while still remaining recognizable as long as the internal relationships of the acoustic image remain intact. Thus, when the word PARIS is uttered by different speakers, the sonagram (cf. Figure 1) records several variations, but the basic form is the same: the term will be clearly discerned irrespective of the speaker. Similarly, the pronunciation of the word TOKYO results in a very different sonagram. This acoustic image could not be confused with the preceding one.

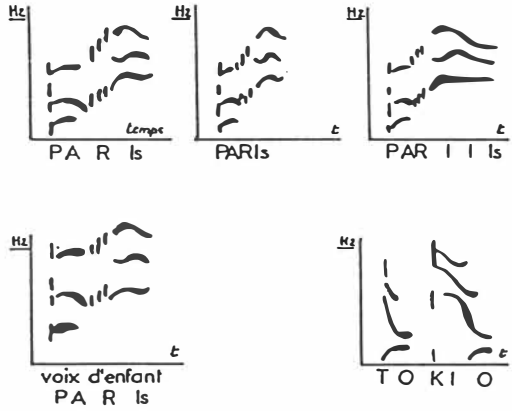


Figure 1: Sonagrams of the word PARIS uttered by different speakers in comparison with the Sonagram of the word TOKYO. Source: Leipp, 1977 (© 1977 MASSON, Paris, reprinted by permission)

However, what happens when the information intended to emerge as a figure on a background gets lost in an environment ? Once again using the sonagrams of the words PARIS and TOKYO, Leipp shows how the image may be appreciably, even severely, damaged by the surrounding environment and eventually "drowned out" entirely (Figure 2). Experiments conducted with very familiar visual images - the Mona Lisa, Beethoven's portrait, flowers - photographed with a badly out-of-focus camera demonstrate that recognition often occurs on the basis of only a few cues, provided

they are very relevant ones. As for the auditory emergence of cues which may have been selected, Leipp states that "the ear possesses the strange faculty, by reason of its adaptability, of making a form emerge on a background in an optimal way, by lowering the background until it disappears" (1977, p. 165). This purely physiological reflex phenomenon, stemming from the role which the muscle tonus of the ossicular system of the middle ear plays in audition, is also operative when the individual brings his perceptive preferences to bear on one piece of information rather than another. Here, it does not operate as a reflex, but regulates the figure-background contrast according to the subject's psychological requirements. Leipp places particular emphasis on this point and thus deems inadequate the concept of a signal-noise relationship. However, the author does not deny the authenticity of seeming paradoxes such as the one cited by Radau: a rather deaf woman was able to understand the person speaking to her better when her maid stood beside her and played the tambourine! (p. 166). Contrary to the traditional idea of the signal-noise relationship then, there would appear to exist situations where the accumulation of certain sound tracks is partial to the emergence of certain signals. If this is indeed the case, the emergence of appropriate "figures" - the cues - in relation to the "background" of a musical work should be favoured.

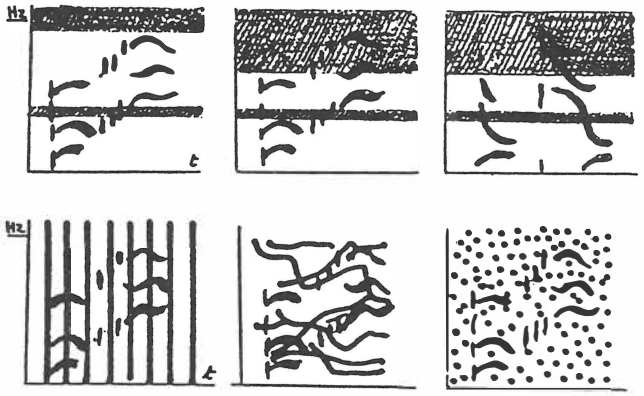


Figure 2: Sonagrams of the words PARIS and TOKYO damaged by the surrounding environment. Source: Leipp, 1977 (© 1977 MASSON, Paris, reprinted by permission)

2. The cue as external reference to the musical work: the case of the Wagnerian leitmotiv.

In the *cue / recognition* relationship, it is clearly possible that musical structures may be connected with any type of image or exterior symbol and that they are useful for designating, by direct association, the idea they are invested with. This is the case in the operas of Richard Wagner. The cue - the *leitmotiv* -is in Wagner "a highly characteristic, brief, melodic, harmonic and rhythmic motif which undergoes few variations and whose role it is to draw attention to, recall and illustrate a character, idea or feeling in the course of a lyric drama" (Amy, 1961). The musical cue thus takes on a semantic, even emotional, connotation and in so doing, may no longer be classified with those elements which convey musical form. However, it remains a signal and retains its power to evoke reminiscences through its recurrent appearances. It becomes a distinctive element *differentiated* from the rest of the musical information. Its appearances are relatively far apart and sometimes unpredictable. In addition to their extra-musical import, the groupings -formed on the basis of likeness - will be arranged in a totally different way on the temporal plane. Whereas the cue, through its continuous reiterations, cements together structures which are close together in time, the reiterations of the *leitmotiv* will generally be situated at indeterminate distances: they appear suddenly but hardly go by unnoticed. Adorno, speaking of the *leitmotiv* in his "Essay on Wagner", sees it as serving "a function similar to that of advertising" (1962/1966, p. 34). "It is easily imaginable... that the public... may be inattentive, and that, while it lets itself be swept along by the current, the music, its own impresario, *makes its imprint*[1] on the audience through its roar and innumerable repetitions" (ibid, p. 35).

Approaching the effectiveness of the cue and its imprint in perceptual organization from the work of Richard Wagner offers the experimenter unique possibilities. The symbolic value with which the composer invests the *leitmotiv* in relation to a particular character or situation takes nothing away from its force as a signal of musical structures. On the contrary, this support shapes the cue from the outside, so that it may enter the work itself. One thus has the opportunity to focus on the cue "in its pure state" and evaluate its role as "attention getter" (Richard, 1980, pp. 169-173) as well as examine its relevance with respect to its configurational and sound pro-

1 My italics

perties. The association of the *leitmotiv* with any external idea was not alluded to in the instructions and was not known by the subjects. Thus, this new stage of research does not mark a new point of departure nor does it attempt to investigate the area of extra-musical associations; on the contrary, it falls within the scope of previous studies concerning the investigation of the basic hypothesis, but is more particularly interested in the intrinsic qualities of the cue structures concerned in relation with the mode of treatment required.

The Experiment

The work was based on an excerpt from "Das Rheingold". The subjects were required to recognize a target-motif which they had had the opportunity to listen to before the experimental phase itself began.

Three *leitmotivs* with very different configurations were selected:

- WALHALL-MOTIV: a sequence characterized by its melodious design, easy to hum (example 1a);
- VERTRAGS-MOTIV: long line, striking in its descending movement (example 2a); memorizing its intervals exactly is rather complex and less immediate;
- RIESEN-MOTIV: motif whose rhythmic configuration stands out from the first listening (example 3).

In the course of the work, the composer does not always use the entire *leitmotiv*. Sometimes only a fragment appears, taken either from the beginning or the end of the sequence: the WALHALL-MOTIV is a case in point. Similarly, very slight modifications are sometimes introduced independently of changes in register and orchestration. As well, certain *leitmotivs* share rather similar melodic structures or rhythmic figures, although they may symbolize different situations within the drama itself. This is true of two of the motifs selected, as examples 1b and 2b make clear. Thus, the melodic contour of the RING-MOTIV is rather close to that of the WALHALL-MOTIV: a short descending line followed by an ascending line which is also based on thirds, but with a modified rhythm. Also, the descending configuration of the VERTRAGS-MOTIV is encountered in the VERTRAGSTREUE-MOTIV (Lavignac, 1965, pp. 340-364; J. d'Arièges, 1968, pp. 239-251). These aspects will be taken into account in the discussion which follows.

The *leitmotivs* are listed below and assigned an abbreviation by which they are referred to throughout the work. This abbreviation designates the form the *leitmotiv* takes in the sequence chosen for experimentation: original, variation or fragment (cf. examples 1a and b, 2a and b, and 3).

Target-motif 1

WA: (the WALHALL-MOTIV heard in its entirety in its original form);

WAv: (idem with variations - the RING-MOTIV);

A (end of the original motif only - the second measure); Av (end of the original motif with variations according to different formulae);

Target-motif 2

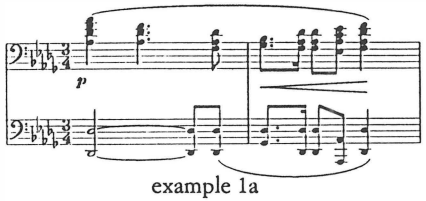
VE (the VERTRAGS-MOTIV heard in its entirety in its original form);

VEv (idem with variations - the VERTRAGSTREUE-MOTIV);

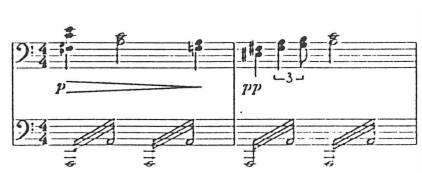
Target-motif 3

RI (the RIESEN-MOTIV heard in its entirety in its original form);

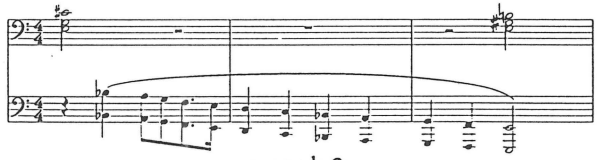
R (beginning of the motif - the rhythmic starting formula);



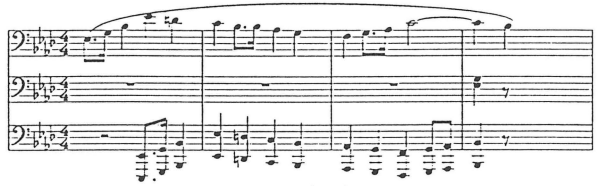
example 1a



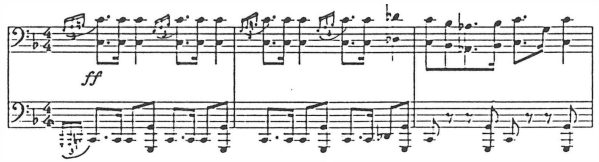
example 1b



example 2a



example 2b



example 3

The structural characteristics mentioned above, particular to each of the stimuli chosen, are likely to bring about different modes of treatment and thus possibly influence memorization and performance in recognition tasks: psychological demands may indeed vary and necessitate a specific type of adaptation in direct relation to the rhythmic and/or melodic characteristics present in the material. Garner (1978), taking an survey of the problem, suggests that the properties of the stimulus could be of two types: *constituent* properties (or features); and what might be called *holistic* properties, their overall aspect being situated on a whole or configural level. Consequently, these properties should occasion different kinds of cognitive treatment: the constituent properties, features and particular dimensions of the stimulus would call for an "analytic" treatment; and the general or configural properties would necessitate a "holistic" treatment which could involve a less detailed consideration, although the point is hardly developed.

Access to the so-called local aspects (the opportunity given the listener to extract a few restricted features from musical sequences) as opposed to their general aspects (when only a few characteristics compel recognition, local features not having been able to emerge in any perceptible way) - brings up the question of whether there is a chronology in the manifestation of these two kinds of features during processing. Is it the general or local aspects which first command one's attention ? Which of the two acts more rapidly and more effectively? In musical perception, the process of rhythmic segmentation intervenes at an early stage in the acquisition and memorization of information (see model proposed in I. Deliège: 1987 and I. Deliège et al.: 1989/1990). The rhythmic grouping is established on the basis of the discrimination of accented traits (local by definition) - changes in timbre, articulation, register, dynamics, duration etc. - grasped throughout the listening process (Lerdahl and Jackendoff, 1983). Contemporaneous with this is the extraction of characteristics to be selected as cues and their imprints. It follows, then, that access to general or configural properties (e.g. the melodic contour of a sequence) could take place more slowly, as a sufficient amount of time must have passed for such information to be assimilated. This time factor, which determines the registering of musical characteristics, would thus lead one to expect that general features will be responded to with less immediate effectiveness than particular ones. A greater number of listenings would likely be required for these features to be made truly operative.

Predictions

For the reasons mentioned above, motif 2 (VERTRAGS-MOTIV) might be expected to present more problems than the other motifs. Its particular cue - a descending melodic line - renders the discrimination between the constituent intervals of the sequence difficult. Further complicating matters is the fact that, as far as rhythmic segmentation is concerned, the accented elements do not favour particularly relevant divisions. Memorization could thereby be hindered in direct proportion to the length of the motif. On the other hand, the melodic configuration of motif 2 (WALHALL-MOTIV) will be more immediately accessible. The same should be true of motif 3 (RIESEN-MOTIV) whose rhythm is particularly conspicuous from the outset. However, the striking pace of the "head" of the sequence may be deceptive: this motif was chosen precisely for this reason. It will help reveal how, from highly relevant cues, the processes generate an imprint whose lack of clarity goes hand in hand with the excessive immediacy of its selection and positioning. If this is so, this *leitmotiv* should be erroneously recognized during the experimental sequence.

The existence of a rhythmic affinity (the presence of the same rhythmic figure in all three motifs - the dotted quaver/semiquaver) may be at the origin of interference in the recognition tasks. In addition, false alarms may be caused by the presence of musical parameters in the musical background similar to those appearing in the motifs to be recognized.

The comparisons made in earlier studies on the difference in the performances of professional musicians and non-musicians are returned to here. The distinctive signs proper to all *leitmotifs* should elicit good performances from all subjects, which would corroborate earlier findings (I. Deliège: 1987, 1989). Any differences should be located in one or both of the following areas. The first is in the identification of variations in the form of *leitmotivs;* i. e. when, following certain kinds of transformation, only excerpts from the general *leitmotiv* are presented. For example, a variation which uses only the end of the motif -as in the WALHALL-MOTIV as we will see below - will be all the less relevant as the cue value is generally more strongly incorporated in "heads" of sequences than in what follows. The second area is greater difficulty encountered in memorizing the material to be recognized.

Method

Subjects: Two categories of subjects - musicians and non-musicians - were tested.

The non-musicians: three groups of twelve subjects, either students at or graduates of post-secondary institutions. They had received no musical training of any kind. Their average age was twenty-three.

The musicians: three groups of nine subjects, selected on the basis of their curriculum vitae. They were required to have obtained at least the first prize from the Royal Conservatory in a major area and be engaged in public professional activities either as a performer or as a teacher. These strict conditions were intended to establish a clear distinction between the two categories as to their musical competence and knowledge and to prevent music lovers without theoretical training from being classified as "musicians". The musicians' average age was twenty-eight, this somewhat higher age being the product of the selection criteria.

Material: A twenty-five minute excerpt from the opera was selected, from the beginning of scene 2 until *Loge's* appearance : "Ersatz für Freia zu suchen, wie er den Riesen wohl recht" followed by a fermata. It was performed by the Wiener Philharmoniker conducted by Georg Solti (Decca CD 414101 - 2DH3).

This excerpt as well as the three *leitmotivs* chosen, such as they first make their appearance in the sequence (unaccompanied by singers), were recorded beforehand on magnetic tape and played on Teac equipment in stereo during the experimental sessions. Two high-fidelity loudspeakers were placed three metres apart and at a height of two metres on either side of the subject. Subjects were to respond by pressing either of two keys on a Yamaha KX88 keyboard. A green key was to be used for correct responses while a red key would "erase" incorrect responses. The answers were registered on a Macintosh SE, equipped with a Studio Plus Two MIDI interface, by the Performer software (version 1.22). It was essential that the beginning of the musical sequence and the registering of responses be perfectly synchronized: the use of a Yamaha RX5 rhythm box ensured that the Macintosh SE micro-computer would start with respect to a *point* placed just before the first sound of the sequence.

The complete duration of the experimental sequence had previously been divided into 212 segments in preparation for a pilot sequence intended to compare subjects' responses in accordance with norms defined by

software created on this occasion (URPM, internal report, 1989). Segments correspond to no particular musical structure *a priori* and may be defined according to the user's needs with each new use of the software as need be. For this study, the complete experimental sequence was divided into parts of varying lengths whose boundaries were registered beforehand by computer. Our objective was to analyze subjects' responses in relation to perceived musical structures, more specifically the recognition of target motifs as well as the search for reasons for any false alarms which might occur. Short segments, an average of seven seconds in length, were chosen so that the various types of responses given during the twenty-five minute session could be identified more easily.

The segments were numbered in ascending order. The four responses - correct recognition, false alarms, omission, justified rejection - could thus be identified automatically in terms of the nine types envisaged, four types corresponding to *the 4 types of presentation of motif 1:* WA - motif 1 in its entirety (11 segments); WAv - motif 2 in variation (8 segments); A - final part of motif 1 (17 segments); and Av - final partof motif 1 in variation (6 segments); *2 types of presentation of motif 2:* VE - motif 2 in its entirety (17 segments); VEv - motif 2 in variation (2 segments); *2 types of presentation of motif 3:* RI - motif 3 in its entirety (4 segments); R - initial part of motif 3 (12 segments) and MISCELLANEOUS, which encompasses the remaining 135 segments where none of the motifs is easily recognizable.

Procedure: To test the three *leitmotivs* on different subjects, each category of subjects was divided at random into three groups of equal size: twelve subjects in each group of non-musicians and nine in each group of musicians.

They were read the following instructions before the session began: "You are going to be played a musical motif. You are to attempt to memorize it so you may recognize it later when it appears as part of a long sequence. It is possible that this motif may not appear in the same form as in the learning sequence: it may be played with different instruments; as a variation; or be shortened or lengthened. Press the green key as soon as you think you have detected the motif regardless of its variations. Keep the key pressed down as long as the motif continues. If you think you have made an error, press the red key briefly to so indicate. You may listen to the motif as many times as you wish until you are certain you have memorized it perfectly".

The experiment was conducted as follows :

(1) Acquisition phase: the subject listened to the target *leitmotiv* as many times as he wished, with the experimenter noting the number of repetitions requested. A short excerpt taken from elsewhere in the opera where the *leitmotiv* appears only once was then played as pre-test sequence; this was done to verify if the instructions had been understood.

(2) Repetition of the acquisition phase (optional): the subject could, if he so desired, ask to listen to the motif as many times as he wished before moving on to the definitive phase. The number of additional listenings requested was also noted by the experimenter.

(3) Recognition phase: listening to the twenty-five minute excerpt and performance of the tasks specified beforehand.

Following the session, the subjects were asked several questions in order to evaluate their degree of familiarity with the music they had just listened to. It would thus be possible to single out any subject having a relatively profound knowledge of Wagner and eliminate him from the study, thereby preserving the homogeneity of the samples.

Results

1. ACQUISITION OF MOTIFS (experimental phases 1 and 2)

Figure 3 shows the average number of listenings requested for each motif for each category of subjects during the two acquisition phases. The various

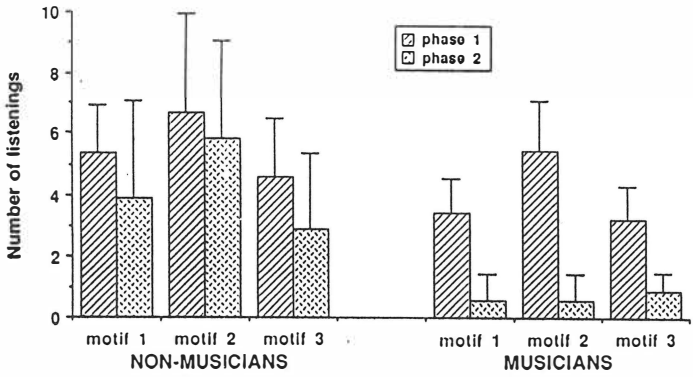


Figure 3: Mean number of listenings requested by musicians and non-musicians for each motif during the aquisition phases.

elements of the data analysis, presented in Tables 1a, b and c, are commented on below.

1.1. *Influence of the subjects' musical training.* There is a significant difference between the musicians and non-musicians in the average number of listenings requested during the first and second acquisition phases (Table 1a). Fewer listenings are required during the second phase, especially by the musicians. It is also worth mentioning that the musicians almost never asked to listen to the target motif again after the pre-test.

TABLE 1 A

Analysis of the variance in the number of listenings requested in relation to category of subjects and target motifs

Sources of variation	d.l.	F	p		$\bar{x}$ musicians	$\bar{x}$ non-music.
First acquisition phase						
- Effect related to category of subjects	1	8.64	0.005		4.04	5.53
- Effect related to motifs	2	6.60	0.003	motif 1	3.44	5.33
				motif 2	5.44	6.67
				motif 3	3.22	4.58
- Interaction	2	0.16	0.852 ns			
- Error	57					
Second acquisition phase						
- Effect related to category of subjects	1	36.71	0.0001		0.67	4.22
- Effect related to motifs	2	2.44	0.096	motif 1	0.56	3.92
				motif 2	0.56	5.83
				motif 3	0.89	2.92
- Interaction	2	2.58	0.084			
- Error	57					

1.2. *Influence of the musical structure of the target motif in relation to the subjects' musical training.* Once again, a significant influence of the motif is observed in the first but not the second phase (Table 1a). Furthermore, there is no interaction effect between the motifs and the subjects' musical background.

The relationship between the difficulty of memorizing the musical structure of motifs and musical training may be determined more precisely first through an analysis of variance, then by multiple comparisons of the

average number of listenings requested for each motif during each of the acquisition phases (Table 1b). It reveals that during phase 1 the musicians asked to listen to motif 2 a significantly greater number of times than to either of the other two motifs. For the non-musicians, however, no significant difference is observed during the first acquisition stage. The situation is reversed for the second phase: there is no significant difference for the musicians as to the acquisition of motifs since they seldom required further hearings at this stage (cf. above). The difficulty of motif 2 is apparent in the results of the non-musicians, even though multiple comparisons did not demonstrate a significantly different pair of means.

TABLE 1 B

Analysis of the variance to a three level factor (the motifs) of the number of listenings requested during each of the acquisition phases and multiple comparisons of the mean number of listenings.

Source of variation	d.l.	F	p	$\bar{x}$
First acquisition phase				
a) **musicians**				
- motif 1				3.44
- motif 2				5.44
- motif 3				3.22
- Effect related to motif	2	7.70	0.003	
- Error	24			
b) **non-musicians**				
- motif 1				5.33
- motif 2				6.67
- motif 3				4.58
- Effect related to motif	2	2.39	0.11	
- Error	33			
Second acquisition phase				
a) **musicians**				
- motif 1				.56
- motif 2				.56
- motif 3				.89
- Effect related to motif	2	0.52	0.60	
- Error	24			
b) **non-musicians**				
- motif 1				3.92
- motif 2				5.83
- motif 3				2.92
- Effect related to motif	2	3.03	0.06	
- Error	33			

Table 1c compares the average number of listenings requested by the musicians and non-musicians motif by motif. During the first acquisition phase, a significant difference is observable for the acquisition of motif 1 only. The musical structure of motif 2 appeared to be more complex both for musicians and non-musicians, all of whom requested more listenings to this motif than the others, but no significant difference was noted in regards to musical training. Finally, given the particularly reduced number of listenings required by the musicians during the second acquisition phase (see above), the results are significantly different for the three motifs.

TABLE 1 C

Comparaison of the mean number of listenings requested by musicians and non-musicians for each motif

First acquisition phase

	t (19)	p	$\bar{x}$ musicians	$\bar{x}$ non-music.
motif 1	-3.07	0.006	3.44	5.33
motif 2	-1.02	0.322 (ns)	5.44	6.67
motif 3	-1.93	0.068	3.22	4.58

Second acquisition phase (*)

	U	p	$\bar{x}$ musicians	$\bar{x}$ non-music.
motif 1	10.00	0.0012	0.56	3.92
motif 2	1.00	0.0001	0.56	5.83
motif 3	17.50	0.0071	0.89	2.92

(*) Because of the excessively large divergence of the two samplings, the results of the second acquisition phase were analyzed by means of the non parametric Mann-Whitney rank-order test.

2. THE RECOGNITION OF THE TARGET MOTIFS (experimental phase 3)

As mentioned above, subjects could activate a key if they felt they had made an error. The results will be analyzed according to two criteria: 1) before correction (i.e. spontaneous recognition); and 2) after correction.

2.1. Recognitions registered before correction

A. *Breakdown of the average number of responses.* Figures 4a, b and c show, in addition to the maximum number of responses possible, the total average number of responses registered for each type of segment in each target motif for both musicians and non-musicians. The correct responses (correct recognitions and justified rejections), omissions and false alarms are thus clearly distinguishable. Overall, a high number of correct responses may be noted; however, the exact number of such responses varies according to the subjects' musical training (musicians/non-musicians), the motif to be recognized and the different types of segments encountered during the entire duration of the experimental sequence.

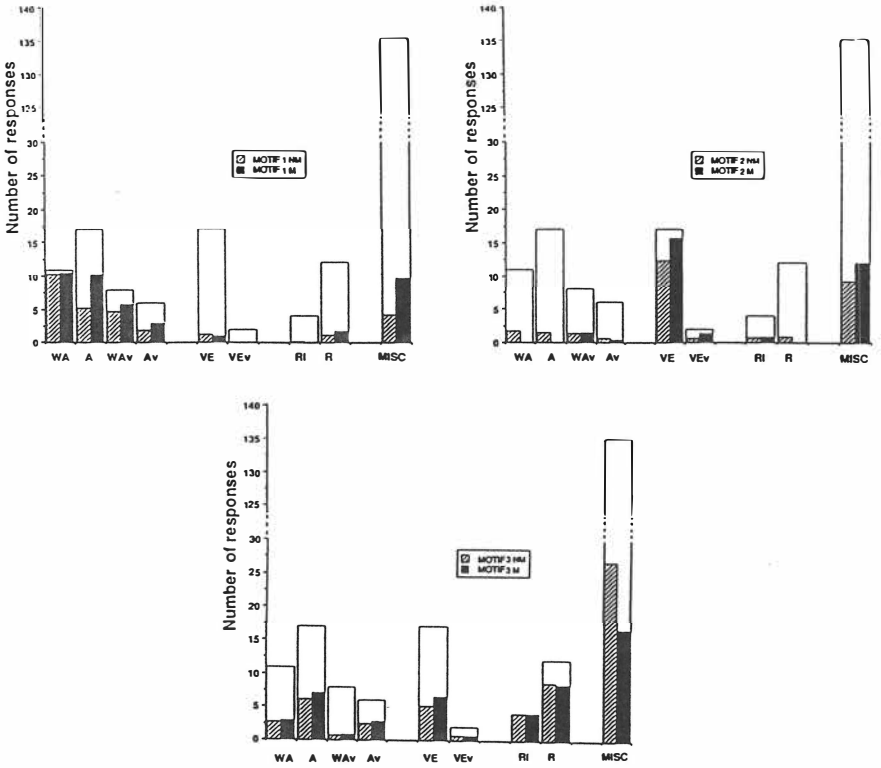


Figure 4a, b, c: Maximum number of responses possible (in white) and the average number of responses noted for each type of segment in relation to each of the target motifs.

B. *Comparison of the average number of correct responses for each motif for both categories of subjects.* Tables 2a, b and c present the details of the analysis of variance for each motif taken as a whole and for each type of particular segment.

There are several points here which bear mentioning. As concerns the recognition of motif 1 (Table 1a), the difference between musicians and non-musicians is significant for the means considered as a whole (encompassing the four different types of presentation of this motif). This difference is not very representative in itself: it is the product of the decline in performance registered for the non-musicians for the A segments (final part of the motif) and affects the overall total. No significant difference is observable for the two categories of subjects for the other types of presentation of motif 2 (WA, WAv, Av). The same is true for the recognition of the two different presentations of motifs 2 and 3 (Tables 2b and 2c).

C. *Interference between the three target motifs and other false alarms.* The analysis of the false alarms has been broken down into two categories. In the data, we may observe responses to segments of the score where no motif is present as well as recognitions of the target motif when in fact

TABLE 2 A

Analysis of the variance of the number of recognitions for **motif 1**

Source of variation : effect related to category of subjects (musicians / non-musicians). 1 d.l.
error 19 d.l.

	F	p	$\bar{x}$ musicians	$\bar{x}$ non-music.
Correct recognitions	6.91	0.017	29.44	21.92
WA	0.30	0.593 ns	10.44	10.25
A	11.50	0.003	10.22	5.17
WAv	1.72	0.206 ns	5.78	4.67
Av	1.97	0.177 ns	3.00	1.83
False alarms	1.92	0.181 ns	12.44	6.75
other motifs	0.003	0.956 ns	2.67	2.58
VE	0.15	0.708 ns	1.00	1.25
VEv (*)	-	-	0.00	0.00
RI	0.74	0.400 ns	0.00	.17
R	0.26	0.615 ns	1.67	1.67
Miscellaneous	3.96	0.061 ns	9.78	4.17

(*) non-calculable, the dependent variable is constant for each category of subjects.

TABLE 2 B

Analysis of the variance of the number of recognitions for **motif 2**

Source of variation : effect related to category of subjects (musicians / non-musicians), 1 d.l.
error 19 d.l.

	F	p	$\bar{x}$ musicians	$\bar{x}$ non-music.
Correct recognitions	4.48	0.048	17.11	13.00
VE	4.05	0.06 ns	15.78	12.33
VEv	3.43	0.080 ns	1.33	0.67
False alarms	0.04	0.852 ns	14.67	16.00
other motifs	5.70	0.028	2.67	6.83
WA	12.34	0.002	0.00	1.75
A	4.49	0.048	0.00	1.50
WAv	0.03	0.874 ns	1.44	1.33
Av	0.56	0.464 ns	0.33	0.58
RI	0.27	0.606 ns	0.89	0.67
R	1.58	0.225 ns	0.00	1.00
Miscellaneous	0.52	0.482 ns	12.00	9.17

TABLE 2 C

Analysis of the variance of the number of recognitions for **motif 3**

Source of variation : effect related to category of subjects (musicians / non-musicians), 1 d.l.
error 19 d.l.

	F	p	$\bar{x}$ musicians	$\bar{x}$ non-music.
Correct recognitions	0.07	0.789 ns	12.44	12.75
RI	---	---	4.00	4.00
R	0.07	0.789 ns	8.44	8.75
False alarms	0.17	0.684 ns	39.11	44.75
other motifs	0.38	0.543 ns	21.22	18.00
WA	0.07	0.791 ns	3.00	2.67
A	0.17	0.681 ns	7.11	6.17
WAv	0.07	0.795 ns	0.89	0.75
Av	0.14	0.709 ns	2.78	2.50
VE	0.90	0.356 ns	6.67	5.17
VEv	0.01	0.945 ns	0.78	0.75
Miscellaneous	0.88	0.361 ns	17.89	26.75

TABLE 3

Comparison of the mean number of recognitions before and after corrections

	WA	A	WAv	Av	VE	VEv	RI	R	MISC
musicians {t (8)}									
motif 1	1.00	0.00	1.00	1.00	1.64	--	--	0.00	1.51
p	0.35	1.00	0.35	0.35	0.14			1.00	0.17
motif 2	--	--	1.00	1.00	1.51	1.51	1.51	--	2.25
p			0.35	0.35	0.17	0.17	0.17		0.055
motif 3	1.00	1.00	1.00	1.00	1.41	1.00	--	1.00	1.65
p	0.35	0.35	0.35	0.35	0.20	0.35		0.35	0.14
non-musicians {t (11)}									
motif 1	0.00	2.24	1.77	1.39	2.46	--	0.00	1.91	1.91
p	1.00	0.046	0.10	0.191	0.03		1.00	0.082	0.082
motif 2	1.45	1.00	2.24	1.77	2.55	1.00	1.91	1.34	2.32
p	0.18	0.34	0.046	0.10	0.03	0.34	0.08	0.21	0.04
motif 3	1.00	0.00	0.00	1.00	1.91	1.48	--	1.00	2.43
p	0.34	1.00	1.00	0.34	0.08	0.17		0.34	0.03

TABLE 4 a

Analysis of the variance in the number of recognitions after correction for **motif 1**

Source of variation : effect related to category of subjects (musicians / non-musicians), 1 d.l.
error 19 d.l.

	F	p	$\bar{x}$ musicians	$\bar{x}$ non-music.
Correct recognitions	6.94	0.016	28.78	20.75
WA	0.01	0.949 ns	10.22	10.25
A	15.35	0.0009	10.22	4.58
WAv	1.20	0.288 ns	5.44	4.33
Av	2.88	0.106 ns	2.89	1.58
False alarms	2.77	0.112 ns	11.67	5.00
other motifs	0.139	0.713 ns	2.11	1.58
VE	0.02	0.901 ns	0.44	0.50
VEv (*)	----	-----	0.00	0.00
RI	0.74	0.400 ns	0.00	0.17
R	0.57	0.461 ns	1.67	0.92
miscellaneous	4.69	0.043	9.56	3.42

(*) non-calculable, the dependent variable is constant for each category of subjects.

TABLE 4 b

Analysis of the variance in the number of recognitions after correction for **motif 2**

Source of variation : effect related to category of subjects (musicians / non-musicians). 1 d.l.
error 19 d.l.

	F	p	$\bar{x}$ musicians	$\bar{x}$ non-music.
Correct recognitions	5.23	0.034	16.67	12.33
VE	5.19	0.034 ns	15.56	11.75
VEv	1.97	0.176 ns	1.11	0.58
False alarms	0.12	0.730 ns	12.11	10.75
other motifs	3.01	0.099	2.00	4.58
WA	6.51	0.019	0.00	1.33
A	4.37	0.050	0.00	1.42
WAv	0.65	0.432 ns	1.22	0.75
Av	0.37	0.552 ns	0.11	0.25
RI	0.41	0.530 ns	0.67	0.42
R	1.90	0.184 ns	0.00	0.42
miscellaneous	1.71	0.208 ns	10.11	6.17

TABLE 4 C

Analysis of the variance in the number of recognitions after correction for **motif 3**

Source of variation : effect related to category of subjects (musicians / non-musicians). 1 d.l.
error 19 d.l.

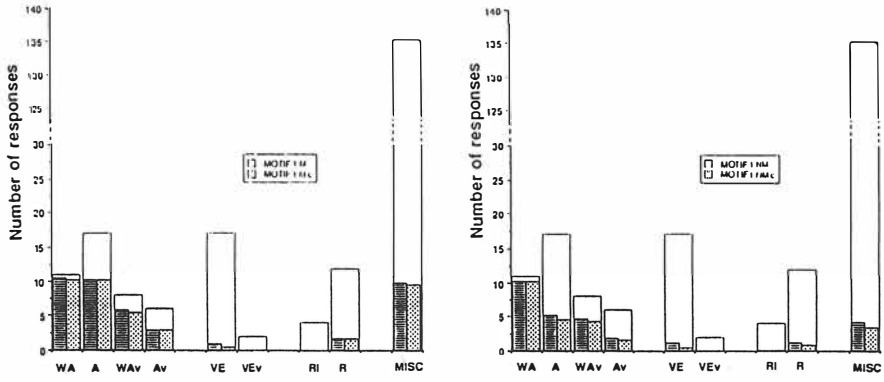
	F	p	$\bar{x}$ musicians	$\bar{x}$ non-music.
Correct recognitions	0.15	0.707 ns	12.22	12.67
RI	----	---	4.00	4.00
R	0.15	0.707 ns	8.22	8.67
False alarms	0.17	0.686 ns	37.33	42.75
other motifs	0.34	0.570 ns	20.33	17.42
WA	0.06	0.809 ns	2.89	2.58
A	0.14	0.717 ns	7.00	6.17
WAv	0.003	0.956ns	0.78	0.75
Av	0.13	0.728 ns	2.67	2.42
VE	0.82	0.377 ns	6.33	4.92
VEv	0.04	0.843 ns	0.67	0.58
miscellaneous	0.83	0.373 ns	17.00	25.33

another motif is being played. For this reason, Tables 2a, b and c make the distinction between false alarms localized in miscellaneous segments and those induced by the hearing of another motif. This latter category appears in the tables under the heading "other motifs": i.e., the overall mean of false alarms due to the hearing of another motif, with each type of presentation then considered separately.

The behaviour of the musicians and non-musicians is very comparable here: the breakdown of the false alarms is similar, irrespective of musical training. The sole element of any significance is the motif to be recognized itself: it is in the recognition of motif 3 *(Riesen-Motiv)* that the greatest number of errors between motifs and false alarms may be observed.

2.2. Responses registered after correction.

The musicians show a lesser tendency to correct a given response than the non-musicians (cf. Figures 5: a1 a2, b1 b2, c1c2). The mean differences before and after correction for both musicians {(t (8)} and non-musicians {t (11)} are detailed in Table 3. The significant differences appear negligible. Nevertheless, as a precaution, the variance was analyzed: 1. to compare mean results for both categories of subjects after correction of responses; and 2. to evaluate its effect on the results of spontaneous recognition presented in Tables 2a, b and c. A comparison between Tables 2 and 4 demonstrates that this procedure has not affected the results in any substantial way, although some subjects did eliminate correct responses at times.



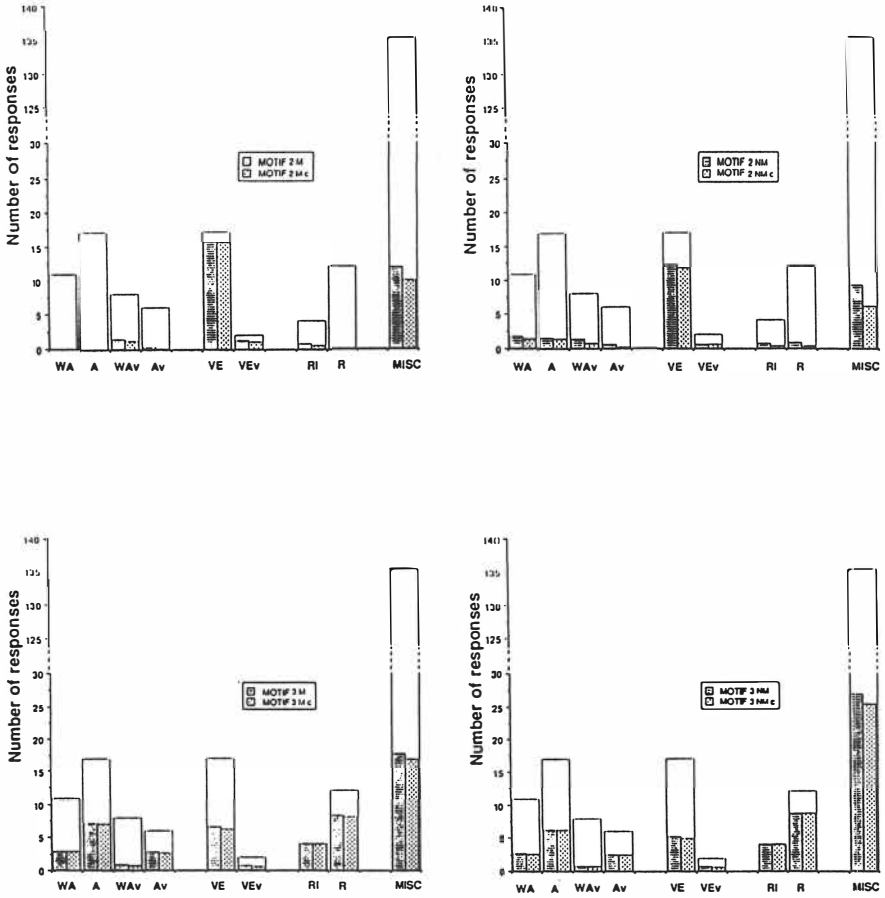


Figure 5: Comparison beween the average number of responses registered before and after correction for each of the target motifs.
a1. The various fragments of the WALHALL-MOTIV (target motif 1) in the musician category;
a2. idem, in the non-musician category;
b1. The various fragments of the VERTRAGS-MOTIV (target motif 2) in the musician category;
b2. idem, in the non-musician category;
c1 The various fragments of the RIESEN-MOTIV (target motif 3) in the musician category;
c2 idem, in the non-musician category.

3. ANALYSIS OF THE VARIANCE OF THE RECOGNITION RATE

Figure 6 presents the recognition rates (before and after correction), defined as the ratio of the number of times the motif was recognized correctly (before and after correction respectively) to the total number of times the same motif appears, regardless of its form of presentation. Also provided is the error rate (before and after correction) in terms of the corresponding motif to be recognized, defined as the ratio of the number of false alarms registered to the total number of appearances of miscellaneous segments and a motif other than the one to be recognized.

Table 5 shows the evaluation of recognition rates before and after correction respectively (the dependent variable) in relation to the two independent variables (the two categories of subjects and the three motifs) and the evaluation of the error rate here considered as covariable. The covariable (the rate of false alarms) is clearly significant. Its positive regression coefficient shows that an increase in the rate of false alarms is accompanied by an increase in the rate of correct recognitions. However, the introduction of this variable does not eliminate the significant effect of the category of subjects nor the motifs to be recognized, which consolidates the results of previous analyses.

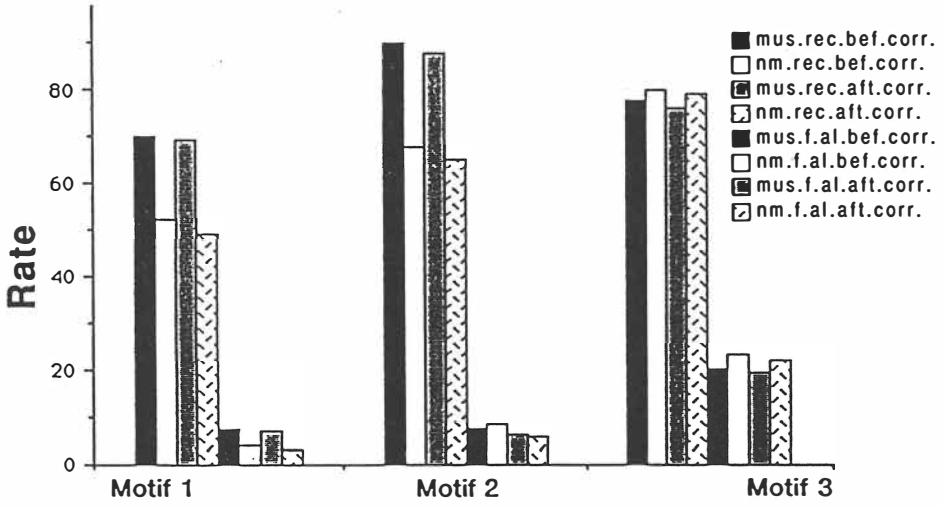


Figure 6: Recognition rates and false alarm rates before and after correction.

TABLE 5

Analysis of recognition rate (before and after correction) in relation to the category of subjects (musicians vs non-musicians), the 3 motifs and a covariable : the rate of false alarms (before and after correction).

Sources of variation	d.l.	F	p		musicians' rate		non-musicians' rate	
					Rec.	F. al	Rec.	F. al.
Before correction								
- Effect linked to covariable : rate of false alarms	1	20.14	<0.001					
- Effect related to category of subjects	1	8.46	0.005					
- Effect related to motifs	2	4.58	0.014	motif 1	70.11	7.35	52.18	3.98
				motif 2	90.06	7.60	68.43	8.29
				motif 3	77.78	19.95	79.69	22.83
- Cat.subj./motifs Interaction	2	2.22	0.118 ns					
- Error	56							
- Regression Coefficient of rate of false alarms : 0.79								
After correction								
- Effet linked to covariable : rate of false alarms	1	25.20	<0.001					
- Effect related to category of subjects	1	8.42	0.005					
- Effect related to motifs	2	4.80	0.012	motif 1	68.52	6.86	49.41	2.94
				motif 2	87.72	6.27	64.91	5.57
				motif 3	76.39	19.05	79.17	21.81
- Cat.subj./motifs Interaction	2	2.41	0.099 ns					
- Error	56							
- Regression Coefficient of rate of false alarms : 0.90								

Comments

False alarms: some possible explanations

GENERAL REMARK. Subjects sometimes continued pressing the response key for several seconds after the recognized motif had ended. This

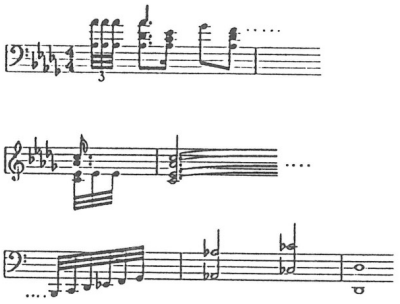
was true both for the musicians and non-musicians and accounts for some of the responses included with the "miscellaneous" segments and "other motifs" in the breakdown of responses used here. It is to be noted that when different *leitmotivs* follow each other in the sequence, this may give rise to what has been called "interference between motifs". However, this occurred infrequently and does not invalidate the results.

PARTICULAR REMARK. A greater tendency to making false alarms was observed in subjects called on to recognize the *Riesen-motiv* (target motif 3 RI, R). Independently of what will be discussed below concerning the rhythmic impact of the cues extracted for this motif, an element related to its place in the experimental sequence must be mentioned. While the three target motifs were to be recognized in the same twenty-five minute sequence, they do not appear at an equal distance from the beginning. The *Walhall-motiv* (target motif 1, WA, A, WAv, Av) is synchronous with the beginning; the *Vertrags-motiv* (target motif 2, VE, VEv) is heard some two minutes from the start; and the *Riesen-motiv* (target motif 3, RI, R) appears after an approximate seven minute wait. It is conceivable that the subjects may have felt a certain impatience; the fact of not having perceived the motif for this rather appreciable length of time and the fear of forgetting it may have caused erroneous recognitions.

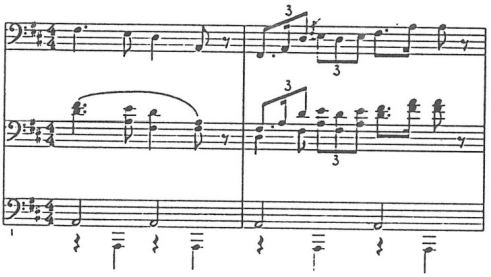
INTERFERENCES BETWEEN MOTIFS OR BETWEEN CUES? Our objective here was to ascertain if an affinity between certain musical structures of motifs could lead to false alarms, in particular the presence of the *dotted quaver/semiquaver* rhythm referred to in the hypotheses.

In fact, this rhythm did elicit erroneous recognitions for target motif 3 *(Riesen-motiv)* in particular: where they occur, though, the rhythm is generally preceded by a group of rapid sounds in the form of an appoggiatura as is the case in example 4 below. Thus, one may not speak of interference between motifs but only - and this is consistent with the mechanisms investigated - *interferences produced by particular cues.* The one just mentioned is above all an accented rhythmic group, but cues specific to the melodic contour, the presence of standard intervals and the effects of dynamic and instrumental similarity have also caused erroneous recognitions. A perfect example of this is the affinity between the melodic contour and intervals of the *Walhall-motiv* and the *Ring-motiv,* considered above (cf. examples 1a et 1b) as a variation of the motif to be recognized (cf. WAv). This situation was highly predictable and particularly clear-cut but the cue remains operative even when the elements are less obviously similar.

Suffice it to mention that the *Jugend-motiv* (example 5) was erroneously recognized as the *Walhall-motiv* by four musicians (one-quarter of the sampling): this is perhaps due to the similarity of the melodic contour in the two *leitmotivs.*



example 4



example 5

RESPONSES BEFORE AND AFTER CORRECTIONS. This distinction did not produce any particular information, other than the fact that subjects do not correct their answers only in the event of an obvious false alarm (i. e. the absence of the target motif). A slight drop in correct recognitions was registered following "erasing": the subjects - both the musicians and non-musicians - cancelled out a number of correct recognitions. The effect of the signal given by the cue is thus once again noticeable in the fact that the first auditory impression creates a steady and direct impact. As noted by Tiberghien and Lecocq apropos of recognition, one obtains "an obvious automaticity usually accompanied by a heightened feeling of subjective certainty" (1983, p. 16).

Conclusion

It would be most fruitful to evaluate the interest of this study in terms of the central theme of the work presented in the introduction. The focal point of the experiment is the effect of auditory qualities and the arrangement of the structures on the extraction of cues leading to the memorization and recognition of musical patterns. Drawing up an exhaustive table of all possible effects is obviously an unrealizable goal given the multiplicity of conceivable arrangements of musical structures. However, the specific qualities of the experimental material selected do invite comments of a general nature.

1. EFFECT OF "HEAD" STRUCTURES AS CUES

A decided effect of motif "head" structures was noted. This result may be compared to observations made in regards to the memorization of words by Horowitz et al. (1968). These authors also observed the true significance of initial letters as opposed to those in the mid- or final position in regard to the accuracy and speed of subjects' responses. However, given that the observations in this study are particular to musical material, certain differences may be introduced. Here, the more immediate effect of motif "head" structures is in fact clearer in the case of the non-musicians than musicians. Is it not possible, then, to conceive of a relationship between the more limited scope of the mental schema of the musical work in the non-musician (I. Deliège: in the press) and the fact that they catch more readily onto more pointed and shorter structures and a more immediate effect when listening for cues?

2. THE ACCENT IN CUE PERCEPTION AND RECOGNITION : EFFECT OF LOCAL FEATURES VS GLOBAL CHARACTERISTICS

The presence of accents which are often more distinct in the initial structures of motifs may be related to the positive effect of "head" structures on musical perception. The decisive role accents play in the formation of rhythm groups as well as their effect on memory has been observed repeatedly in the writings of theoreticians beginning with Gestalt and in experimental research (cf. in particular Teplov, 1966, p. 336; Francès, 1958, p. 150; Deutsch 1978, p. 206; 1980; 1982 a; 1982 b; Fraisse, 1982; Povel & Okkerman, 1981; I. Deliège, 1987). Having examined the results of the

recognitions of *leitmotivs* in Wagner's music, we are now able to add a further element: *a relationship between the time necessary for the memorization of the information and the more or less clear discrimination of an accent.* Indeed, the memorization of musical structures was slowed when this process was disturbed : the greater number of listenings requested for the *Vertrags-motiv* speaks for itself. An accent, regardless of its quality, is a local point of limited duration. It defines highly relevant sound contrasts which take shape and become fixed rapidly. If no accent is identified, however, additional "steps" are introduced before another type of cue is selected. The accented area along with the correct distribution of the rhythmic groups of a musical pattern would thus seem to be bearers of a striking cue marker, one which lends itself more immediately to the organization of a work's perceptual design. Furthermore, it is possible - in any event for the uninitiated ear - that memorization could be organized "by default" on the basis of global characteristics such as melodic contour. It is well known that psychological processes always seek out the easiest and shortest route. It is not outside the realm of possibility, then, to assume that global characteristics, more difficult of access, are selected during the listening process only insofar as more local aspects have not been identified. Consequently, characteristics of this type are acquired less readily. On the other hand - and this has often been noted in the preservation of the melodic contour of folk songs from one region to another (Sloboda, 1982) - once acquired, they tend to become part of long-term memory: witness the correct recognitions of the *Vertrags-motiv* compared to those of the other two motifs. However, the decoding of this type of characteristic could have a drawback: postponing the establishment of a design during the listening process.

For the layman, the access to cue characteristics would appear to operate more on the selection of concrete elements which are more apt to make a clear impression on the memory. Here, we would seem to be approaching strategies at work in the formation of concepts in spoken language: concepts such as "chair" or "carrot" for example, or the creation of a corresponding image; these are always more immediately accessible than abstract concepts such as "friendship" or "hatred", where the formation of any mental picture is dependent on metaphor (Paivio, 1963). The local features/global characteristics dichotomy would seem to be accompanied by a second dichotomy : concrete features/abstract features. In the context of a comparison between the performances of musicians and non-musicians,

this leads us to a conclusion which is slightly different from that arrived at by Pollard-Gott in his study on the formation of "thematic concepts" in listening to music (1983, p. 93). Therein, the author suggested that the cognitive task which underlies the memorization of musical structures was the same for all subjects: the results presented here seem to have brought a new element to bear on the subject.

Translated from the French by Douglas Craig

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