The Influence of Contextual Cues on Cultural Bias in Music Memory

Steven M. Demorest
Northwestern University

Steven J. Morrison
University of Washington

Vu Q. Nguyen
University of Indianapolis

Erin N. Bodnar
Graceland University

We have ample evidence of cultural bias influencing music cognition in a variety of ways including memory. The purpose of this study was to explore the influence of various musical elements on Western-born listeners' cross-cultural recognition memory performance. Specifically, we were interested in whether the enculturation effect found in previous studies would be observed when tuning, timbre, texture, and rhythm were equalized in the presentation of music from two different cultures. In addition we wanted to explore the possible influence of music preference on recognition memory performance. Listeners were randomly assigned to hear Western and Turkish music in one of three musical context conditions (full, monophonic, isochronous) and subsequently tested on their recognition memory. Results indicated that memory performance was superior for in-culture music regardless of contextual condition, with no significant correlation between preference and memory performance. This points to the statistical properties of pitch sequences as a possible source of culturally biased responses in music listening.

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Much of the research in music cognition has been conducted to identify presumably universal processes by which we come to understand music and how those processes interact with individual and collective experiences. However, such work has traditionally been situated primarily within a Western cultural framework (Patel & Demorest, 2013). Cross-cultural music psychology offers a unique opportunity to explore those aspects of music cognition common across most cultures (culture-general) and those particular to certain cultures (culture-specific). The notion that one's cultural background and identity biases or shapes cognition has been demonstrated in such diverse areas as self-concept (Chiao et al., 2008; Markus & Kitayama, 1991), face detection and memory (Chiao, Heck, Nakayama, & Ambady, 2006; Lucas, Chiao, & Paller, 2011), test performance (McFarland, Lev-Arey, & Ziegert, 2003), and language perception (cf. Kuhl et al., 2008). While music cognition has been popularly characterized as "universal," there is ample evidence of cultural bias influencing music cognition in a variety of ways (Morrison & Demorest, 2009; Patel & Demorest, 2013).

Unlike formal music training, enculturation is an implicit process. All normally developing children acquire an understanding of the music and language of their culture without explicit instruction (Trehub, 2003). Recent research in infant music cognition and development has identified the age at which encultured responses to music begin to emerge and influence our musical judgment. In general, infants are equally skilled at musical tasks based on material from any culture until around 12 months of age (Hannon & Trehub, 2005a; Schellenberg & Trehub, 1999). After that point, they begin to exhibit culturally biased responses to aspects of tonality (Lynch & Eilers, 1991; Lynch, Eilers, Oller, & Urbano, 1990) and rhythm (Hannon, Soley, & Levine, 2011; Hannon & Trehub, 2005b). This critical period for developing encultured music perception is very similar to that identified for linguistic perception (McMullen & Saffran, 2004).

In previous cross-cultural music cognition research it has been found that musical judgments are often a blend of cultural-general responses to statistical properties of the music and encultured understandings of their significance. For example, research on tonal hierarchy theory found that listeners were able to generate fairly accurate tonal profiles for out-of-culture music that reflected

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statistical properties of tone distributions in melodies, but that certain nuances of tonality and melodic expectancy were culturally dependent (Castellano, Bharucha, & Krumhansl, 1984; Krumhansl, Louhivuori, Toiviainen, Jarvinen, & Eerola, 1999; Krumhansl et al., 2000). These culturally dependent understandings can even be exploited to yield biased responses to out-of-culture music (Curtis & Bharucha, 2009).

Research in cognitive neuroscience has examined the influence of culture on neurological responses to music. Findings indicate that while the neurological responses involved in musical judgments are similar across cultures, there is an in-culture bias for music expectancy judgments (Bischoff Renninger, Wilson, & Donchin, 2006; Demorest & Osterhout, 2012; Neuhaus, 2003), phrase recognition (Nan, Knosche, & Friederici, 2006; Nan, Knosche, Zysset, & Friederici, 2008) and recognition memory performance (Demorest, Morrison, Stambaugh, Beken, Richards, & Johnson, 2010) that is reflected in the patterns of activation in each context. It has also been suggested that bimusical individuals may process music in qualitatively different ways than monomusical individuals from the same culture (Wong, Chan, Roy, & Margulis, 2011).

Cultural Bias in Music Memory

The encoding and retrieval of new music seems to be influenced strongly by cultural variables. Demorest, Morrison, Beken, and Jungbluth (2008) had American and Turkish subjects with varying levels of music training listen to brief unfamiliar excerpts from Western art music, Turkish classical music, and Chinese orchestral music traditions. The excerpts were matched as closely as possible for surface characteristics of tempo, texture, and instrument type while retaining distinct cultural identities. After hearing a block of three excerpts from one culture, subjects completed a recognition memory task where they distinguished between old (target) and new (foil) excerpts. While there was no effect for music training, there was a significant effect for culture with all subjects performing significantly better on music of their home culture.

This "enculturation effect" has been replicated with children and adults using simplified musical materials (Morrison, Demorest, & Stambaugh, 2008), with Indian and Western monocultural listeners (Wong, Roy, & Margulis, 2009), and with children after a period of instruction about an unfamiliar music culture (Morrison, Demorest, Campbell, Bartolome, & Roberts, 2012). Demorest et al. (2010) found that cultural bias in music recognition was reflected neurologically by greater activation during presentation of culturally unfamiliar stimuli than culturally familiar stimuli in areas associated with music and memory processing. Regardless of the culture of the music heard or cultural background of the listeners, activation during these tasks has been observed to occur in regions associated with basic auditory processing and memory, suggesting that listeners are engaging with both in-culture and out-of-culture stimuli in a similar way. However, activation is significantly greater during out-of-culture tasks in the R angular gyrus (AG), paracingulate gyrus (PG), posterior precuneus (PC), and middle frontal areas extending into the inferior frontal cortex (FC), which, coupled with poorer task performance, has been interpreted as reflecting greater cognitive load. This pattern of greater activation for harder tasks is similar to that found for out-of-culture music phrase processing (Nan et al., 2008), difficult tone recognition tasks (Holcomb et al., 1998), and verbal memory encoding (Baker, Sanders, Maccotta, & Buckner, 2001).

The presence of an in-culture bias in the encoding and retrieval of music from unfamiliar music styles is a consistent finding across a number of studies (Patel & Demorest, 2013). Less clear are the specific features of the music that are responsible for such culturally biased responses. Several of the studies cited above used simplified material or synthesized timbres yet still yielded a clear enculturation effect for recognition memory (Morrison et al., 2008; Wong et al., 2009). However, none of the prior studies directly compared listeners' responses to simplified or complex versions of the same musical material. Further, regardless of complexity, the stimuli used still provided certain contextual cues such as tuning and timbre that may have facilitated encultured responses.

In addition to contextual variables, another possible explanation for superior memory performance for in-culture music is preference. A listener's enjoyment of culturally familiar music may be greater than that for a type of music that is unfamiliar and seemingly strange sounding. This "mere exposure effect" is well established in music (see Peretz, Gaudreau, & Bonnel, 1998, for a review) and has been shown to create a positive affective bias and improved memory. Cross-culturally, several studies have indicated that listeners prefer in-culture music to out-of-culture music at least on first hearing (Demorest & Schultz, 2004; Fung, 1996; Morrison & Yeh, 1999) likely due to a sense of familiarity. Recent research with Western music also found a direct positive association between emotional reactions (i.e., liking) to novel music and recognition memory (Stalinski & Schellenberg, 2013). This leaves open the possibility that enculturation effects in memory performance are simply a reflection of listener preference and its relationship to subsequent recognition rather than structural differences in the music itself.

The purpose of this study was to explore the influence of various contextual music features on Western-born listeners' cross-cultural recognition memory performance. Specifically, we were interested to determine whether the enculturation effect found in previous studies would be observed when the tuning, timbre, texture, and rhythm were equalized across the music of two different cultures. In addition we wanted to explore the possible influence of music preference on memory performance. The research hypotheses were:

1. Western music will be remembered significantly better than Turkish music in all presentation conditions – this prediction is based on the prior robustness of the enculturation effect on recognition memory across different study contexts.
2. Recognition memory performance will be influenced by the musical context – this prediction is based on findings from a previous study (Morrison et al., 2008) that found that subjects' performance improved when the texture (monophonic versus polyphonic), timbre (plucked string versus strings and winds), and form of the examples were simpler. However, in the previous study the source musical material was completely different in the two conditions (simple and complex), so this prediction may not hold true when comparing within the same pieces of music.

Method

Participants for this study were adults (sampled from a university community) who were born in the United States or Canada and had not lived outside North America for more than one year ($N = 128$). Mean participant age was 26.1 ($SD = 10.1$) years with a range of 18.0 to 63.0 years. Most participants had some musical experience with 45 participants reporting private study; 13 reported no formal training of any kind. In previous research (Demorest et al., 2008) we found that listeners with formal training did not perform differently on cross-cultural recognition memory tasks than those without training. Participants were randomly assigned to one of three presentation and testing conditions: a) original ensemble recording ($n = 39$), b) monophonic - reduction to single line melody with original rhythm ($n = 49$), or c) isochronous - reduction to single line pitch sequence with equal rhythmic values ($n = 40$). Participants in every condition heard blocks of both Western and Turkish music examples in a counterbalanced order.

STIMULI & DESIGN

The stimuli for this study were taken from a previous fully comparative study of cross-cultural musical memory (Demorest et al., 2008). That study established that the Turkish examples used here were significantly more memorable than the Western examples for Turkish listeners, suggesting that differential memory performance on these stimuli were a result of the listener's culture, not inherent memorability of the excerpts. For that reason we felt comfortable using a partially comparative design (only Western-born listeners) to test whether the presence or absence of various musical elements would alter out-of-culture memory responses.

The stimuli in this experiment consisted of six music excerpts, each with a duration of 23-34 s taken from Demorest et al. (2008).[1] Three excerpts were taken from the Western art music tradition and three excerpts from the Turkish classical music tradition (see Appendix for titles of source recordings and a URL where one can hear sample excerpts in various contexts). The Western pieces chosen were intended to be relatively obscure to all but highly trained musicians who might specialize in music of the pre-classical or early classical period. The memory test for each culture's music (Western and Turkish) consisted of a total of 12 test items (6 targets and 6 foils, 4-6 s each presented in a random order). Both targets and foils were taken from the same larger pieces of music used for the stimulus recordings; the foils were extracted from musically different portions not previously heard by the participants but featuring similar tempo, texture, register, and key.

Excerpts and test items for both cultures were presented to all subjects in a counterbalanced order in one of three conditions representing different levels of musical context. The full context presentation condition used excerpts taken from the original commercial recordings of the pieces and featured a performance by a chamber ensemble of artists from the culture. Although the excerpts were matched between the two cultures for tempo range and instrument "families" represented (e.g., winds or strings), they featured the texture, timbre, tuning, and ornamentation typical of the culture.

[1] One change from the previous study was that we used an excerpt from a different movement of the Scarlatti for both exposure and testing. The similarity between the d' score in the original condition of this study (1.03) and the US subjects of the 2008 study (1.22) suggests that this change did not make the Western excerpts more memorable.

The monophonic condition represented a significant reduction of both complexity and cultural context. In this condition, only the melodies of the chamber pieces were transcribed using Sibelius notation software and then exported as .WAV audio files. The resulting audio examples were the same length as the originals, but featured only the melody line presented using a synthesized piano timbre with tuning adapted to Western equitempered norms and rhythm slightly quantized to adhere to Western proportions (see Figure 1a for an example). In addition to simplifying the texture, the purpose of the monophonic condition was to remove cultural cues of timbre and tuning from the Turkish examples while retaining basic pitch and rhythm information. If out-of-cultural contextual cues interfered with musical memory, we should have seen an improvement in the performance of Western listeners for culturally unfamiliar music in this condition.

For the isochronous condition the same notation files from the monophonic condition were edited to equalize all rhythmic values, leaving only the pitch sequence from the original excerpts played using a synthesized piano timbre (Figure 1b). The tempo of the isochronous examples was adjusted so that the length of the isochronous excerpts matched the length of the full context and monophonic listening conditions. While this tempo adjustment did create a slightly greater variation in felt tempo[2] between source melodies (56 bpm - 74 bpm in monophonic versus 56 bpm - 78 bpm in isochronous), both targets and foils for each melody in this condition were matched to the new tempo to remove any memory cues based on tempo. We predicted that removing rhythmic information would make the memory task more difficult overall; however, if out-of-culture rhythmic cues interfered in culturally unfamiliar contexts, memory scores in that context could have demonstrated improvement.

[2] The tempo adjustment for the isochronous condition was calculated using the "Fit Selection To Time" plug-in from within the Sibelius software. Once the rhythmic values were equalized into eighth notes, the notes were selected and run through the plug-in. The plug-in provided the option to set the selection to a given duration. The duration from the other conditions was entered resulting in the adjusted tempo. For example, the tempo of the Scarlatti excerpt was 70 bpm (at the half note) and 23.2 s in duration. After the rhythmic values were equalized into eighth notes, the tempo was adjusted to 87.1 bpm in order to maintain the same 23.2 s duration. By "felt" tempo we mean that the isochronous versions were not always heard as if each note received a beat (e.g., quarter notes), but could be heard as a string of equal half beats (e.g., eighth notes) for more dense examples. Examples are available in the supplementary materials section at the online version of this paper.

PROCEDURE

All participants began the experiment by filling out a background questionnaire about their musical and cultural experience. Following that, each experimental condition consisted of five parts: (1) Participants were familiarized with the experimental procedure by listening to two 30 s excerpts (jazz piano combo and solo classical guitar) that were from different musical styles than those presented in the experimental procedure followed by a short four-item memory test to illustrate what would be asked in the experiment. (2) Participants were then presented with the first of two 3-excerpt blocks grouped by culture presented in the context appropriate to the assigned condition. After hearing each longer excerpt, participants indicated their preference for it using a 7-point Likert-type scale anchored by 1 (*dislike*) and 7 (*like*). (3) A 12-item free-choice recognition memory test began immediately following completion of the listening portion featuring a randomized set of targets and foils. After each short example participants were asked to respond "yes" if they believed the test item was heard previously (old) or "no" if it was not (new). (4) Participants were presented with the second 3-excerpt block and indicated preference ratings for each excerpt followed by (5) a second 12-item free-choice recognition memory test. The order of presentation, Western first or Turkish first, was counterbalanced in each of the three conditions.

Results

Prior to analyzing the data, raw hit and false alarm rates were converted to *d*-prime (d'). *D*-prime is a standard test statistic for free-choice recognition memory because it controls somewhat for response bias by measuring the proportion of hits (correctly identified targets) to false alarms (incorrectly identified foils). One limitation of d' occurs in testing situations where participants might receive a perfect score on hits or false alarms, resulting in an infinite d' statistic. This can happen for any number of reasons; for example, a person who answers "no" on all 12 items would receive 0 out of a possible 6 for their hits score but a perfect 6 for 6 on rejection of foils. Of the 512 total scores (hits and false alarm totals for Western or Turkish items), 74 (14.5%) indicated either a perfect 6 hits or 0 false alarms on at least one of the two memory tests; responses to Western items (40 hit scores of 6, 21 false alarm scores of 0) accounted for 82.4% of these scores. All perfect scores were adjusted using a procedure from Macmillan and Creelman (1991) in which all perfect hit scores (*p* value of 1) were adjusted by subtracting 1/2N from their

a. First 5 measures of the Concerto no. 12 in C minor for treble recorder by Alessandro Scarlatti, Movement I. Moderato

b. Same 5 measures in isochronous reduction.

c. First 4 measures of Dilkeside Pesrev by Neyzen Emin Yazici.

d. Same 4 measures in isochronous reduction.

FIGURE 1. Four measures of monophonic and isochronous versions of two of the test melodies (See Appendix A for full list of music used).

p value, in this case 1 - 1/12. All perfect false alarm scores (*p* value of 0) were adjusted by adding the value 1/2N or +1/12. The resulting adjusted d' scores for each test were used as the dependent statistic. Table 1 provides the means for the memory test scores as proportional hit and false alarm rates and as adjusted d' scores by test condition.

To test for the influence of context and culture on memory we used a 2 x 3 x 2 factorial design (using Type III sums of squares to accommodate unbalanced data) that included one within-subject variable of music culture (Turkish and Western music) and two between-subject variables of music context (original, monophonic, or isochronous condition) and presentation order (Turkish/Western or Western/Turkish). A mixed analysis of variance revealed a significant main effect for music culture, $F(1, 122) = 38.58$, $p < .001$, partial $\eta^2 = .24$, revealing overall better memory for Western music ($M = 1.27$,

TABLE 1. *Mean Proportions of Hits and False Alarms (FA) and d-Prime Statistics by Condition and Music Type (SD in Parentheses)*

	Western				Turkish			
Condition	Hits	FA	d'	c	Hits	FA	d'	c
Original ($n = 39$)	.77 (.17)	.43 (.23)	0.97 (0.97)	−0.29 (0.31)	.64 (.23)	.43 (.20)	0.58 (0.87)	−0.09 (0.43)
Monophonic ($n = 49$)	.85 (.17)	.24 (.19)	1.69 (0.80)	−0.15 (0.32)	.61 (.17)	.40 (.20)	0.57 (0.82)	−0.01 (0.33)
Isochronous ($n = 40$)	.70 (.16)	.33 (.19)	1.03 (0.75)	−0.03 (0.33)	.66 (.17)	.44 (.19)	0.54 (0.72)	−0.13 (0.37)

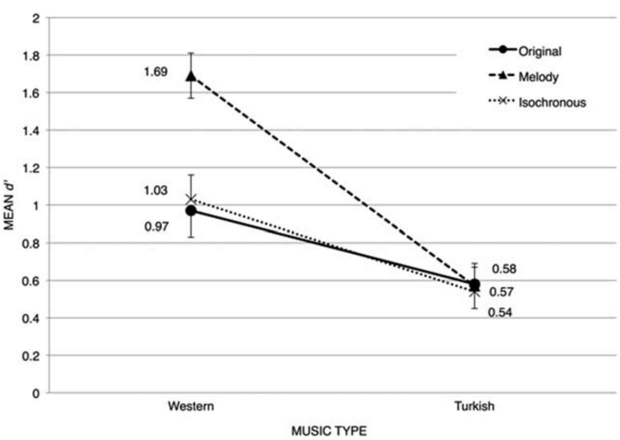

FIGURE 2. Mean memory (d') scores for Western and Turkish music in original, monophonic, and isochronous listening conditions (error bars indicate standard error).

$SD = 0.90$) than for Turkish music ($M = 0.56$, $SD = 0.80$) across conditions. There was also a significant between-subjects main effect for context, $F(2, 122) = 5.75$, $p < .01$, partial $\eta^2 = .09$. Post hoc tests using Least Significant Differences revealed that performance on the monophonic condition ($M = 1.13$, 95% CI [0.97, 1.29]) was significantly better than either the isochronous ($M = 0.78$, 95% CI [0.61, 0.96]) or original condition ($M = 0.77$, 95% CI [0.59, 0.95]). This difference was further explained by a significant context by culture interaction $F(2, 122) = 4.94$, $p < .01$, partial $\eta^2 = .08$, with monophonic scores significantly higher for Western music, but not for Turkish music. Figure 2 illustrates the interplay between culture and context on subjects' memory performance. There was no main effect for presentation order and no order interactions with any of the variables. Thus both null hypotheses predicting no difference by culture or context were rejected.

To examine response bias, we calculated c as a measure of participants' tendency to answer "yes" or "no" to memory test items (Stanislaw & Todorov, 1999). With a score of 0 indicating no tendency toward either response, negative values of c denote a tendency to respond affirmatively while positive c values reflect a bias toward "no" responses. Across all three contexts for both music cultures participants demonstrated a slight tendency toward responding "yes," they had heard the item before (Table 1). To identify any differences in response bias, we conducted a mixed ANOVA on c scores with music culture as a within-subjects variable and context as a between-subjects variable. We observed a significant interaction between music culture and context, $F(2, 125) = 5.66$, $p < .01$, partial $\eta^2 = .08$. Using a Bonferroni correction for multiple comparisons (adjusted $\alpha = .017$), we conducted paired t-tests on Western and Turkish c scores for each context. Participants demonstrated a significantly greater tendency toward "yes" responses to Western items in the original, $t(38) = -2.54$, $p = .02$, and monophonic, $t(48) = -2.58$, $p = .01$, contexts. No difference was observed among responses to isochronous items.

Given the consistently low d' scores in the culturally unfamiliar conditions, we wanted to be sure that the lack of difference was not due to a "floor" effect where all of the responses were simply at chance. For d' chance is represented by a score of 0. We performed three one-sample t-tests and found that listeners' memory performance on out of culture music was significantly better than chance in all three conditions: original, $t(38) = 4.12$, $p < .001$, monophonic, $t(48) = 4.81$, $p < .001$, and isochronous, $t(39) = 4.74$, $p < .001$, thus ruling out a floor effect.

In addition to the primary hypotheses regarding the influence of musical context on encultured memory responses, we wanted to explore whether preference might also influence participants' performance. Figure 3 illustrates preference judgments across the three listening conditions. A 2 x 3 x 2 mixed ANOVA (Type III sums of squares) for preference with music culture as a within-subjects variable and contextual condition and order as between-subjects variables indicated a significant main effect for music culture, $F(1, 122) = 99.96$, $p < .001$, partial $\eta^2 = .45$, with Western examples ($M = 4.64$, $SD = 1.14$) rated higher than Turkish examples ($M = 3.52$, $SD = 1.13$), but no main effect for context.

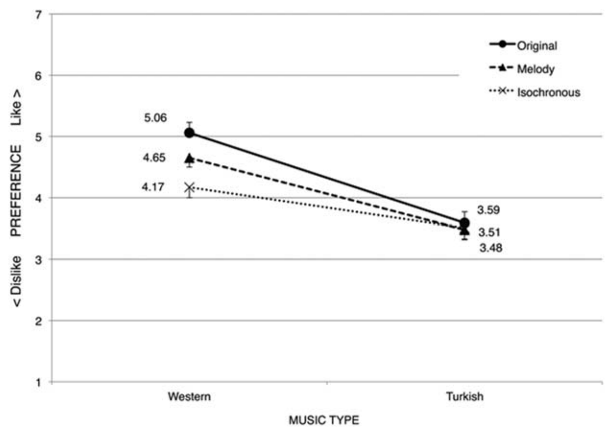

FIGURE 3. Mean preference scores for Western and Turkish examples across listening conditions (error bars indicate standard error).

There was a significant interaction between context and culture, $F(2, 122) = 4.40$, $p < .05$, partial $\eta^2 = .07$, demonstrating greater differences among responses to the three different contextual presentations of Western music than to Turkish music (Figure 3).

Unlike the memory scores, preference scores revealed a significant interaction between presentation order and culture $F(1, 122) = 6.18$, $p < .05$, partial $\eta^2 = .05$. Neither the main effect for presentation order nor its interaction with context was significant. Preference scores for the culturally familiar Western music were higher overall when it was presented second. Table 2 shows the mean preference scores by condition for the two orders. We treated the 7-point preference measure as an interval measure for the purpose of this analysis and results must be interpreted with appropriate caution.

While this result suggests an overall preference for culturally familiar music consistent with previous research, it does not directly explain memory performance. To test the relationship between preference and memory, we used Spearman's *rho* to measure correlation between participants' preference ratings and their

TABLE 2. *Mean Preference Scores for Western and Turkish Music by Context and Presentation Order (SD in Parentheses)*

Order	Context	Western	Turkish	Total
Turkish / Western	Original	5.33 (1.01)	3.37 (1.48)	4.35 (0.83)
	Monophonic	5.15 (0.86)	3.73 (0.87)	4.44 (0.74)
	Isochronous	4.25 (1.13)	3.50 (1.07)	3.88 (1.04)
	Total	4.93 (1.08)	3.55 (1.14)	4.24 (0.89)
Western / Turkish	Original	4.79 (1.09)	3.81 (1.20)	4.30 (0.93)
	Monophonic	4.14 (1.21)	3.20 (1.21)	3.67 (1.04)
	Isochronous	4.08 (0.97)	3.52 (0.89)	3.80 (0.77)
	Total	4.32 (1.13)	3.49 (1.13)	3.91 (0.95)

TABLE 3. *Correlation (Spearman's rho) of Preference Ratings and Recognition Hit Rates by Music Example**

Western			Turkish		
Ex. 1	Ex. 2	Ex. 3	Ex. 1	Ex. 2	Ex. 3
0.050	0.168	0.038	−0.101	−0.090	−0.092

*All correlations non-significant, $p > .05$.

recognition hit rates for each of the six excerpts (3 Western, 3 Turkish). There were no significant correlations between preference ratings and hit rates for any of the excerpts (Table 3).

Discussion

Listeners displayed an enculturation effect in their memory performance, with significantly better memory for culturally familiar music in all contextual conditions. While the present findings generalize to Western-born participants only, the results are consistent with previous studies regarding the influence of enculturation on music memory performance involving listeners of other cultures (Demorest et al., 2008; Demorest et al., 2010; Wong et al., 2009). This study extends the findings of previous studies by employing musical stimuli that were stripped of many of the surface musical characteristics that are culturally specific. The isochronous condition in particular maintained only the pitches of the original melodic sequences from each culture but without the characteristic rhythm, timbre, or tuning of Turkish music, thus eliminating a number of possible contextual cues for culturally biased memory performance. Even with the distortions inherent in producing an isochronous version of a real melody the effect was still apparent.

Manipulating musical features did influence in-culture memory responses significantly, suggesting that simplification of the texture of an example can improve memory encoding and retrieval within a familiar cultural context. This is consistent with previous work on context and memory in Western music. Halpern and Müllensiefen (2008) found that explicit memory for music was influenced by changes in either tempo or timbre between the presentation and recognition conditions. While the simpler versions of Western music were better recognized, this benefit was reversed when rhythmic information was equalized between examples, suggesting that simplicity is only beneficial when the crucial features of a melody are maintained.

Perhaps the most surprising aspect of these results is the *lack* of influence that altering contextual cues had on memory performance for culturally unfamiliar music across the three presentation conditions (Figure 2), even when the manipulations created examples that sounded more Western in timbre and tuning. This suggests that surface variables such as timbre or texture exert minimal influence on recognition memory performance for culturally unfamiliar music. Even removing such structural information as rhythm (or, more precisely, rhythmic variability) had no significant effect on out-of-culture responses. We conclude that the cues listeners were using to encode and recognize out-of-culture music were centered on the pitch sequences. Future research should explore whether Turkish listeners would show a similar effect with decontextualized in-culture and out-of-culture stimuli (e.g., Chinese and Turkish music simplified with only Turkish musical characteristics) or whether responses to such manipulations are themselves a cultural phenomenon.

Western listeners also demonstrated a significant preference for in-culture music, which has been found consistently in comparative studies of music preference (Demorest & Schultz, 2004; Fung, 1996; Morrison & Yeh, 1999; Shehan, 1985). There was also a significant influence of context on preference, but again only for in-culture preference judgments. The differences in preference across the two cultures did not correlate with memory performance on individual melodies, thus ruling out the influence of preference on cultural bias in music memory responses. While this would seem to contradict the findings of Stalinski and Schellenburg (2013) regarding liking and memory, there were important differences between the studies. Experiment one of their study tested recognition memory after a ten-minute delay and so was closest to our protocol. Both asked listeners to rate preference on a 7-point scale after the first hearing, but in their study preference ratings were collapsed into three ranked categories of *liked* (6-7), *disliked* (1-2), and *neither* (3-5). These categories were used as within-subject independent variables to compare ratings of familiarity in the recognition phase. The only memory effect they found was for "liked" examples versus the other two categories. The present study only included music from two very specific genres, both quite unfamiliar to the participants. Given the strong relationship reported between familiarity and preference (Demorest & Schultz, 2004), it is not surprising that mean preference responses across our items were within a limited range (from a high of 5.33 to a low of 3.20) that rarely crossed into the "liked" category. Examining individual item responses, even the most liked Western example received only 50 (out of a possible 128) ratings of 6 or 7; the least liked Western example still received almost twice as many ratings of 6 or 7 as the most liked Turkish example (29 compared to 15). Perhaps by using more liked stimuli for future cross-cultural research, preference may yet be identified as a factor in memory.

The enculturation effects we observed for music memory are more likely due to fundamental differences in the pitch sequences of melodies from different cultures. Such a difference might be represented by differences in tonal hierarchies or in the statistical properties of melodic structure (i.e., transitional probabilities related to contour, interval, or pattern). If this is true, then encultured understandings of music may be rooted in inductive rule systems based on the statistical properties of melodies from a given cultural tradition built through long exposure. While some studies have suggested that transitional probabilities of unfamiliar musical structures can be acquired quickly (Loui, Wessel, & Hudson Kam, 2010), prior research has also demonstrated that immersive instruction in culturally unfamiliar music did not significantly improve memory among elementary students relative to music of their own culture (Morrison et al., 2012). In previous writings (Demorest & Morrison, 2003; Morrison & Demorest, 2009), we have hypothesized that listeners in an out-of-culture memory task may attempt to use in-culture schemata to organize culturally unfamiliar music rather than a new, more appropriate construct. This idea is supported by findings like those of Curtis and Bharucha (2009), who presented listeners with music stimuli that exploited their cultural biases, leading to incorrect recall responses for culturally unfamiliar music.

If our understandings of out-of-culture music are filtered through in-culture expectations, then a comparison of the statistical properties of a listener's home culture with that of an unfamiliar culture might yield predictive information about subsequent memory performance. The more different two cultures are in their melodic organization, the poorer one would expect a listener from either culture to perform on an out-of-culture memory task. Through corpus studies (Müllensiefen & Frieler, 2004; Pearce, Müllensiefen, & Wiggins, 2010; Pearce & Wiggins, 2006) researchers have begun developing algorithms to inductively extract statistical properties of melody and rhythm from large databases of musical material in a given culture. If these systems were applied cross-culturally they might allow us to compare melodic properties of two distinct cultures directly and draw inferences about listener performance. These differences in the statistical properties of melodies from two cultures might be thought of as the "cultural distance" between two musics (Demorest & Morrison, 2016). If such a distance can be quantified according to a particular inductive set of melodic statistics, it may yield insights into the implicit learning process of enculturation.

These results strongly support the idea that in-culture bias in music memory results from structural differences in the melodic properties of the music cultures under comparison, rather than from surface differences in tuning or timbre. If true, then previous cross-cultural findings suggesting cultural-general responses in areas like tonal hierarchy perception in Indian music might be reevaluated in terms of the degree of difference between the melodic properties of the chosen stimuli from each culture (Raman, 2013). The finding that in-culture memory performance was influenced by contextual changes is consistent with some previous work (Halpern & Müllensiefen, 2008; Morrison et al., 2008) and may provide further insights into the mechanisms of music memory and how such mechanisms reflect cultural (semantic) versus newly heard (episodic) melodic features.

The findings may also help music educators identify those cultures that might most easily be assimilated in a multi-cultural music curriculum based on their similarity to properties of the home culture. It is unclear what effect cultural similarity might have on the process of mastering the music of another culture, such as with bimusicality. It is possible that greater cultural similarity could create interference in the process of implicit or explicit learning of two cultures. Previous research on bimusicals (Wong et al., 2011) has found that such individuals may possess a different neural architecture for processing music. It would be interesting to explore how such architecture might be influenced by differences or similarities in the structural properties of the two cultures they have learned.

It would appear that enculturation, like other forms of implicit learning, comes down to pattern detection and subsequent prediction, processes laid out by expectancy theories of cognition (Huron, 2006). The application of statistical learning to implicit musical knowledge has been tested further by Pearce and Wiggins (2006). They used a statistical learning algorithm developed by Pearce (2005) as a computer model to mimic human expectancy judgments. The computer's performance was compared to human judgments from previous expectancy studies (Narmour, 1990; Schellenberg, 1997). The computer model based on statistical learning principles was significantly better at predicting human response than either of the theoretical models tested in the previous studies. These results support the proposition that statistical learning plays a role in the development of our implicit knowledge of music. Consequently, the process of music enculturation, like language acquisition, may best be explained by models that incorporate some form of statistical learning (Saffran, Aslin, & Newport, 1996; Saffran, Johnson, Aslin, & Newport, 1999). Future cross-cultural research in music cognition should, to the extent possible, identify the statistical properties of the musics under study as a means of explaining or predicting culturally biased responses.

Author Note

Correspondence concerning this article should be addressed to Steven M. Demorest, Henry and Leigh Bienen School of Music, Northwestern University, 70 Arts Circle Drive, Evanston, IL 60208-2405. E-mail: sdemorest@northwestern.edu

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Appendix. Source recordings for Stimuli

Western Excerpts

1. Concerto no. 12 in C minor for treble recorder, strings and basso continuo, by Alessandro Scarlatti in Baroque Recorder Concertos, EMI (1987). Mvmt. I – Moderato
2. Concerto for Cello in D, by Joseph Haydn in Cello Concertos, EMI (1976). Mvmt. II – Adagio
3. Trio Sonata in G minor, op. 2, no. 6, by Arcangelo Corelli in Corelli Trio Sonatas, Archiv (1986). Mvmt. I – Allemande

Turkish Excerpts

1. Saba Pesrevi by Osman Bey in Mevlana Dede Efendi Saba Ayini, 1996. Kalan Music: 42
2. Ussak Pesrevi by Nayi Osman Dede in Nayi Osman Dede Mevlana Ussak Mevlevi Rite, 2004. Çınar Music: Classical Turkish Music Collection 02
3. Dilkeside Pesrev by Neyzen Emin Yazici in Kani Karaca, Archive Series, 1999. Kalan Music: 147

To hear examples of the stimuli in monophonic and isochronous transformations please see the supplementary materials section at the online version of this paper.