The effects of musical training and culture on meter perception

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Abstract
Western music is characterized primarily by simple meters, but a number of other musical cultures, including Turkish, have both simple and complex meters. In Experiment 1, Turkish and American adults with and without musical training were asked to detect metrical changes in Turkish music with simple and complex meter. Musicians performed significantly better than nonmusicians, and performance was significantly better on simple meter than on complex meter, but Turkish listeners performed no differently than American listeners. In Experiment 2, members of Turkish classical and folk music clubs who were tested on the same materials exhibited comparable sensitivity to simple and complex meters, unlike the American and Turkish listeners in Experiment 1. Together, the findings reveal important effects of musical training and culture on meter perception: trained musicians are generally more sensitive than nonmusicians, regardless of metrical complexity, but sensitivity to complex meter requires sufficient exposure to musical genres featuring such meters.

Keywords
cross-cultural, culture, meter, musical expertise, musical training, music perception, rhythm

Music is both universal and culturally relative, exhibiting similarities as well as differences in structure, function, and interpretation across cultures (Savage, Brown, Sakai, & Currie, 2015; Trehub, Becker, & Morley, 2015). For example, all societies have music with an isochronous pulse and simple meter (Nettl, 2000), but some (e.g., Balkan, Turkish, Indian) also have music with a non-isochronous pulse and complex meter (Bates, 2010; Clayton, 2000; Rice, 2003).

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Moreover, various global music genres (e.g., Turkish \textit{taksim}, Persian \textit{avaz}, Chinese \textit{qin}, and Japanese \textit{shakuhachi}) feature unmetered music (Clayton, 1996).

Western music theory distinguishes between simple and compound meters, the latter involving a subdivision of the basic isochronous pulse in duple meter into three rather than two parts, as in 6/8 time. However, simple and compound meters are considered simple when contrasted with non-isochronous, complex meters, in which the basic pulse \textit{alternates} between groups of two and three beats, for example, $2+3$, $3+2$, $3+2+2$, $2+2+3$, $3+3+2$, and so on. In Turkish classical music, such asymmetrical metric structures are referred to as \textit{aksak} (limping), especially in the context of traditional dance (see Bates, 2010).

Suggestions of biological predispositions for simple meters (Bergeson & Trehub, 2006; Drake & Bertrand, 2001) are consistent with Western adults’ difficulty with complex meters but inconsistent with Western infants’ ease of processing complex meters (Hannon & Trehub, 2005a). They are also inconsistent with the ability of adults of Balkan, Turkish, and Indian origin to perceive such meters (Hannon & Trehub, 2005a; Kalender, Trehub, & Schellenberg, 2013). These observations raise the possibility that the typical processing advantage observed for simple meters results from enculturation to Western music.

Infants’ ease of perceiving foreign musical meters (Hannon & Trehub, 2005a), foreign speech contrasts (Werker & Tees, 2005), and other-race faces (Kelly et al., 2005) reflect culture-general processing, and adults’ difficulty with such stimuli reflect culture-specific processing. Such enculturation processes involve progressive attunement to culturally relevant categories and diminished sensitivity to culturally irrelevant categories – a process known as perceptual narrowing (Lewkowicz, 2014; Maurer & Werker, 2014). Perceptual narrowing can also account for adults’ enhanced memory for music that conforms to the conventions of their culture (Demorest, Morrison, Beken, & Jungbluth, 2008).

Enculturation processes affect various aspects of music perception. For Western listeners, an unfamiliar Indian \textit{thāt} or Turkish \textit{makam} is likely to pose encoding difficulties, given the presence of unfamiliar musical intervals that cannot be readily assimilated into major–minor tonal schemata (Curtis & Bharucha, 2009; Justus, Yates, Atalay, Mert, & Curtis, 2016). Similarly, the dominance of simple meters in Western music undoubtedly underlies Western listeners’ difficulty in perceiving complex metrical patterns in Balkan and Turkish music (e.g., Hannon & Trehub, 2005a, 2005b; Kalender et al., 2013). Indeed, some scholars contend that familiarity rather than metrical complexity accounts for differences between the metrical processing of Turkish and American adults (Hannon, Soley, & Ullal, 2012) and infants (Soley & Hannon, 2010). In line with this view, French and Tunisian listeners exhibit enhanced metrical processing (i.e., tapping at higher hierarchical levels) for pop songs from their own culture than from the other, despite comparable metrical structure (Drake & El Heni, 2003). Nevertheless, there is evidence that limited exposure to complex meters from one musical culture (e.g., Indian) can facilitate the processing of complex meters from another (Turkish) (Kalender et al., 2013).

Musical enculturation processes begin in infancy and continue through the school years (see Trainor & Hannon, 2013, for a review). For example, 4-month-old Western infants exhibit listening preferences for the musical meters of their own culture (Soley & Hannon, 2010). By 6 months, they detect changes to complex as well as simple meters (Hannon & Trehub, 2005a) and, by 12 months, they have adult-like difficulty with complex meters (Hannon & Trehub 2005b). However, until 5 years of age, Western children can readily learn to perceive complex meters, but older children and adults have difficulty overcoming their listening biases (Hannon & Trehub, 2005b; Hannon, Vanden Bosch der Niederlanden, & Tichko, 2012). By contrast, there is a more protracted developmental course for culture-specific processing of pitch relations. For example, implicit knowledge of key membership and aspects of harmony are
apparent by 4 or 5 years of age (Corrigall & Trainor, 2010, 2014), but the understanding of Western tonality continues to develop for several years (Trainor & Hannon, 2013).

Music perception is influenced not only by enculturation or incidental exposure to music (Tillmann, 2012) but also by music lessons and other forms of musical enrichment. Musically trained adults outperform untrained adults on some pitch discrimination (Schellenberg & Moreno, 2010) and melodic memory (Weiss, Vanzella, Schellenberg, & Trehub, 2015) tasks, and their responses on probe-tone tasks suggest more clearly differentiated tonal hierarchies (Halpern, Kwak, Bartlett, & Dowling, 1996). Musically trained children exhibit enhanced sensitivity to various musical elements (Putkinen, Tervaniemi, Saarikivi, Ojala, & Huotilainen, 2014). Moreover, informal musical enrichment at home or elsewhere accelerates the development of auditory pattern perception in infants (Gerry, Unrau, & Trainor, 2012) and preschoolers (Putkinen, Saarikivi, & Tervaniemi, 2013).

The advantages of musical training extend to the temporal dimension of music, with trained musicians exhibiting greater sensitivity than nonmusicians to changes in tempo (Drake & Botte, 1993) and temporal intervals (Banai, Fisher, & Ganot, 2012) and better auditory-motor coupling (van Vugt & Tillmann, 2014). With regard to metrical processing, musicians exhibit enhanced sensitivity to changes in simple meters (Geiser, Ziegler, Jancke, & Meyer, 2009), more clearly differentiated metrical hierarchies in probe-beat tasks (Palmer & Krumhansl, 1990), and more accurate sensorimotor synchronization (Repp & Doggett, 2007), including more flexible tapping at different levels of the metrical hierarchy (Drake, Penel, & Bigand, 2000).

Nevertheless, untrained Western listeners can acquire implicit knowledge of unfamiliar metrical structures, including complex meters (Tillmann, Stevens, & Keller, 2011).

In the present study we explored the contributions of culture (Turkish vs. American) and musical training (musicians vs. nonmusicians) to adults’ perception of Turkish music with simple (isochronous) or complex (non-isochronous) meter. For comparability with previous research, we used the task and Turkish musical materials developed by Kalender et al. (2013), in which listeners’ responses reflected their sensitivity to metrical structure. Kalender et al. (2013) tested Western nonmusicians, some of whom had limited exposure to non-isochronous meters. The present experiment is the first to examine the processing of simple and complex meters in a cross-cultural sample of musicians as well as nonmusicians.

We expected listeners to detect metrical changes more readily in the context of simple meter than in complex meter, with metrical sensitivity being modulated by culture and musical training. Regarding culture, we expected greater performance differences between simple and complex meter for American listeners than for Turkish listeners, in line with previous enculturation effects (Hannon, Soley, et al., 2012; Hannon & Trehub, 2005a; Kalender et al., 2013). We also anticipated better performance for Turkish listeners than for American listeners because the stimuli were drawn from Turkish folk music (cf. Drake & El Heni, 2003). Finally, we expected musicians to exhibit greater metrical sensitivity than nonmusicians, consistent with their enhanced performance on other metrical tasks (Drake et al., 2000; Geiser et al., 2009).

**Experiment 1**

**Method**

**Participants.** The participants were Turkish musicians \((n = 12; \text{age}: M = 23 \text{ years}, SD = 2; \text{education}: M = 16 \text{ years}, SD = 1; \text{musical experience}: M = 9 \text{ years}, SD = 6)\), Turkish nonmusicians \((n = 12; \text{age}: M = 21 \text{ years}, SD = 2; \text{education}: M = 16 \text{ years}, SD = 1; \text{musical experience}: M = 1 \text{ year}, SD = 1)\), American musicians \((n = 12; \text{age}: M = 19 \text{ years}, SD = 1; \text{education}: M = 14 \text{ years}, SD = 1)\), and American nonmusicians \((n = 12; \text{age}: M = 19 \text{ years}, SD = 1; \text{education}: M = 14 \text{ years}, SD = 1)\).
years, $SD = 1$; musical experience: $M = 12$ years, $SD = 5$), and American nonmusicians ($n = 12$; age: $M = 19$ years, $SD = 1$; education: $M = 14$ years, $SD = 1$; musical experience: $M = 1$ year, $SD = 1$). The Turkish participants were students at Middle East Technical University, whereas the American participants were students at the Claremont Colleges. Many of the Turkish participants, whose primary language was Turkish, spoke one or more additional languages, especially English. Similarly, many of the American students, whose primary language was English, also spoke one or more additional languages, especially Spanish.

Turkish as well as American participants reported listening to Western music on a daily or weekly basis. Whereas no American participants reported listening to Turkish music, two thirds of the Turkish participants reported listening to Turkish music on a daily or weekly basis. The Turkish musicians had been trained on voice ($n = 12$), guitar (5), bağlama (3), piano (3), violin (3), organ (2), and recorder (2), whereas the American musicians had been trained on piano ($n = 9$), voice (7), ukulele (4), guitar (3), violin (2), clarinet (2), saxophone (1), and percussion (1).

**Stimuli.** The stimuli were from Kalender et al. (2013), consisting of multi-instrument MIDI versions of four Turkish folk songs, two in simple (2/4) meter and two in complex (5/8) meter, the latter featuring alternating groups of two and three beats. The instrumental timbres were pan flute, bagpipe, banjo, dulcimer, ocarina, agogo, and shakuhachi, which played the melody in unison. A taiko drum with two pitches always highlighted the metrical structure. The duration of a quaver or eighth note was either 300 or 333 ms for the two sets of simple-meter stimuli and 250 ms for both sets of complex-meter stimuli. This resulted in measures of either 1200 or 1332 ms for the simple meters (average of 1266 ms), and measures of 1250 ms for the complex meters. Sound samples are available in the Supplementary Materials of Kalender et al. (2013).

For the practice phase, the familiarization stimuli were 30 s in duration. The first familiarization stimulus was a MIDI version of *Twinkle, Twinkle, Little Star*, featuring a simple meter. The second familiarization stimulus was a MIDI version of a song based on complex meter. The familiarization phase was followed by the presentation of two test stimuli that were also 30 s in duration: one featuring an alteration (i.e., an added tone) that preserved the original meter (*meter-preserving*) and the other featuring an alteration (also an added tone) that changed or violated the meter (*meter-violating*).

For the test phase, there were four familiarization stimuli, each presented for 2 min, and four test stimuli for each familiarization stimulus, each presented for 30 s. In addition to the meter-preserving and meter-violating conditions, as in the practice phase, a third condition presented an exact repetition of the familiarization stimulus (*no change*), and a fourth condition presented an obvious, meter-violating change in which two additional tones were added (*obvious change*). The addition of the latter two conditions was to ensure that participants understood the task, even those who might not be sensitive to subtle differences between the meter-preserving and meter-violating conditions. Figure 1 illustrates the four familiarization stimuli, two in simple meter and two in complex meter, along with the corresponding meter-preserving and meter-violating changes.

**Procedure.** Participants were tested individually. After providing information about their music and language background, participants were taken to a sound-attenuated room where the procedure was implemented with Presentation software (Neurobehavioral Systems) on a Dell PC running Windows 7 OS. All participants wore Sennheiser HD 280 Pro headphones, followed instructions presented on a computer screen, and entered their responses on a keyboard without time pressure. Questionnaires and computerized instructions were provided in English for the participants in the United States and in Turkish for the participants in Turkey.
Figure 1. The four familiarization stimuli with meter-preserving and meter-violating changes. Seven instruments played the melodies in unison and were accompanied by a taiko drum whose two pitches reinforced the meter. D represents *dim* or the lower drum pitch, and T represents *tek* or the higher drum pitch. Redrawn from Kalender et al. (2013).
The session began with a practice phase consisting of two trial blocks: one featuring a familiarization stimulus in simple meter followed by two test trials with the meter-preserving and meter-violating changes and a second block featuring the familiarization stimulus in complex meter followed by two test trials with meter-preserving or meter-violating changes. Participants rated the difference between each test stimulus and the familiarization stimulus on a 7-point scale from 1 (the same) to 7 (very different). Following Kalender et al. (2013), the instructions emphasized the rhythm (ritm in Turkish) rather than the meter (metrum) of the music because the latter term is unfamiliar to many untrained adults. Any participant who did not provide a higher difference rating for the meter-violating stimulus than for the meter-preserving stimulus repeated the practice session to ensure that the task requirements were understood.

The test phase consisted of four trial blocks presented in a different random order for each participant. Each block consisted of a familiarization stimulus featuring a Turkish folk song and the four test stimuli (no change, obvious change, meter-preserving change, meter-violating change), also in a different random order for each participant. After hearing each test stimulus, participants rated its dissimilarity from the familiarization stimulus on the 7-point scale. Following the offset of each sound file, as well as each response, participants were reminded of the instructions and pressed return to continue. The onset of the next sound file followed a 2000-ms inter-trial interval. Participants completed the entire task in approximately 15 min.

**Results and discussion**

For each participant, eight dissimilarity scores representing the two meters (simple meter, complex meter) and four types of change (meter-preserving change, meter-violating change, no change, and obvious change) were obtained by averaging over the two observations in each cell.

Following Kalender et al. (2013), responses to test stimuli involving no change or an obvious change were included in an initial analysis to confirm participants’ understanding of the task requirements (Figure 2). A $2 \times 2 \times 2 \times 2$ Analysis of Variance (ANOVA) with Culture (Turkish, American) and Musical Training (nonmusician, musician) as between-subjects factors and
Change (no change, obvious change) and Meter (simple, complex) as within-subjects factors revealed a significant main effect of Change, $F(1, 44) = 354.3, p < .001, \eta^2_p = .89$, a marginal main effect of Meter, $F(1, 44) = 3.8, p = .06, \eta^2_p = .08$, and a significant interaction between Change and Meter, $F(1, 44) = 9.8, p = .003, \eta^2_p = .18$. The simple-meter test stimuli with obvious changes ($M = 5.1, SD = 1.1$) yielded higher dissimilarity ratings than did the simple-meter test stimuli with no changes ($M = 1.4, SD = 0.7$). To a lesser extent, the complex-meter test stimuli with obvious changes ($M = 4.3, SD = 1.6$) yielded higher dissimilarity ratings than did the complex-meter test stimuli with no changes ($M = 1.7, SD = 0.9$). Critically, there were no main effects of Culture or Musical Training, nor any interactions involving these factors ($ps > .18$). Each group provided higher dissimilarity ratings for test stimuli with obvious changes than for test stimuli with no changes, $p < .001$. This preliminary analysis confirmed listeners’ understanding of the task.

The main analyses focused on listeners’ implicit understanding of simple and complex meters, specifically their responses to test stimuli with meter-preserving and meter-violating changes (Figure 3). A $2 \times 2 \times 2 \times 2$ ANOVA with Culture (Turkish, American) and Musical Training (nonmusician, musician) as between-subjects factors and Change (meter-preserving, meter-violating) and Meter (simple, complex) as within-subjects factors revealed main effects of Change, $F(1, 44)= 14.8, p < .001, \eta^2_p = .25$, and Meter, $F(1, 44) = 16.1, p = .001, \eta^2_p = .27$, as well as an interaction between Change and Meter, $F(1, 44) = 15.1, p < .001, \eta^2_p = .26$. The main effect of Change reflected higher dissimilarity ratings for test stimuli with meter-violating changes ($M = 3.8, SD = 1.5$) than for meter-preserving changes ($M = 2.8, SD = 1.4$), as expected. Mean dissimilarity ratings tended to be higher for meter-violating than for meter-preserving changes for all groups and conditions except for Turkish nonmusicians’ ratings of changes to patterns with complex meter. The main effect of Meter reflected higher dissimilarity ratings for changes to stimuli involving simple meters ($M = 3.5, SD = 1.4$) than to those involving complex meters ($M = 3.0, SD = 1.3$), as predicted. Moreover, the interaction between Change and Meter reflected greater differences in dissimilarity ratings between meter-preserving and meter-violating changes for trials with simple meter ($M = 2.7$ and $4.3$, respectively) than for those with complex meter ($M = 2.8$ and $3.3$, respectively), also as predicted. Differences in
mean ratings between meter-preserving and meter-violating test stimuli tended to be greater for simple than for complex meters for all groups except for Turkish nonmusicians.

Of particular interest was whether the interaction between Change and Meter was influenced by Musical Training or Culture. The only significant interaction involving the latter two variables was between Musical Training and Change, $F(1, 44) = 6.4, p = .02, \eta_p^2 = .13$, reflecting musicians’ more differentiated responses to meter-violating and meter-preserving changes relative to those of nonmusicians. The three-way interaction of Change, Meter, and Culture was not significant, $p = .18$, nor was the three-way interaction of Change, Meter, and Musical Training, $p = .12$. All other interactions involving either Culture or Musical Training in the main ANOVA were not significant, $p > .12$.

Because there were no main effects or interactions involving Culture, the data were collapsed across this factor for further analyses (Figure 4). Following up the significant interaction between Musical Training and Change, we performed separate $2 \times 2$ ANOVAs for musicians and nonmusicians, with Meter (simple, complex) and Change (meter-preserving, meter-violating) as within-subjects factors. For musicians, there was a main effect of Change, $F(1, 23) = 18.7, p < .001, \eta_p^2 = .45$, reflecting higher dissimilarity ratings for meter-violating than for meter-preserving changes, and a main effect of Meter, $F(1, 23) = 12.1, p = .002, \eta_p^2 = .34$, reflecting higher dissimilarity ratings for changes to simple meters than to complex meters. In addition, there was an interaction between Meter and Change, $F(1, 23) = 11.8, p = .002, \eta_p^2 = .34$. For simple meter, dissimilarity ratings were greater for meter-violating changes ($M = 4.8$) than for meter-preserving changes ($M = 2.2$), $t(23) = 5.5, p < .001$. For complex meter, dissimilarity ratings for meter-violating changes ($M = 3.3$) exceeded those for meter-preserving stimuli ($M = 2.4$) at marginally significant levels, $t(23) = 2.0, p = .06$.

For nonmusicians, there was a main effect of Meter, $F(1, 23) = 4.3, p = .05, \eta_p^2 = .16$, but no effect of Change, $p = .33$, and a marginally significant interaction between Change and

![Figure 4. Mean dissimilarity ratings in Experiment 1 for meter-preserving and meter-violating changes as a function of meter (simple, complex), and musical training (nonmusicians, musicians), collapsed over culture (Turkish, American). Error bars represent standard errors.](psm.sagepub.com)
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Meter, $F(1, 23) = 3.6, p = .07, \eta_p^2 = .14$. For simple meter, dissimilarity ratings for meter-violating ($M = 3.9$) and meter-preserving changes ($M = 3.2$) did not differ, $p = .15$. Similarly, dissimilarity ratings for meter-violating ($M = 3.3$) and meter-preserving stimuli ($M = 3.2$) in the context of complex meter did not differ, $p = .95$.

Although we found the expected effects of musicianship (musicians outperforming nonmusicians) and meter (better detection of changes to patterns with simple than with complex meter), we failed to find the expected advantage for Turkish over American listeners, especially on complex Turkish meters. Because of the widespread influence of Western music in Turkey, it was possible that the Turkish musicians had more exposure to Western music than to Turkish music. In fact, a third of the Turkish musicians reported listening to Turkish music less than once weekly. To gain further insight into the role of enculturation in metrical processing, we recruited Turkish participants who had more systematic exposure to the complex meters in Turkish classical and folk genres.

**Experiment 2**

To ensure that participants had adequate exposure to the Turkish genres of interest, we recruited members of Turkish classical and folk music clubs at Middle East Technical University.

**Method**

**Participants.** The students ($n = 12$) were of similar age ($M = 22$ years, $SD = 2$), education ($M = 16$ years, $SD = 2$), and years of musical experience ($M = 8$ years, $SD = 3$) as those in Experiment 1. As before, many of the Turkish participants, whose primary language was Turkish, spoke one or more additional languages, especially English.

Unlike the Turkish groups in Experiment 1, every participant reported listening to traditional Turkish genres on a daily or weekly basis. Specifically, they were regular listeners of Turkish classical ($n = 10$), Turkish folk ($9$), Turkish protest ($7$), Western classical ($6$), Western pop ($6$), Rock ($5$), Arabesk ($3$), Turkish pop ($2$), Rap ($1$), Techno ($1$), and Underground ($1$). The instrument(s) on which the Turkish classical and folk music listeners had been trained included oud ($n = 4$), bağlama ($4$), guitar ($3$), piano ($2$), cümbüş ($1$), violin ($1$), clarinet ($1$), flute ($1$), and harmonica ($1$).

**Stimuli and procedure.** These were identical to those of Experiment 1.

**Results and discussion**

As before, responses to test stimuli involving no change or an obvious change were compared to confirm participants’ understanding of the task (Figure 5). A $2 \times 2$ Analysis of Variance (ANOVA) with Change (no change, obvious change) and Meter (simple, complex) as within-subjects factors revealed a significant main effect of Change, $F(1, 11) = 152.2, p < .001, \eta_p^2 = .93$, no main effect of Meter, $p = .34$, and no interaction between Change and Meter, $p = .19$. The simple-meter test stimuli with obvious changes ($M = 5.6, SD = 1.2$) yielded higher dissimilarity ratings than did the simple-meter test stimuli with no changes ($M = 1.3, SD = 0.3$). Similarly, the complex-meter test stimuli with obvious changes ($M = 5.1, SD = 1.3$) yielded higher dissimilarity ratings than did the complex-meter test stimuli with no changes ($M = 1.4, SD = 0.8$). As before, the data suggest that participants understood the task.
The more critical analyses concerned the responses to test stimuli with meter-preserving and meter-violating changes (Figure 6). A $2 \times 2$ ANOVA with Change (meter-preserving, meter-violating) and Meter (simple, complex) as within-subjects factors revealed no main effect of Meter, $p = .50$, a main effect of Change, $F(1, 11) = 27.7, p < .001, \eta^2_p = .72$, and an interaction between Change and Meter, $F(1, 11) = 11.9, p = .005, \eta^2_p = .52$. Dissimilarity ratings were greater for meter-violating than for meter-preserving changes for simple meter ($M = 4.9$ and $1.3$, respectively), $t(11) = 6.5, p < .001$, and for complex meter ($M = 4.2$ and $1.7$, respectively), $t(11) = 3.8, p = .003$.

The sensitivity to complex meter demonstrated by members of Turkish music clubs suggests that effects of Culture might have been observed in Experiment 1 if Turkish musicians had comparable exposure to the relevant genres. To explore this possibility, the main analysis of Experiment 1 was repeated with the Turkish musicians of Experiment 2 replacing those of Experiment 1. A $2 \times 2 \times 2 \times 2$ ANOVA with Culture (Turkish, American) and Musical Training (nonmusician, musician) as between-subjects factors and Change (meter-preserving, meter-violating) and Meter (simple, complex) as within-subjects factors confirmed the previously observed main effects of Change, $F(1, 44) = 22.7, p < .001, \eta^2_p = .34$, and Meter, $F(1, 44) = 10.5, p = .002, \eta^2_p = .19$, as well as the interaction between Change and Meter, $F(1, 44) = 18.7, p < .001, \eta^2_p = .30$. As before, there was also an interaction between Musical Training and Change, $F(1, 44) = 12.5, p = .001, \eta^2_p = .22$, with musicians having more clearly differentiated responses to meter-violating and meter-preserving changes than did nonmusicians.

Unlike the corresponding analysis of Experiment 1, this analysis revealed significant interactions with Culture. Specifically, there was a two-way interaction between Meter and Culture,
F(1, 44) = 5.2, p = .03, ηp² = .11, reflecting American listeners’ higher dissimilarity ratings for simple compared to complex meter, as well as a marginal three-way interaction among Change, Meter, and Culture, F(1, 44) = 3.5, p = .06, ηp² = .03, reflecting Americans listeners’ more differentiated responses to meter-preserving and meter-violating changes for simple compared to complex meter, and Turkish listeners’ comparable differentiation of the two change types for simple and complex meters (Figure 7).

General discussion

In Experiment 1, Turkish and American musicians and nonmusicians listened to multi-instrument versions of Turkish folk songs and rated the extent to which subsequent alterations, some of which violated the established metrical structure, differed from the originals. In principle, Turkish listeners had advantages over American listeners stemming from their prior exposure to complex meters (Kalender et al., 2013) and to the music of their home culture (Drake & El Heni, 2003). The advantages of musicians were expected to stem from their systematic training and analytic listening experience (Drake et al., 2000; Geiser et al., 2009).

In fact, musicians exhibited greater differentiation of meter-preserving and meter-violating changes than did nonmusicians, who performed at very modest levels. This is the first evidence of musicians’ enhanced processing of simple and complex meters, which extends the available evidence on musicians’ advantages for simple meters (Geiser et al., 2009). In previous research involving simple and complex meters, musical training was uncorrelated with performance (Kalender et al., 2013) or its benefits were limited to simple meters (Hannon & Trehub, 2005a). Although the present finding is consistent with other reports of musician
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advantages (Penttinen, Huovinen, & Ylitalo, 2013; Roden et al., 2014), such advantages have been absent in several other studies (e.g., McAuley, Stevens, & Humphreys, 2004).

Contrary to our expectations, the Turkish listeners of Experiment 1 did not show enhanced sensitivity to meter in Turkish music, deriving no apparent benefit from a familiar musical idiom, unlike French and Tunisian listeners in previous research (Drake & El Heni, 2003). Similarly, the Turkish listeners in Experiment 1 showed no benefit of previous exposure to complex meters, unlike Canadian listeners with limited exposure to Indian and Arabic music who showed a modest benefit on the same complex-meter stimuli (Kalender et al., 2013). These Turkish listeners were also unlike Balkan and Turkish listeners tested with Balkan music, whose performance was comparable on simple and complex meter (Hannon, Vanden Bosch der Nederlanden, et al., 2012; Hannon & Trehub, 2005a). By contrast, the Turkish listeners in Experiment 2 – members of Turkish classical and folk music clubs – performed comparably on simple and complex meters, like the Balkan (Hannon, Vanden Bosch der Nederlanden, et al., 2012) and Turkish (Hannon & Trehub, 2005a) listeners in previous research. It is likely that the critical difference between the Turkish musicians in both experiments was the club members’ systematic exposure to Turkish classical and folk music featuring complex meters. We concur with Hannon and collaborators (Hannon, Soley, et al., 2012; Hannon & Trehub, 2005a) that familiarity is more important than metrical complexity in predicting performance on meter-perception tasks.

It is important to explore musical training or systematic exposure in a more differentiated manner than in the present research or in previous research. Because musicians develop distinct perceptual-motor skills for their instrument of study, it is no surprise that percussionists outperform other musicians on rhythm perception and synchronization tasks (Hinton & Rauscher, 2003; Krause, Pollok, & Schnitzler, 2010). Training on different instruments and genres may also involve differential exposure to meters varying in complexity. Some of the Turkish musicians in the present study had studied traditional Turkish instruments such as the bağlama or saz,
and such training is especially likely to include exposure to complex meter. American musicians who have experience with jazz or 20th-century art music are likely to have exposure to complex meters even if their listening experience is dominated by simple meters.

Some forms of musical exposure, even without formal training, can have consequences for temporal processing. For example, professional disc jockeys, many of whom may lack the formal training of musicians, exhibit comparable rhythm processing to that of percussionists, perhaps because of their experience with precise temporal coordination (Butler & Trainor, 2015). Dancers are systematically exposed to music through their formal training and informal experience, which increases their awareness of rhythm and meter (cf. Brown, Martinez, & Parsons, 2006). Perhaps the Balkan listeners in previous research, who participated in traditional cultural activities, performed comparably on Balkan music with simple and complex meter because the stimuli were derived from traditional dance music (Hannon & Trehub, 2005a). When infants are bounced to music, the pattern of bouncing influences their perception of its meter (Phillips-Silver & Trainor, 2005). Adults’ experience of movement while listening to music has comparable consequences for meter perception (Phillips-Silver & Trainor, 2007). These examples of exposure to movement in the context of music are consistent with the notion that music is experienced as a sensorimotor event (Maes, Leman, Palmer, & Wanderley, 2014). Future cross-cultural studies of meter would benefit from exploration of the diverse ways in which musicians and nonmusicians are exposed to music.

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References


McAuley, J. D., Stevens, C., & Humphreys, M. S. (2004). Play it again: Did this melody occur more frequently or was it heard more recently? The role of stimulus familiarity in episodic recognition of music. *Acta Psychologica, 116*, 93–108.


