DOI: 10.4312/mz.58.2.107-119
UDK 781.7(560):004.93

Temporal Evolution of *Makam* and *Usul* Relationship in Turkish *Makam*

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ABSTRACT

Turkish *makam* music is transmitted orally and learned through repetition. Most previous computational analysis works focus either on *makam* (its melodic structure) or *usul* (its rhythmic pattern) separately. The work presented in this paper performs a combined analysis to explore the descriptive potential of the relationship between these in over 600 *makam* pieces.

Keywords: music information retrieval, Turkish *makam*, computational musicology

IZVLEČEK

Turška *makam* glasba se prenaša skozi ustno izročilo in usvoji s pomočjo ponavljanja. Večina prejšnjih računalniških analiz se osredotoča bodisi na *makam* (melodično strukturo) ali *usul* (ritmične vzorce). Pričujoče delo pa predstavlja kombinirano analizo obeh in tako raziskuje opisni potencial odnosa med *usul*om in *makam*om v preko 600 skladbah.

Ključne besede: pridobivanje glasbenih informacij (MRI), turški *makam*, računalniška muzikologija

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Introduction

Numerous traditions belonging to a large geographical region of Asia, North Africa and Eastern Europe include the term of *makam/maqam* as part of their music vocabulary. This work is focused on the Ottoman-Turkish *makam* music (OTMM) tradition that proliferated in the Ottoman Empire and continues developing until nowadays. The term Ottoman-Turkish Music (*Osmanlı-Türk Musikis*) was coined by Behar (2015).[1] OTMM is comprised by a melodic structure called *makam* (plural *makamlar*) and rhythmic patterns called *usul* (plural *usuller*) described in the following subsections.

Makam

Makam derives from the Arabic *maqam* that means place, location, position or station/stop which is conceptually related with space, motion and stop/final in music. The concept of *makam* that has given a distinctive quality to Turkish music is based on multifaceted relations that are still very controversial from a musicological point of view.[2] For instance, the *makam* concept is not equivalent to the Western music definition of scale, even when some aspects can be regarded as similar considering that some notes play a key role in the development of a melodic progression such as the *durak* or *tiz durak* (functionally related to tonic), *güçlü* (related to dominant) or *yeden* (related to leading tone) in Western music. In addition, the initial and final tone (*agâz* and *karar*, respectively) also play an important role in *makam* theory.[3] Differently from Western music, a single *makam* can have more than one note playing the same role. As an example, *makam Segâh* is shown in Figure 1. In OTMM, the basic intervallic unit is the *Holdrian comma* that is obtained by dividing the octave into 53 equal parts. However this resolution has never been fully utilized in Turkish *makam*.[4] For these reasons, a higher number of different notes and accidentals are usually found in scores and there is no one-to-one mapping to fixed frequency values.[5] Therefore, it is especially important to consider these aspects while performing analyses based on symbolic data, due to the limitations they represent in regards to the ground truth performance where

1 Sertan Şentürk, "Computational Analysis of Audio Recordings and Music Scores for the Description and Discovery of Ottoman-Turkish *Makam* Music" (Doctoral dissertation, Universitat Pompeu Fabra Barcelona, 2016), 7, DOI: http://mtg.upf.edu/node/3675.

2 Okan Murat Öztürk, "How Was the Traditional Makam Theory Westernized for the Sake of Modernization," *Rast Müzikoloji Dergisi* 6, no. 1 (2018): 1773.

3 Ibid., 1769–1787.

4 Ozan Yarman, "A Comparative Evaluation of Pitch Notations in Turkish Makam Music," *Journal of Interdisciplinary Music Studies* 1, no. 2 (2007): 51–62, DOI:/10.13140/RG.2.2.14971.72483.

5 Mustafa Kemal Karaosmanoglu, "A Turkish Makam Music Symbolic Database for Music Information Retrieval: SymbTr," in *Proceedings of the 13th International Society for Music Information Retrieval Conference* (Porto: FEUP Edições, 2012), 223–228.

differences are possibly larger compared to Western music scores. Additionally, the total number of *makamlar* is estimated to be over four hundred. However, not all of them are frequently used.

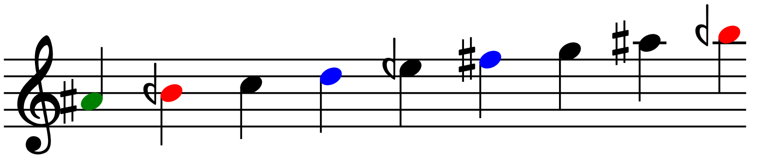

Figure 1: Makam Segâh. Colored noteheads correspond to the leading tone (green), root (red) and dominant (blue).[6] It can be observed that this makam has two dominant tones.

Usul

The term *usul* is used to describe a rhythmic pattern that is usually given by a sequence of onomatopoeic words that describe a series of intonations with varying weights that in practice are ornamented and varied by the performer, starting from a baseline pattern. A particular *usul* may present more than one baseline pattern, as shown in Figure 2 where two different baseline patterns are presented for *usul Musemmen*. Generally, multiple ornamentations of different *usuller* can be found for different tempi as well as for different percussion instrument sets.[7] When an *usul* is given in score notation, it will not describe the notes' onsets in the same way as in Western music. Instead, it will serve as a mere guideline and cannot be easily mapped into a well-formed hierarchical rhythmic structure, perhaps except for the fact that notes in the upper part of the staff commonly correspond to strongly accented strokes as opposed to notes in the lower part of the staff that correspond to less accented strokes. Additionally, the concept of syncopation seems to be inherently present in some *usuller* (such as *Düyek*) more than others.[8]

6 Ali C. Gedik and Barış Bozkurt, "Pitch-Frequency Histogram-Based Music Information Retrieval for Turkish Music," *Signal Processing* 90, no. 4 (2010): 1049–1063, DOI:/10.1016/j.sigpro.2009.06.017.

7 Barış Bozkurt, "Usul Samples by barisbozkurt," *Freesound.org*, sound recordings posted by user barisbozkurt, accessed April 16, 2021, https://freesound.org/search/?q=usul.

8 André Holzapfel and Barış Bozkurt, "Metrical Strength and Contradiction in Turkish Makam Music," in *Proceedings of the 2nd CompMusic Workshop* (Istanbul: Universitat Pompeu Fabra, 2012), 83.

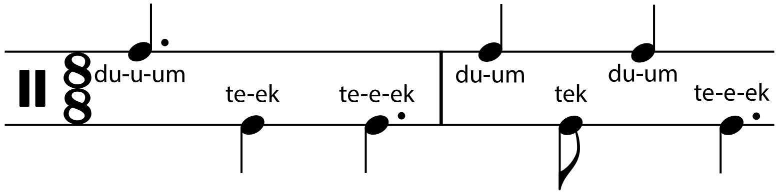

Figure 2: *Usul Musemmen*.

In Figure 2, each bar represents a different baseline. The accompanying expression of each note provides information about how it should be played as an onomatopoeic expression. In the case of baseline form I (left), the pattern is composed by three different onomatopoeic expressions (du-u-um, te-ek and te-e-ek), whereas in the case of baseline form II (right), the pattern has four expressions instead (du-um, tek, du-um, te-e-ek) where one of them (du-um) is repeated twice. These expressions just serve as a baseline and further ornamentations may be played in between.

Combined Approach

For all previously mentioned reasons, working with symbolic data can provide a significant simplification for some OTMM exploration tasks that otherwise would involve a laborious audio processing work where algorithms created for other music traditions may not be applicable. However, additional considerations of this music tradition may be required to perform a sensible interpretation of the results. While previous research works separately explore aspects of *usul* or *makam* in OTMM,[9] this research is focused on a combined exploration of the relationship between estimate *usul* and *makam* offsets for a subset of 687 scores corresponding to ten *makamlar* and twelve *usuller* extracted from the SymbTr dataset in order to find potentially useful patterns of interest in (ethno-)musicological research as well as development of computational tools for OTMM. Our work explores the temporal evolution of the vertical relationship of the *usul* and *makam* progression over time as we hypothesize that by studying it, potentially descriptive outlines may be encountered as a product of the intrinsic and idiomatic interaction between rhythm and melodic progression in this music tradition.

9 Barış Bozkurt, "Features for Analysis of Makam Music," in *Proceedings of the 2nd CompMusic Workshop* (Istanbul: Universitat Pompeu Fabra, 2012), 61–65; Barış Bozkurt, "Computational Analysis of Overall Melodic Progression for Turkish Makam Music," in *Penser l'improvisation*, ed. Ayari Mondher (Sampzon: Éditions Delatour France, 2015), 289–298; Gedik and Bozkurt, "Pitch-Frequency Histogram-Based Music," 1049–1063; André Holzapfel, "Relation Between Surface Rhythm and Rhythmic Modes in Turkish Makam Music," *Journal of New Music Research* 44, no. 1 (2015): 25–38, DOI:/10.1080/09298215.2014.939661; Holzapfel and Bozkurt, "Metrical Strength," 79–84.

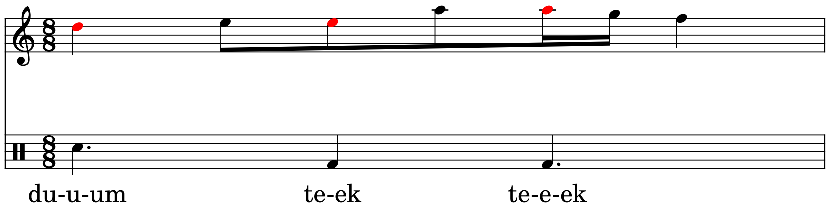

Figure 3: Melody notes filtering based on coincidence with the underlying *usul* pattern exemplified on an excerpt of the proposed SymbTr subset.

The excerpt shown in Figure 3 features *makam Hüseyni* and *usul Musemmen*. In this study, the notes highlighted in red are referred to as being visited because the onset of both *usul* and *makam* coincide. Every time the *usul* and *makam* onset are temporarily aligned counts as a visitation.

Methodology

To be able to explore the data, we have chosen a subset of the SymbTr dataset that contains the highest amount of scores per *makam* among all the available ones and that we were able to gather bibliographical support for. This selection corresponds to *makamlar Hicaz*, *Nihavent*, *Rast*, *Hüzzâm*, *Hüseyni*, *Segâh*, *Mâhur*, *Sabâ*, *Acemaşiran*, *Bûselik* and *usuller Aksak*, *Düyek*, *Sofyan*, *Curcuna*, *Semai*, *Nim Sofyan*, *Aksak Semai*, *Turk Aksagi*, *Yuruk Semai*, *Devr-i Hindi*, *Evfer* and *Musemmen*. For our analysis, we worked with the concept of what we refer to as a 'visitation.' It refers to the temporal alignment of melody and *usul* pattern. A visitation happens when the onsets of melody notes coincide with strokes of the underlying *usul* pattern (see Figure 3). The frequency (number of instances, as exemplified in Figure 5d) and mean duration in quarter notes of such visitations (Figure 5b) have been shown to correlate with theoretical *usul* weight patterns (Figure 5a) by Holzapfel and Bozkurt.[10] All visitation measurements were done respecting the individual *usul* baseline pattern and time signature of each score. In order to simplify the subsequent analysis, scores that presented more than one *makam*, time signature or *usul*, were discarded from the initial selection. Additionally, a synthetic score note to the *Holdrian comma* representation was curated based on the text annotations of the SymbTr dataset[11] which was exclusively designed and used for hierarchical visualization purposes rather than as ground truth tones due to the notation limitations discussed in section *Makam* above.

10 Holzapfel and Bozkurt, "Metrical Strength," 79–84.

11 Karaosmanoglu, "A Turkish Makam Music," 223–228.

Durations of Usul *Visitations*

First, we computed the mean note duration for each visitation with respect to the underlying *usul* patterns for each song on the chosen SymbTr subset. Additionally, we collected the mean note duration of melody notes that did not meet the criteria of a visitation or – in other words – did not happen to temporally coincide with the *usul* pattern. On the whole corpus, we then compared the mean note duration of visitations and non-visitations. To filter out notes that we assumed to have a rather ornamental function, we also disregarded notes that did not temporally coincide with an eighth note grid (see Figure 4).

Accent Patterns and Melody

We proceeded to extend previous work done by Holzapfel,[12] who measured correlations of theoretical *usul* accent patterns with melodic note onset patterns and could show significant discriminative potential in an *usul* classification task. We further investigated in this direction by making observations on visitation distribution patterns, specifically visualizing distributions against the underlying *usul* strokes. Measurements were taken on groups of scores that shared the same *usul* and in three metrical categories. One category counts the frequency of visitations (exemplified in Figure 5d), the second one measures the average duration for each of these visitations (see Figure 5b) and a third category sums all note durations in such cases (see Figure 5c).

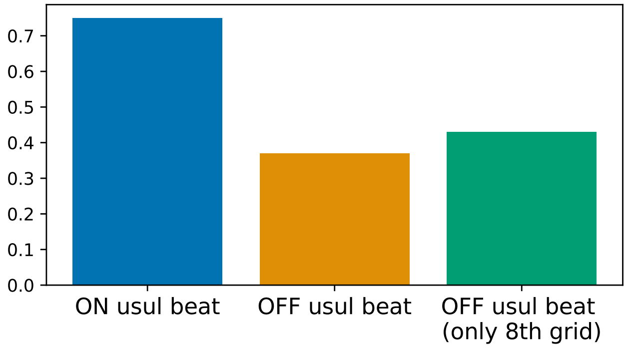

Figure 4: The y axis represents the average duration (in quarter notes) of notes that coincide with *usul* strokes (blue) and notes that do not (yellow). For a less fine-grained measurement grid, we filtered out notes that do not rhythmically coincide with eighth note multiples (green).

12 Holzapfel, "Relation Between Surface," 25–38.

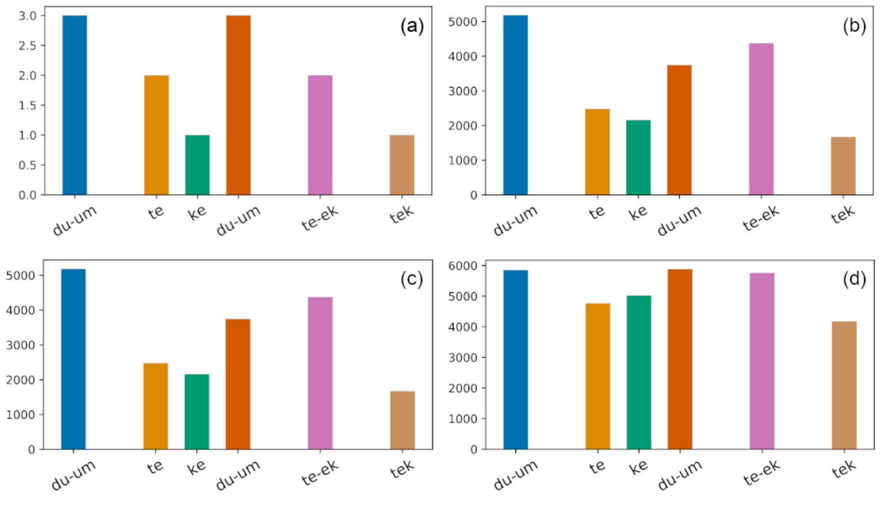

Figure 5: Example of usul Aksak in comparison to melodic features (inspired by Holzapfel's and Bozkurt's measurements):[13] (a) theoretical weight patterns, (b) mean duration per visitation in quarter notes, (c) sum of durations per visitation, (d) frequency count of usul visitations. The x axis represents stroke types according to their temporal occurrence in the given usul pattern. The y axis represents visitation measurements for each stroke type based on the aforementioned metrics.

Melodic Visualization over Histogram

Motivated by the visualization work on melodic progressions by Bozkurt,[14] we implemented a computational approach to complement melodic analysis of OTMM through multi-feature visualization of melodic and rhythmic information over time. This includes a note histogram and note outline based on melodic *usul* visitations (hence disregarding non-visitations) over time. For this purpose, scores are separated in various time frames, from which their respective mean pitch and pitch histogram are derived. In Bozkurt's proposal, the temporal selection of these melodic time frames does not take into account musical form (or structure) and hence we wanted to present an extended approach to this type of analysis. In an effort to better represent musical form, our time frame selection corresponds to individual bars. Extensive analysis plots were created for individual scores from the dataset (as opposed to aggregated groups of scores used in Bozkurt's work).[15] With this approach,

13 Holzapfel and Bozkurt, "Metrical Strength," 79–84.

14 Bozkurt, "Computational Analysisof," 291.

15 Ibid., 289–298.

we propose a summarized rhythmic and melodic analysis that accounts for the temporal evolution of a score. We have also ensured to provide melodic-semantic information such as the note function as well as the description of a *makam* direction (ascending, descending or ascending-descending).

Results

All previously described computations were performed on our selection of scores. In this section, the results are separately addressed for each analysis presented throughout the methodology.

Durations of Usul Visitations

By calculating the average duration in quarter notes of all notes categorized by their visitation property, a tendency toward longer melody note length for visitations versus non-visitation notes can be observed. On the entire selected SymbTr subset, visitations average about 0.75 quarter note lengths in duration, while non-visitations last for 0.37 quarter note lengths (0.43 quarter note lengths ignoring all notes that do not align with the eight note subdivisions grid). While the outcome in Figure 4 might appear biased through the fact that all *usul* baselines in this study have a stroke on the first beat of each measure, we have found that a similar relative distribution of note durations can be observed even when ignoring all notes that occur on beat one. In fact, the measured average note duration for *usul* visitations is 0.66 quarter note lengths, while non-visitations correspond to an average of 0.37 quarter note lengths (0.45 quarter note lengths ignoring all notes that do not align with eight note subdivision grid).

Accent Patterns and Melody

On our data of 687 scores and due to uneven distribution of scores across the proposed *usul* classes, we have measured between 110 and 31,450 overall melodic visitations per *usul* in total. For each stroke of each *usul*, between 13 and 6,703 occurrences of melodic visitations were counted, which lasted between 0.39 and 1.65 quarter note lengths on average. An outcome of this measurement task for the *usul Aksak* is shown in Figure 5.

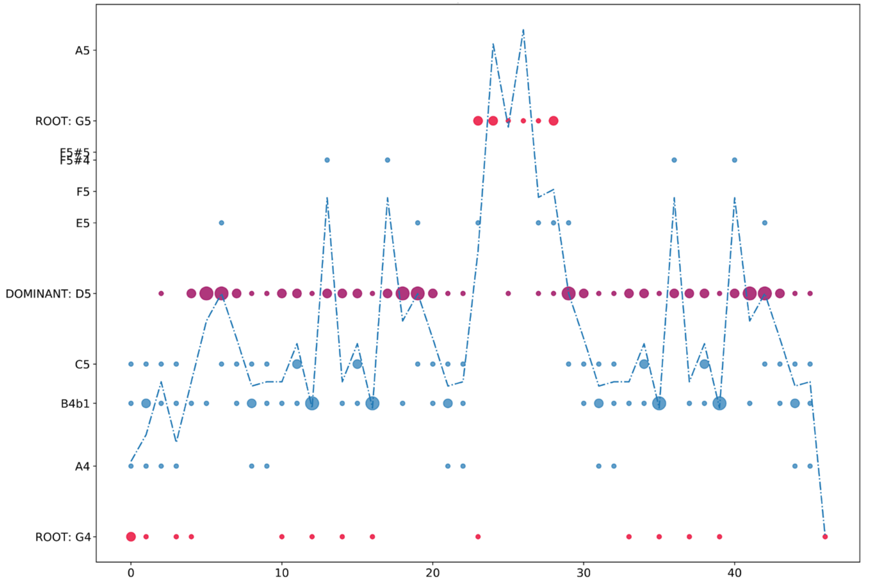

Figure 6: The proposed visualization of melody based on *usul* visitations for *makam Rast* and *usul Yuruk Semai*. The x axis represents the measure number. The y axis represents the note pitch calculated using our synthetic *Holdrian comma* mapping. The colored circles represent note histograms for each measure. Dominant (D5) and root notes (G4 and G5) are highlighted in purple and red, respectively. The mean pitch value of the notes played in each measure creates the melodic outline represented as a dashed blue line.

Melodic Visualization over Histogram

We have processed all scores in our SymbTr subset and computed plots that show the melodic outlines of *usul* visitations together with measure-wise histograms. To facilitate the analysis, we have organized these plots to be grouped by *makam* type and *usul* type pairs in the accompanying repository. The resulting 120 groups (combining ten *makamlar* and twelve *usuller*) show to yield between zero and 26 scores (average 5.26). It is observed that the chosen approach of creating a time frame for each bar facilitates the visual assessment of melodic repetitions in the outline, while histograms help to visualize melodic target points over time.

Discussion

We have found that the hypothesis of relative semantic importance of melodic onsets over an *usul* baseline pattern can be supported by the observation of longer note durations for visitations versus non-visitations as shown in Figure 4. However, it is important to note that we do not consider the metric of note durations as sufficient for semantic importance of melodic events, because additional aspects outside of the scope of this research may also have impact on this feature such as the limited information that can be extracted by analyzing purely symbolic data. Further investigations on other metrics such as pitch or dynamics would need to be conducted to state such a claim and could be the topic of further research. These findings could also be contrasted with audio recordings of OTMM.

After the application of the methodology described in section *Accent Patterns and Melody*, we noticed that the combination of occurrence count and average duration – the sum of durations – seems to reflect Holzapfel's theoretical accent pattern weight distributions[16] in the melody in most cases (example in Figure 5c).

In the majority of cases, both the histogram and temporal plot (see Figure 6) coincide with the fact that the note that can be regarded as 'dominant' is the most visited along the score, being even more frequent than the root, regardless of the underlying *usul*. Additionally, when a *makam* presents two 'dominants,' usually one of them is predominant over the other, and the root can be also more predominant than the second 'dominant.'

As seen in Figure 6, the temporal patterns described by the matched *makam/usul* onsets can visually summarize the melodic progression of the score. Ornaments and variations added by the performer may not be present in this visualization since these usually occur between the baseline *usul* pattern onset and therefore, we believe that the depicted visualization can potentially help to summarize a score and be used to detect repeating patterns in melody as well as form, especially through the property of using individual bars as the smallest temporal unit. Future work may start from this visualization in order to explore the usefulness of it in tasks such as phrase segmentation or form detection.

Conclusion and Future Work

This research presents a collection of analysis strategies motivated by the interaction between rhythm and melodic progression embodied by the concepts of *usul* and *makam* in Ottoman-Turkish *makam* music (OTMM). The concept of visitation is also introduced as a criterion to obtain a summarized description

16 Holzapfel, "Relation Between Surface," 25–38.

of a score. Our results corroborate previous work on rhythmic analysis and also contribute with an extended temporal analysis that includes both melodic and rhythmic progressions that are observed to have descriptive potential to summarize the content of a *makam* score. This analysis could also drive future work on *makam* segmentation and classification tasks. An accompanying repository is included as a contribution of this research, enabling other researchers to adapt our methodology, replicate our results and to further explore the SymbTr dataset.

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POVZETEK

Časovni razvoj odnosa med *makam*om in *usul*om v turškem *maka*mu

Turška *makam* glasba izvira iz ustne tradicije in se poučuje prek vajeništva oz. odnosa med mojstrom in vajencem, kjer se vajenec skladb nauči s ponavljanjem. Monofone kompozicije so grajene v okvirih melodične strukture, ki se imenuje *makam*, ter ritmičnih vzorcev, poimenovanih *usul* (edn.). Ker v primerjavi z zahodno glasbeno tradicijo turški *makam* uporablja večje število tonov v oktavi, pa tudi veliko množico idiosinkratičnih ritmičnih struktur, analitičnih modelov, ki delujejo po premisah tradicije zahodne glasbe, pogosto ne moremo neposredno prenesti na *makam*.[17] Dosedanje računalniške analize turškega *makam*a uporabljajo metode, kot so historigrami tonskih višin, n-gram analize in kratkoročni historigrami tonskih višin, ter se tako osredotočajo predvsem na melodični vidik kompozicije[18] oziroma analizirajo ritem ločeno.[19] Pričujoči članek proučuje deskriptivni potencial kombinirane časovne analize ritmičnih vzorcev ter melodičnih postopov, pri tem pa uporablja podsistem sistema SymbTr, nabor simbolnih glasbenih notacij, ki vsebuje več kot 1.500 notnih zapisov s 155 različnimi *makam*i in 48 *usul*i.[20] Na voljo je tudi podatkovni repozitorij, ki omogoča reproduciranje te raziskave ter omogoča drugim raziskovalcem, da uporabljajo ta skupek podatkov (*dataset*).[21]

17 Mustafa Kemal Karaosmanoglu, "A Turkish Makam Music Symbolic Database for Music Information Retrieval: SymbTr," v *Proceedings of the 13th International Society for Music Information Retrieval Conference* (Porto: FEUP Edições, 2012), 223–228.

18 Barış Bozkurt, "Features for Analysis of Makam Music," v *Proceedings of the 2nd CompMusic Workshop* (Istanbul: Universitat Pompeu Fabra, 2012), 61–65; Barış Bozkurt, "Computational Analysis of Overall Melodic Progression for Turkish Makam Music," v *Penser l'improvisation*, ur. Ayari Mondher (Sampzon: Éditions Delatour France, 2015), 289–298; Ali C. Gedik in Barış Bozkurt, "Pitch-Frequency Histogram-Based Music Information Retrieval for Turkish Music," *Signal Processing* 90, št. 4 (2010): 1049-1063, DOI:/10.1016/j.sigpro.2009.06.017.

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20 Mustafa Kemal Karaosmanoglu, "A Turkish Makam Music Symbolic Database for Music Information Retrieval: SymbTr," v *Proceedings of the 13th International Society for Music Information Retrieval Conference* (Porto: FEUP Edições, 2012), 223–228.

21 Esteban Gómez in Benedikt Wimmer, "Turkish Makam Temporal Analysis," GitHub, dostop oktobra 2022, https://github.com/eagomez2/turkish-makam-temporal-analysis.

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O AVTORJIH

BENEDIKT WIMMER (benedikt.wimmer@fhws.de) je raziskovalec na področju računalniške muzikologije. Ukvarja se z razumevanjem interakcijskih vzorcev v diadični glasbeni improvizaciji. Po zaključku študija informatike na Tehnični univerzi v Münchnu je magistriral na Univerzi Pompeu Fabra v Barceloni (računalništvo zvoka in glasbe), trenutno pa kot doktorski kandidat dela skupaj s prof. dr. Thomasem Woschem na Univerzi za aplikativne vede Würzburg-Schweinfurt. Njegova prejšnja dela vključujejo izobraževalni računalniški program ter glasovno tehnologijo, osnovano na umetni inteligenci.

ESTEBAN GÓMEZ (esteban.gomezmellado@aalto.fi) je magistriral iz glasbene produkcije, tehnologije ter inovacije na Berklee kolidžu za glasbo ter iz računalništva zvoka in glasbe na Univerzi Pompeu Fabra. Trenutno je doktorski kandidat s področja elektrotehnike na Univerzi v Aaltu (Finska). Njegova predhodna področja delovanja vključujejo raziskovanje glasbene tehnologije za ohranjanje glasbene dediščine, umetniško udejstvovanje na področju glasbe ter strojno učenje za področje glasbene analize in procesiranje jezika.