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SHORT PAPER

Context effects on melody recognition: A dynamic interpretation

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Abstract

The aim of the present study was to investigate how context effects, previously observed in a perceptual task (Bigand, 1993, in press), influence melody recognition. Three factors were manipulated: key context, rhythm context, and musical expertise. The key context effect was achieved by making a few small changes in the pitches of the melodies, and the rhythmic context effect was achieved either by shifting the rhythmic structure or altering the duration of the tones. Participants were asked to evaluate the percentage of tones that had been changed from a standard to a comparison melody. The data support the dynamic theory of attention developed by Jones, (1976), Jones and Boltz (1989), and Jones and Yee (1993). The perception and memorization of melodies are dynamic, context-specific activities: irrespective of musical expertise, varying the strength of tonal and rhythmic accents in a melody affects the way listeners' attention is guided through time, which in turn alters the overall *dynamic shape* of the melody and renders its recognition difficult.

Key words: Dynamic attention, context effects, musica expertise.

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INTRODUCTION

A melody is a temporal arrangement of pitches which can be represented in memory by several features related to the pitch and the rhythmic structures. Three kinds of features in the pitch structure have been shown to govern melody recognition (Dowling, 1986, 1994; Dowling & Harwood, 1986, for a review): the melodic contour of the melody, (i.e., the rise and fall in pitch created by successive tones), the interval size between melodic tones (i.e., the number of semitones between two tones), and the scale degree of the tones in the melody's underlying key. Compared to the first two features, the third is a more abstract and relies on knowledge of the organization of the tonal system of the West. In this musical system, tones are organized into sets of seven tones which define a major or minor key. A tone may have a different scale step value depending upon the *key context* of the melody in which it appears. For example, the C is the first scale degree in the key context of C major, but is the fifth scale degree in the key context of F major, and the second scale degree in the key of B flat, and so on. Scale degrees are of psychological importance because they partially determine the melodic function of the tones (Meyer, 1956). Indeed, it has been shown that the tones of the first, third, and fifth and scale degrees act in major key contexts as cognitive reference points (of increasing stability, respectively) to which the other (more unstable) tones are anchored (Francès, 1958; Bharucha, 1984; Krumhansl, 1990; Bigand, 1993). Changing the key context surrounding a tune provokes several changes in the scale degree of the melodic tones, completely modifying their melodic function. As reported by Dowling (1986), such a change in key context renders the recognition of short 6-tone melodies difficult. One of the goals of the present study was to extend this key context effect to much longer melodies.

In addition to pitch structure, most melodies display a rhythmic organization. Rhythm refers to three components (Handel, 1989): tempo (i.e., the rate at which the events appear in time), duration pattern (i.e., quarter notes, eighth notes, and so on), and meter (the feeling of a regular succession of strong beats on which we tap our feet). Changing the rhythm of melodies greatly lowers their recognition rate (Dowling, 1973; Jones, Boltz, & Kidd, 1982; Deutsch, 1980), even when the melodies are very famous (Bigand, 1990, Exp. 4). One interpretation of this rhythm effect on melody recognition is that rhythm contributes to segmenting the melody into small chunks, which determines the storage of melodic information in memory (Bower & Wizenz, 1969; Deutsch, 1980). Changing the rhythm modifies the chunks into which the tune is segmented, and then modifies the way melodic information is located in memory (Dowling, 1973).

For a long time, pitch and rhythmic structures were investigated separately in music cognition. Because of this, the way in which melodic and rhythmic features interact in melody recognition has not been studied in depth. The theory of dynamic attention developed by Jones (1976, 1987) and her collaborators (Jones & Boltz, 1989, 1991a & b; Jones, Summerell, & Marshburn, 1987; Jones & Yee, 1993; Jones & Ralston, 1991) provided an elegant framework for studying this topic. According to this author, the perception and the remembering of a musical sequence are dynamic, context-specific activities that are related to attention. Pitch structure and rhythm display several kinds of melodic accents whose common function is to capture listeners' attention during the unfolding of the melody. Jones (1987) distinguished three kinds of accents in the pitch structure. "Melodic contour accents" are defined by any change in the melodic contour, "melodic pitch interval accents" by large skips in pitch, and "tonal melodic accents" (also called "harmonic accents") by the most stable tones in the melody's underlying key. Rhythm displays other temporal accents, such as long durations or silences and metrical accents (Jones & Boltz, 1989). The way these accents are phased creates a unified accent structure (called joint accent structure) which dynamically orients the listeners' attention as the melody unfolds. The *dynamic shape* of a musical sequence refers to the dynamic attentional trajectories developed by the individual as he/she listens to a piece.

According to Jones (1987), the way attention is guided during music listening is an essential determinant of melody recognition. Indeed, melody recognition depends "on what initially captures a listener's attention and on how these relations are reinstated later during some recognition test" (p. 626). From this point of view, changing the rhythm of a tune renders its recognition difficult since it modifies the way the melodic and rhythmic accents are coupled in time, and thus, the dynamic attending activity developed throughout the listening process. As shown by several experiments, melody recognition decreases when changes in either the pitch structure or the rhythm of an original melody cause changes in the joint accent structure, but not when similar changes preserve the dynamic shape of the melody (Jones, Summerell, & Marshburn, 1987; Jones & Ralston, 1991). These findings provide evidence that melodic information is not represented in memory by isolated static features (such as melodic contour, pitch skip intervals, or duration values), but by a more dynamic unified structure.

Dynamic theory of attention also provides an elegant framework for the understanding of contextual effects in music perception and memorization. Small changes in pitch or rhythmic features may have strong repercussions on the overall dynamic shape of a melody even when all other features are held constant. Consider, for example, the melodies displayed in Figure 1a: The key context is varied between T1 and T2 melodies while holding the rhythm, the melodic contour, and most of the pitch interval sizes constant. Let's consider this key context in more detail. T1 melodies are in A minor. The key context is changed in T2 by altering the pitches of the first three notes, which evoke a strong feeling of the key of G major. With the exception of the two G#s (Numbers 1 and 4), all remaining notes are the same in T1 and T2. Given this difference in the melody's underlying key, the scale degrees of the tones differ, so that tones with strong tonal accents in T1 are accented less in T2, and vice versa. For example, the A (Number 2) instills a strong tonic accent in T1 (first scale degree) but a weak one in T2 (second scale degree). The B (Number 3) instills a weak tonal accent in T1 (second scale degree), but a stronger one in T2 (third scale degree), and so on. Since tonal accents contribute to defining the dynamic shape of Western melodies, we may assume, in the light of Jones' theory, that such changes in key context strongly affect the perceptual identity of the T1 and T2 melodies. In a similar way, varying the rhythmic context in which the pitch structures are played between R1 and R2 melodies should strongly affect their perceptual identity. Following Palmer and Krumhansl (1987) the rhythm was phase-shifted relative to the pitch structure in set 1. Consequently, most of the tones with strong rhythmic accents in one context were accented less in the other context and vice versa. Because this manipulation changes the way the rhythm and pitch structures fit together, it should alter the dynamic shape of the melody. In set 2, several rhythmic changes were made that were designed to affect the duration and the metrical position of the tones without making the melodies sound too awkward.

Data obtained in a previous experiment performed with a perceptual task supported these key and rhythmic contextual effects (Bigand, in press). Participants were asked to evaluate on a seven-point scale the degree of musical stability perceived on the melodic tones (phrase completion judgment). Key context effects were evidenced by the fact that the tones perceived as stable melodic reference points in T1 melodies were perceived as unstable in T2 melodies, and vice versa. Consequently, the profiles of musical stability significantly differed between T1 and T2 melodies, and were even negatively correlated for the melodies displayed in Figure 1a. Similarly, rhythmic context effects were evidenced by the fact that changing the rhythm from R1 to R2 caused significant changes in the musical stability profiles: as a main tendency, tones of long duration with a strong metrical accent were perceived as more stable reference points than were those of shorter duration falling on a weak metrical beat. In addition, these context effects were observed both in musicians and nonmusicians, and were significantly accounted for by a model computing the strength of the various melodic and rhythmic accents distinguished by Jones (1987), and Jones and Boltz (1989). This suggests that the most accentuated tones in a melody (i.e., tones on which several strong accents coincide) capture listeners' attention, and consequently tend to be perceived as very stable melodic reference points.

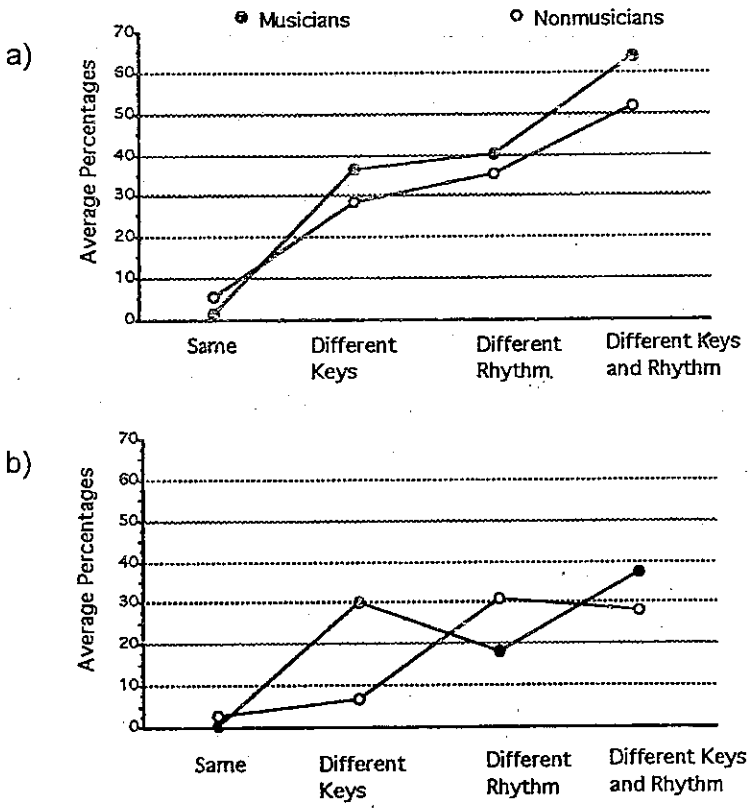

Figure 1. Two sets of four melodies used in the experiment. Melodies in set 1 (a) are from Bigand (in press, Exp. 1), and melodies in set 2 (b) from Bigand (in press, Exp. 2). In boths sets, key contexts varied between T1 and T2, and rhythmic contexts, between R1 and R2.

The purpose of the present experiment was to investigate such key and rhythmic context effects in a recognition task using the same sets of melodies. Since these melodies were perceived as having clearly different dynamic shapes (i.e., different profiles of musical stability), it was assumed that significant context effects would appear despite the fact that the melodies shared long sets of identical tones in the same sequential order and identical superficial features.

EXPERIMENT

Participants

Sixty students of the French Music Conservatory (referred to henceforth as "musicians") participated in the experiment. They had received at least 10 years of intensive training in music (i.e., music theory, ear training, and instrumental performance). Sixty college-age students in psychology (referred to henceforth as "nonmusicians") also took part in the experiment. They had never had any formal instrumental or musical training. All participated in the experiment on a volunteer basis.

Material

The two sets of four melodies tested in a previous study (Bigand, in press, Exp. 1 & 2) were used. In both sets, the T1 melodies differed from the T2 melodies with respect to their underlying key (A minor and G major, respectively, in set one; F major and G major, respectively, in set 2). The R1 and R2 melodies differed in rhythm (Figure 1). The rhythm was changed either by shifting the rhythmic structure with respect to the pitch structure (first set of melodies) or by changing the duration of several tones (second set of melodies). The melodies were played with sampled piano sounds produced by the EMT10 Yamaha Sound Expander at a tempo of 120 quarter notes per minute. The Yamaha sampler was controlled through a MIDI interface by a MacIntosh computer running Performer software. *Velocity* – a parameter related to the force with which a key is struck – was held strictly constant for all pitches. Participants were allowed to adjust the output of the amplifier to a comfortable level. There was no silent pause between the offset of a tone and the onset of the succeeding one.

Procedure and design

During the first part of the experiment, participants were trained to identify one melody in each set. The two melodies to be learned were chosen randomly, but in such a way that each of the eight melodies was learned by the same number of participants. Each melody (labelled Melody A or Melody B) was presented three times, then melodies A and B were played six times in random order, one octave above or below. Participants had to label the melody (A or B) and identify the octave (higher versus lower) in which it was played. All participants performed this easy task without error. During the recognition task, participants heard pairs of melodies. In each pair, the first (standard) melody was one of the learned melodies. The comparison melody was played one octave below the standard, as is the usual procedure in the melody recognition paradigm. Standard and comparison melodies came from the same set of melodies. Thus, the comparison melody was either identical to the standard melody, or varied with respect to one or both of the following features: underlying melodic key and rhythm. In all, participants listened to ten pairs of melodies, six in which the comparison melody was assumed to be perceived as different from the standard, and four in which the standard and comparison melodies were identical.

Participants were informed that more or less numerous changes in pitch and/or rhythm may have been made in order to alter the tune of the standard melody. They were asked to estimate the percentage of notes whose pitch had been changed in the comparison melody. They marked their responses on a subjective scale ranging from 0% to 100%. Participants were informed that the comparison melody was played one octave below the standard melody, and that they should focus on the difference in tune and not the difference in octave. Given that they had already been exposed to this kind of transposition in the first part of the experiment, no participant reported having been confused by this change in pitch.

RESULTS

The percentages of tones actually changed in the melodies were subtracted from the percentages of tones judged to have been changed by the participants in the corresponding experimental situations. The average percentages obtained after subtraction are displayed in Figure 2. As one can see, the percentage of tones judged as changed by participants when the standard and comparison melodies were identical were very low. This confirmed that the transposition one octave below did not lower the recognition rate of the melodic pitch structure, which is consistent with the well-established phenomenon of octave equivalence. To test the effect of the different factors, a 2 × 2 × 2 × 2 (musical expertise × key context × rhythmic context × set of melodies) ANOVA was performed with the first variable as the between-subject variable, and the others as the within-subject variables. There was a main significant effect of the key context, $F(1, 30) = 29.44$, $p < .001$, indicating that varying the key context caused an increase in the percentage of tones judged as changed by the participants. A further analysis indicated that the percentages of tones judged as changed by musicians when the key context alone was varied were much higher than the actual percentage of tones changed, $t(15) = 6.73$, $p < .01$ in set 1, and $t(15) = 4.46$, $p < .01$

Figure 2. Average percentages of perceived pitch changes obtained after the subtraction of the percentages of actual pitch changes: (a) melodies in set 1; (b) melodies in set 2.

in set 2. With the nonmusicians, this difference reached the significance level in set 1 only, $t(15) = 6.25$, $p < .01$. The ANOVA also revealed a significant effect of the melody set, $F(1, 30) = 35.66$, $p < .001$, and a significant effect of rhythm: the percentages of tones evaluated as changed significantly increased when the rhythm was varied, $F(1, 30) = 82.07$, $p < .001$. In addition, the key context effect was stronger for the melodies in the first set, $F(1, 30) = 9.25$, $p < .001$, and was more pronounced in musicians, $F(1, 30) = 8.95$, $p < .001$. There were no other significant interactions.

DISCUSSION

The present data showed that changes in the key and rhythm contexts significantly affected the recognition of the pitch structure of relatively long melodies for both musicians and nonmusicians. The importance of the key context was demonstrated by the fact that the estimated percentage of tones changed was, on average, two and three times higher than the percentage of tones actually changed. This indicates that small pitch variations in a few tones (five in the first set of melodies) managed to deeply affect the recognition of the overall melody, despite the fact that all other musical parameters were held constant. Using longer melodies, these findings replicated the key context effect already observed by Dowling (1986). Both studies provide evidence that listeners perceive and remember physically identical acoustic events as very different auditory events. This suggests that in music, as in other symbolic human activities, acoustic events are not only mentally represented by their sensory features, but by more abstract features as well. According to Dowling (1986), scale-step representation is an important feature of such an abstract representation.

The present findings are consistent with the key context effect we obtained in a perceptual task with the same melodies (Bigand, in press). In the perceptual task, participants were asked to rate the degree of musical stability perceived on each melodic tone. The analysis of the data provided evidence that participants were inclined to infer different keys in the T1 and T2 melodies. Such a change in the inferred key causes changes in the scale degrees of the melodic tones and leads participants to perceive different degrees of musical stability on the T1 and T2 tones: tones that were stable in one melodic context were perceived as unstable in the other, so that the overall musical stability profiles strongly differed between T1 and T2. The data from the present recognition task provided evidence that such a change in the overall dynamic musical shape of the melodies influences melody recognition. The consistency of the two experiments furthers our understanding of the cognitive function of scale-step representation. It suggests that a change in key context modifies the musical stability profiles of a melody, which in turn leads listeners to believe that several tones of the standard melody have been modified in the comparison melody. According to Jones' theory of dynamic attending, scale-step representation may be of psychological importance in this case, since it contributes to defining the dynamic shape of the melodies.

The scale degree of the melodic tone is not the sole feature governing the dynamic shape of a melody. Bigand (in press) also observed that changing the rhythm from R1 to R2 significantly alters the musical stability profiles of the melodies. The data from the present recognition task indicated that changing the rhythm of the melodies also strongly affected the recognition of their pitch structure: participants evaluated, on average, that 18% to 40% of the R1 tones had been changed in the R2 melodies, while in fact no tones had been changed. Taken together, these two set of results provide convergent evidence that changing the rhythm from R1 to R2 changed the musical stability profiles, which rendered the overall pitch structure difficult to recognize. Such an effect of rhythm on melody recognition is consistent with previous findings reported by several authors (see Peretz & Kolinsky, 1993). According to the theory of dynamic attention, changes in rhythm alter the way melodic and temporal accents are coupled in time, so that tones that are attention-getting in one rhythmic context fail to attract listeners' attention in another context. Therefore, changing the rhythm of a comparison melody makes it difficult to recognize the pitch relationships previously salient in the standard melody. Stated differently, changing the rhythm leads participants to define new stable cognitive reference points in the melody, which in turn modify its perceived identity.

In addition, the fact that a change in rhythm alone was sufficient to alter the recognition of the melody's pitch structure suggests that pitch and rhythm are not two independent perceptual components, but are in fact processed as a unified dimension in a musical sequence: a change in rhythm interferes with the processing of the pitch structure and affects the perception of the melody as a whole. Such a "single-component model" of melody processing has been challenged by a "two-component model" (see Peretz & Kolinsky, 1993) but has recently been supported by several empirical studies asking subjects to recall melodies (Deutsch, 1980; Boltz & Jones, 1986; Boltz, 1991a), recognize melodies (Jones, Summerell, & Marshburn, 1987; Jones & Ralston, 1991; Boltz, 1993a), evaluate how complete a melody is (Boltz, 1989a, b), or estimate the duration of melodies (Boltz, 1991b, 1993b; Jones, Boltz, & Klein, 1993). According to Jones' dynamic theory of attention, pitch and rhythmic structures are integrated into a unified joint accent structure that constrains melodic markers of different strengths. Changing the rhythm or some of the features of the pitch structure would change the strength of these markers, which in turn would affect the overall dynamic shape of the melody. The present data support this one-component model of melody processing.

The last striking finding of the present study concerns the very slight influence of the participants' musical expertise: key and rhythmic context effects were in fact observed for both groups of participants. That a key context effect was observed in nonmusicians emphasizes the fact that the formal musical training is not necessary for an individual to react to subtle differences in musical structures. The weak influence of musical expertise in the present study is consistent with several other results obtained with melodies (Bharucha, 1984; Boltz, 1989b; Smith & Cuddy, 1989; Bigand, 1993; Laden, 1994) and with chord sequences (Bigand, Parncutt, & Lerdahl, 1996). The present study also pointed out some slight differences between the two groups of listeners, since the key context effects were more pronounced in musicians. A consistent interaction between musical expertise and key (or tonal) structure was also observed by Bigand (in press) with the same melodies, and by Bigand, Parncutt, and Lerdahl (in press) with short chord sequences. In all of these studies, musicians' responses were determined to a greater extent by the tonal structure of the musical sequences, whereas those of the nonmusicians were influenced to a greater extent by more easily perceptible features. This suggests that musicians and nonmusicians may be sensitive to the same kinds of musical features, musicians being more highly sensitive to features related to the tonal (harmonic) structure of the musical sequence.

RÉSUMÉ

Cette étude considère comment des effets de contexte, préalablement observés dans une tâche perceptive (Bigand, 1993, sous presse), peuvent influencer la reconnaissance des notes d'une mélodie. Trois facteurs sont manipulés : le contexte tonal, le rythme et le degré d'expertise

musicale. L'effet de contexte tonal est provoqué par des petites modifications de la hauteur de certaines notes. L'effet de contexte rythmique est effectué, soit en décalant la structure rythmique de la mélodie initiale, soit en modifiant la durée de ses notes. Les sujets devaient évaluer le pourcentage de notes changées entre une mélodie standard, préalablement apprise, et une mélodie test de comparaison. Les résultats confirment la théorie de l'attention dynamique de Jones, (1976), Jones et Boltz (1989), Jones et Yee (1993). Percevoir et mémoriser une mélodie sont des activités attentionnelles dynamiques dépendantes du contexte : quelque soit le degré d'expertise musicale des sujets, modifier la force des accents tonaux ou rythmiques dans une mélodie change la forme dynamique globale de la mélodie ce qui altère le suivi attentionnel de la mélodie et la rend plus difficile à reconnaître.

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