

Introduction

While several comprehensive theories of the perception of tonal music have been proposed in the last decade, and much experimental work has shed light on the nature of the perceptual processes that may be employed in listening to music, one of the most intractable problems for the psychology of music remains that of how to investigate the perception of complete pieces of tonal music. The structural idiosyncrasies of real pieces from the tonal repertoire are difficult to square with the requirements for rigorous control that experimental methods demand, while it is difficult to frame experimental procedures that provide information about listeners' perceptions without requiring listeners to make responses that might interfere with the perceptions that are the focus of the experimental enquiry.

A useful summary of recent experimental research in this area is found in Bigand (1993). Bigand's overview appears to indicate that both musically trained and musically untrained listeners are highly sensitive to the structural relations (largely in the harmonic domain) between the components of tonal musical works as they unfold in time, a conclusion that would imply that processes of enculturation and of formal musical training play a role in determining such sensitivities. However, a recent study conducted by the present authors (Deliège, Mélen, Stammers and Cross, 1994) indicated that the perceptions of musically expert and musically untrained listeners were quite sharply differentiated. While musically trained listeners indeed displayed considerable sensitivity to structural harmonic relations between components of a brief tonal musical work, the perceptions of untrained listeners appeared more closely bound to local features of the musical surface, tending to abstract salient features which were then employed as cues in subsequent hearings or in judgments based on memory for the work.

Deliège, Mélen, Stammers and Cross (1994) employed three different experimental procedures to elucidate listeners' cognitive representations of a single short musical work, Franz Schubert's *Valse sentimental*, D 779, Op. 50 No 6. The research reported here applies a further experimental procedure to perceptions of the same work and to another, similar piece, Josef Haydn's *Menuet* 8 (Hob IX; 12). The experimental procedure that was applied was intended to examine the representations in short-term memory that listeners formed of a complete, brief, tonal work, and also to examine the degree to which listeners could employ any schematic knowledge of tonal harmonic relations that they might possess in making judgments about the piece. Both pieces are short (sixteen bars), were unknown to any of the subjects who participated, and conform to what Ratner (1980), following Koch's treatise of 1793, suggests is one of the simplest tonal-musical forms (originating in the binary forms of dance music): a "two-phase action" comprising an eight-bar antecedent and an eight-bar consequent, each eight-bar section subdivided into two four-bar phrases functioning as antecedent and consequent.

Procedures and hypotheses

All experiments reported here employed the same generic procedures. Subjects first heard a short piece of tonal music (repeat marks not being observed) lasting about 30 seconds three times, with an intervening period of one minute between each playing. They then heard a sequence of trials composed of all possible orderings of pairs of segments of the piece. The segments were formed by dividing the piece into eight chunks of more-or-less equivalent durations, each chunk constituting a structural unit having a specific tonal function within the piece (a partitioning analogous to that which would be formed by the application of Lerdahl and Jackendoff's (1983) "grouping" and "time-span reduction" rules to the piece,

with the tonal function of each group being equated largely with that of the head of each time-span). Subjects were required to state whether the order in which the two segments occurred in each trial was the order in which the segments had occurred in the piece. To give an example, Schubert's sixteenbar *Walse* was divided into segments of roughly two-bars each; the correct answer to a trial consisting of segments one and five in that order would be "yes", whereas the correct answer to an ordered segment-pair such as four-two would be "no".

Two different subject populations were used (both groups had an average age of ca 22), one comprised of undergraduate students reading music at the University of Cambridge, and one of undergraduate students who had had no formal musical training and were reading psychology at the University of Liège.

Several initial hypotheses were formulated. It was felt that the degree to which the piece was represented in memory as a coherent whole was likely to be evident in a difference between responses to segment-pairs within which segments occurred in the correct order and those in respect of trials in which the segment-pair was incorrectly ordered (the former trial type being felt more likely to lead to higher levels of accurate performance). It was also felt that short-term memory constraints were likely to lead to higher levels of performance for segment-pairs containing either the first or last segment due to serial position (or prefix-suffix) effects. It was further proposed that the complexity of the relations between segments in a pair would affect subjects' performance, with pairs of segments that were simply related being more likely to evoke higher levels of performance than segment-pairs that were more complexly related.

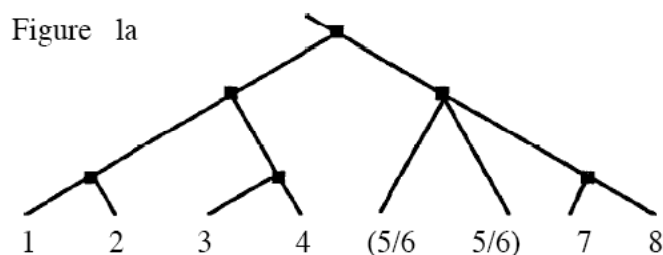


Figure 1a: Time-span reduction of Schubert's *Walse* depicting complexity of segment relatedness (segments 5 and 6 were identical and were not differentiated between in the analysis of experimental results or in the time-span reduction)

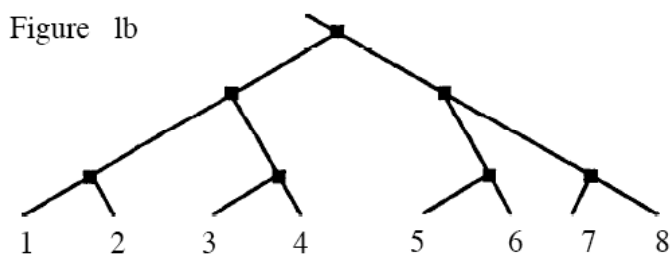


Figure 1b: Time-span reduction of Haydn's *Menuet* depicting complexity of segment relatedness

In order to arrive at an operational definition of the degree to which any two segments were related, diagrams depicting inter-segment relations within a tree-structure were constructed and the number of nodes (marked in Figures 1a and 1b as black squares) intervening between segments was used as a measure of segment-relatedness. These diagrams can be taken as corresponding to both time-span and prolongational reductions

(after Lerdahl and Jackendoff) as within these simple pieces both analytic domains coincide at the segment level.

So, for example, in Schubert's *Valse*, segment-pairs 1-2, 1-4 and 1-8 all have only one node intervening between their constituent segments, and are thus taken to exemplify (along with pairs 3-4, 5/6-8 and 7-8) the simplest type of relation between members of a segment-pair. Other segment-pairs in the *Valse* embody more complex types of segment relation, having either two (e.g., 2-4) three (e.g., 2-3) or four (e.g. 3-5/6) intervening nodes between their constituent segments.

Experiments on Schubert's Valse

The first experiment employed nine student musicians from Cambridge and ten student non-musicians from Liège and investigated perceptions of Schubert's *Valse*. The experimental procedure described above was employed, subjects first hearing the piece three times and then hearing all 42 possible segment-pairs.

Analyses indicated that musicians performed at a higher level than non-musicians, and that only musicians' responses showed a clear effect of order within segment-pair (responses to trials within which segments were presented in correct order being significantly more accurate than to those within which segments were in the incorrect order). This was taken to indicate that musicians were more likely to be able to represent the piece as a coherent whole in memory than could non-musicians. Musicians also performed significantly better when one of the segments in a segmentpair was the first of the piece, indicating the operation of a primacy or prefix effect deriving from memory constraints. A hint of a suffix effect was observed in the nonmusicians' results, but this was inconclusive.

Further analysis indicated a marginally significant effect of complexity of inter-segment relation in musicians' responses, with complexly-related pairs presented in the incorrect order evoking worse levels of performance than simply-related pairs also presented in the incorrect order. No clear effect of relatedness was found in musicians responses to pairs presented in the correct order (which may have been due to a ceiling effect), but neither was a clear effect of relatedness found in analysis of non-musicians' responses to either correctly or incorrectly ordered segment-pairs. Hence it appeared that musicians were either sensitive to tonal-harmonic relations in the course of listening to short pieces of tonal music or had access to schematic information about tonal relations that they employed in the course of making post-listening order judgment, and that nonmusicians were either insensitive to tonal-harmonic relations in listening or had little access to any schematic knowledge of such relations that they might possess in making post-listening judgments.

To clarify these results (which accorded with our previous findings but seemed to conflict with those reported by Bigand), a further experiment was performed that used a variant of the *Valse* in which a recurring upbeat figure in the original was excised so as to delineate segments more explicitly in the initial hearings of the piece. Nine musicians and eleven non-musicians acted as subjects (none having participated in the first experiment).

Results indicated that, puzzlingly, there was now no overall effect of segment-pair ordering for either musicians or non-musicians; however, both subject groups now exhibited prefix effects (performing better when one of the segments of a pair was the first of the piece). Moreover, analyses of the effects of segment relatedness indicated that musicians' and non-musicians' results now showed marginally significant effects of complexity of relations between segments in a pair. Musicians exhibited a sensitivity to this factor (as before) for trials in which segments were presented in incorrect order, with responses deteriorating

with increasing inter-segment complexity only when segments were incorrectly ordered within pairs. Non-musicians now showed a sensitivity to degree of relatedness but only for trials in which segments were presented in the correct order, responses decreasing in accuracy as complexity of segment relatedness increased only when segments were in correct order.

It can be hypothesised that this difference in sensitivity to tonal structure reflects the relative difficulty of the task for musicians and for non-musicians. While musicians' responses are in the order of 90% correct, those of non-musicians are around 60%; musicians evidently find the task quite easy, while non-musicians have considerable difficulty. Thus, assessment of whether a segment-pair is in the correct order might require non-musicians to draw on all possible cognitive resources and different types of information that might be retrievable, while musicians may be required to "stretch themselves" and to make use of information about the piece's tonal structure only when more easily accessible sources of information fail to provide an immediate answer, as when the order of segments in a segment-pair does not coincide with the order embodied in the time-course of the piece.

Experiments on Haydn's Menuet

In an attempt to clarify these results a further experiment was carried out using Haydn's *Menuet 8* (Hob IX; 12). This piece was chosen as, unlike the *Valse*, none of its constituent sections were repeated. It was felt that the repetition of segment 5 as segment 6 in the *Valse* might have contributed to uncertainty about the order and the tonal function of segments in the piece; moreover, the non-repeating nature of the Haydn *Menuet* also enabled more segment-pairs that were complexly related to be presented than was the case for the *Valse* (e.g., five segment-pairs -2-5, 3-5, 3-7, 3-6 and 4-5- now being related by four or more nodes).

Nine musician and sixteen non-musician subjects took part in this experiment (none having participated in the earlier studies). Experimental procedure was as described above, with the difference that the lack of repetition in the Haydn resulted in 56 (rather than 42) trials of differently-ordered segment-pairs.

The results indicated a significant effect of order of presentation of segments within pairs only for musicians, which was attributable to a ceiling effect when pairs were presented with segments in the correct order. There was a significant effect of the inclusion of segment one in trials for musicians, and a highly significant effect of this factor on non-musicians' responses; in other words, both subject groups' responses clearly showed prefix or primacy effects. There was a significant effect of degree of relatedness (performance decreasing as complexity of relation increased) for musicians only when segments were incorrectly ordered within a pair; for non-musicians, there was an effect of degree of relatedness when segments were in both correct and incorrect orders within pairs, but trend tests showed that this was significant only when segments were correctly ordered within pairs.

Conclusions

The results of the last experiment appear to concur with the earlier findings by Bigand and others that even musically untrained subjects appear to be sensitive to tonalharmonic relations in musical listening. In other words development of schematic knowledge of tonal-harmonic relations does not appear to be solely dependent upon formal musical training, but may arise through processes of enculturation. However, if the results of all the present experiments are considered, there is a specific and consistent difference between the patterns of responses and of musicians and nonmusicians; while musicians' responses

exhibit a sensitivity to tonal structure when segment in a pair are presented in an order that is different to their order within the piece, non-musicians exhibit a similar sensitivity when segments of a pair occur in the same order as in the piece. It appears that both musicians and non-musicians have access to similar types of schematic information about tonal structure but employ this information in different situations, and at different levels of performance. However, the nature of the access enjoyed by both musicians and non-musicians is debatable. Non-musicians certainly appear to have little or no conscious access to this information; the experiments reported in Deliège, Mélen, Stammers and Cross, 1994 that required non-musicians to construct pieces or report on the order of events within pieces evoked verbal responses such as "well, it just doesn't sound good...". Even for musicians access to this information is neither automatic nor certain, as witness the decrease in performance with increasing complexity of segment interrelation when segments are incorrectly ordered within a pair.

It might be that these results can be best explained by taking account of the primacy effect that is present for both musicians and non-musicians in several of these experiments. This could be taken as indicating that both non-musicians and musicians make use of information about the piece at the level of a more-or-less uninterpreted trace in immediate memory - that is, about characteristics of the musical surface and the order of events of that surface - as well as at the level of more abstract structural relations. It could be that the results obtained here emerge from the use of multiple types of representation, with changing levels of task difficulty leading to the use of whichever type of representation best facilitates the retrieval of the information required. Such a multi-levelled approach to listening would be unsurprising; after all, the drawback of employing "real" pieces of music in examining perceptions of music unfolding in time is that in general their composers have tried to do something more than articulate the unfolding in time of a simple tonal-harmonic scheme. Real pieces tend to embody the multi-faceted notions of their creators rather than merely to exemplify categories of functional tonal structures; to employ them as though they constituted only the latter is probably necessary in experiment, but it is scarcely why they should be considered as pieces of music in the first place.

References

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