NOTE

SHifting EAR DIFFERENCES IN MELODY COMPARISON THROUGH TRANSPOSITION

Isabelle Peretz

(Université Libre de Bruxelles, Université de Montréal)

Theories of melody processing have attempted to characterize the types of features that are selectively encoded in memory in order to allow reliable recognition. Over the last decade, a substantial body of research has demonstrated the importance of two kinds of features: the pitch of individual notes or the specific interval size between two adjacent notes and the contour, which characterises pitch directions independently of the precise pitch values (for reviews see Pick, 1979; Dowling, 1982). The use of these two types of features, that can be described as local and global, depends on whether or not transposition occurs. Transposition consists of shifting a melody to a new starting pitch while holding constant the relative interval sizes and the contour. When melodies are novel and transposed, contour information is used as a means of recognizing melodies of up to 9 notes in length (see Edworthy, 1985, in particular, who systematically studied these aspects). In contrast, when the need for establishing the key of a melody is minimal, by presenting the melodies to be compared in the same key, then the information about specific pitches is immediately available and can be encoded precisely. In such cases, contour effects are negligible.

The documented differential use of local and global properties in melodies according to whether or not transposition is introduced was the motivation for the present study, since it was particularly attractive from a neuropsychological perspective. There is indeed a widely held view, although a controversial one (see the open peer commentaries in Bradshaw and Nettleton, 1981), that the left cerebral hemisphere is better equipped for processing local features while the right hemisphere for processing global features. This notion has met supportive evidence in normal subjects through the study of ear-asymmetries, particularly in the field of melody perception. Right-ear advantages (REAs) are elicited when listeners are induced to pay special attention to melody local elements, while left-ear advantages (LEAs) generally emerge when there is no such requirement. These findings were obtained with both musicians (Bever and Chiarello, 1974) and nonmusicians (Gates and Bradshaw, 1977; Peretz and Morais, 1980; Peretz, Morais and Bertelson, 1987). As this latter group of subjects is less prone to label musical events, and thus not result in a verbal left-hemisphere intervention, nonmusicians are better suited for studying the direction of ear-asymmetries in terms of a local-global distinction. As this was the aim of the present study, only nonmusicians were considered.

They are presented here with an adapted form of the “same-different” classification task used mostly in the cognitive literature mentioned above. The adaptation consisted in using a dichotic mode of presentation in order to facilitate laterality effects. On each trial, the melodies to be compared were delivered to one ear, with the comparison melody being simultaneously presented with a contralateral “melodic distractor” that had to be ignored. The task of the subjects was to judge whether or not the comparison melody differed from the target melody. There were two versions of the same set of melodies. One was made of untransposed melodies, that is the two melodies to be compared always started at the same pitch level, while in the transposed version, the two melodies were presented at a different pitch level. The “different” comparisons were always made of melodies differing by their contour in order to allow reliable comparison through transposition. All subjects performed the task on both versions, but in a different order.

Subjects were further instructed to respond as fast as possible. This instruction was added in order to ensure that nonmusicians pay attention to the local melody features, in particular with the untransposed version where the global contour was also available for discrimination. Time pressure was indeed found to be effective in inducing nonmusicians to search for local discrepancies in the comparison melody (Peretz and Morais, 1987). Therefore, under such constraints, a REA was expected for the untransported material whereas a LEA was predicted for the transposed one, since transposition hinders access to melody specific pitches but promotes the use of melody contour as a discriminant cue.

Materials and Method

Subjects

Subjects were selected among the undergraduate students who had never received any musical training and who did not have any hearing disorder in either ear in a preliminary audiometry test. Sixteen of them, 6 females and 10 males, whose ages ranged from 18 to 25, participated in the experiment. They were all strongly right-handed as assessed by handedness questionnaire, which was a French adaptation of Oldfield’s (1969) questionnaire.

Material

Several constraints were placed on 12 initial melodies that were generated so to make them close to actual ones. They were tonal in that they started and ended on the tonic, and included only notes from the diatonic scales. The melodies contained 9 notes, each lasting about 175 msec. except for the last note that lasted twice as long, and were played on a recently tuned piano. Two types of manipulation were applied to each of these 12 initial melodies. One manipulation consisted of transposing each initial melody to a near key, either by raising each pitch by a perfect fifth (as in Figure 1) or by diminishing each pitch by a fourth. These distances were chosen given their most frequent use since Gregorian song and Middle-Age polyphony. The other manipulation consisted of creating a contour-violated alternate melody of each initial melody by inverting it (i.e. each
ascending interval was replaced by a descending one taken from the same scale, and vice-versa). Thus, the initial and contour-violated melody pairs started and ended on the same pitch. Four of the contour-violated melodies were then randomly selected and served for creating a “melodic distractor” by recording them in superposition so that none was distinguishable.

Two sets of 2 practice trials and 48 experimental trials were constructed with these stimuli. Each trial consisted of a warning signal and a target melody. Then, after a silent interval, a comparison melody followed, all recorded on track 1. On track 2 the “melodic distractor” was recorded in synchrony with the comparison melody. The stimulus onset asynchrony (the time interval between the onsets of the target melody and the comparison one) was 4.2 sec. long, while duration of a trial was 13 sec. long. The first 24 trials of the first set of the untransposed version, was constructed so that half were made of identical melodies (i.e. exact replication of a target melody) and half of different melodies (a target and its contour-violated alternate) in random order. This series was then copied in a different order. The second set of 2 practice and 48 experimental trials, the transposed version, was constructed by copying the entire untransposed version, in a different order and by replacing each target melody with its transposition transformation. Therefore, on each trial of this latter set, the target melody was always higher or lower in pitch level than the comparison melody; the comparison melody, which was the same as the one used in the untransposed version, elicited the response.

The stimuli were recorded on a Revox A77 stereophonic tape recorder and delivered over Beyer Dynamic DT 480 headphones by the same apparatus. An advance TC 12 electronic timer was connected to a voice key, which was fed by the output of track 2. It measured the time from the onset of the comparison melody to response.
Procedure

Half the subjects were first presented with the untransposed version and then the transposed version in one session of 45 minutes, while the other half were presented these two versions in the reverse order. On each trial of both materials, subjects were instructed to judge as rapidly and accurately as possible whether the two successive melodies, presented to the ear previously indicated to them, were “same” or “different”, and to ignore the contralateral distractor. For the transposed version, they were further instructed to disregard the fact that the melodies were played at different pitch levels, as if they were to judge whether a melody sung by a man was the same or not to a following melody sung by a woman. After an error, the subjects were informed but they did not receive feedback regarding their speed.

Headphones were reversed every 12 trials. In each group defined by a particular order of version presentation, half the subjects started with track 1 in the left ear while the other half had the opposite ear-track order. Half of them answered by moving a two-way switch away from themselves if the melodies were different and towards themselves if they were identical; the other half answered in the reverse direction. Response hand was changed every 24 trials and starting hand was counterbalanced in each group defined by ear-track order and response direction. All subjects retained the same combination with both materials.

Results

The mean percentage of correct responses obtained for each ear and averaged over the two ears according to the version presented are summarized in Table I. No ear-asymmetry emerged on these accuracy measures in either conditions (1). With the untransposed version, the absence of ear differences is probably due to a ceiling effects, since performance was almost perfect (in fact, 6 out of 16 subjects obtained a perfect score). In contrast, there was a large decrement in performance on the transposed material (t15 = 6.2; p < .001). Hence, the level of performance (of 82.4% correct responses) obtained with the transposed version theoretically allows ear-asymmetries to emerge. Thus, the absence of ear-asymmetry observed in that condition may reflect a true lack of asymmetry (as it was indeed the case for 11 out of 16 subjects).

The response times, which are presented in the same Table I, were more revealing than accuracy measures. The response times were only computed for the correct responses. It will be noted that decisions were made well before melody offset (mean melody duration was about 2100 msec) when melodies were untransposed, whereas they were produced close to their offset when melodies were presented at different pitch level. The contrast in response speed between these two conditions was highly significant (t15 = 5.67; p < .001).

In order to examine ear differences on these time measures, a laterality score

\[ 1 \] Analyses of variance were performed on these individual correct responses, and on all time measures as well, including Sex and Version order as between-subject factors, Version, Response type and Ear as within-subject factors. As these analyses did not yield any other effect than those presented in the text, for the sake of clarity they were omitted from the presentation of the results.
was computed to titrate out the effect of noise introduced by small variations in melody length. As each comparison melody was presented twice, once to each ear, the time differences between left and right ear presentations were computed for each pair of trials and averaged for each subject. Thus, a positive score represents here a right ear advantage, a negative score a left ear advantage. The mean scores can be seen in Table I. Subjects were found to respond quicker when untransposed melodies were presented to their right ear (t15 = 1.78; p < .05, one-tailed), whereas they tended to respond quicker when transposed melodies were presented to their left ear (t15 = 0.65). This shift in laterality was significant (t15 = 2.07; p < .05, one-tailed). These laterality scores were not found to correlate significantly with the time taken to respond, in either condition.

**DISCUSSION**

The purpose of the present study was to examine if the laterality pattern exhibited by nonmusicians in the comparison of melodies can be affected by treatments designed to either promote or hinder extraction of local features. The underlying assumptions are that the left hemisphere is better equipped for dealing with local melody features and the right hemisphere for arriving at global melody representations.

The treatments designed here to induce subjects to search for melody local features consisted of instructing them to compare two melodies presented at the same pitch level as quickly as possible. A RÉA in time measures was obtained. This was associated with decision times, averaged over both ears, which were produced well before melody offset. This latter indication gives support to the notion that with untransposed melodies subjects were using a process of analytic search independently of ear-asymmetries. They appear indeed to have stopped their search as soon as they accumulated sufficient local evidence for deciding if melodies were "same" or "different", thus indicating the use of a self-terminating analytic search (Bamber, 1966; Egeth, 1969).

These findings are highly consistent with the conclusion found in the cognitive literature that with melodies presented in the same key, information about specific pitches is immediately encoded and in a precise manner (Dowling, 1982; Edworthy, 1985). Furthermore, they replicate previous data (Peretz and Morais, 1987), thus providing more empirical support to the notion that the left hemisphere is endowed with a mechanism that allows extraction of local melody features.
The treatment applied here to induce consideration of the whole melody consisted of transposing one of the two melodies to be compared. A nonsignificant tendency in favour of the left ear was observed in time measures, along with decision times matching roughly melody duration. This outcome contrasted significantly with the results obtained with the same material which was not transposed. Transposition was found to be instrumental both in cancelling out the REA observed in its absence and in slowing down the decision times drastically.

This pattern of results is consistent with the hypothesis that the right hemisphere would be more involved in processing the global melodic pattern, but is not self-sufficient. It cannot be ascertained solely on the basis of the responses that subjects relied more often on melody contour than local melody features. However, the cognitive literature abounds with evidence that in similar melodic contexts, i.e. novel transposed melodies in a “same-different” classification task, subjects rely essentially on melodic contour. The rationale is that subjects encounter difficulty in establishing a new key so rapidly, and therefore, in extracting specific pitch invariance. There is no particular reason to suspect that subjects did otherwise here, except that they might have searched more actively for local evidence given the addition of time pressure in the present study. This in turn can explain the ineffectiveness of transposition in eliciting a clear LEA. However, as this study is the first one to examine the role of transposition in a neuropsychological perspective, no firm conclusion can be drawn on this particular issue. Nevertheless, the present findings do support the idea that material characteristics themselves provide some bounds on the possibility to promote melody analysis by the left hemisphere.

**ABSTRACT**

Nonmusicians were required to classify pairs of melodies as “same” or “different”. When they were instructed to compare melodies played at the same pitch level as fast as possible, a REA was elicited. In contrast, a tendency in favor of the left ear came out when, all other things being equal, melodies were transposed, i.e. played at a different pitch level. Transposition was thus instrumental in leading subjects to rely more on right-hemisphere processing. Independent evidence for a change in the processing mode that was adopted with these two types of material was provided by the response times. The results indicated the use of a self-terminating process of analytic search only with the untransposed melodies. Results are discussed in terms of the notion that the preferential use of local or global properties in melodies determines the intervention of the left or the right cerebral hemisphere, respectively.

*Acknowledgements.* The present study has been supported by the Belgian Fonds de la Recherche Collective under convention 2.4505.80. The author was supported by the Belgian Fonds de la Recherche Scientifique at the time the work was carried out. She wishes to thank José Morais for his invaluable comments and Jack Ryalls for editorial assistance.
REFERENCES


PERETZ, I., and MORAIS, J. Analytic processing in the classification of melodies as same or different. *Neuropsychologia*. 1987 (in press.)


Isabelle Peretz, Centre de Recherche, Centre hospitalier Côte-des-Neiges, 4565, chemin de la Reine-Marie, Montréal (Québec), H3W 1W5 Canada.