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MUSICAL CHORD PREFERENCE: CULTURAL OR UNIVERSAL?

DATA FROM A NATIVE AMAZONIAN SOCIETY

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Abstract (338 words)

Purpose. Recent evidence suggests that when listening to Western music, subjects cross-culturally experience similar emotions. However, we do not know whether cross-cultural regularities in affect response to music also emerge when listening to the building blocks of Western music, such as major and minor chords. In Western music, major chords are associated with happiness, a basic pan-human emotion, but the relation has not been tested in a remote non-Western setting. Here we address this question by measuring the relation between *(i)* listening to major and minor chords in major and minor keys and *(ii)* self-reported happiness in a remote society of native Amazonian hunters, gatherers, and farmers in Bolivia (Tsimane').

Methods. 40 adults (women=20; men=20) were exposed to 4 music stimuli played in the same octave on a portable keyboard. Each subject heard one stimulus, which consisted of 3 pairs of classic tonic chords. Each pair of chords consisted of one major chord and one minor chord, both in the same key. Except for Do major, often associated with happiness, other keys were chosen to represent a sample of keys. The stimuli varied in key (Major: Do, La, Mi; Minor natural= Mi $^{\flat}$, Si, Fa) and chord order (e.g., major chord came first, then minor, or vice versa). After listening to each pair of chords, subjects were asked which made them happier.

Results. Without controlling for the subject's sex, we found no significant difference in affect after listening to major or minor chords, but after controlling for sex, we found that men had a greater propensity than women to associate major chords with happiness. Subjects were less likely to feel happy after listening to chords in the Do major key.

Conclusion. Results cast doubt on the universality of chord and key preferences because *(i)* men, who interact more with non-Tsimane' and have more access to Western musical conventions, were more likely to associate major chords with happiness and *(ii)* there was a negative relation between Do major (a key that evokes joy in Western music) and happiness.

Key words: major, minor, keys, Tsimane', Bolivia

> …[the minor third] is very soft, and it has something sad, and a tendency to go downward…this consonance, in slow movement, will serve well for words of sadness (Nicola Vicentino 1555; quoted in Lowinsky 1961: 91)

Introduction

Since at least the early sixteenth century, musicians and the lay public in Western societies have associated the major chords with feelings of happiness and the minor chords with feelings of sadness (Lowinsky 1961, p. 28, 68; Heinlein 1928; Hevner 1937; Meyer 1956; Turner and Huron 2008; Curtis and Bharucha 2010). Consistent with this, researchers have found that people from Western industrial nations ranked major triads as happier or more pleasant than minor triads (McDermott et al. 2010, p. 1036; Cook 2002, 2007; Pallesen et al. 2005) and that they were more likely to associate happiness with melodies in major keys (Krumhansl 1997; Peretz, Gagnon and Bouchard 1998; Flom, Gentile, and Pick 2008, p. 717; Scherer and Oshinksy 1977). Researchers have explained these musical preferences in terms of the physics of acoustics, the neural circuitry of the human brain (Tervaniemi and Brattico 2004; McDermott et al. 2008; Tramo et al. 2001), and socialization into the Western tonal system of music (Curtis and Bharucha 2009; Lundin 1947; McDermott et al. 2010; Krumhansl and Keil 1982). Empirical support for the acoustic and neurobiological roots of musical preferences comes from studies suggesting that some types of chord preferences (e.g., consonance versus dissonance) may already be present in infancy and early childhood (Trainor, Tsang, Cheung 2002; Trainer and Heinmiller 1998; Zenter and Kagan 1996) and that by the age of at least three, children in Western industrial nations may already associate happiness with major chords or with major keys and sadness with minor chords or with minor keys (Gregory et

al. 1996; Kastner and Crowder 1990; Curtis and Bharucha 2009; Flom, Gentile, and Pick 2008). Some of the clearest evidence supporting the role of socialization on musical preferences comes from studies suggesting that formal musical training and even inattentive listening to music influence preferences for harmony (Tillmann, Bharucha, and Bigan 2000; McDermott et al. 2010; Micheyl et al. 2006; Butler and Daston 1968; Catellano, Bharuch, and Krumhansl 1984: 411; Brattico et al. 2008). However, reviews of the cross-cultural evidence have found much variation in affect response to music (Juslin and Laukka 2003; Scherer et al. 2001), suggesting that the nature-nurture debate about chord preferences remains unresolved (McDermott et al. 2010; Krumhansl 2002).

Here we contribute to quantitative research on the universality of chord preferences with an experiment done during 15 consecutive days (June 29-July 13, 2010) in a native Amazonian society of hunters, gatherers, and farmers in Bolivia, the Tsimane'. The main aim of the study was to estimate the association between hearing major classic tonic chords or minor classic tonic chords and self-reported feelings of happiness while controlling for possible exposure to Western musical conventions. We focus on happiness rather than on other emotions because it is one of the basic human emotions, and one that has received much attention in studies of affect response to music (Scherer 2003; Juslin and Laukka 2003). Therefore, while the familiar Western dichotomy suggests a relationship between happiness and major keys on the one hand and sadness and minor keys on the other, this experiment directly addresses only the former relationship. Our approach avoids undue dependence on the polarity and mutual exclusivity of happiness and sadness, an emotional scheme that underlies the Western

discourse of affect response to major and minor modes, but that might not be necessarily valid across cultures.

Most cross-cultural quantitative studies on music preference come from Western industrial nations, or from people in developing nations with considerable access and exposure to radios and televisions, making it hard to disentangle the role of nature from the role of socialization in affect response to music since people may have already been exposed to Western music and to the feelings that composers aim to transmit. Recent years have seen pleas for *in-situ* cross-cultural, quantitative research on musical preferences, particularly before relatively isolated non-Western populations disappear or become fully exposed to the outside world (Curtis and Bharucha 2010; Fritz et al. 2009; Krumhal 2000). This article is a response to those pleas.

We know of only one quantitative study done *in situ* to assess musical preferences in a population that is relatively isolated from Western musical conventions. Fritz et al. (2009) recently reported the results of a study among the Mafa, an isolated ethnic group in Cameroon. They presented 13 men and 8 women 37-90 years of age with 42 piano music excerpts that varied in tempo, pitch range, tone density, and mode; the variations were designed to produce music excerpts that conveyed Western perceptions of sadness, happiness, or fear. After listening to each excerpt, subjects pointed to pictures of faces expressing the three emotions. Fritz et al. found that music that is considered happy by people in Western industrial societies was also associated with happiness by the Mafa. The Mafa recognized happy music above chance, and more accurately than sad music or than scary music. More importantly for our purposes, they found that subjects classified as happy most of the pieces in major keys; pieces in minor keys were more likely to be

classified as fearful. Further, subjects were more likely to classify as happy melodies with higher tempo, suggesting that emotional reactions to music also reflect psychophysical cues, such as rhythmic complexity, tempo, timbre, articulation, and pitch range.

The cross-cultural consistencies observed by Fritz et al. suggest that emotional responses to major and minor keys are not determined only by exposure to Western musical conventions, perhaps because humans process music through universal psychophysical cues (Balkwill and Thompson 1999; Gabrielsson and Juslin 1996; Scherer 1995, p. 238; Juslin and Laukka 2003, p. 796). Nonetheless, it is unclear from their study whether the operative units of affect are the intervals themselves, or whether the regularities are better explained by higher-order musical phenomena, such as tempo and composition (and perhaps performance). We do not know whether cross-cultural regularities in affect response to music extend down to buildings blocks of music such as intervals and chords, or whether they emerge in response to higher-order musical structures such as tempo, loudness, keys, pitch range, and melodies (Krumhansl 2002).

The population

The Tsimane' are a native society of hunter, gatherers, and farmers in the Bolivian Amazon. They number ~8,000 people and live in ~100 relatively isolated villages scattered along rivers, mostly in the department of Beni. The Tsimane' started to come into continual contact with Westerners during the 1950s, when Protestant and Catholic missionaries entered the area. The last four decades have seen increasing exposure to outsiders, such as traders, loggers, cattle ranchers, highland colonist farmers,

and government officials (Reyes-García et al. 2010). More Tsimane' now travel to nearby towns to buy commercial goods (e.g., clothing) or to sell forest goods or to sell farm crops. Two recent books (Huanca 2008; Ringhofer 2010) contain descriptions of the ethnography, history, and the geographic setting of the Tsimane'.

During the mid 1970s, Riester and Roeckl, an anthropologist and an ethnomusicologist, compiled 140 traditional songs from native Amazonians who had settled in a Catholic mission along the Maniqui River, in the Tsimane' territory (Riester 1978). The residents of the mission included several native Amazonian groups, such as the Tsimane', Mosetene, and Mojeño. Riester and Roeckl found that 74% of the songs they recorded dealt with traditional subsistence (e.g., songs to bring good luck in hunting). As part of our longitudinal study in progress with the Tsimane' (Leonard and Godoy 2008; http://www.tsimane.org), we have compiled over 100 traditional songs from the Tsimane', and have also found that most songs deal with utilitarian ends. For example, in many songs the singers ask guardian spirits of animals or plants to replenish wildlife. Less commonly, songs deal with love or recount what happened on trips.

In the past, shamans sang during rituals, but the transmission of these songs ended with the Protestant ban on shamanism. Today, many adults report having learned to sing from shamans; children today learn to sign from listening to adults sing, often when adults gather to drink. It is becoming more common to put on cassettes or to turn on radios with highland Andean music while drinking. Unaccompanied songs account for the largest share of music among the Tsimane', but in the past shamans played drums made from the skin of wild animals and flutes made from hollow reeds or from the bones of wild animals. We know of at least two Tsimane' men who have made wooden violins

and who play traditional Tsimane' songs while playing the violin. Exposure to the violins probably came from contact with neighboring ethnic groups. Some of the neighboring ethnic groups (e.g., Mojeño, Ignaciano) were exposed to the Jesuits missions during much of the colonial period, and it is possible that some Western musical conventions, including knowledge of how to make violins, diffused into the Tsimane' territory through these ethnic groups.

The last two decades have seen the diffusion of highland Andean music through the radio and cassettes into the Tsimane' territory. Of the 607 adults or people over 16 years of age interviewed in the 2007 longitudinal survey, 170 (28.01%) reported having a battery-operated radio. The share of households owning radios has increased from 49.72% during 2002 (the first year of the longitudinal study) to 61.60% during 2007 (the last year of the longitudinal study with clean data for public use). Assessing the impact of radio ownership on musical preferences is difficult because radios have countervailing effects. The figures just reported may overstate the impact of radios because some of the radios lacked batteries, or were broken. However, radios have spillover effects, since people can hear the radios of neighbors. At present, Tsimane' listen to commercial stations in Spanish and to the station of Protestant missionaries. The Protestant mission transmits daily radio programs in the Tsimane' language during three one-hour blocks of time during the morning (7-8am), noon (12-1pm), and evening (7-8 pm). The radio programs broadcast local news and religious hymns with Western harmonies.

Methods

Subjects

Study participants included 20 women and 20 men over 16 years of age (and younger if they headed a household). We selected 16 years as the cut-off age because Tsimane' typically set up independent households by that age. The mean age of the 20 women was 39.44 years (standard deviation [SD] = 22.38; range: 13-81) and the mean age of the 20 men was 42.45 years (SD=21.51; range: 15-90).

We wanted to collect all the data from only one village, Santa Maria, to control for community attributes (e.g., village-to-town distance), but the village did not have enough people over 16 years of age (n=34) or younger heads of households, so we tested the remaining six subjects in the nearby village of Maraca. Santa Maria and Maraca lie ~13 km apart. Both are along the Maniqui River and lie about 35 kilometers (km) in a straight line from the market town of San Borja. Depending on the conditions of the footpaths, the time of the year, and the pace, it takes ~2-4 hours to walk from Santa Maria to Maraca.

The two villages and the subjects were part of an ongoing longitudinal study that began in 1995. The study consists of annual socioeconomic surveys and anthropometric measures taken from ~1500 Tsimane' in ~ 300 households of 15 villages. The longitudinal study includes all the residents of the 15 villages. All the villages of the panel study lie along the Maniqui River and were selected to capture variation in proximity to San Borja. Of the 15 villages in the panel study, the two villages used for this study are among the most remote.

The study in the village of Santa Maria took place during a summer data collection training program for PhD students in cultural anthropology. The students who took part in the training program did not participate in the music study. Subjects did not receive compensation for participating in the music study, but did receive compensation at the end of the summer for taking part in the PhD training program. Women received wool, soap, a metal knife, sugar, and a topical medical ointment, and men received flashlight batteries, bullets, fishing line, fishing hooks, and a cigarette lighter.

Musical stimuli

Table 1 contains a summary of the four musical stimuli used and the sample size of subjects exposed to each stimulus. Each subject heard only one stimulus, which consisted of three pairs of classic tonic chords (hereafter chords). Each pair of chords was in the same key, and subjects heard chords either in three major keys (Do, La, Mi) or in three natural minor keys (Mi$^{\flat}$, Si, Fa) (hereafter minor key). Stimuli 1-2 were in major keys and stimuli 3-4 were in minor keys. All chords were played in the middle octave.

INSERT TABLE 1 ABOUT HERE

We limited the experiment to a total of six of the 24 keys to avoid burdening subjects with too many tasks. We selected three major and three minor keys because affect should respond differently to major and minor keys. Among the major keys or the minor keys, we arbitrarily selected three keys in each group (major or minor) since we are not aware of any study that has ranked keys by affect response. Among the three major keys we included one (Do major) that, in Western music, is known to be associated

with happiness. Among minor keys, we arbitrarily selected natural rather than harmonic or melodic minors. We avoided parallel minor keys to reduce overlap between major and minor keys.

The only difference between stimulus 1 and 2 or between stimulus 3 and 4 was the order in which we played the chords. In stimuli 1 and 3 we first played the major chords followed by the minor chords, and in stimuli 2 and 4 we first played the minor chords followed by the major chords.

To clarify how we executed the experiment, we next illustrate the procedure for subjects who heard stimulus 1. The ten subjects (five women, five men) exposed to stimulus 1 heard three pairs of chords in the following order. *First*, in the key of Do major, they heard the major tonic chord Do-Mi-Sol, followed by the minor tonic chord Do-Mi$^{\flat}$-Sol. *Second*, in the key of La major, they heard the major tonic chord La-Do$^{\#}$-Mi, followed by the minor tonic chord La-Do♮-Mi. *Last*, in the key of Mi major they heard the major tonic chord Mi-Sol$^{\#}$-Si, followed by the minor tonic chord Mi-Sol♮-Si.

We played the chords as arpeggios on a battery-operated, rubber keyboard (Model: Rollable Rubber Keyboard made by Cyber Gear). The keyboard has only two volume levels: low and high. Chords were always played at high volume. RG and a Tsimane' translator who had worked with the longitudinal study since its inception appeared in the home of subjects, took out the keyboard, and allowed subjects to play notes before the experiment. Most subjects had never heard about or seen a piano or a piano keyboard. After 45-60 minutes of casual conversation in which subjects explored the keyboard and played notes, we administered a short survey and then began the experiment. We dedicated 45-60 minutes to casual conversation so subjects would

become accustomed to the keyboard and focus their attention on the chords rather than on the keyboard itself.

Since subjects were part of the longitudinal study, we did not have to collect background information on them. However, we collected information that was highly time-specific, including their current self-reported general health (1=good or fair; 0=sick), and whether they had a functioning radio in the household at the time of the survey (1=yes; 0=no)[i]. We measured radio ownership because we wanted to control for intra-cultural variation in exposure and socialization to non-Tsimane' music. During the survey we noted the time of the day and the day of the week. The survey took about 2-3 minutes per subject.

After the survey, we played the three pair of chords[ii]. After playing one pair of chords, RG asked Tsimane' who could understand Spanish the following question in Spanish: "Which of the two chords makes you happier, the first chord or the second chord?" For monolingual speakers in Tsimane, the translator asked the same question, but in the Tsimane' language. The exact question in Tsimane' was: "Ju'ñis ra' ma'e'dye' anic mojo'cha' jima'joyin (jima'jotyin)," which translates as "Which sounds makes you happier, this [first chord] or this [second chord]". After the study ended we found out that the translator toward the end of the study had occasionally changed the wording of the question to "Which sound do you like more?" ("Ju'ñis ra' ma'e'dye' anic jämyi' coi' mi, oij, are' oyi").

We coded answers about the music stimuli as follow: 1 if the subjects said the major chord made them happy, and 0 if subjects said the minor chord made them happy.

In most cases, subjects answered immediately, but if subject did not answer, either because of shyness or because they could not make up their mind, we played the chords again until they selected one of the two chords. After subjects answered the first question, we played the second pair of chords and asked the same question. We then played the third pair of chords, asked the subject the question, and thanked them for participating in the study.

We remained in the subject's home for an additional 30-60 minutes talking with them about the keyboard and their traditional songs. Because we tried to minimize intrusiveness by doing the experiment in the subject's home, we sometimes had onlookers. Some of the onlookers were adult, some were members of the subject's households, and some were likely tested later. We did not code for the presence of others during the experiment, so we cannot assess whether the presence of others affected responses, but later we assess if having been exposed to the experiment as an onlooker might have affected the responses of onlookers tested later.

Results

We used Stata 10 for Windows for the statistical analysis. We present results in two stages. In the first stage we present descriptive statistics and results of bivariate regression analysis. In the second stage we report the results of multivariate regressions with chords as the unit of analysis.

Descriptive statistics and bivariate analysis

Figure 1 shows descriptive statistics of happiness in relation to the pair of chords heard. Since subjects were presented with three pairs of chords, answers about chord preferences could range from 0 (subjects said that the minor chords always made them happier) to 3 (subjects said that the major chords always made them happier). A number close to 3 indicates a strong association between happiness and major chords (consistent with Western affect response), and a value of 1.5 implies that the strength of the association between *(i)* happiness and major chords or between *(ii)* happiness and minor chords is the same.

INSERT FIGURE 1 ABOUT HERE

When we examine the pooled results of women and men combined, we find that subjects associate major and minor chords with happiness to roughly the same degree. 18 of the 40 subjects (45%) said that in two or three of the three pairs of chords, the major chords made them happier. Slightly over half (55%; n=22) of the subjects said that either the minor chords always made them feel happier (17.50%; n=7), or that in only one of the three pair of chords the major chord made them feel happier (37.50%; n=15). The pooled sampled had a mean score of 1.47 (SD=0.01). The value of 1.47 was not statistically different from 1.50 (one-sample t-test, p=0.87), suggesting that, on average, there was no statistical difference between happiness and listening to major chords or to minor chords.

We next assess whether chord preferences varied by the subject's sex. The analysis disaggregated by sex suggests that men were more likely to associate major chords with happiness, but results were not statistically significant. For example, six men (30%) but only two women (10%) said that the major chords always made them feel happier. Men had a mean score of 1.70 (SD=1.08) and women had a mean score of 1.25

(SD=0.91). The difference in scores between women and men was not statistically significant. A two-tailed t-test comparing the difference in the two means (0.45) yielded a p value of 0.162) ($F_{19,19}$=1.41, p=0.461; pooled variance t-test, t_{38}=1.42, p=0.162).

The results just presented could be biased by omitted variables linked with both happiness and with how subjects processed the music stimuli. For this reason, we next estimate if there was an association between chord preferences and variables such as access to radio, health, age, and survey date. As noted, researchers have pointed out that socialization into Western music might explain some of the variation in music preferences. To explore this question, we test whether ownership of a functioning radio affected chord preference. People who own a radio or who have access to a radio are more likely to be exposed to the outside world, not just by listening to radio music, but also by engaging in economic transactions with outsiders to acquire the money to buy the radio.

Health in an isolated, poor, rural setting might affect both emotions and audiological health. At least one study (Counter 1986) has shown that a very remote native Amazonian population in Suriname was afflicted by a variety of audiological health problems, that the range of audiological health problems was comparable to those found in Western populations, and that their hearing ability deteriorated with age. To control for the possible confounder of health we measured self-reported health. The control is not ideal both because it does not directly measure audiological health and because it relies on self reports. Unfortunately, we did not have trained technical personnel to carry out objective tests of audiological health.

We included self-reported age because hearing ability deteriorates with age and because older people might have been less exposed to Western music. The age variable likely has considerable random measurement error because the practice of knowing exact birth date was introduced by Westerners. As a result many people, particularly older people, guess when reporting their age (Emlen et al. 2010).

Recall that having been present as an onlooker in prior experiments may have affected the results later when the onlooker did the experiment. To address this concern we examine the association between survey date and chord preference. Survey date allows us to assess whether subjects who took part in the study later were more likely to prefer one type of chord, perhaps remembering that their peers had chosen those chords. Also, survey date allows us to control for some of the variation introduced later in the study from changes in the wording of questions.

The results shown in Table 2 suggest no statistically significant association at the 90% confidence interval or above between preference for major chords or minor chords and ***(a)*** access to radio (column A), ***(b)*** health (column B), ***(c)*** age (column C), or ***(d)*** survey date.

INSERT TABLE 2 ABOUT HERE

In sum, the results of the descriptive and bivariate analysis suggest no large or statistically significant difference between preference for major chord or minor chords ***(a)*** in the pooled sample of women and men combined, ***(b)*** between women and men, ***(c)*** between subjects with and without access to radio, and ***(d)*** between subjects in good or average health and subjects with poor health. There was also no significant association between chord preference and subject's age or survey date.

Results of multiple regressions

Table 3 contains the results of probit regressions with a dichotomous dependent variable and clustering by subject. Of the two pairs of chords heard in sequence, the dependent variable took the value of 1 if subjects associated the major chord with happiness and 0 if subjects associated the minor chord with happiness. To ease the interpretation of results, we report regression coefficients as marginal probabilities in response to marginal changes in the explanatory variables. For dichotomous explanatory variables (e.g., major chord=1; minor chord=0), the coefficient for the explanatory variable represents the change in the probability that the explanatory variable was associated with happiness as the value of the explanatory variable changed from 0 to 1. For continuous explanatory variables (e.g., age), the coefficients represent the change in the marginal probability that the major chord was associated with happiness for a unit change in the explanatory variable above the sample mean of the explanatory variable. For example, the coefficients for the variable *age* in Table 3 represent the change in the marginal probability that a subject would associate a major chord with happiness as the age of the subject increased by one year, from the mean age in the sample, 40.9 years, to 41.9 years.

INSERT TABLE 3 ABOUT HERE

We include two broad types of explanatory variables in Table 3. In section I of Table 3 we include attributes of the music stimuli, including the type of chord (*Major chord*: major chord=1; minor chord=0), the type of key (*Major key*: major key=1; minor key=0), the order in which we played the key (*Key order*: 1=first, 2=second, 3=third), and dummy variables for each of the specific keys played, with Fa minor arbitrarily

selected as the excluded category. The choice of the excluded category did not affect results. In section II we include attributes of the subject, including sex (*Women*=1; men=0), *radio* access (1=yes; 0=no), *health* (1=good/ok; 0=ill), *age* in years, and the *date* of the survey. The words in italics in this paragraph are the name of the variables as they appear in Table 3.

The first row of section I suggests that subjects who listened to major or minor chords were equally likely to associate either type of chord with happiness. Column [a], the most naïve estimate, suggests that simply listening to the major chord (without including any control variables) was associated with a 1.66% lower probability of associating the chord with happiness compared with listening to the minor chord, but the result was statistically insignificant (p=0.876) . The results of column [b], first row of section I, suggest that the probability did not change after conditioning for the type of key or for the order in which we played the key. After controlling for attributes of the subject (column [c]), first row of section I, we find that the association between listening to a major chord and happiness became even more insignificant. The probability declined to 0.53% (p=0.961). The results of the multivariate analysis are consistent with the results of the descriptive and bivariate analysis presented earlier suggesting no significant difference in self-reports feelings of happiness after listening to major chords or minor chords.

In columns [d]-[e] we include dummy variables for each key, with (column [e]) and without (column [d]) controls for the attributes of the subject. Recall that in Western music both major chords and major keys are associated with happiness. The binary variable *Major key* (section I, second row) might be too gross and might mask

heterogeneity in how people responded to specific keys. The results of column [d] suggest that, on average, listening to chords in the key of *Do major* was associated with a 28.91% lower probability of reporting feelings of happiness (p=0.062), compared with listening to chords in the key of *Fa minor*. After controlling for the attributes of the subject, the probability increased slightly to 30.85% and became slightly less significant (p=0.066).

The results of section II, suggest that among subject's attributes, only the subject's sex bore a significant association with feelings of happiness. The results of column [c] suggest that, on average, women were 23.37% less likely than men to associate major chords with happiness (p=0.061). This probability remained almost unchanged after controlling for specific keys (column [e]). The new probability was -23.55% (p=0.074).

Caveats and limitations

Caveats and limitations fall under two rubrics: those dealing with the design of the experiment and those dealing with its execution.

Design: First, the major chords and the minor chords shared the first and fifth notes, and differed only by the third note; the third note changed by only a half-step (semitone) to produce the major chord or the minor chord. Perhaps a semitone change is too small to have an effect on how people relate the chords to happiness (McDermott and Oxenham 2008, p.454), though this is the claim made about affect response in Western music, as some researchers cited in the introduction have noted. The difference in the sounds between major and minor chords in the same key may have been more noticeable if the

major and the minor chords did not share a root. For example, against the major chord Do-Mi-Sol in Do major, one could have played the minor chord Re-Fa-La, rather than Do-Mi$^{\flat}$-Sol (the minor chord we actually played). Further, exposure to Western music theory and conventions may prepare us to discuss relations between particular tones independent of their appearance in a melody or performance. Thus, the treatment of these relations as autonomous objects that can be meaningful on their own is likely the product of years of formal and informal socialization into the discourse and theoretical traditions of Western music theory. All this said, the current study at least allows us to assess if small changes in tone to produce major chords or minor chords are associated with happiness.

A second limitation has to do with the selection of keys. We selected six of 24 keys, and it is possible that the keys we used did not capture the extremes of happiness in Western music. This may have been true for some of the keys chosen, but not for others. For instance, we selected the keys of Do major and Fa minor, two sharply contrasting keys in affect response in Western music. It is interesting that the only key to have a statistically significant association with happiness was Do major, but the coefficient for the variable *Do major* had an unexpected sign – it was associated with a lower probability of reporting happiness. In sum, there is some truth to the fact that other keys (e.g., La major) might have produced stronger results, but we partially addressed this concern by selecting a key, Do major, which often conveys joy in Western music.

A third limitation has to do with the question asked or with how we elicited data on happiness. As Scherer (2004) notes, music may not impact a person's affect but might still be considered happy. Perhaps the use of facial pictures conveying different

intensities of smiles or happiness would have produced sharper results. Further, if chords elicited many different emotions, not just happiness, and if some of these emotions were more salient than happiness, then our forcing subjects into the "corset" of having to rank chords only by happiness may have confused subjects and induced them to guess (Scherer 2004; Juslin and Laukka 2003, p. 204). All these issues would have introduced random measurement error into the outcome variable. This problem would have been present even if we had asked subjects about happiness or asked them to point to pictures best conveying the emotion. However, changing the wording of questions or the format to elicit questions might not yield different results if people in non-Western settings find it hard to distinguish between major and minor chords owing to their socialization into a different musical tradition.

Execution: Despite our attempts to minimize distraction with the keyboard during the test, some subjects may have been unable to give us their undivided attention during the test, and may have guessed when reporting happiness. This would introduce more random measurement error in the outcome because attention affects the processing of sounds (Loui and Wessel 2007). Random measurement error in the outcome should not affect mean values of descriptive statistics, but weakens the statistical results of regressions.

A second limitation related to execution has to do with how we played the music. For practical reasons, we could not pre-record chords, which would have ensured that all subjects heard the same stimulus. The execution of arpeggios between subjects may have varied in speed. Although we set the volume in the keyboard to "high", there may have been some variation in the volume due to variation in the distance between the subjects

and the keyboard. Arpeggios likely convey emotions not only through the notes themselves, but also through psychophysical cues, such as tempo (Balkwill and Thompson 1999; Gabrielsson and Juslin 1996; Juslin and Laukka 2003), so variation in performance might have affected emotional reactions to the chords. However, the amount of measurement error we could have introduced from variation in performance is likely small since arpeggios of only three notes in the same keyboard do not leave much room to introduce psychophysical cues (e.g., complexity, dynamics, timber), and variation in volume was likely small since we placed the keyboard in front of the subject.

Discussion and conclusion

We organize the discussion around three topics: ***(a)*** main findings and potential explanations, ***(b)*** comparison with other studies, and **(c)** implications for the cross-cultural understanding of music cognition. We conclude with suggestions for future research.

(a) Main findings and potential explanations. We found: ***(1)*** that in the pooled sample of women and men combined (without controlling for the subject's sex) listening to major chords and to minor chords produced no significant difference in affect response, ***(2)*** that women had a lower tendency than men to associate major chords with happiness, and ***(3)*** that subjects were less likely to associate happiness with the key of Do major. The results raise questions about the universality of musical preferences when examined at the level of the chord. In addition to the technical reasons discussed earlier, there may be substantive reasons why major and minor chords bore no strong association with happiness. We next present two potential explanations for the finding.

First, the ability of Tsimane' people to interpret abstract musical phenomena may differ from that of Western populations. Tsimane' may have been socialized into a different musical idiom that has little to do with harmonic progression or with major and minor keys (Jackendoff and Lerdahl 2006)[iii]. This explanation finds support in the cross-cultural literature stressing the different dimensions around which cultures organize their music, including melody, pitch, rhythm, and timbre (Castellano, Bharucha, and Krumhansl 1984; Jackendoff and Lerdahl 2005). Unfortunately, our limited ethnographic and ethno-musicological understanding of Tsimane' music does not permit us to address these issues fully.

Second, the hearing of Tsimane' may differ due to health reasons, not just due to socialization into a different musical tradition. Poor general health, particularly problems associated with hearing, may prevent subjects from distinguishing small tonal differences. In other studies we have documented the poor health of Tsimane', including absence of a secular improvement in adult height (Godoy et al. 2008), widespread parasitism (Tanner et al. 2009), and growth stunting (McDade et al. 2008). It is possible that poor health might have hindered the subjects' ability to distinguish between chords. Put differently, if Tsimane' in fact associated major chords with happiness, but their poor health prevented them from distinguish between major and minor tonic chords in the same key, they may have guessed when pressed to select a chord.

The greater propensity of men (compared with women) to associate major chords with happiness probably reflects socialization into the Western musical tradition and the traditional sexual division of musical training in Tsimane' society. In part because of their greater fluency speaking Spanish, Bolivia's national language, men are more likely

to travel to town, or to work for loggers, ranchers, or traders and become exposed to Western music. Furthermore, because they are more likely to earn money, men are also more likely to own radios and listen to music, either in the village or when they travel to town, ranches, or to logging camps. We used the 2002-2007 longitudinal data to run a bivariate probit regression with ownership of a radio as a dichotomous outcome variable and the subject's sex as an explanatory variable and found that, compared with women, being a men was associated with a 35.40% greater probability of owning a radio ($p=0.001$; $n=3683$). The longitudinal data suggests that adult men ($n=398$) had twice as much schooling (mean=3.22 years; SD=3.23) as adult women ($n=375$; mean=1.57; SD=1.79); the difference in mean education was statistically significant at the 1% level. Over half (59.84%; $n=244$) of adult men but only 15.73% ($n=39$) of adult women were fluent in Spanish. Taken together all these data from the longitudinal study suggest that men are more exposed to the rest of the world and socialized into national values. Besides socialization, men probably have greater socialization into music than women. Even in the past, most shamans were men and they were the main performers of traditional instruments. Most of the songs we and others have compiled of traditional Tsimane' songs involve mostly men singing. So the two factors combined – a stronger role in the performance of traditional music and greater exposure to Western musical conventions – might explain why men differed from women in their answers about chord preferences.

The two main findings discussed so far – the absence of a strong link between chord type and affect response when we do not control for the subject's sex, and the greater propensity for men to associate major chords with happiness – are both partially

explainable by the low general levels of socialization of the Tsimane' into the Western musical tradition and by the greater relative socialization of men compared with women into the values of Bolivia's national society. The third finding, the negative association between the key of Do major and happiness presents a puzzle to which we advance one explanation. Perhaps chords in the Fa minor key among the Tsimane' elicit a greater sense of peace, beauty, and contentment than chords in the other keys; if these emotions are also positively associated with happiness, then the greater propensity to associate chords in the Fa minor key with happiness (or the lower propensity to associate chords in the Do major key with happiness) might capture the role of these unmeasured emotions. This explanation is in accord with Scherer's (1995, p. 241) observation that music stimulus might not impact affect in a discrete way, but might influence a blend of emotions.

(b). Comparison with other studies. Quantitative cross-cultural studies of music cognition in relatively isolated non-Western sites by Krumhansl et al (1995, 1999, 2000, 2002) have found that musical expectations reflect universal principles of perceptual organization. After listening to melodies that stopped in the middle of a phrase, listeners had to indicate the tone that best fit their musical expectation of what should have come next. Krumhansl et al. found small differences in results between cultures, suggesting that psychological principle of expectation may be universal, but they also found that results varied by the musical style and by the level of musical training, suggesting that musical expectations might reflect both universal cognitive processes and socialization.

We know of only one study that tried to assess the universality of musical intervals (Butler and Daston 1968). Butler and Daston presented undergraduate students

in the USA and Japan with 12 dyads of a diatonic scale, and asked subjects which of the two dyads they preferred. Some of the students had musical training and were considered experts. Butler and Daston found high correlation in the ranking of dyads between undergraduate students and undergraduate experts, and no difference in preference between students in Japan and the USA. They concluded that preference for consonance was universal, but ignored that similarities in preferences might have reflected common exposure to the same musical culture, as Fritz et al. (2009) have pointed out. Further, their results are hard to interpret since "preference" could capture many emotions. For example, Japanese subjects may have preferred some dyads because they associated them with calmness, whereas USA subjects may have preferred the same dyads because they associated them with happiness.

(c). Implications for the cross-cultural understanding of music cognition. The broad aim of this study was to explore the universality of affect response to music. In particular, we wanted to build on the research of Fritz et al. (2009) and attempt to identify regularities in affect response at lower levels of musical structure, while controlling for individual or intra-cultural exposure to Western (or outside) musical conventions. The results suggest that the distinction between major chords and minor chords, one of the major building blocks of musical structure in the Western tradition, may not be associated with happiness across cultures. Cross-cultural regularities in affect response to music may more likely emerge at the level of higher-order musical structures, such as melody (Fritz et al. 2009) that vary along psychophysical cues (Balkwill and Thompson 1999). But before moving on to some of the higher-order structures, it is important to note that we found support for the idea that preference for musical chords may be learned.

Tsimane' men, who are typically more exposed to the rest of the world than Tsimane' women, were more likely to associate major chords with happiness. In sum, the association between happiness and major intervals may not be universal but may be acquired through exposure to Western music.

We close with some suggestions for future research on cross-cultural music cognition, and with a commentary on the future of quantitative cross-cultural studies of music cognition.

Future cross-cultural studies of music cognition should control for hearing ability or, more broadly, for health, since health may affect both mood and the ability to hear or differentiate sounds. In university laboratories of Western industrial nations, one can ignore hearing ability since one can assume that undergraduates are in good health, but this assumption may require reappraisal in isolated settings of the non-Western world. Future studies should also include children and teenagers to estimate life-cycle and secular changes in musical preference. Before discarding the idea that the link between chord preference and emotions may not be universal, one should expand the type of study done here with: ***(a)*** a greater range of major keys and minor keys, ***(b)*** more variation in the types of major and minor chords within and across keys, ***(c)*** greater variation in timbral classes to elicit affect (including perhaps Andean musical instruments, with which Tsimane' are more likely to be familiar than with a portable keyboard), and ***(d)*** greater attention to how one elicits information about emotions (Sherer 1995, 2004; Juslin and Laukka 2003, p. 804).

Except for the study by Fritz et al. (2009) and the studies on musical expectation by Krumhansl et al. (1995, 1999, 2000), most of the cross-cultural quantitative studies on

music cognition among isolated non-Western populations have not been done *in situ*. We know relatively little about the affect response to music of people who have not been exposed to Western music, and whether there are cross-cultural patterns in emotional reactions to music. We suspect the gap arises from disciplinary parochialism. Researchers who conduct quantitative studies on music perception tend to be psychologists, neuroscientists, or human biologists, and they typically do not carry out fieldwork in remote settings. On the other hand, ethnomusicologists understand the musical constructs of different cultures from long-term fieldwork in remote settings, but they rarely employ a quantitative approach to hypothesis testing. Quite aside for the substantive contribution this article might make, we hope it contributes to bridging the disciplinary divide.

TABLE 1. Summary of experimental research design: Stimuli (classic tonic chords) played to adult Tsimane' (one stimulus/subjects)

Stimuli	Key and order in which key played		Order in which chord played:		Number of subjects:	
			First	Second	Women	Men
[a]	[b]	[c]	[d]	[e]	[f]	[g]
1	Major	1. Do	Do^{Δ}	Do^{-}	5	5
		2. La	La^{Δ}	La^{-}		
		3. Mi	Mi^{Δ}	Mi^{-}		
2	Major	1. Do	Do^{-}	Do^{Δ}	5	5
		2. La	La^{-}	La^{Δ}		
		3. Mi	Mi^{-}	Mi^{Δ}		
3	Minor natural	1. Mi ^{b}	Mi^{Δ}	Mi^{-}	5	5
		2. Si	Si^{Δ}	Si^{-}		
		3. Fa	Fa^{Δ}	Fa^{-}		
4	Minor natural	1. Mi ^{b}	Mi^{-}	Mi^{Δ}	5	5
		2. Si	Si^{-}	Si^{Δ}		
		3. Fa	Fa^{-}	Fa^{Δ}		
Total number of subjects:					20	20

TABLE 2. Comparison of preference for major classic tonic chords by radio ownership, health, age, and survey date among adult Tsimane' women and men, Bolivia, 2010

Score in preference for major chords:	Radio access		Health		Age	Survey date
	Yes	No	Good/ok	Ill		
	[A]		**[B]**		**[C]**	**[D]**
N	23	17	23	17	40	40
Mean	1.39	1.58	1.39	1.58	36.57	6.85
Standard deviation	1.07	0.93	1.03	1.00	19.21	3.57
Statistic	$F_{16,22}$=0.76 (p=0.58)		$F_{16,22}$=0.94 (p=0.92)		β=0.004 (p=0.58)	β=0.082 (p=0.11)
	T_{38}=0.60 (p=0.55)		T_{38}=0.60 (p=0.55)			

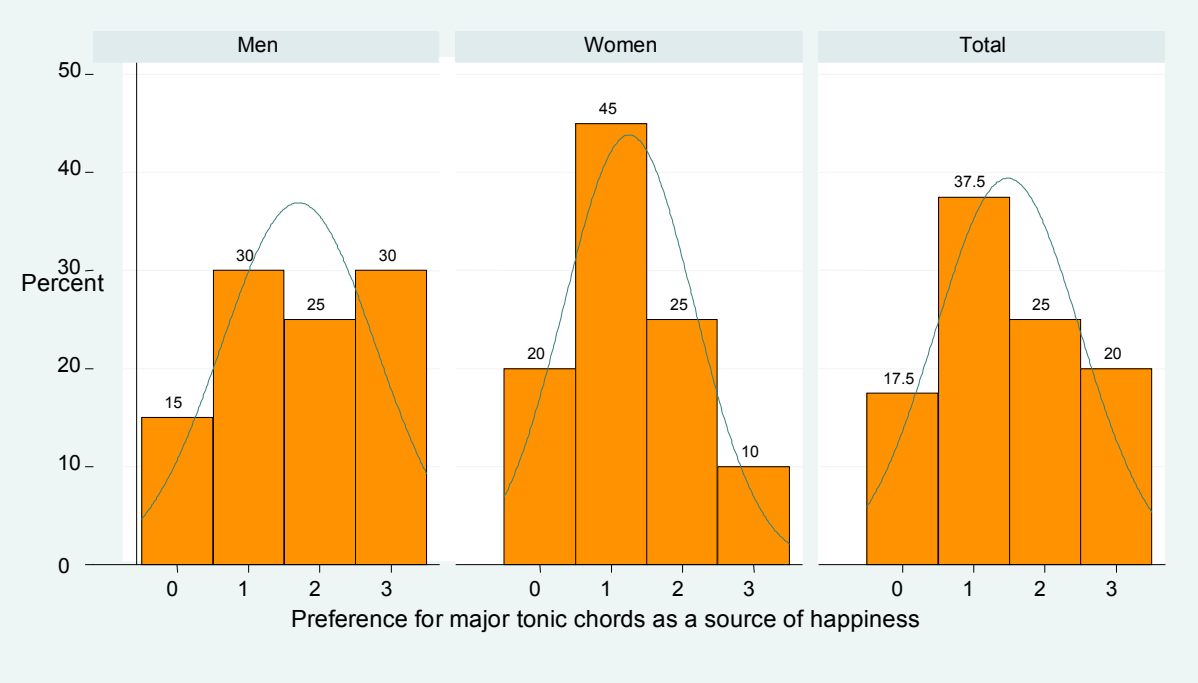
Notes: In column [A]-[B] we assess whether the difference in the mean scores between two groups for column [A] or column [B] was statistically significant at the 90% confidence interval or higher. For columns [C]-[D] we use ordinary-least squares regressions (OLS), with the score as the outcome variable; explanatory variables include either age (column C) or survey date (column D).

TABLE 3. Association between ***(a)*** self-reported happiness (outcome variable) and ***(b)*** attributes of the music stimuli and the subjects (explanatory variables) among adult Tsimane', Bolivia, 2010: Results of probit regressions (marginal effects) with robust standard errors and clustering by subject (n=120)

Explanatory variables:	Dependent variable self reported happiness: 1=major chord made subject feel happy; 0=minor chord made subject feel happy				
	[a]	**[b]**	**[c]**	**[d]**	**[e]**
[I]. Attributes of music stimuli:					
Major chord: 1=major; 0=minor	-0.016	-0.016	0.014	^	^
Major key: 1=major; 0=minor	^	-0.084	-0.096	^	^
Key order : order in which keys played (1=first, 2=2nd, 3=3rd)	^	0.063	0.066	^	^
Keys (*Fa minor* excluded category):					
La major	^	^	^	-0.151	-0.158
Mi major	^	^	^	-0.151	-0.159
Si minor	^	^	^	-0.243	-0.246
Mi b minor	^	^	^	-0.102	-0.102
Do major	^	^	^	**-0.289***	**-0.308***
[II]. Subject's attributes:					
Sex (*Women*=1; men=0)	^	^	**-0.233***	^	**-0.235***
Radio access (1=yes; 0=no	^	^	-0.107	^	-0.105
Health (1=good/ok; 0=ill)	^	^	-0.197	^	-0.196
Age in years	^	^	-0.0001	^	-0.0001
Date of survey	^	^	0.016	^	0.017
Pseudo R square	0.0002	0.0128	0.0512	0.0278	0.0668

Notes: ^ = variable intentionally left out. * significant at 10% level. For binary explanatory variables, coefficients represent the probability of being happy from a discrete change in the variable. The coefficient for the age variable represents the marginal probability of being happy for a one year increase in age over the mean age of the sample (40.9 years). The variables for specific keys are binary, with the name of the variable as the +1 category, and zero for all other keys. For example, the variable for *La major*=1 if the chords were in the key of La major, and zero for chords in all other keys.

FIGURE 1. Comparison of preference for major classic tonic chords as a source of self-reported happiness between adult Tsimane' women and men, Bolivia, 2010



Notes: Subjects heard three pairs of classic tonic chords. Each pair had one major chord and one minor chord, both chords in pair were in the same key. For each pair of chords heard, subjects had to say which of the two chords made them happier. Possible scores ranged from zero (subjects always said minor chord made them happier) to three (in response to each of the three pair of chords, subjects said the major chord always made them happier).

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[i] During the annual surveys, we asked about the total quantity of different assets owned by the subject (e.g., radios, bows), but do not ask about the current status of the asset, so we cannot tell from the longitudinal data whether radios work. However, in this study of musical preferences we did ask subjects if their radio was working at the moment of the interview.

[ii] Audio examples of the chords used in this study but played on a regular piano can be found at the following web site under the year 2010 and the title of this paper: http://tsimane.org/research/pgs/workingpapers.html. The chords played in the audio example correspond to the four stimuli of the first column of Table 1.

[iii] We can probably rule out the idea that Tsimane' are unfamiliar with chords because their main instruments (flute, drums) or singing do not allow them to play several notes simultaneously. Recall that we played the chords as arpeggios.