



Brief article

Differentiation of classical music requires little learning but rhythm

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Abstract

Detecting distinctions between the styles of classical music (e.g. Baroque and Romantic) is often viewed as the privilege of musicians. However, this elite perspective underestimates the abilities of non-musicians. We report that Western musicians and non-musicians, and non-Westerners (i.e. Chinese participants) rated pairs of excerpts presented auditorily as more similar as their compositional styles were closer in history. Moreover, the styles were considered by all participants as more different when presented in historical order, the older style preceding the more recent style (e.g. Baroque followed by Romantic), than the reverse (e.g. Romantic followed by Baroque). This historical distance effect appears related to rhythm (or temporal variability).

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When asked to identify the compositional style of a piece of classical music (e.g. Baroque or Romantic), musicians are able to do so with remarkable ease. This sophisticated skill is viewed as a signature of formal musical training, whereby one learns to attach stylistic labels to music as a function of its distinctive properties. Explicit recognition of classical styles is typically not mastered by the average listener.

One may infer that only musically educated listeners can appreciate distinctions between the styles of classical music. However, this view may be erroneous.

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Styles discrimination (i.e. assessing whether two excerpts are similar or different “in style”) does not require labelling and may occur without referring to explicit stylistic knowledge. In order to discriminate styles, non-musicians may rely on implicit knowledge of classical music, acquired over time by mere exposure (e.g. Meyer, 1989). Musically naive listeners are constantly exposed to music in everyday life. This exposure is apparently sufficient to acquire sophisticated knowledge, albeit implicitly, of the general rules of Western music (e.g. Krumhansl, 1990; Tillmann, Bharucha, & Bigand, 2000). Similarly, exposure may lead non-musicians to internalize the rules that allow distinction between the styles of classical music. The aim of the present study was to assess this possibility.

The concept of style, despite substantial theoretical work carried out by musicologists (e.g. Meyer, 1989; Narmour, 1990; Nattiez, 1975), remains ill-defined. “Style” may refer to a particular musical language (e.g. Tonal music), to the music composed within a given historical period (e.g. Baroque style) or to one composer’s way of writing (e.g. Bach’s style). In the present study, the term “style” refers to the music created by a group of composers within a given historical period, as in most of the studies on style sensitivity (e.g. Hare, 1977). We study here the capacity of discriminating the four major tonal styles of Western classical music, spanning about three centuries of music history (from XVII to XIX Century). These are, in historical order, Baroque, Classicism, Romanticism, and Post-romanticism. Styles properties progressively evolve with history (Crocker, 1986). For instance, from Baroque to Post-romanticism, composers deviated from the principles of tonality, by creating progressively less tonally stable (e.g. Grout & Palisca, 2001) and more rhythmically variable music (e.g. Daniele & Patel, 2004; Patel & Daniele, 2003b). Accordingly, proximity in history is expected to reflect similarity in musical structure. Styles should be judged more similar when they are close in history (e.g. Baroque and Classicism) than when they are more distant (e.g. Baroque and Post-romanticism). Such an effect, termed “historical distance effect”, provides an operationalization of sensitivity to Western styles.

The historical distance effect has been observed in several studies (Campbell, 1992; Eastlund, 1990, 1992; Gardner, 1973; Gromko, 1993; Hare, 1977). Participants judging pairs of musical excerpts on a similarity scale rate the fragments as more similar as they are closer in history (Eastlund, 1990; Gromko, 1993; Hare, 1977). Similarly, participants are affected by historical distance when asked whether two fragments come from the same composition or not (Gardner, 1973) or whether the third fragment in a triad of excerpts is written in the same musical style as the first two excerpts (Campbell, 1992).

Hence, the historical distance effect is a fairly robust phenomenon. What remains unclear, however, is whether this effect requires explicit knowledge of musical styles. A few studies suggest that only musicians are sensitive to historical distance (Eastlund, 1992; Gromko, 1993; Hare, 1977) while others report that non-musicians may also exhibit the historical distance effect (Campbell, 1992; Eastlund, 1990; Gardner, 1973). This inconsistency across studies may arise, at least in part, from differences in prior familiarity with the musical material. When an effect of training was obtained (e.g. Hare, 1977), the stimuli were not controlled for familiarity. Excerpts are likely to be more familiar to musicians than to non-musicians. Thus, the former may have been favored in using their explicit stylistic knowledge (e.g. by labelling music) to perform the task.

In order to tease apart the possibility that the effect of training results from familiarity differences, in the present study we asked listeners to discriminate musical fragments that are novel but that keep stylistic characteristics. We predicted that both musicians and non-musicians' judgments would be affected by historical distance, since exposure is generally sufficient to acquire sophisticated musical knowledge in ordinary listeners. In contrast, we did not expect listeners mostly exposed to non-Western music (e.g. Chinese music) to exhibit sensitivity to Western stylistic differences. Thus, a group of non-Westerners served as control.

1. Method

1.1. Participants

Three groups participated in the experiment. Twelve Western musicians (6 males and 6 females), aged between 19 and 28 ($M=23.8$ years), were students at the Faculty of music of the University of Montreal. Twelve Western non-musicians (5 males and 7 females), aged between 21 and 26 ($M=22.7$ years), were university students who had not received any formal musical training. Finally, 12 non-Western non-musicians (6 males and 6 females), aged between 19 and 41 ($M=29.2$), were mostly university students without musical training raised in China ($n=11$) or Taiwan ($n=1$). They had resided in Canada for an average of 9.5 months (range=0.5–16 months) and reported that they had grown up listening to Chinese music and that they had had little exposure to Western music, as assessed through a questionnaire.

1.2. Material

Sixteen excerpts imitating Baroque, Classical, Romantic, and Post-romantic music were composed. For each style, four piano excerpts were written by two professional composers from the Conservatory of Parma, Italy, to be highly representative of the intended style. The stimuli have been inspired by piano works and were 30 s. long. All begun with high intensity (e.g. *f*, *ff*), were written in G Major, and in a binary meter.

The stimuli were controlled so that the historical distance across styles could not be derived from trivial material-related properties (i.e. tempo, duration, pitch of the first note, number of notes, note density, and dissonance), which can affect similarity ratings (e.g. Eerola, Järvinen, Louhivuori, & Toivianen, 2001). Other variables that may covary with historical distance, and thus may contribute to stylistic judgments, have been computed for the 16 excerpts (see Table 1). On the pitch dimension, two measures of tonality were calculated using Matlab Midi Toolbox (Eerola & Toivianen, 2004). *Tonal stability* indicates to what extent a musical piece is perceived as deviating from its starting tonality (G Major, for our excerpts). This measure was obtained by projecting the pitch distribution of each excerpt (i.e. the number of Cs, Ds, and so forth) on a self-organized map (SOM) previously trained using the Krumhansl and Kessler tonality profiles (see Krumhansl & Toivianen, 2001). The region of the map which is maximally activated indicates the tonality in which the musical piece is typically perceived. Tonal stability is the distance

Table 1

Mean values for the musical characteristics of stimuli. Mean pitch, number of notes, and note density were computed from the Midi recordings using Matlab Midi Toolbox (Eerola and Toivianen, 2004), whereas simultaneous sensory Dissonance was obtained from the signal using IPEM Toolbox (Leman, Lesaffre, & Tanghe, 2001). Dissonance was calculated using a roughness estimation algorithm where roughness is defined as the energy of the relevant beating frequencies in the auditory channels (see Leman, 2000). *Significant difference between styles, with $P < 0.05$ (Kruskal–Wallis-test).

Characteristic	Style			
	Baroque	Classicism	Romanticism	Post-romanticism
Tempo (M.M, beat=quarte note)	103.0	112.0	108.3	106.5
Duration (s)	29.6	29.9	31.5	31.7
Pitch first note (Hz)	440.8	515.5	367.3	313.5
Mean pitch (Hz)	393.0	417.6	346.8	286.0
N. of notes *	296.0	277.0	371.5	288.8
Note density (notes/s)	10.0	9.3	11.9	9.3
Dissonance	1.1	1.2	0.9	1.1
Tonal stability	4.0	1.9	2.8	4.6
Tonal change	4.2	3.6	3.7	4.1
SD-duration (ms)	89.8	125.5	147.7	233.1
nPVI*	36.9	49.2	54.4	60.5

between this point of maximum activation and the point in the SOM indicating G Major (i.e. music's starting tonality). Larger distance indicates larger tonal instability. An example for one of the Baroque stimuli is presented in Fig. 1. *Tonal change* reflects the extent to which tonality varies within a piece. Each excerpt was divided into adjacent 500-ms segments. The pitch-distribution of each segment was projected on a SOM as before and the distance between G Major and the point of maximum correlation was calculated. Tonal change was the standard deviation of this distance within the piece.

On the time dimension, two measures of temporal variability were calculated. *SD-duration* is the standard deviation of note duration. *nPVI* is the normalized pairwise variability index which quantifies the durational difference between neighboring

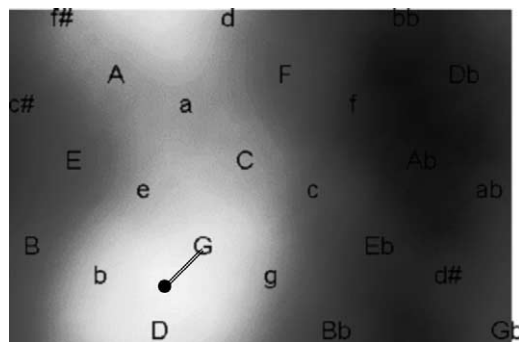


Fig. 1. Example of self-organized map for the stimulus Baroque 1 obtained with Matlab Midi Toolbox (Eerola and Toivianen, 2004). Letters refer to tonalities. Tonal stability is indicated by the distance between the point of maximum activation (i.e. the black point within the lightest region) and G Major (i.e. music's starting tonality).

Table 2

Matrix of all possible pairings between styles. Historical distances (0, 1, 2, and 3) and presentation order of styles (historical and reversed) are shown.

	Style of second excerpt																			
Style of first excerpt	Baroque	Classicism	Romanticism	Post-romanticism																
	Historical Order <table><tr><td>0</td><td>1</td><td>2</td><td>3</td></tr><tr><td>1</td><td>0</td><td>1</td><td>2</td></tr><tr><td>2</td><td>1</td><td>0</td><td>1</td></tr><tr><td>3</td><td>2</td><td>1</td><td>0</td></tr></table> Reversed order				0	1	2	3	1	0	1	2	2	1	0	1	3	2	1	0
0	1	2	3																	
1	0	1	2																	
2	1	0	1																	
3	2	1	0																	
Baroque	0	1	2	3																
Classicism	1	0	1	2																
Romanticism	2	1	0	1																
Post-romanticism	3	2	1	0																

notes.¹ The latter measure has been used in order to quantify rhythmical differences between languages (e.g. Low, Grabe, & Nolan, 2000) and has been shown to extend to music (Patel & Daniele, 2003a,b). Recent studies have shown that nPVI progressively increases in the history of tonal music (e.g. Daniele & Patel, 2004; Patel & Daniele, 2003b). As can be seen in Table 1, temporal variability seems the only musical characteristic that systematically increases with historical period (style).²

The excerpts were performed on the piano by six advanced students from the Conservatory of Padua (Italy). Each student played four excerpts, each taken from one of the four styles, to avoid confusion between compositional styles and styles of performance. The excerpts were played on a keyboard Technics PCM Digital Ensemble PR370 and recorded using Cubase software. Examples are available on the website <http://www.brams.umontreal.ca/peretz>.

The excerpts were arranged in pairs so that all possible pairs were obtained, with the exception that a stimulus was never paired with itself. There were 240 pairs, with four possible distances between styles. Table 2 represents a matrix of all possible pairings between styles. Zero is used when the stimuli in a pair belong to the same style, and one, two, and three when excerpts are separated by one, two and three historical periods. The two possible orders of the excerpts within a pair were used. The order was qualified as “historical” when the style of the first excerpt preceded the style of the second excerpt in

¹ The normalized Pairwise Variability Index (nPVI) applied to music is defined as: $nPVI = 100m - 1 \times \sum_{k=1}^{m-1} |dk - dk + 1| dk + dk + 12$ where m is the number of notes in an excerpt, and d_k is the duration of the k th note.

² In prior studies, nPVI was computed for monodic music (i.e. melodies). We extended the use of nPVI to polyphonic music. The original formula for nPVI was applied, except the case of exactly simultaneous notes where durational differences could not be computed.

history (e.g. Baroque–Romantic) and as “reversed order” when the opposite sequence occurred (e.g. Romantic–Baroque).

1.3. Procedure

Each participant performed a familiarity task and a similarity task. In the familiarity task, all 16 excerpts were presented auditorily in random order. The familiarity of each excerpt was rated on a 7-point scale with 1 = “I don’t know this musical excerpt. It doesn’t sound familiar at all. I don’t know anything similar” and 7 = “I know perfectly this musical excerpt. I can predict the continuation of the excerpt by listening to a part of it. I am able to give the name of the composer”. In the similarity task, each subject was presented auditorily with 128 pairs of excerpts taken from the pool of 240 possible pairs. Within the 128 pairs, the four historical distances were equally represented, by using 32 pairs for each distance (16 pairs in historical order and the same 16 in reversed order). All possible pairs were employed across subjects. For each pair, the subjects had 10 s to rate the stylistic similarity of the two excerpts on a 7-point scale. One corresponded to “very different” and 7 to “very similar”.³

In both tasks, instructions were provided both orally and on the computer screen. Participants responded using the computer keyboard. The experiment was run on PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993) using a Macintosh PowerPC computer. Moreover, there were four practice stimuli before each task. The entire experiment lasted about 4 h over two sessions.

2. Results and discussion

2.1. Familiarity ratings

All subjects showed low-familiarity with the excerpts. However, Western musicians rated excerpts as more familiar ($M=3.1$) as compared to both Western ($M=2.4$) and non-Western non-musicians ($M=1.9$), $P<0.01$ (Friedman test). In addition all participants rated the excerpts from earlier periods (e.g. Baroque) as more familiar, with $P<0.05$ (Kruskal–Wallis-test).

2.2. Similarity ratings

2.2.1. Effect of historical distance

The similarity ratings provided by each group were averaged for each stylistic distance (see Fig. 2) and for each order (see Fig. 3). The similarity ratings were submitted to a 3 (Group) $\times$ 4 (historical Distance) mixed Analysis of Variance (ANOVA), by taking subjects as the random variable.⁴ Musicians were more affected by distance than

³ Judgments of *stylistic similarity* were used instead of open-ended judgments of *similarity*. It is unknown whether the use of *style* in our instructions affected judgments.

⁴ For all the analyses, the same results have been obtained when the ANOVAs have been carried out considering pairs instead of subjects as the random variable.

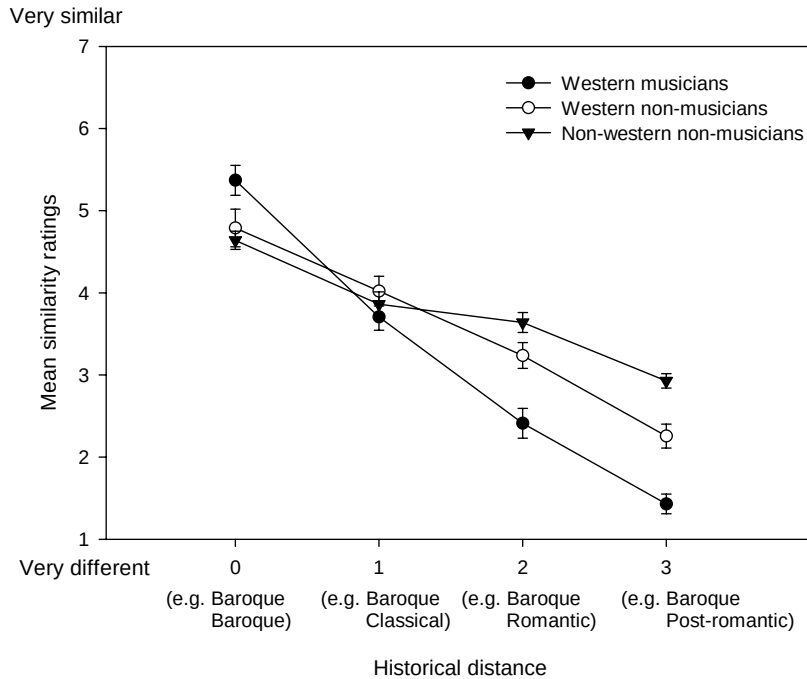


Fig. 2. Mean similarity ratings provided by each group for each stylistic distance (0, 1, 2, and 3). Error bars represent standard errors of the mean.

Western non-musicians who, in turn, exhibited a larger effect of historical distance than non-Westerners (with $F(6, 99) = 14.84$, $P < 0.001$, for the interaction between Group and Distance). However, all groups were significantly influenced by distance: the closer the styles, the more similar the music was judged (Western musicians, $F(3, 99) = 155.58$, $P < 0.001$; Western non-musicians, $F(3, 99) = 62.99$, $P < 0.001$; non-Western non-musicians, $F(3, 99) = 26.60$, $P < 0.001$).⁵

In order to uncover the nature of the determinants that may account for style discrimination, the mean similarity ratings from each group were submitted to Multidimensional Scaling (MDS), using Alscal algorithm (see Young & Hamer, 1987). To facilitate comparison across groups, two-dimensional MDS representations were rotated, so that the x -axis was aligned with historical time. MDS representations are shown in Fig. 4 (a–c). Correlations were then performed between the x and y axes of MDS representations and measures of tonal stability (*Tonal stability*, *Tonal change*) and temporal variability (*SD-Duration*, *nPVI*) that are likely to be involved in judging style similarity. These correlation values are presented in Fig. 5. As can be seen, the x -axis

⁵ An Analysis of Covariance (ANCOVA) has been run by taking the absolute difference in familiarity (as measured in the familiarity task) between the excerpts of each pair as the Covariate. The ANCOVA revealed the same effects and interactions, as previously found.

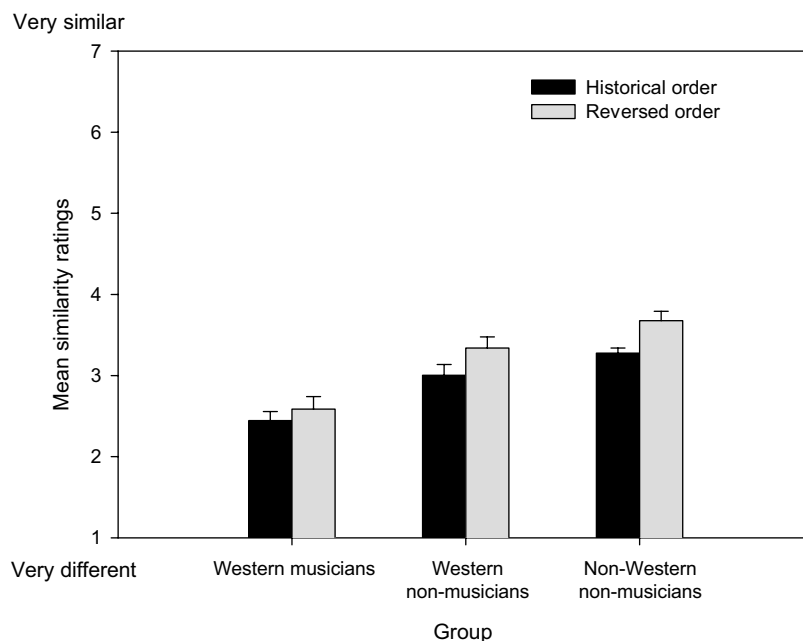


Fig. 3. Mean similarity ratings provided by each group for each order (historical and reversed). Error bars represent standard errors of the mean.

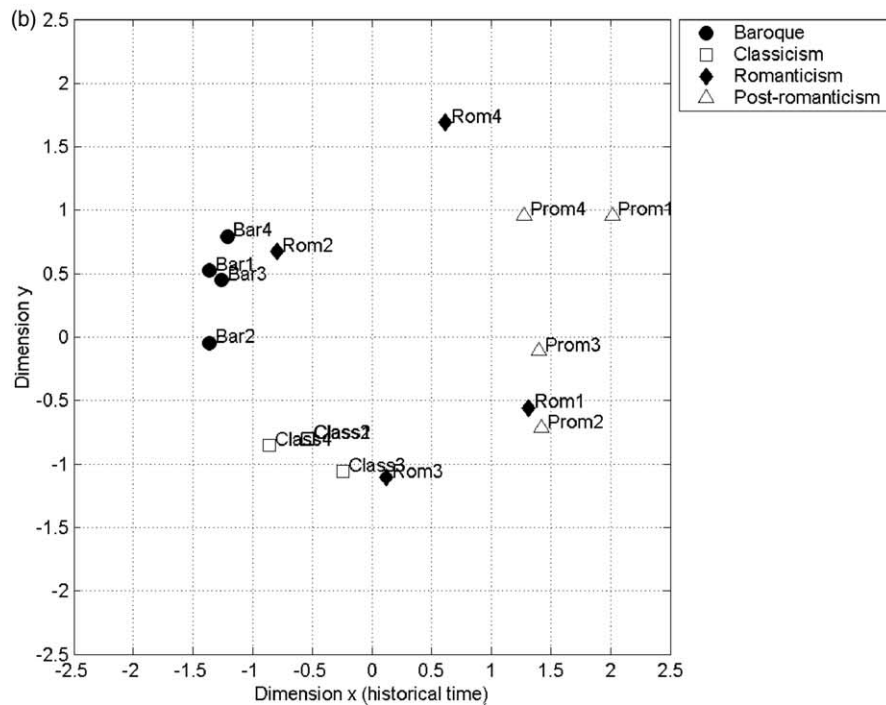
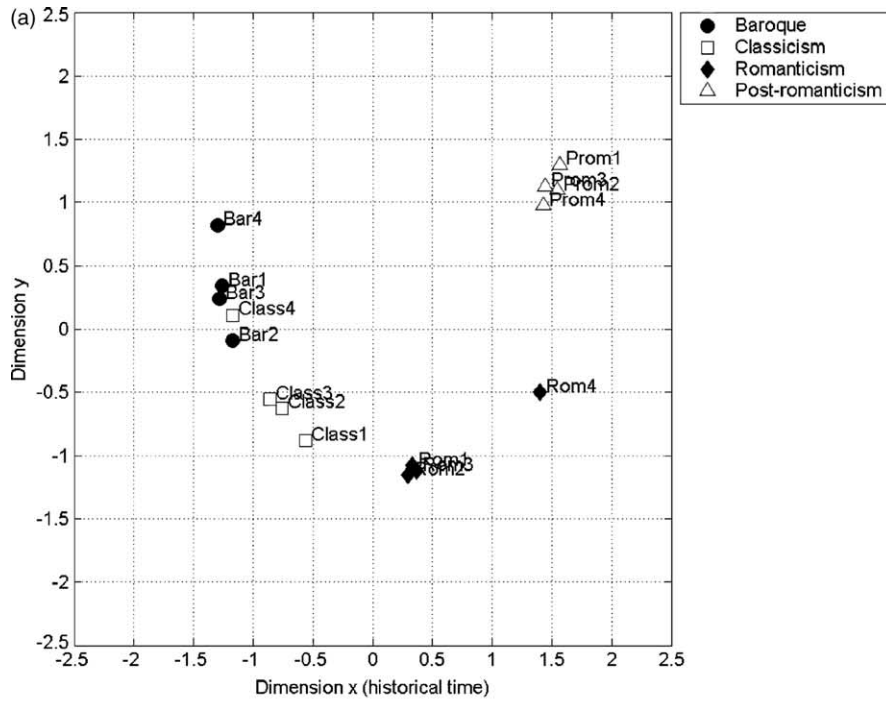
(historical time, top panel) is significantly correlated with time variables, in particular with nPVI. Correlation with nPVI is significant in all groups but largest in Western musicians. In contrast, the y-axis is significantly correlated with tonality-related measures (Fig. 4, low panel). Both tonal stability and tonal change are significantly correlated with the y-axis for Western musicians, whereas only tonal change was in Western non-Musicians. No significant correlations were found in the case of non-Westerners.

In sum, temporal variability (in particular nPVI) may account for the historical distance effect. Consideration of temporal variability appears to be used as a criterion by all groups. Consideration of tonality-related characteristics also contributes to similarity judgments but this requires extended exposure to Western music.

2.2.2. Effect of order

Similarity ratings for distances 1, 2, and 3 were further examined as a function of order (historical vs. reversed). A 3 (Group) $\times$ 2 (Order) mixed ANOVA was carried out by taking subjects as the random variable. Styles were more easily discriminated when

Fig. 4. MDS representations for Western musicians (a), Western non-musicians (b), and non-Western non-musicians (c). The proportion of variance of the scaled data accounted for by their corresponding distances (RSQ) were comparable across groups (Western musicians, RSQ=0.81; Western non-musicians, RSQ=0.70; non-Western non-musicians, RSQ=0.61).



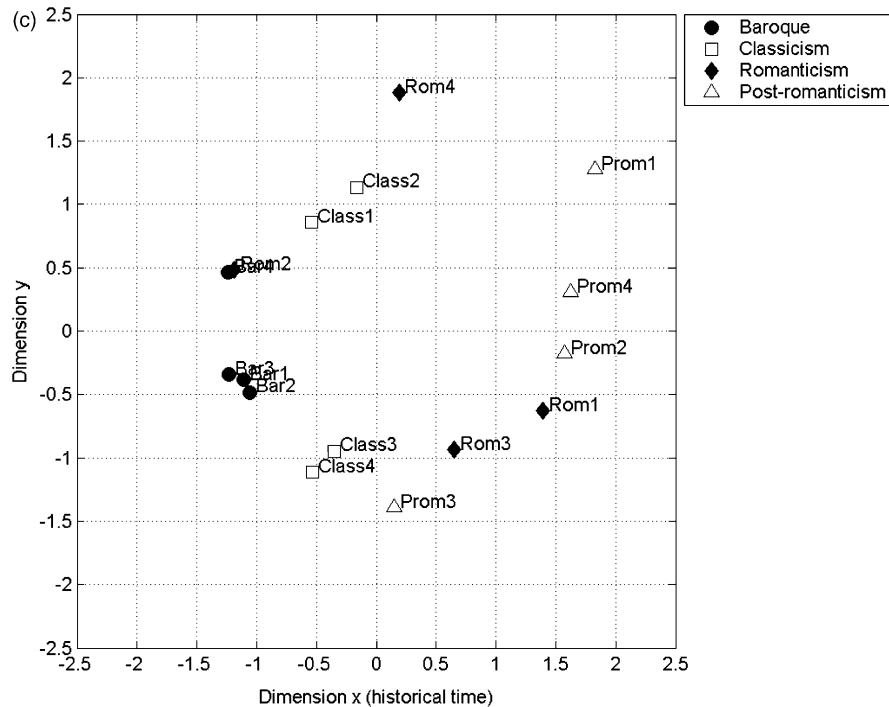


Fig. 4 (continued)

presented in historical order than when presented in reversed order ($F(1, 33)=21.73$, $P<0.001$). This effect did not vary with group. Further t -tests revealed that the effect of order was significant for all distances (with $P<0.05$), except for the comparisons Classicism/Romanticism and Romanticism/Post-Romanticism.

Judgment asymmetries are common in discrimination/categorization studies (see Hahn & Chater, 1997). In music, there is evidence that when tones (Bharucha, 1984; Krumhansl, 1990), melodies (Bartlett & Dowling, 1988; Dowling & Bartlett, 1981), and chords (Bharucha & Krumhansl, 1983) are compared in a same-different task, performance is best when the standard stimulus is tonally stable and the comparison stimulus is less stable than the reverse. A similar effect is reported with regular rhythms and irregular rhythms (Bharucha & Pryor, 1986). These effects have been mostly interpreted as occurring when one of the categories acts as a cognitive or perceptual reference point (i.e. a prototype). The reference point is typically considered as more similar to the non-reference point than the reverse.

Many reference points are culturally specific, thus acquiring their status after repeated exposure (e.g. tonal prototypes). Others are more universal, such as the intervals with small-integer frequency ratio (e.g. see Schellenberg, 2002; Schellenberg & Trehub, 1999). Because the effect of order we obtained is not affected by musical training and expertise, it is likely that this asymmetry result from culture-general low-level processes, such as sensitivity to variability in duration. Excerpts which are less variable in duration may have

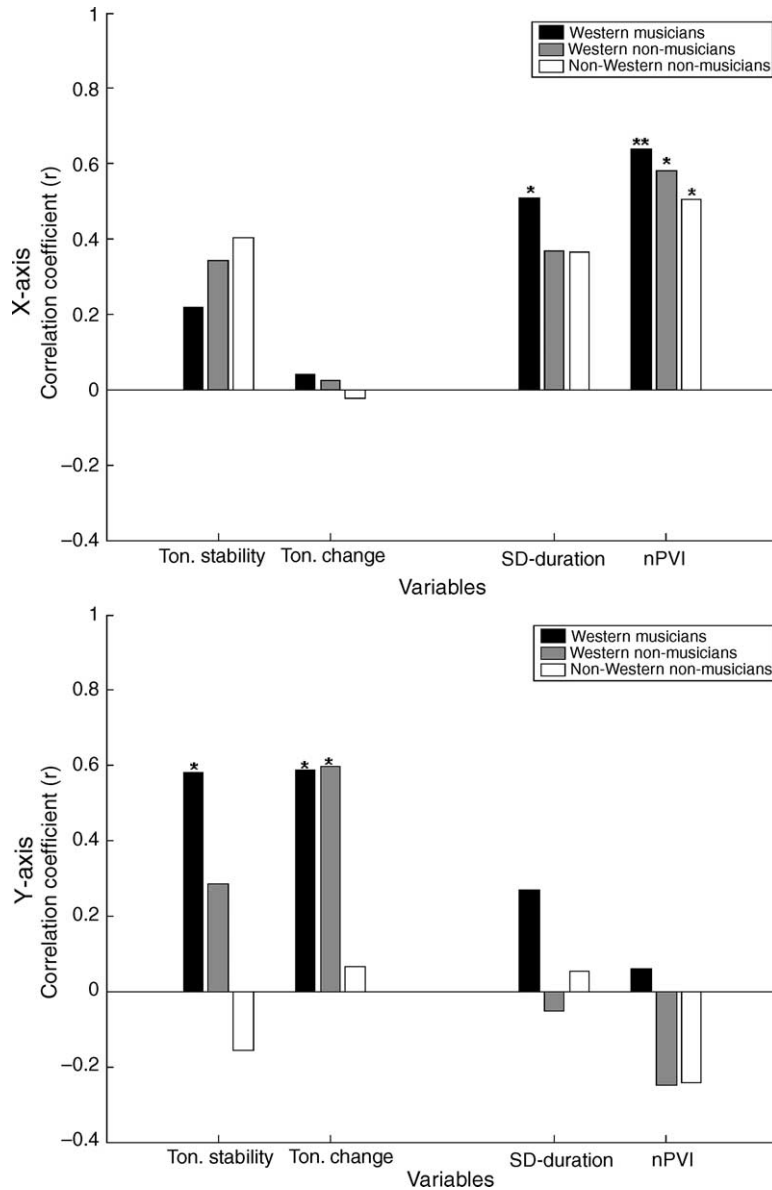


Fig. 5. Correlations between Tonal stability, Tonal change, SD-duration, nPVI and the x - (top panel) and y -axes (low panel) of MDS representations, for Western musicians, Western non-musicians, and non-Western non-musicians. Note: * $P < 0.05$; ** $P < 0.01$.

acted as reference points, similarly to what observed in the case of regular rhythms (Bharucha & Pryor, 1986). Early styles (e.g. Baroque) may have played this role since they are less temporally variable than recent styles (e.g. Post-romantic), as attested by the nPVI measure.

This effect of order was not due to familiarity, whereby familiar stimuli are judged as more different than less familiar stimuli, because the effect of order emerges even when styles are equally familiar or when familiarity is considered as a covariate.

3. Conclusion

The results of the present study show that sensitivity to Western musical styles is influenced but not conditional on formal musical training. Musicians displayed greater sensitivity to historical distance than non-musicians did, although the latter clearly exhibited the historical distance effect. These results are consistent with some previous studies (i.e. [Campbell, 1992](#); [Eastlund, 1990](#); [Gardner, 1973](#)), thus supporting the hypothesis that passive long-term exposure to music is sufficient for developing styles sensitivity. Interestingly, prolonged exposure to Western music is not the sole contributing factor. Non-Westerners also displayed the historical distance effect, albeit less pronounced than in Westerners.

We propose that low-level universal perceptual processes underlie styles sensitivity. This hypothesis is consistent with recent evidence showing that even lower vertebrates are capable of discriminating musical genres (e.g. blues from classical music; see [Chase, 2001](#)). In particular, the analysis of *temporal variability*, as expressed by nPVI, appears as relevant for style sensitivity. Indeed, temporal variability was able to account for the effect of historical distance in all groups. Since nPVI can equally well account for temporal differences between languages (e.g. [Low et al., 2000](#)), it is very likely that domain-general processes, such as the ability to analyze variability in event duration, are involved in styles sensitivity. This is consistent with the idea that the ability to analyze temporal regularities is shared across cultures (e.g. [Drake & Bertrand, 2001](#)). However, note that low-level perceptual processes cannot fully account for the appreciation of stylistic differences. Culture-specific mechanisms, in particular related to the analysis of Western tonality (e.g. as expressed by *tonal stability* and *tonal change*) also contribute to style discrimination. Indeed, the use of tonal knowledge was found to be conditional on musical training and exposure.

Furthermore, all groups of listeners differentiated musical segments more easily when music was presented in historical order as opposed to the reversed order. A similar effect of order was found by [Bigand and Barrouillet \(1996\)](#), thus indicating that this effect is reliable. Training and exposure did not influence this effect. This effect of order might be another anchoring effect whereby music with reduced temporal variability serves as a culture-general reference point.

To summarize, these findings provide compelling evidence that everyone is sensitive to the styles of Western classical music. Underneath such abilities lie cross-cultural perceptual processes, which allow the discrimination of key perceptual features (i.e. temporal variability), which, in turn, mark music evolution.

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