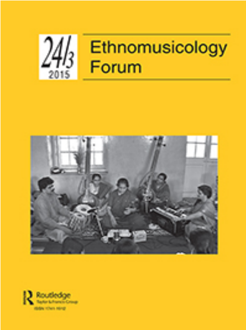

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Understanding the cultural and genetic origins of the Ainu of northern Japan has important implications for understanding the history of the Japanese archipelago. Ethnomusicologists have tended to emphasise connections between Ainu music and a 'circumpolar' culture area. However, the 'dual structure' model from physical anthropology describes the Ainu as descendants of the first inhabitants of Japan with minimal circumpolar influence. To examine Ainu musical diversity empirically from a comparative perspective, we analysed 680 traditional songs from two Ainu and 33 surrounding East Asian and circumpolar populations. The Ainu repertoire contained a majority (~50%) of unique stylistic song-types and lower frequencies of types shared with circumpolar (~40%) and East Asian (~10%) populations. These frequencies were similar to the corresponding frequencies of mitochondrial DNA types within the Ainu gene pool (~50%, ~30% and ~20%, respectively), consistent with an emerging 'triple structure' model of Japanese archipelago history.

Keywords: Music; Genes; Dual Structure; Triple Structure; Ainu; Circumpolar

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Introduction

Genes and languages have provided powerful tools for studying human biological and cultural history, but a fuller picture of human history requires the integration of other markers (Cavalli-Sforza, Menozzi and Piazza 1994; Diamond and Bellwood 2003). There are several reasons why music may provide a useful supplement in understanding human history (for a review see Savage and Brown 2013). Music is a universal but highly diverse aspect of culture that shows both similarities and differences with language (Feld and Fox 1994; Patel 2008; Wallin, Merker and Brown 2000). Comparative musicologists and ethnomusicologists have long proposed that peoples and their musics share deep and complexly interwoven histories (Nettl 2015). Recently, new quantitative evidence has emerged of correlations between musical and genetic diversity, suggesting that music may be preserving ancient connections in the order of thousands of years or more (Callaway 2007; Pamjav et al. 2012). One such study (Brown et al. 2014) found that music and language were both significantly correlated with genes but not with one another, suggesting that music and language can capture at least partially independent aspects of human history. Furthermore, music can move independently of both genes and languages, and such dissociations may capture important information about historical interactions, such as those involving trade, religion, colonialism and/or globalisation.

The idea that music might preserve traces of ancient human history was explored most comprehensively in Alan Lomax's (1968, 1976, 1980, 1989) Cantometrics Project. Initially, Lomax's proposals relating music and human history were overshadowed by controversy over his causal interpretation of correlations between singing style and social structure (e.g., sexual sanctions being reflected in nasal singing; for overviews see Averill 2003; Dubinskas 1983; Wood 2008). However, there has recently been renewed interest in reviving and refining the methods and goals of Cantometrics to revisit questions of music and human history by integrating advances in genetic anthropology.

Cantometrics' co-creator Victor Grauer (2006, 2011) has argued that the global distribution of specific stylistic acoustic features coded by Cantometrics (e.g., vocal interlock) matches the proposed dispersal of anatomically modern humans out of Africa ~50,000 years ago. On a regional scale, ethnomusicologists such as Nattiez (1999) and Keeling (2012) have argued that the distribution of certain musical features (e.g., throat-rasping, animal imitation songs) match proposed dispersals of humans from Siberia across the Bering Strait to the Americas some time after the last glacial maximum that occurred ~15,000 years ago. These qualitative approaches allow for sophisticated and complex musical analyses, but at the cost of subjectivity of analysis and sample selection, because the reader must take the word of these authors that the features and examples they have presented to make their case are representative of broader trends in the repertoire, and are not simply a subset that has been cherry-picked to match existing genetic knowledge (Leroi and Swire 2006; Stock 2006).

In contrast, several recent scientific projects have attempted more quantitative approaches to directly compare musical and genetic diversity. One study compared matching Cantometric musical data and autosomal genetic data from 39 populations in Africa (Callaway 2007). Another compared musical data from Cantometrics and a closely related scheme, CantoCore (discussed later), with mitochondrial DNA (mtDNA) from nine indigenous populations in Taiwan (Brown et al. 2014). A third study compared musical data based on an automated contour analysis of musical transcriptions with mitochondrial and Y-chromosome data from ∼30 Eurasian and North American populations (Pamjav et al. 2012). Each of these studies used slightly different methods of statistical analysis, but all argued that the substantial correspondence between musical and genetic diversity reflected the preservation of shared musical and genetic histories over long spans of time.[1] These quantitative studies using standardised sets of features and samples provide more rigorous evidence of a relationship between music and genetic history than the qualitative studies mentioned earlier.[2] However, because these studies compared average trends across entire repertoires, they are unable to explore the same kinds of musically nuanced comparisons in which specific songs or genres can be linked with different historical influences.

Recently, Savage and Brown (2014) proposed a method of musical cluster analysis that attempts to combine the precision of the quantitative methods with the song-level focus of qualitative approaches. This method allows broad cross-cultural quantitative comparison without assuming that a given musical culture can be represented by a single 'favoured song style'—a highly criticised assumption of the original Cantometrics Project (Henry 1976; Rzeszutek, Savage and Brown 2012). Applying this technique to the same Taiwanese musical dataset analysed by Brown et al. (2014), they were able to group each song into one of five different 'cantogroups' (i.e., stylistic song-types) and map the regional distribution of these cantogroups throughout Taiwan. However, quantitative techniques are most effective when used to test and extend nuanced hypotheses built from qualitative intuitions. While there were pre-existing hypotheses about the genetic and linguistic origins of Taiwanese populations, there were no clear pre-existing theories about their musical origins. In contrast, our current study chooses a specific culture—the Ainu of northern Japan—who have been the subject of a number of musicological and genetic studies. This allows us to quantitatively test these musical proposals, as well as to compare them with existing genetic data.

[1]None of the authors argued for a causal connection, and neither do we (i.e., there is no suggestion that these correlations reflect 'genes for music').

[2]Of course, these quantitative studies are still only partially objective because they are based on data from classifications or transcriptions that were done by ear (a situation analogous to the use of cognate data based on expert judgments in quantitative linguistic studies). Their reliability is thus imperfect, although the limited empirical testing published thus far has shown acceptable levels of inter-rater reliability (List 1974; Lomax 1976; Savage et al. 2012). Fully objective automated music analysis of audio recordings remains prohibitively difficult, particularly for non-western music (Tzanetakis et al. 2007), and even then sample selection remains inherently subjective on some level.

Ainu Music and the Circumpolar Region

A number of scholars have noted possible ancient connections between the Ainu and a 'circumpolar music culture' (Keeling 2012; Malm 1967; Nattiez 1983, 1999; Tanimoto 2000, 2001a) encircling the Arctic from the Saami in Arctic Europe to the Inuit in Greenland. The most striking example is the throat-rasping genre shared between the Ainu (Figure 1), Siberian populations (e.g., Chukchi) and the Canadian Inuit, but other genres include animal imitation songs and shamanic drumming. In the Cantometrics Project (still the only quantitative attempt to characterise Ainu music to date), Lomax grouped the Ainu as part of a 'Siberian' song-style area characterised by 'guttural, raspy, punchy, slurred, nonsense-syllable kind of soloizing in extremely uneven phrases' (Lomax 1976: 38). In this group he included not only the Ainu and most indigenous Siberian populations, but also the Saami of Arctic Europe and several indigenous populations of the Americas.

In contrast, research in physical anthropology and linguistics has tended to emphasise links between the Ainu and the other inhabitants of the Japanese archipelago, rather than any circumpolar connections.[3] Early theories proposing that the Ainu were a lost Caucasoid group (Bickmore 1868) have now generally been rejected in favour of Hanihara's (1991) 'dual structure' model. This model proposes that the major populations of the Japanese archipelago—Ainu, Ryukyu (Okinawan) and mainland Japanese—all originated from two primary sources: the original hunter-gatherer inhabitants, who were already making distinctive 'Jomon' pottery at least 15,000 years ago; and a later wave of 'Yayoi' agriculturalist immigrants from mainland East Asia beginning ~3000 years ago. The Ainu are proposed to be relatively pure descendants of the Jomon, while the Ryukyu and mainland Japanese are proposed to have experienced substantial admixture between the Yayoi and Jomon, with the Ryukyu having relatively more Jomon ancestry and thus being more similar to the Ainu than are the mainland Japanese, despite the geographic separation between the Ryukyu and the Ainu. Most genetic studies have supported the general assertion of the dual structure model that the Ainu are most closely related to the other populations of the Japanese archipelago, particularly the Ryukyu (Hudson 1999; Japanese Archipelago Human Population Genetics Consortium [JAHPGC] 2012; Koganebuchi et al. 2012; Matsukusa et al. 2010; Omoto and Saitou 1997).

To our knowledge, no contemporary genetic studies support a purely circumpolar origin of the Ainu. Hanihara in fact explicitly rejected a circumpolar contribution to Ainu genetic history:

> The view of Kiyono that the intermixture between Jomonese and north Asians gave rise to the present-day Ainu is not acceptable because Ainu show almost none of the north Asian characteristics found in the people of the extremely cold north. (Hanihara 1991: 22)

[3]The history of research on Ainu origins is inextricably linked with the political history of Japanese nationalism. Interested readers can refer to book-length treatments by Hudson (1999) and Hudson et al. (2014).

Figure 1 Photograph of two Ainu musicians, Ogasawara Sayo (left) and Ehara Utae (right), performing *rekuhkara* throat-rasping games. *Source*: Patrick E. Savage, 2013; still image from a video available online. http://youtu.be/3ijAaLHBi18.

However, some genetic studies have in fact suggested some degree of northern influence on the Ainu (Adachi et al. 2011; Sato et al. 2009; Tajima et al. 2004). This evidence of northern influence has yet to be formally integrated into an alternative to the dual structure model.

With regard to languages, Greenberg (2000–02) proposed that the Ainu language is most closely related to Japanese and Korean. This proposal is less widely accepted than the dual structure model, but Ainu is generally viewed as not closely related to circumpolar languages. The most widely accepted classification of Ainu is as a linguistic isolate (Lewis 2009) that may be descended from one spoken by the Jomon-era hunter-gatherers (Hudson 1999).

Thus, if the characterisation of Ainu music as being predominantly circumpolar is correct, this would imply either that geneticists and linguists have underestimated the degree of circumpolar influence on the Ainu, or that the diffusion of music between Siberia and the Ainu occurred on a large scale, mostly independently of human migration.[4] If incorrect, it could imply that patterns of Ainu musical diversity do in fact match those of genetic and linguistic diversity. In either case, this would have important theoretical implications for understanding the history of the Japanese archipelago. Our goal was to quantitatively re-examine Ainu musical diversity by analysing musical samples from Ainu and surrounding East Asian and circumpolar populations.

[4]Convergent evolution is also a possibility—cold environments might conceivably lead to the independent adoption of similar singing styles.

By using new methods, we aimed to estimate the relative frequencies of different song-types within populations and to compare these with published genetic data.

Song Sample

To better understand Ainu musical diversity from a comparative perspective, we assembled recordings of 680 traditional folk songs from 35 populations.[5] Table 1 presents the population names, number of songs per population and recording source for each population. Although the current study focuses primarily on music, the musical sample was selected as part of a larger project with the eventual aim of directly comparing patterns of musical and genetic diversity in populations relevant to understanding the history of the Japanese archipelago. Thus, our primary goal was to find as broad a sample as possible of traditional songs from many populations that also had matching genetic data already published.

Rather than using many different smaller recording projects carried out by different groups at different times with different goals and varying quality, we aimed to use a small number of large-scale, high-quality recording projects to make the sample as amenable as possible to comparison. There were two recording projects that clearly provided the most comprehensive coverage of the Japanese archipelago and circumpolar populations. Both projects were coordinated across large geographic regions, including all traditional folk song genres from a number of different populations.[6] The first was a massive nationwide survey begun by Nippon Hōsō Kyōkai (NHK) in the 1940s and continuing through the 1970s involving leading ethnomusicologists, such as Machida Kashō, Koizumi Fumio and Tanimoto Kazuyuki (NHK 1944–94, 1951, 1965).[7] This included songs from the Ryukyu Islands, mainland Japan, Hokkaido Ainu and Sakhalin Ainu who had recently been relocated to Hokkaido from Sakhalin Island following its annexation by the USSR at the end of World War II.[8] The second was a series of 11 CDs recorded between 1992 and 2011 by Henri Lecomte (1995–2012) featuring the music of Siberia's indigenous peoples. Because these two recording projects did not include music of three populations—Korean, Saami and Inuit—that were crucial to evaluating proposals of Japanese archipelago musical and genetic histories, we supplemented our sample with the most comprehensive recordings available for these populations (see Table 1 for detailed references).[9] To

[5]The details of Lomax's Cantometric sample were never made publicly available, so it was not possible to directly re-analyse his data.

[6]These projects also included some purely instrumental tracks, but these were excluded because our classification schemes were primarily designed to classify and compare only the vocal part.

[7]Throughout this article, we use the standard surname-given name order for Japanese names (including Ainu).

[8]Sakhalin's Japanese name is *Karafuto*. Nattiez (1983, 1999) refers to Sakhalin Ainu as 'Kraft Ainu'. Ainu also formerly lived in the north of the mainland Japanese island of Honshu, and in the Kurile (*Chishima*) Islands, Kamchatka peninsula and Amur valley in Siberia, but historical information about them is scarce and none of their music was recorded.

[9]Most recordings are available for purchase in digital form, with the exception of the NHK Ryukyu and Ainu recordings. The Hokkaido Ainu recordings (NHK 1965) are available as records at many Japanese libraries

Table 1 Breakdown of the 680-song sample, listing the number of songs, geographic region and recording source for each of the 35 populations.

Region	Population	Number of songs	Recording source
Ainu	Ainu (Hokkaido)	30	NHK (Japan)
Ainu	Ainu (Sakhalin)	30	NHK (Japan)
East Asian	Japanese (Aomori)	30	NHK (Japan)
East Asian	Japanese (Saga)	30	NHK (Japan)
East Asian	Japanese (Shizuoka)	30	NHK (Japan)
East Asian	Japanese (Tokushima)	30	NHK (Japan)
East Asian	Ryukyu (Okinawa)	30	NHK (Japan)
East Asian	Ryukyu (Yaeyama)	30	NHK (Japan)
East Asian	Korean (Gangwon)	30	MBC (Korea)
East Asian	Korean (South Jeolla)	30	MBC (Korea)
Circumpolar	Buryat	30	Buda (Siberia)
Circumpolar	Koryak	30	Buda (Siberia)
Circumpolar	Evenk	28	Buda (Siberia)
Circumpolar	Altai	26	Buda (Siberia)
Circumpolar	Nivkh	19	Buda (Siberia)
Circumpolar	Even	17	Buda (Siberia)
Circumpolar	Nganasan	15	Buda (Siberia)
Circumpolar	Chukchi	14	Buda (Siberia)
Circumpolar	Nanai	13	Buda (Siberia)
Circumpolar	Nenets	12	Buda (Siberia)
Circumpolar	Selkup	12	Buda (Siberia)
Circumpolar	Yukaghir	12	Buda (Siberia)
Circumpolar	Khanty	11	Buda (Siberia)
Circumpolar	Sakha/Yakut	8	Buda (Siberia)
Circumpolar	Mansi	7	Buda (Siberia)
Circumpolar	Ujl'ta/Orok	6	Buda (Siberia)
Circumpolar	Udege	4	Buda (Siberia)
Circumpolar	Ulch	4	Buda (Siberia)
Circumpolar	Oroc	3	Buda (Siberia)
Circumpolar	Saami	30	SF (Norway)
Circumpolar	Inuit (Iglulik, Canada)	30	MFV (Canada)
Circumpolar	Inuit (North Greenland)	20	ULO (Greenland)
Circumpolar	Inuit (East Greenland)	12	ULO (Greenland)
Circumpolar	Inuit (South Greenland)	9	ULO (Greenland)
Circumpolar	Inuit (West Greenland)	8	ULO (Greenland)
	Total	680	

NHK = Nippon Hōsō Kyōkai (1944–94, 1951, 1965); MBC = Munhwa Broadcasting Corporation (Choi 2000); Buda = Buda Musique (Lecomte 1995–2012); SF = Smithsonian Folkways (Laade 1956); MFV = Museum für Völkerkunde (Nattiez and Conlon 1993); ULO = ULO (Hauser 1992).

and can sometimes be purchased online secondhand. To our knowledge, the only remaining publicly accessible copies of the Sakhalin Ainu recordings (NHK 1951) are at the National Diet Library in Tokyo (call numbers Cas-671–Cas-673). The unpublished Ryukyu recordings were kindly provided by Uemura Yukio and Kaneshiro Atsumi and selected by Matt Gillan.

Table 2 Overview of the three-step cantogroup analysis framework (adapted from Savage and Brown 2014).

Step	Level of analysis	Methods	Description
1. Classification of songs (Supplemental Data spreadsheet)	Individual songs	CantoCore (Savage et al. 2012), Cantometrics (Lomax 1976)	Classify each song according to 41 features of song structure and performance style
2. Clustering of songs into cantogroups (stylistic song-types) (Figure 2)	All songs of a corpus	Cluster analysis (Hartigan and Wong 1979)	Assign songs to song-type clusters based on their musical similarities, irrespective of geography
3. Mapping of cantogroup frequencies (Figure 3)	Geographic regions	Pie charts	Map frequencies of all cantogroups in each population's repertoire onto geographic regions

minimise the number of additional recording sources included, we decided at this stage to refrain from including additional recordings from other populations more broadly relevant to understanding the regional history, such as those in China, Southeast Asia or northwestern parts of North America.

To reduce these samples to manageable sizes for manual comparison, we followed the sampling and analysis framework described in detail by Savage and Brown (2013, 2014; see Tables 1–3). For populations represented by fewer than 30 songs, all available traditional adult songs were used (including both solo and group songs). For those populations with more than 30 songs available, only 30 randomly-selected songs were used. For completeness, our analyses included all eligible populations, even those with small sample sizes of less than ten songs or those whose 'circumpolar' status was questionable (i.e., Buryat, Altai). Follow-up analyses excluding these populations did not affect any of our conclusions.

Methods

Classification of Songs

P.E.S. analysed each song individually using 41 different classification characters (see Table 3). These included 26 structural features from CantoCore (e.g., metre, melodic range, phrase repetition; Savage et al. 2012) and 15 performance features from Cantometrics (e.g., tempo, embellishment, vocal rasp; Lomax 1976; Lomax and Grauer 1968).[10] Each character was classified manually by ear from a range of three to six

[10]The one methodological difference from Savage and Brown (2014) was the inclusion of 15 Cantometric performance features in addition to the 26 CantoCore structural features, as recommended by those authors. These 41 features were the same ones used for music–gene comparison by Brown et al. (2014). The 15

Table 3 Breakdown of the 41 CantoCore (Savage et al. 2012) and Cantometrics (Lomax 1976) classification features used for the analysis.

Feature	Domain	Original line number
1. Metre	Rhythm	1 (CantoCore)
2. Number of beats	Rhythm	2 (CantoCore)
3. Beat sub-division	Rhythm	3 (CantoCore)
4. Number of sub-beats	Rhythm	4 (CantoCore)
5. Syncopation	Rhythm	5 (CantoCore)
6. Motivic redundancy	Rhythm	6 (CantoCore)
7. Durational variability	Rhythm	7 (CantoCore)
8. Tonality	Pitch	8 (CantoCore)
9. Mode	Pitch	9 (CantoCore)
10. Number of pitch classes	Pitch	10 (CantoCore)
11. Hemitonicity	Pitch	11 (CantoCore)
12. Melodic interval size	Pitch	12 (CantoCore)
13. Melodic range	Pitch	13 (CantoCore)
14. Melodic contour	Pitch	14 (CantoCore)
15. Melisma	Text	15 (CantoCore)
16. Vocables	Text	16 (CantoCore)
17. Number of vocal parts	Texture	17 (CantoCore)
18. Rhythmic texture	Texture	18 (CantoCore)
19. Harmonic texture	Texture	19 (CantoCore)
20. Relative motion	Texture	20 (CantoCore)
21. Phrase repetition	Form	21 (CantoCore)
22. Phrase length	Form	22 (CantoCore)
23. Phrase symmetry	Form	23 (CantoCore)
24. Solo/group arrangement	Form	24 (CantoCore)
25. Responsorial arrangement	Form	25 (CantoCore)
26. Phrase overlap	Form	26 (CantoCore)
27. Tonal blend	Blend	5 (Cantometrics)
28. Rhythmic blend	Blend	6 (Cantometrics)
29. Tempo	Dynamics	24 (Cantometrics)
30. Volume	Dynamics	25 (Cantometrics)
31. Rubato	Dynamics	26 (Cantometrics)
32. Register	Dynamics	32 (Cantometrics)
33. Embellishment	Ornamentation	23 (Cantometrics)
34. Glissando	Ornamentation	28 (Cantometrics)
35. Tremolo	Ornamentation	30 (Cantometrics)
36. Glottal shake	Ornamentation	31 (Cantometrics)
37. Vocal width	Timbre	33 (Cantometrics)
38. Nasalisation	Timbre	34 (Cantometrics)
39. Raspiness	Timbre	35 (Cantometrics)
40. Accent	Timbre	36 (Cantometrics)
41. Enunciation	Timbre	37 (Cantometrics)

Cantometric characters were chosen to avoid structural characters that overlapped with CantoCore and instrumental characters that were unreliable to code (Savage et al. 2012). Full metadata for all songs, including classifications and discographic information, is listed in the Supplemental Data spreadsheet.

different character-states. For example, melodic range was classified as either small (less than 750 cents), medium (750–1250 cents) or large (greater than 1250 cents). Full details of classification criteria and inter-rater reliability values for each feature can be found in Lomax (1976) and Savage et al. (2012).

Clustering of Songs into Cantogroups (Stylistic Song-types)

Average similarities between songs based on these 41 classification characters were calculated using the method of Rzeszutek, Savage and Brown (2012), after which k-means cluster analysis (Hartigan and Wong 1979) was used to group the songs into cantogroups.

Mapping of Cantogroup Frequencies

The frequencies of each cantogroup within each population's repertoire were mapped onto geographic space using pie charts.

Results

Song-level Analysis and Clustering

To demonstrate the musical relationships among the 680 songs used in our sample, we used a multidimensional scaling plot, as shown in Figure 2. Cluster analysis identified five cantogroups (coloured in greyscale) as the optimal number of clusters. The high frequencies of East Asian songs in cantogroups E1 and E2, circumpolar songs in cantogroups C1 and C2, and Ainu songs in cantogroup A suggest that there are important musical differences between these geographic regions. Thus, for ease of interpretation, we have given each cantogroup a label according to its predominant geographic distribution (see Figure 3). However, the cluster analysis does not incorporate any *a priori* information about cultural or geographic affiliations.

Table 4 presents a summary of some of the notable musical features that are most regionally distinctive for each cantogroup, colour-coded as in Figure 2. To provide concrete examples of these abstract descriptions, we have included links to brief 30-second excerpts from 11 recordings of prototypical Ainu and non-Ainu songs from each cantogroup (these songs are highlighted with arrows in Figure 2).[11]

It is impossible to give comprehensive descriptions of these songs, since cantogroups are defined based on overall family resemblance and not by specific features. However, the following trends emerge:

(1) *East Asian*. Cantogroup E1 contains many East Asian ornamented solo songs with loose or non-existent metre, while cantogroup E2 contains many East

[11]The 30-second audio clips and metadata for these examples can be found in the Supplemental Data.

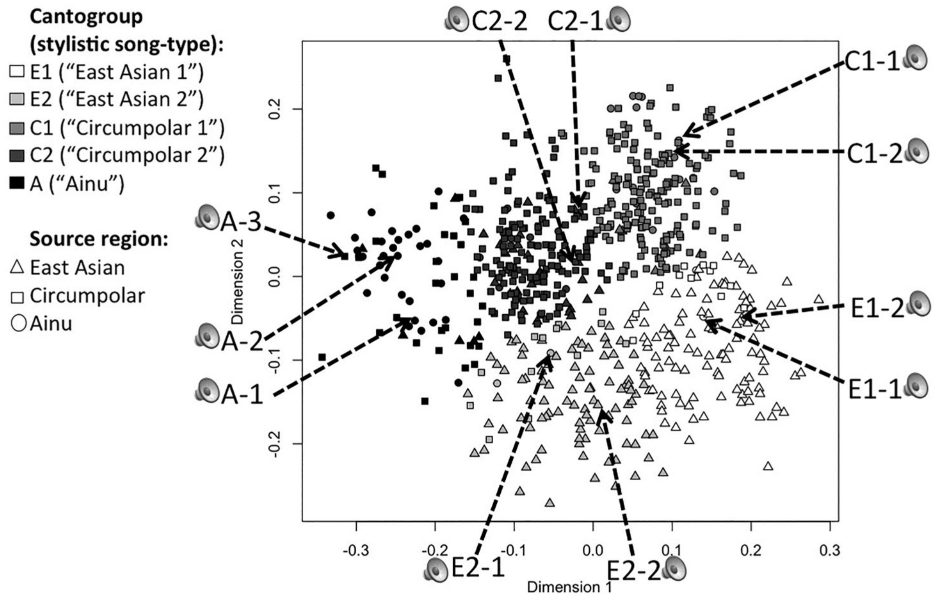

Figure 2 Multidimensional-scaling visualisation of the cluster analysis of 680 traditional folk songs from 35 populations in and around Japan. Each point represents a single song, with different shapes representing different source regions (see legend to left). Songs that are closer together in the plot have greater average musical similarity—as based on their CantoCore/Cantometric codings—than songs that are further apart. Songs are colour-coded in greyscale according to their membership in one of five cantogroups (stylistic song-types), as identified through cluster analysis and shown in the legend. Two or three example songs from each cantogroup are highlighted with arrows. These songs are described in detail in Table 4, along with notable musical features of each cantogroup.

Asian metric, group-accompanied songs. These correspond to Koizumi's (2009)[12] distinction between two archetypal Japanese folksong types: 'Oiwake' (ornamented, solo, a-metric) and 'Yagibushi' (metric, group-accompanied). In terms of Lomax's global taxonomy, E1 and E2 could be thought of as contrasting sub-types within his Pan-Eurasian 'Old High Culture' type, where he classified Korean, Ryukyu and mainland Japanese music (Lomax 1968, 1980).

(2) *Circumpolar*. Cantogroup C1 contains many solo, irregular, harsh-voiced circumpolar types, while cantogroup C2 mostly contains a slightly more regular, vocable-heavy, often drum-accompanied circumpolar type. These seem to correspond to Lomax's distinction between 'Siberian' and 'Circum-Pacific' types, respectively.

[12]Originally written in 1962–63 and first published in 1984.

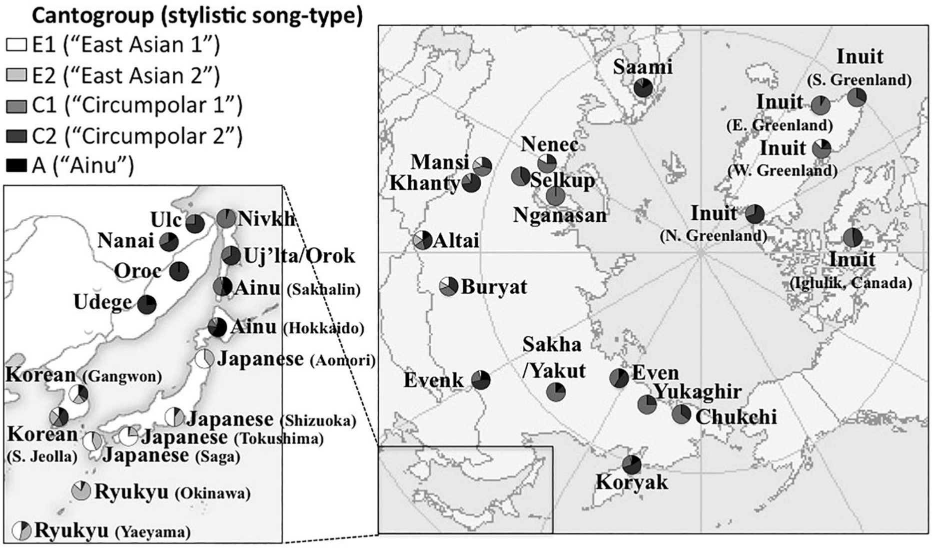

Figure 3 A musical map of the 35 populations based on cantogroup frequencies. Relative frequencies of all five cantogroups (colour-coded in greyscale as in Figure 2) are shown separately for each of the 35 populations using pie charts. See Figure 2 for cantogroup identification. Population locations are based on approximate recording locations.

(3) *Ainu*. Cantogroup A contains many Ainu songs known as *upopo*[13] in Hokkaido (Song A-1) and *heciri* in Sakhalin that often use a canonic texture known as *ukouk*, as well as other highly regular, overlapping group songs. Cantogroup A seems to be most similar to the regular, overlapping group songs of Lomax's 'African Gatherer' type, common among central African Pygmies and southern African Khoisan Bushmen. Lomax (1976: 38) also mentions this African Gatherer type as appearing among the Ainu, although he classifies Ainu music as a whole as part of a 'Siberian' song-style region. However, the vocal timbre of cantogroup A is generally much harsher than Lomax's prototypical African Gatherer style and also includes songs that contain little or no overlap, particularly songs that were near the outer borders of this cantogroup.

This cantogroup also includes the Ainu *rekuhkara* throat-game genre (Song A-2) and a handful of other circumpolar throat-rasping duets, such as from the Koryak (Song A-3) and Iglulik Inuit, a connection suggested by Nattiez (1983, 1999), Tanimoto (2000, 2001a) and Keeling (2012). However, it does not include some of the other songs in the sample containing throat-rasping, such as the Ainu *tusu-sinotca* shamanic drum song (Song C2–1) and the Ulc shamanic

[13]The Ainu language was traditionally transmitted orally without writing, and transliterations have not been widely standardised. In this article we adopt Chiba's (2008) usage.

Table 4 Simplified descriptions of notable musical features for each of the five cantogroups.

Cantogroup	Notable musical features	Examples
E1 ('East Asian 1')	Irregular: metre loose/absent, solo *a cappella*, large melodic range, pentatonic scales, long phrases, melismatic, nasal	E1-1: *Yaykatekara* (Ainu love song; No. 33) E1-2: *Jongarabushi* (Japanese entertainment song; No. 75)
E2 ('East Asian 2')	Semi-regular: iso-metric, unison/call-and-response, large melodic range, often chordophone accompaniment	E2-1: *Sucho choy choy na* (Ainu seed-planting song; No. 17) E2-2: *Hatuma nakamuri* (Ryukyu *sanshin* song; No. 236)
C1 ('Circumpolar 1')	Irregular: metre loose/absent, solo *a cappella*, small melodic range, sparse scales, microtonal glides, glottal shake	C1-1: *Hawki* (Ainu epic; No. 35) C1-2: *Tilgur* (Nivkh epic; No. 439)
C2 ('Circumpolar 2')	Semi-regular: regular beat (but not necessarily regular metre), non-lexical vocables, often self-accompaniment on (shaman) drum	C2-1: *Tusu-sinotca* (Ainu shamanic drum song; No. 50) C2-2: *Shamanic song with* uŋtu *drum* (Ulc; No. 418)
A ('Ainu')	Regular: iso-metric, group canon (*ukouk*)/call-and-response (*iekaye*), sparse scales, short/repetitive phrases, often accompanied by clapping	A-1: *Upopo* (Ainu group song; No. 3) A-2: *Rekuhkara* (Ainu throat-game; No. 44) A-3: *Knylju* (Koryak lullaby; No. 378)

Cantogroups colour-coded in greyscale as in Figures 2 and 3. Examples of Ainu and non-Ainu songs from each cantogroup correspond to the labelled points in Figure 2. Song number ('No.') refers to the song's number in the Supplemental Data spreadsheet; refer to this for additional metadata for these songs. Not all songs in each cantogroup necessarily contain all of these features, since cantogroups are defined based on overall similarity rather than any particular features.

drum song (Song C2-2) found in cantogroup C2, or the animal-imitation songs of the Even and Chukchi found in cantogroup C1.

Although each cantogroup has certain features that are regionally distinctive (summarised in Table 4), there appears to be surprisingly little blending of individual features between cantogroups. For example, while the overlapping *ukouk* texture is the most consistent and distinctively Ainu feature of cantogroup A, *ukouk* is rarely found in Ainu music outside of cantogroup A. Other notable features of cantogroup A presented in Table 4 that are most unique to the Ainu (e.g., sparse scales, short/repetitive phrases, clapping) are also rare in Ainu music outside cantogroup A. Instead, it seems that the stylistic features of songs may tend to be transmitted as discrete packets, such that an Ainu *tusu-sinotca* shamanic drum song (Song C2-1) in cantogroup C2 includes not only the use of shaman drums common in the circumpolar region, but also other typically circumpolar features (e.g., throat-rasping, irregular metres). Likewise, an Ainu *yaykatekara* love song (Song E1-1) in cantogroup E1 shares not only pentatonic scales common in mainland Japan, but also other typically mainland Japanese features (e.g., long, melismatic phrases). In the future, we will explore more complex quantitative techniques such as multiple correspondence analysis (Greenacre and Blasius 2006) in order to more precisely determine the degree to which each individual musical feature contributes to creating regionally distinctive styles.

Cross-cultural Distribution of Cantogroups

Figure 3 uses pie charts to map the geographic distribution of the five cantogroups. These charts confirm the impression from Figure 2 that the 'East Asian', 'Circumpolar' and 'Ainu' cantogroups are indeed largely restricted to their respective regions:

(1) *East Asian*. Cantogroups E1 and E2 were largely restricted to East Asia, where they were on average the most common types across all mainland Japanese, Ryukyu and Korean populations (although when breaking populations down by sub-region, the Korean province of South Jeolla had slightly more of 'Circumpolar' cantogroups C1 and C2). E1 and E2 were rare within the Ainu repertoire (7% across both Hokkaido and Sakhalin Ainu). When they did appear, it was with genres known to have had recent influence from mainland Japan within the last few hundred years, such as songs involving agriculture (introduced in the eighteenth century; Song E2-1) and *sinotca* lyric songs (including *yaykatekara* love songs as in Song E1-1) that incorporate stylistic and/or linguistic elements from the mainland Japanese (Chiba 2008; NHK 1965; Tanimoto 2000).[14]

[14]Excluding these songs does not substantively affect any of our major conclusions regarding the frequencies of circumpolar or Ainu cantogroups.

(2) *Circumpolar*. Likewise, cantogroups C1 and C2 were found predominantly among circumpolar populations in Siberia and the Arctic, where they are the most common song-types in each population's repertoire. These types occur fairly frequently within the Ainu repertoire (42% across both Hokkaido and Sakhalin Ainu), particularly in that of the Sakhalin Ainu, where they actually outnumber the 'Ainu' cantogroup A by 53% to 43%, respectively. The only other non-circumpolar population where these types are most common is in the Korean province of South Jeolla. But when considering Korean and Ainu repertoires as a whole across all sub-regions, the 'East Asian' and 'Ainu' cantogroups, respectively, are most common.

    Some of the Circumpolar types in the Ainu repertoire have known historical connections to Siberia. For example, the *tusu-sinotca* shamanic drum songs (Song C2-1) are considered to be related to Siberian shamanic drum song traditions such as those of the Ulc (Song C2-2; Tanimoto 2000). Others, such as the epics known as *hawki* in Sakhalin (Song C1-1) and *yukara* in Hokkaido, share stylistic similarities with Siberian epics, such as the Nivkh *tilgur* (Song C1-2) and the Sakha/Yakut *olunkho*.

(3) *Ainu*. Cantogroup A was the most common cantogroup within the Ainu repertoire, accounting for 52% of all Ainu songs across both Hokkaido and Sakhalin Ainu. It reached its highest frequency (60%) among the Hokkaido Ainu, followed by the Sakhalin Ainu (43%). In all other populations, it was either absent or present at very low frequencies, never more than 25%. The non-Ainu songs in this cantogroup were almost always songs found near the border with cantogroup C2, except for the cases of the throat-rasping duets shared with Koryak and the Iglulik Inuit mentioned in the previous section.

Music–Gene Comparison

To compare patterns of musical and genetic diversity for the Ainu, we compared the frequencies of the discussed Ainu-specific, circumpolar and East Asian cantogroups with frequencies of mtDNA haplotypes (unique DNA sequences) published by Tajima et al. (2004) (Table 5).[15] This comparison showed intriguing parallels between music and genes, with both Ainu songs and Ainu mtDNA containing a majority of unique Ainu types (52% vs. 51%, respectively), followed by circumpolar types (41% vs. 28%) and then by East Asian types (7% vs. 18%). A small amount of Ainu mtDNA (4%) was also shared with Southeast Asia, but we were unable to make the matching comparison with our present musical sample.

[15]We plan to offer a more comprehensive musical and genetic comparison including all populations (cf. Brown et al. 2014) and/or other genetic markers such as Y-chromosome DNA and autosomal DNA in a future publication.

Table 5 Comparison of Ainu musical and genetic diversity.

Putative source region	Ainu songs (%)	Ainu mtDNA (%)
Ainu	52	51
Circumpolar	42	28
East Asian	7	18
(Southeast Asian)	(N/A)	(4)

The percentages of songs derived from Ainu, circumpolar and East Asian sources are estimated based on the combined percentages of cantogroups A (Ainu), C1 and C2 (Circumpolar) and E1 and E2 (East Asian) averaged across both the Hokkaido and Sakhalin Ainu repertoires. The percentage of mtDNA derived from these sources and from Southeast Asia is taken from the published analysis of Tajima et al. (2004). The percentages add up to 101% rather than 100% owing to rounding error.

Discussion

A 'Triple Structure' Model for Japanese Archipelago Cultural History

Our analyses provide the first quantitative evidence that the Ainu musical repertoire contains nearly equal parts that are uniquely Ainu versus shared with surrounding populations, and that sharing has been much more extensive with circumpolar populations than with the mainland Japanese. These findings do not contradict qualitative studies (e.g., Keeling 2012; Malm 1967; Nattiez 1983, 1999; Tanimoto 2000, 2001a) that have argued for a circumpolar component to the Ainu repertoire. In fact, our findings complement these studies by providing quantitative support for such a component. However, our findings also extend previous studies by demonstrating that the circumpolar component is only one part of the broader Ainu repertoire, thus helping to unify the apparent discrepancy between Ainu musical and genetic histories. Such an integration of quantitative and qualitative approaches is essential for improving our understanding of music and human history, and may help to resolve other controversies, such as Grauer's (2006, 2011) proposal of an ancient out-of-Africa musical expansion.

By applying improved methods that allow us to quantify the relative frequencies of different musical types within and between populations, we in fact find that there is less contradiction between the musical and genetic evidence than expected based on Lomax's (1980) musical analysis or Hanihara's (1991) original dual structure model. In fact, the presence of high frequencies of unique cantogroups (~50%), medium frequencies of circumpolar cantogroups (~40%) and low frequencies of East Asian cantogroups (~10%) are similar to corresponding estimates of mtDNA diversity (~50%, ~30% and ~20%, respectively) obtained by Tajima et al. (2004).[16] It seems logical that

[16]Tajima et al. (2004) also report evidence for some (~13%) circumpolar contribution to the Ainu paternally-inherited Y-chromosome gene pool, but this evidence seems more equivocal, given the similar level (~14%) of this haplogroup (C-M217*) among Han Taiwanese found in the same study. Other genetic studies are still harder to interpret. Studies supporting circumpolar influence have shown that mtDNA haplogroup Y is the most common haplogroup among the Ainu (20%), Nivkh (66%) and ancient Okhosk (43%), but not among ancient Jomon (0%) or contemporary mainland Japanese (1%) (Adachi et al. 2011; Sato et al. 2009). Many of

these parallels could have arisen through the joint migration of people and their songs (including through intermarriage), but other explanations are also plausible, such as musical borrowing and genetic 'isolation by distance' taking place independently due to geographic proximity (Savage and Brown 2013; Wright 1943). The current study has focused primarily on characterising the musical patterns, with only limited direct comparison with genetic data. In the future, we hope to more directly and comprehensively compare the regional patterns of musical and genetic diversity in order to better understand how and why these similarities and differences arose.[17]

Many scholars have long felt that Hanihara's dual structure model—while extremely valuable—was overly simplistic in the case of the Ainu. Most historians believe that the Ainu only emerged as a distinct culture around 1200 AD from the merging of the Okhotsk culture from Siberia with the indigenous, Jomon-descended Satsumon culture in Hokkaido (Hudson 1999).[18] Recently, a major consortium of population geneticists published a diagram of Japanese archipelago population history that extends this idea (JAHGPC 2012: 793). In addition to interactions that are recognised by the dual structure model between the indigenous Jomon and mainland East Asian Yayoi and their descendants, this diagram also included interactions with the Okhotsk and their descendants. We propose terming this scenario the 'triple structure' model (see Figure 4) to recognise the importance of Hanihara's dual structure model as well as the need to acknowledge the circumpolar influence on the Ainu that Hanihara initially rejected. This model does not imply that each source population only contributed to one historical period; rather, there have been multiple ongoing interactions. For example, 'East Asian' influences on the Ainu may ultimately have their roots in the movement of Yayoi agriculturalists from mainland Asia ~3000 years ago, but most East Asian influences did not become incorporated by the Ainu until the assimilation policies introduced by the Meiji government in the late nineteenth century. Likewise, circumpolar influences that are pronounced among the Sakhalin Ainu but not the Hokkaido Ainu, such as *tusu-sinotca* shamanic drum songs, are likely to have been introduced not by the movement of the Okhotsk culture to Hokkaido ~1500 years ago but by more recent contact with the Nivkh and other inhabitants of Sakhalin after the Ainu expanded there from Hokkaido ~600 years ago (Ohyi 1985).

It is crucial to remember that all of these populations today have, and have had in the past, a great deal of internal diversity which developed over the course of tens of thousands of years of evolution and contact. Thus, even as the ancestors of the Ainu

the studies supporting the dual structure model have not included likely sources of circumpolar influences such as the Nivkh or Okhotsk in the sample, and were thus unable to evaluate the degree of potential circumpolar influence (e.g., JAHPGC 2012; Koganebuchi et al. 2012; Matsukusa et al. 2010; Omoto and Saitou 1997).

[17]For instance, the different uniparental markers (matrilineally inherited mtDNA and patrilineally inherited Y-chromosome DNA) may correlate better with songs performed by the respective sexes, just as sex-biased migration can affect the geographic distribution of genes (Oota et al. 2001) and gene–language correlations (Forster and Renfrew 2011). Music-making worldwide tends to be highly gendered (Koskoff 1987), and the circumpolar tradition of unilineal transmission of personal songs from mother to daughter and from father to son (Tanimoto 2001b) in particular would be expected to amplify sex-biased correlations between musical and genetic lineages.

[18]Satsumon culture was descended directly from the Jomon culture via the epi-Jomon culture.

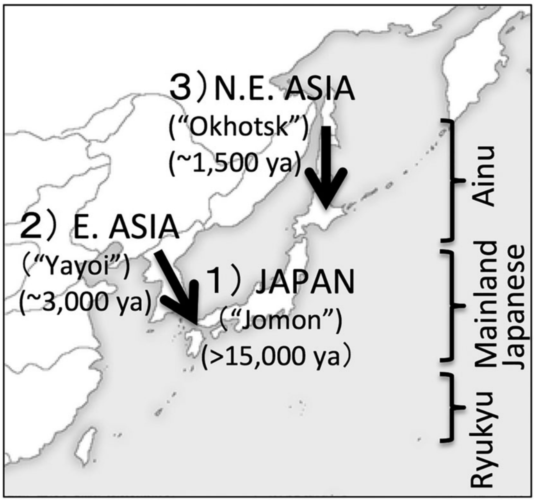

Figure 4 Schematic diagram of the 'triple structure' model of Japanese archipelago cultural history (adapted from JAHPGC 2012). Approximate source-regions and dates of origin (ya = years ago) of three major founding cultures are inferred from archaeological records, using the names given to those archaeological cultures. The direction by which the creators of the Jomon culture entered the Japanese archipelago is not shown, because there are disputes over this point (Omoto and Saitou 1997). Approximate historical distributions of three major contemporary ethnolinguistic groups in Japan are shown to the right.

were experiencing complex cultural transitions and interactions, similar but distinct processes—including continuing contact within the Japanese islands and with mainland Asia—were taking place among the ancestors of the modern groups now known as 'Ryukyu' and 'Japanese'. Indeed, these processes never ended—if anything, they have intensified with globalisation.

The point of models is not to capture everything that happened historically, but to provide tractable hypotheses that can explain a substantial portion of the observed data. Simple models thus provide a way of helping us make sense of what are, in reality, highly complex phenomena. In formulating models it is good practice to start with simple models and then add in greater complexity, if it is justified by the data. While the triple structure model seems to explain at least some of the genetic and musical data better than the dual structure model, the true history was undoubtedly even more complex (Sasaki 1997). Thus, with additional data and analyses there may very well be further extensions needed to the triple structure model, just as Hanihara (1994) encouraged modifications and extensions of his dual structure model.

Degrees of 'Circumpolar-ness'

While the musical and genetic similarities are intriguing, they are not identical, and there is substantial variation even within the Ainu. In particular, the music of the

Sakhalin Ainu seems to have received particularly strong circumpolar influence relative to the Hokkaido Ainu,[19] a point also described in detail by Tanimoto (2000). He noted that a number of circumpolar features—including the *kaco* shaman frame drum used in *tusu-sinotca* shamanic drum songs, the *tonkori* five-string zither and associated *tonkori-heciri* song genre, and the throat-rasping technique used in *tusu-sinotca* and in *rekuhkara* throat-game genres—were all traditionally found only in Sakhalin, not Hokkaido. Our analysis confirmed all of these points within our sample.

Some scholars have placed a strong emphasis on the *rekuhkara* throat-game genre as being the key link between the Ainu and circumpolar cultures as far removed as the Canadian Inuit (Malm 1967; Nattiez 1983, 1999). In particular, Nattiez (1999) has inferred shamanic symbolism in the throat-rasping technique that connects the *rekuhkara* with other circumpolar genres, including the *pič eynen* dance of the Chukchi and the *katajjaq* throat-games of the Eastern Canadian Inuit. However, our analysis shows that, across all 41 classification features used, *rekuhkara* are generally quite similar to non-*rekuhkara* Ainu songs, such as *upopo/heciri*, and do not always necessarily use throat rasping (e.g., Song A-2). They may thus be thought of as a special *heciri* variant, as proposed by Chiri (1955) and Chiba (2008). If anything, it seems that the styles most similar to *rekuhkara*, such as the *knylju* lullaby of the neighbouring Koryak (Song A-3), could well have originated from the Ainu *rekuhkara* and been transmitted to other circumpolar traditions, rather than *vice versa*.[20] In any case, we believe that the seldom-discussed *tusu-sinotca* shamanic drum song genre is the strongest candidate for an Ainu genre of circumpolar origin, because it contains not only throat-rasping and an unambiguous shamanic function, but also the distinctive shaman frame drum that is perhaps the clearest musical circumpolar marker (Tanimoto 2001b), being ubiquitous throughout Siberia and stretching as far west as the Saami in Arctic Europe and as far east as the Greenland Inuit.[21]

For the purposes of this study, we have not greatly explored the internal diversity of repertoires other than that of the Ainu, but there is a great deal of it. In particular, there seems to be a rough northeast/southwest geographic/cultural split in which Altaic-speaking and Uralic-speaking populations from southern/western Siberia and Arctic Europe tend to have higher frequencies of cantogroup C2, while northern/eastern Siberian and Arctic American populations tend to have higher frequencies of cantogroup C1. Given the massive size and sparse musicological literature in English on this region,[22] and the importance of Siberia to debates regarding the peopling of

[19]It may be difficult to investigate regional genetic differences between Hokkaido and Sakhalin Ainu as, unlike for music, no separate Sakhalin Ainu genetic sample has been collected (although some Sakhalin Ainu may have been included in the major existing Ainu sample, which was collected in Biratori, Hokkaido in the early 1980s; JAHPGC 2012).

[20]It also seems plausible that the different cultures could have independently invented the genres by combining elements of throat-rasping with a regular, canonic form.

[21]No songs in our Saami sample included drumming because shaman drums were banned there by Christian missionaries (Laade 1956). However, Fernandez and Jocelyne (1984) include one recording of a drum-accompanied Saami *joik*.

[22]There is a substantial non-English literature (e.g., Dobžanskaja 2002; Lecomte 2012), particularly in Russian.

the Americas (Cavalli-Sforza, Menozzi and Piazza 1994; Greenberg 1987; Reich et al. 2012), these musical and extra-musical relationships deserve further investigation.

Sampling Limitations

Savage and Brown (2013, 2014) discussed in detail a number of caveats regarding Cantometrics, the cantogroup methodological approach and comparative musicology in general. These issues include sampling, definitions of populations, choice of classification features, modelling musical evolution and musical time-depth, assignment of songs to discrete cantogroup clusters and the need for independent comparisons of multiple different lines of evidence, such as genes and languages. Each of these issues applies to the current study to some degree, but the issue most directly relevant to our analysis is that of comparability of samples collected at different times and places by different people with different purposes.

We tried to limit sampling to a small number of recording projects with a similar general purpose (i.e., to present an overview of the different traditional folk songs of a given population). However, projects like NHK's survey of folk songs throughout the Japanese archipelago took place over a span of several decades and were carried out by different teams of specialists in different places. Each had their own ideas about what they wanted to record, and each worked with communities who had different ideas about what they wanted to be recorded. Some of the songs recorded then are no longer performed today, and some songs performed today did not exist at the time of these recordings. Needless to say, these problems become compounded when one then attempts to further compare these recordings with others produced under still more different conditions, especially when substantial musical changes have been documented in all of these cultures during this time period (Hughes 2008; Kōchi 2001; Sheykin 2001; Tokita and Hughes 2008). Similar (although generally less severe) issues, such as the effects of urban migration and intermarriage, could be pointed out for the genetic studies against which we are comparing our musical data.

While we have attempted to carry out as controlled a comparison as possible by limiting our sample to a small number of large-scale, high-quality recording projects, the results nonetheless need to be viewed with an awareness of the inevitable limitations. Still, the results are unlikely to be merely artefacts of the sampling or analysis procedures, but instead largely capture broad but meaningful patterns of diversity, even if they can never fully account for all of the finer details that inevitably remain overlooked.

In particular, we believe that our primary conclusion regarding the triple structure of Ainu musical diversity is robust to these issues. Although there has been a great deal of change in the Ainu repertoire since these recordings were published in the 1950s and 1960s, most Ainu performances continue to contain diverse styles that still seem to broadly fall within the same Ainu, circumpolar and East Asian stylistic types we identified, and the relative frequencies of the types seem to remain fairly similar. Furthermore, we know of no evidence from any time period that the Ainu-specific style we identified was ever common in any of the non-Ainu populations included. However, future studies of contemporary Ainu music performances will be important to formally assess the degree of stability of these patterns and understand the mechanisms of preservation and change.

Conclusion

We have shown quantitatively for the first time that Ainu music is not simply 'Siberian' or 'circumpolar' in style, but that it contains a majority of unique Ainu types not found at high frequencies in the repertoires of other East Asian or circumpolar populations. We have also shown that the relative frequencies of Ainu, circumpolar and East Asian musical types parallel the frequencies of mtDNA haplotypes derived from these geographic sources.

These results imply that the Ainu are not simply modern-day descendants of the ancient Jomon people, nor is their culture simply 'Siberian' or 'circumpolar'. Rather, they have actively incorporated influences from multiple directions while continuing to maintain and adapt their own diverse cultural and genetic heritage. We hope that a more nuanced 'triple structure' model of Japanese archipelago cultural history that acknowledges this diversity will help to provide more opportunities to promote, preserve and rediscover both the shared and unique aspects of Ainu heritage.

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Supplemental Data

Supplemental data for this article, including raw data, metadata and 30-second audio examples, can be accessed at http://dx.doi.org/10.1080/17411912.2015.1084236

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