On Computational Transcription and Analysis of Oral and Semi-Oral Chant Traditions

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Variation is considered a universal principle in music. In terms of semiotics, variation in music is omnipresent and distinguishes music from language (Middleton, 1990). In oral music traditions, variation is introduced to the music due to the absence of a concrete notation. In this paper we investigate melodic stability and variation in cadences as they occur in oral and semi-oral traditions. Creating a new framework for transcription, we have quantized and compared cadences found in Torah trope, strophic melodies from the Dutch folk song collection *Onder de groene linde* and Qur'an recitation.

We have developed computational methods to analyze similarity and variation in melodic formulas in cadences as they occur in recorded examples of the before-mentioned oral/semi-oral traditions. Concentrating on cadences, we have investigated melodic, durational and contour similarities in cadences within individual songs/chants, within chant types and between chant types. Using computational methods we have extracted tone scales from digital audio data. In our opinion these derived scales accurately present pitch-contour relationships within oral and semi-notated musical traditions. Instead of viewing these pitches to be deviations of pre-existing "normalized" scales, our method defines a more differentiated scale from the outset. Comparing the stability of these scales and their resulting contours we can support the theory that melodic stability in Ashkenazi Torah trope cadences is more prevalent than in Sephardic equivalents. We have discovered relationships between variational embellishment and contour stability within cadences in Indonesian and Dutch-Indonesian Qur'an recitation. We are currently applying similar methods of comparison within Dutch folk song examples.

By developing computational models for cadences in these three chant types we contribute to extending possibilities for musical transcription. Employing computational tools that allow for a more *objective* transcription, we strive to reduce the subjective bias of the ethnomusicologist. While transcription methodologies have been subject to debate we find that this new form of computational transcription presents new means for cross-cultural music analysis, thereby extending the practice of transcription into the modern world.

Musical Collections – Jewish Torah Trope, Qur'an Recitation and Dutch Folk Songs

Jewish Torah trope is "read" using the twenty-two cantillation signs of the *te'amei hamikra*, developed by the Masorite rabbis between the sixth to the ninth centuries. The melodic formulae of Torah trope govern syntax, pronunciation and meaning and their clearly identifiable melodic design, determined by their larger musical environment. These formulae are produced in a cultural realm that combines melodic improvisation with fixed melodic reproduction within a static system of notation. The *te'amim* consist of thirty graphic signs. Each sign, placed above or below the text, acts as a “melodic idea,” which either melodically connects or divides words in order to make the text understandable by clarifying syntax. The signs serve to indicate the melodic shape and movement of a given melody. Even though the notation of the *te’amim* is constant, their pitches are variable. Although the thirty signs of the *te’amim* are employed in a consistent manner throughout the Hebrew Bible, their interpretation is flexible: each sign’s modal structure and melodic gesture is determined by the text portion, the liturgy, by pre-conscribed regional traditions as well as by improvisatory elements incorporated by a given “reader.”

The performance framework for Qur’an recitation is not determined by text or by notation but by rules of recitation that are primarily handed down orally (Zimmermann 2000). Here the hierarchy of spoken syntax, expression and pronunciation play a major role in determining the vocal styles of *Tajwīd*[1] and *Tartīl*[2]. The resulting melodic phrases, performed not as “song” but “recitation” are, like those of Torah trope, determined by both the religious and larger musical cultural contexts. In the context of “correct” recitation contexts improvisation and repetition exist in conjunction. Such a relationship becomes increasingly complex within immigrant communities that strive to retain a tradition of recitation, as found in the Indonesian Muslim community in the Netherlands. Comparing recorded examples of *sura* readings from this community with those from Indonesia, one can observe how melodic contour plays a role in defining the identity of cadence functionality.

The collection *Onder De Groene Linde* consists of c. 7000 audio recordings of Dutch folk songs, made during the 1950s till the 1980s by ethnological fieldworkers Will Scheepers and Ate Doornbosch (Grijp, 2008). The collection is currently hosted by the Meertens Institute in Amsterdam, and is accessible through the website of the Dutch Song Database.[3] Doornbosch was specifically interested in ballads, of which he collected as many variants as possible. The reproduction of the melodies relies on the memory of the singer. Since musical material in oral circulation is changing continuously, many variants of the ‘same’ tune can be found among the recordings. In the collection, we only have ‘end points’ of this oral tradition. The full oral history of the recorded songs is not available. Nevertheless, one of the tasks of the collection specialists at the Meertens Institute is to classify the songs into *tune families* (Bayard 1950). They base this classification on similarity relations between the melodies and on hypotheses about the oral history. The collection is a rich resource of melodic material that allows research of melodic patterns in oral tradition.

One of the research questions we pose is to what extent the melodies in *Onder de groene linde* show stylistic unity. Was there one melodic culture in the Netherlands in the first decades of the twentieth century? Do the melodies show structural correspondences in syntactic-melodic properties? What are the structural units of these melodies? Are there stable melodic formulae that recur among or between tune families? What is common in the entire corpus, and what is common to a specific tune

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[1] “*Tajwīd* [is] the system of rules regulating the correct oral rendition of the Qur’an. The importance of *Tajwīd* to any study of the Qur’an cannot be overestimated: *Tajwīd,* preserves the nature of a revelation whose meaning is expressed as much as by its sound as by it content and expression, and guards it from distortion by a comprehensive set of regulations which govern many of the parameters of the sound production, such as duration of syllable, vocal timbre and pronunciation.” Kristina Nelson, *The Art of Reciting the Qur‘an (*Austin: University of Texas Press, 1985), 14.

[2] “*Tartīl,* another term for recitation, especially implies slow deliberate attention to meaning, for contemplation.” Eckhard Neubaurer and Veronica Doubleday, “Islamic Religious Music” in *Grove Music Online.* <http://www.grovemusic.com.ezproxy.library.uvic.ca> Accessed December 15, 2011.

[3] http://www.liederenbank.nl

family only? From a large number of tune families, we have more than one member melody. This allows us to investigate the corresponding parts of these melodies, in order to understand what parts of the melodies remain stable and what parts are less stable in oral transmission. As a first step, we will investigate cadential patterns in these songs. Since cadences have the clear syntactical function to indicate closure, or 'ending', we expect a number of stable patterns. By exhaustively comparing all cadence patterns computationally, we will test whether this is the case indeed. A subset of recordings of Dutch folksongs have been manually segmented at the level of melodic phrases. Each phrase is supposed to end with a cadence pattern. As with the examples of Torah trope and Qur'an recitation we are examining contour and scale similarities in melodic cadences.

Aims and Motivation

Chant scholars have investigated historical and phenomenological aspects of melodic formulas within melodic cadences. Scholars have looked to discover how improvised melodies might have developed to become stable melodic entities in given religious communities. A main aspect of recent computational investigations has been to explore the ways in which melodic contour defines melodic identities (Ness et al., 2010). The present study employs a computational approach to allow for new possibilities for paradigmatic and syntagmatic analysis of cadences in the three chant types. In particular the question of melodic stability and melodic contour is investigated. Observing the function of melodic cadences in these chant types we investigate aspects of self similarity within and across various chant communities. In particular, the stability and self-similarity of melodic contours are examined in these various traditions. This might give us a better sense of the role of melodic gesture in melodic formulae in chant practices and possibly a new understanding of the relationship between improvisation and notation–based chant in and amongst these divergent traditions.

Data

For this study, we have collected and compared data from field recordings done in the Netherlands, Indonesia, Israel and the United States. These recordings have manually been segmented. The recordings of Torah trope have been segmented into the individual *te'amim*. The recordings of Qur'an recitation have been segmented in terms of syntactical units corresponding to a given *sura.* The Dutch folksongs have been segmented in terms of phrase units for comparison. Each Qur'an and Torah recording has been converted to a sequence of frequency values using the SWIPEP fundamental frequency estimator (Camacho 2007) by estimating the fundamental frequency in non-overlapping time-windows of 10ms. The Dutch recordings have been converted by the YIN algorithm, which appeared to be better able to cope with the typical kinds of distortion in the Dutch recordings. The frequency sequences have been converted to sequences of real–valued MIDI pitches with a precision of 1 cent (which is 1/100 of an equally tempered semitone, corresponding to a frequency difference of about 0.06%).

Methods

As described in Ness et al., 2010, for each of the Torah recordings, we derive a melodic scale by detecting the peaks in a non-parametric density estimation of the distribution of pitches, using a Gaussian kernel. Of these quantized pitches, we choose the two that occur most frequently and use them to scale the pitches in the nonquantized sequences. We denote the higher and lower of the two prevalent pitches as p_{high} and p_{low}, respectively. Each pitch is scaled relative to p_{low} in units of the difference between p_{high} and p_{low}. Thus, scaled pitches with value < 0 are below the lowest of the two pitches and pitches with value > 1 are above the highest of the two and pitches between 0 and 1 are between the two prevalent pitches. As a result, different trope performances, sung at different absolute pitch heights, are comparable. In order to visualize and navigate through the data consisting of annotated clips and the frequency estimation results of the SWIPEP we have developed a web-based interactive interface. This interface combines both visual and auditory modalities, allowing the researcher to see and listen to the results of some of the algorithms we use in this paper. On the thus acquired scaled pitch contours we apply an alignment algorithm as described in (Van Kranenburg et al., 2009), interpreting the alignment score as similarity measure. We use a *global alignment algorithm* with an *affine gap penalty function* (Gotoh, 1982). This results in a distance for each pair of segments. This approach is comparable to the use of *dynamic time warping* in (Ness et al, 2010), but the current approach uses a more advanced scoring function for the individual elements of the pitch sequences. This distance measure is evaluated using evaluation measures from information retrieval, notably the mean average precision, which is the average precision of all relevant items for all queries, taking each segment as query and taking all segments that are a rendition of the same *ta'am* as relevant items.

Results and Implications – Analysis of Specific Cases

In comparing a Hungarian to a Moroccan version of Torah trope the obtained mean average precisions are 0.656 for the Hungarian rendition and 0.299 for the Moroccan one, which are improvements concerning the results that were previously achieved in (Ness et al., 2010). These findings are particularly interesting when observed in connection with musicological and music historical studies of Torah trope. It has long been known that the variety of melodic formulae in Ashkenazi trope exceeded that of Sephardic trope renditions. The *te'amim* actually entail more symbols than necessary for syntactical divisions. Therefore it is clear that part of their original function was representational. Such qualities might have been lost or homogenized by later generations, especially in Sephardic communities, in which many of the *te'amim* are identical in their melodic structure. Simultaneously one can see how the Ashkenazi trope melodies show a definite melodic stability. Observing the trope melodies for *sof pasuq* and *tipha* in the Hungarian tradition, one can derive that they inhibit a definite melodic stability. For the *sof pasuq* we obtain a mean average precision as high as 0.996 and for the *tipha* 0.649 (for comparison, the figures for the Moroccan performance are 0.554 and 0.296 respectively). This indicates that the 17 sof pasuqs in the Hungarian rendition are both similar to each other and distinct from all other te'amim. The same applies to a somewhat lesser extent to the 24 tiphas. Such a melodic stability might have been due to the influence of Christian Chant on Jewish communities in Europe, as is the thesis of Hanoch Avenary (Avenary 1978). Simultaneously, our approach using two structurally important pitches also corresponds to the possible influence of recitation and final tone as being primary tonal indicators within Askenazi chant practice, thereby allowing for a greater melodic stability per trope sign than in Sephardic chant.

In comparing an Indonesian version of the Sura *al Qadr* with versions performed by Indonesian immigrants in the Netherlands, we have found similarities in terms of scale and contour stability. After segmenting the syntactical units found in each reading of the sura we derived melodic scales by detecting the peaks in a non-parametric density estimation of the distribution of pitches, using a Gaussian kernel. These histogram based scales have been compared in terms of their melodic contour and pitch identity and such comparison helps to demonstrate salient structural features of oral transmission within this recitation tradition.

Future Work

The presented methods prove useful for the recordings under investigation. We are currently collecting data, with the aim to study stability and variation between and within performance traditions of Torah trope, Qur'an recitation and Dutch folk songs on a large scale, integrating the results into ongoing musicological and historical research on this topic.

The two recordings of Torah trope used in this study can be consulted at:
http://pierement.zoo.cs.uu.nl/aawm2012

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