Decoding the Song: Histogram Based Paradigmatic and Syntagmatic Analysis of Melodic Formulae in Hungarian Laments, Torah Trope, Tenth Century Plainchant and Koran Recitation

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Abstract

The development of musical notation and the changing relationship between textual syntax and musical semiotics were inherently connected to the transformation of a culture based on oral transmission and ritual to one based on writing and hermeneutic interpretation. Along this historical continuum, notation functioned either to reconstruct a previous, remembered melody or to construct a newly composed melody. For the chant scholar the question arises as to when and under what conditions melodic formulae became solidified as musical material. In the present study we examine examples from improvised, partially improvised, partially notated and gesture-based notational chant traditions: Ashkenazi Torah cantillation, Ninth Century St. Gallen plainchant, and Koran recitation. We explore examples from these various traditions through a novel computational tool for paradigmatic analysis of melodic formulae and gesture.

Sources

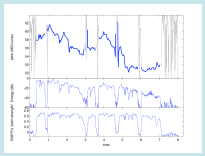
Hungarian Sirató (Laments)
Archived Examples from Hungarian Academy of Science (1968 – 1973)
Early Christian Plainchant
Examples of Tenth Century Plainchant from St. Gallen as performed by Godehard Joppich and Singphoniker: *Gregorian Chant from St. Gallen*
(Gorgmarienhütte: CPO 999267-2, 1994)
Jewish Torah Trope
Archived Examples from Hungary and Morocco from the Feher Music Center at the Bet Hatfatsut, Tel Aviv, Israel
Koran Recitation
Examples from Indonesia and Egypt: in *Approaching the Koran* (Ashland: White Cloud, 1999)

Analysis

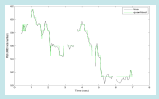
1) Hand Labeling of Audio Segments
2) First Order Markov Model of Sign Sequences
3) F0 Estimation
4) F0 Pruning
5) Scale Derivation: Kernel Density Estimation
6) Quantization in Pitch
7) Scale-Degree Histogram
8) Histogram-Based Contour Abstraction
9) Plotting in per-Sign Segments

Sirató (Hungarian Laments)

Frequency Contour analysis (3, 4). Analysis of a sirató phrase with the SWIPE pitch detector. The top graph shows SWIPE's frequency output; the portions we discard (because the signal energy is too low for at least 100 ms) are in light grey, while those we retain are in thick blue.

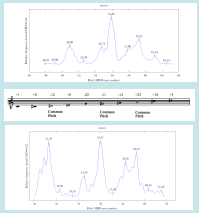


The same phrase before (black) and after (green) **Quantization (6):**



Manual transcription of the same phrase using the computed scale:

The *sirató* is a lament ritual from Hungary that goes back at least to the Middle Ages. This improvised song type is integral for our study, as it exemplifies inherent relationships between speech and singing while demonstrating stable melodic formulae within an oral/aural ritual context.



Scale Derivation via Kernel Density Estimation (5). Derivation of a small number of "scale notes" from a continuous frequency envelope. Here the input comes from the sirató phrase shown to the left, a frequency envelope sampled every 10 ms. First we compute a kernel density estimate (blue curve) by placing a Gaussian (standard deviation 33 cents) centered on each sample of the frequency estimate and adding them all together; like a histogram, this displays the relative prevalence of each frequency. We interpret each peak of the kernel density estimate as a "scale note," with the restriction that if two peaks are within 80 cents we take only the higher one. The upper graph shows this computation applied to the entire 54-second example (followed by a notated representation of the resulting scale); the bottom graph shows the same computation applied only to the 7-second phrase shown to the left.

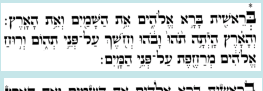
Jewish Torah Trope

Jewish Torah trope is "read" using the twenty-two cantillation signs of the *te'amei hamikra*, developed by the Masorete rabbis between the sixth to the ninth centuries. The melodic formulae of Torah trope govern syntax, pronunciation and meaning. While the written *te'amim* have not changed since the tenth century C.E., their corresponding melodic formulae are determined not only by Jewish tradition of cantillation but also by the melodic framework of their surrounding musical environment

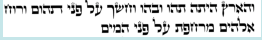
Genesis 1:1 - 1:2

1:1 Bereshit bara Elohim et hashamayim ve'et ha'arets.
In the Beginning G'd created heaven and earth.
1:2 Veha'arets hayetah tohu vavohu vechoshech al-peney tehom veruach Elohim merachefet al-peney hamayim.
The earth was without form and empty, with darkness on the face of the depths, but G'd's spirit moved on the water's surface.

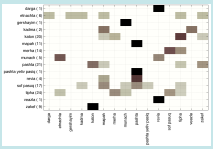
Regional Comparisons of Trope Signs (1,3,4,9)
Comparison of Hungarian and Moroccan Examples of
Trope Signs Merha Sof Pasuq and Sof Pasuq



Text of Genesis 1:1-1:2 displayed as in Tikun (with vowels and recitation signs)



Text displayed as in Torah Scroll: Trope sign Sof Pasuq - "End of Sentence"



Syntagmatic analysis with a first-order Markov model (2) of the sequence of Torah trope signs for the text Shir Ha Shirim ("Song of Songs"). For a given trope sign (a row), how many total times does it appear in the example (numeral after row label), and in what fraction of those appearances is it followed by each of the other trope signs? The darkness of each cell corresponds to the fraction of times that the trope sign in the given row is followed by the trope sign in the given column. (NB: Cell shading is relative to the total number of occurrences of the trope sign in the row, so, e.g., the black square saying that "darga" always precedes "revia" represents 1/1, while the black square saying that "zakef" always precedes "katon" represents 9/9.)

Koran Recitation: Surah Al Qadr ('Destiny')

The performance framework for Koran recitation is not determined by text or by notation but by rules of recitation that are primarily handed down orally (Zimmermann 2000, p. 128). Here the hierarchy of spoken syntax, expression and pronunciation play a major role in determining the vocal styles of *Tajwid* and *Tartil*. 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.

إِنَّا أَنزَلْنَٰهُ فِى لَيْلَةِ ٱلْقَدْرِ ﴿١﴾

Innā	anzalnā	hu	fi	laylati l-qadr
Indeed	we sent it down	to him	on	the night of qadr.

Histograms **Histogram-Based Contour Abstraction Comparison (1,7,8,9)**

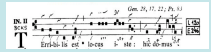
Above is shown the histogram based contour abstraction for the Al-Husari version of Sura Al-Qadr. The top diagram shows the full quantized contour representation that results from selecting all 13 histogram bins. The bottom diagram shows a simplified contour that results from selecting only the two largest histogram bins, which are highlighted in red on the lower histogram.

Plainchant

The early plainchant neumes came from a logogenic culture that was based on textual memorization; the singing of memorized chants was central to the preservation of a tradition that developed over centuries (Treitler 1982). Already in the ninth century the technology of writing was advanced enough to allow for new degrees of textual nuance. Here the ability for formulae to transcend textual syntax is at hand, pointing to the possibility for melodic autonomy from text.

Einsieden 246:
Introit from
Codex Einsiedeln 121
10th Century

Graduale
Triplex 397



Histogram-Based Contour Abstraction (1,8,9) Histogram