TEMPO AND PROSODY IN TURKISH TAKSIM IMPROVISATION

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ABSTRACT

Instrumental improvisation in Turkish makam music, the taksim, is considered to be free-rhythm, that is its rhythm develops without the underlying template of a meter or continuous organized pulsation. In this paper, we want to examine how in this setting, rhythmic idioms are formed and maintained throughout a performance. For this, we will apply a simple signal processing approach. We show differences that can be observed between performers, and raise the question if a tempo could be evoked by certain regularities in the occurring rhythmic elaborations.

1. INTRODUCTION

In Makam music of Turkey, we can distinguish between metered pieces and free-rhythm improvisation. In our paper, we focus on the latter in the form of instrumental improvisation, which is called taksim in Turkish art music. While rhythm in metered pieces of Turkish music was analyzed previously by Holzapfel & Bozkurt (2012), a detailed study of rhythm in Turkish improvisation still remains to be approached. Until now studies on taksim concentrated on aspects of melodic development (Stubbs, 1994), and scale aspects (Bozkurt, 2008). A study on rhythm is timely because improvisation in Turkish music is widely considered as free-rhythm (Clayton, 2009), which means that its surface rhythm is not related to an organized and continuous pulsation. Instead, it has been mentioned that taksim is characterized by pulsations in non-metrical flowing rhythm (Feldman, 1993). To the best of my knowledge it has not been investigated how such a pulsation is formed; i.e. how it appears throughout a performance, and if there is some degree of continuity of such pulsation as it was observed by Widdess (1994) for a specific Hindustani alap performance.

In the presented work we apply a simple signal processing framework in order to investigate the occurrence of pulsation in taksim. We restrict ourselves to taksimler (plural of taksim) played on the instrument tanbur, which is a plugged string instrument. This restriction is imposed in order to avoid any variance in style possibly encountered on different instruments, and because the sound of the tanbur has the advantage, from a signal processing point of view, that the strokes of the pick can be detected relatively easily. This enables us to study some basic rhythmic properties of taksim using a fairly simple signal processing approach.

We compiled a dataset of 52 tanbur taksimler played by five renowned masters, and observe how pulsation develops over the individual taksim. Interesting differences are pointed out that seem to be related to personal style, or to the style predominating the recording period. The creation of a tempo in taksim is discussed, and relations to speech utterances are pointed out.

2. PROCESSING APPROACH: DESCRIPTION, MOTIVATION AND EXAMPLES

First, we need to emphasize signal transients which are positioned at the time instances where the player hits a string. For this, we convert our original audio signal to an onset function by examining positive changes in its spectral magnitude (Holzapfel et al., 2010). Then autocorrelations of this onset function are computed in small shifting windows of 3s length and a hop size from one window to the next of 0.5s, similar to Holzapfel & Stylianou (2011). The obtained autocorrelation vectors are stringed together in a two-dimensional representation, referred to as pulsation matrix hereafter. This matrix has the time of the initial recording on its x-axis, and the lags of the autocorrelations (in seconds) on the y-axis.

We clarify this process using a simple artificial example. We generate a signal, which contains a series of equidistant impulsive sounds (here: noise bursts, could be also e.g. hand claps). In the first half of the signal, each sound is 0.6s from its neighbors apart, while in the second half this period is increased to 0.75s. The onset function derived from this signal has peaks only at the onsets of the impulsive sounds and is zero, or at least very small, otherwise. An autocorrelation of a 3s excerpt from the first half of this signal will have peaks only at the onsets of the impulsive sounds and is zero, or at least very small, otherwise. An autocorrelation of a 3s excerpt from the first half of this signal will have peaks at the period of 0.6s, and at its multiples. This can be seen in Figure 1 from the bright colors located at these lags (0.6s,1.2s,1.8s, higher multiples not shown in the Figure). These lags \( l \), in seconds, can be interpreted as specific tempo locations \( s \) in beats per minute (bpm), by the simple conversion \( s = 60/l \). For
example, the series of sounds in the first half of our example is related to the tempo of 100 bpm, meaning that we have a regular sequence of 100 impulses per minute. However, in the middle of our example we change this period, which causes the shown pulsation matrix to have its peaks related to this second series of pulses, which has a period of 0.75 s or a tempo of 80 bpm. We can see in this simple example that if a pulsation is maintained stable over a period of time, we will observe a relatively stable comb-like structure over several columns of the matrix, which are related to the tempo of the pulsation in this signal. If, as usually in music interpreted by humans without the use of metronomes, the tempo changes gradually, we will observe bright parallel lines that do not remain at a constant position as in our example but change their place gradually. On the other hand, if we have a signal that has no pulsation at all, we will end up with a matrix having an almost uniform color.

![Automatic annotation vs. Manual annotation](image)

**Figure 2:** Two examples of pulsation matrices for recordings of Turkish makam music

In Figures 2a and 2b, we depict such pulsation matrices for a metered piece of Turkish music, and for a taksim, respectively. The lines on top of the pulsation matrices have been obtained by running a beat tracking algorithm (Davies & Plumbley, 2007) (bold black line), and by manually tapping to the piece of music (dotted red line). Both tapping and the beat tracker provide us with a series of time values for the position of the pulses. The value on the y-axis of these lines represents the time-interval between these pulses. For the metered piece in Figure 2a, equidistant horizontal lines are characteristic for the pulsation matrix, with mutual distances of about 0.2 s. We can observe that the black and the red lines of the annotations are exactly on top of one of the ridges formed by the horizontal lines. This clarifies that the piece has indeed strong, continuous and relatively stable periodicities in its surface rhythm. For the taksim, on the other hand, Figure 2b shows parallel line structures which imply the existence of pulsation in the piece. Here, however, they are less stable, which means that they change rapidly, and they are interrupted with sequences that lack pulsation completely (e.g. at about 50 s). Neither beat tracker nor manual annotation follow the pulsation indicated by the ridges in this matrix consistently. This example indicates that, while pulsation occurs in taksim, this does not lead to a clearly trackable pulse throughout a performance.

These two examples seem to be representative for the “behavior” of beat tracking algorithms; In our recent work (Srinivasamurthy et al., 2013) we observed that two different beat tracking algorithms often estimate either the true tempo or a tempo related to ground truth annotation with a factor of 2 on a collection of 63 Turkish makam music recordings. This confirms that for metered pieces of Turkish makam music, tempo obtained from algorithms and human performance tend to be strongly related. For pieces with no or highly ambiguous meter, our work on the mutual agreement of beat tracking algorithms documents that algorithmic output on such signals changes randomly between approaches, which is reflected in the arbitrary relation between algorithmic and human tempo annotation in Figure 2b.

Regarding human behavior it is less apparent how the two examples generalize to other metered pieces or taksims, and the beat or tempo humans would generally perceive in such pieces. We are currently conducting a series of experiment to evaluate for the sensorimotor synchronization (Repp, 2005) of Turkish musicians to metered pieces. We can observe that musicians tend to differentiate between clapping to music in a “technical” way by aligning their strokes to the underlying usul (i.e. rhythmic mode), or by freely accompanying the surface rhythm with their claps. While the claps can show a wide variety of behavior, the technical way of clapping is less limited in its variation because musicians are aware of the alignment between rhythm and rhythmic mode (usul). For taksim, such a behavioral study is even more complex, if not impossible. There is no doubt among practicing musicians that a taksim has no meter. When asked about the rhythmic elaboration of taksim, they usually state that they do not consciously maintain a tempo. On the other hand, some of them do not want to exclude that at least in some examples a continuous pulse might exist.

We believe that an access different from a sensorimotor synchronization experiment has to be found to shed light on the elaboration of rhythm in taksim. The first reason to assume that is the observation that musicians already in a free-form tapping experiment to metered music showed little enthusiasm for tapping rhythmic patterns in an experimental setup. Furthermore, language impedes an explicit access needed in such an experiment, as a term like "pulse" or "beat" is hard to translate to Turkish. Its meaning would be either interpreted as not musical, or as related to a rhythmic mode. However, as the taksim obviously do not have a rhythmic mode, a direct access using language to form a suitable question for an experiment seems impossible.
Finally, sensorimotor synchronization tasks were usually conducted using highly simplified sounds (Repp, 2005). It can be expected that the complexity of taksim sounds in terms of rhythm and other aspects represent another reason to hesitate in conducting such a study.

For these reasons, we want to apply our simple signal processing approach in order to obtain some insights into the rhythmic structure of taksim, as this might help us to form a more precise hypothesis about rhythmic elaboration in taksim. We observe that some periods seem to be prominent throughout a performance, which is exemplified in Figures 3a and 3b, which depict the mean over time of the pulsation matrices in Figure 2a and Figure 2b, respectively. Clear peaks related to the tempo exist for the metered piece (Figure 3a) at the lag related to the tempo (at a period of 0.77s) and at multiples and 1/2 and 1/4 if 0.77s. The taksim shows some clear maxima as well (Figure 3b), however they are not spread over a wide range as for the metered piece. The sharp peak at 0.76s is caused by the periodic noise from the record of the original historic recording. The two peaks below 0.5s are caused by the rhythmic properties of the performance, which might be indicative for a tempo impression in this form. While it is apparent that the pulsation in our example frequently changes its period (the pulsation matrix in Figure 2b is not characterized by parallel, continuous lines over time), we would like to take this observation as a starting point for a stylistic comparison between players and for developing a hypothesis about tempo that is evoked at least in some taksim performances.

![Pulsation profile of peyrev](image1)

![Pulsation profile of taksim](image2)

**Figure 3:** Pulsation profiles, which are obtained by computing the mean over time of a pulsation matrix.

We will first describe the collection of taksim performances which we use in our experiments in Section 3. In Section 4 we will determine the pulsation profiles for all the performances in the collection and use them to obtain a first orientation among the possibly existing different rhythmic idioms in the recordings. Based on these findings, we will focus on comparing two specific players in the collection, and address the question if the differences in their pulsation profiles are indeed in some way related to different styles in rhythmic elaboration. In Section 5, we will give some perspective on how pulsation matrices can be used to evaluate for the existence of a tempo in the sense of a continuous pulsation in some taksim. We will discuss how our representations motivate for searching relations to signals of human speech. Finally, Section 6 concludes the paper.

### 3. MUSIC COLLECTION

Our music collection contains 52 recordings of taksim by five renowned masters of tanbur in Turkey. The players and the numbers of recordings from each player are given in Table 1. These players cover a range of a century of recordings, with Tanburi Cemil Bey marking the beginning of recording history for Turkish music in the beginning of the century. His recordings became influential for generations of players since then, which is why we hope to be able to shed some light on the rhythmic aspects of his playing, and how it possibly differed from other players.

**Table 1:** Tanbur players and numbers of pieces in the collection

<table>
<thead>
<tr>
<th>Name</th>
<th>Number of pieces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ercümen Batanay</td>
<td>11</td>
</tr>
<tr>
<td>Mesut Cemil Bey</td>
<td>8</td>
</tr>
<tr>
<td>Murat Aydemir</td>
<td>5</td>
</tr>
<tr>
<td>Necdet Yaşar</td>
<td>15</td>
</tr>
<tr>
<td>Tanburi Cemil Bey</td>
<td>13</td>
</tr>
</tbody>
</table>

### 4. FATHER AND SON

As a first step we computed all the pulsation profiles for the 52 taksim recordings. In order to compare the profiles we chose the cosine distance, which converts the angle between two vectors to a distance measure in the range between 0 and 1. As we detailed previously (Holzapfel & Stylianou, 2011), this measure is adequate for rhythmic descriptors that contain information about a range of periodicities present in a music signal.

In order to obtain a first orientation, we computed all the mutual distances between the pulsation profiles. We then ordered the distances according to their size, and determined for each taksim which other recording is most similar. In Table 2 shows the results of that experiment, which can be interpreted as a k-nearest-neighbor (kNN) classification with k=1.

It is not the goal to derive some means to classify a recording of a taksim to a specific player, and therefor we will rather try to interpret the meaning of the numbers shown in Table 2. The highest accuracy in kNN classification is related to the taksimler played by Tanburi Cemil
Bey. They seem to be related to pulsation profiles with a very consistent shape, and therefore they should be characterized by pulsations that are concentrated at specific values. As we will see in the following, this is related to a quite characteristic way, in which rhythm is elaborated in his improvisations. While a similar conclusion can be drawn for Ercümen Batanay and Murat Aydemir, the situation seems to be different for Mesut Cemil and Necdet Yaşar. The latter two players seem to be characterized by a wider variety of pulsation profiles, what however does not yet enable us to say anything specific about their rhythmic idioms.

At this point, we would like to take a turn from the overview over the music collection towards a more focused comparison. This more focused comparison will shed light on the reasons for the differences in the pulsation profiles. We chose to compare two players, namely Tanburi Cemil bey and Mesut Cemil. The former became a legend with his recordings in the beginning of the last century, in the last phase of the Ottoman empire. The latter was his son, and contributed significantly to many changes in style in Turkish music with the beginning of the Turkish republic. Therefore, as shortly pointed out by Feldman (1993), their musical styles in taksim differed in terms of the applied rhythmic idioms. This might be a cause for the differences we observe in their pulsation measurements. A comparison of two examples taken from Mesut Cemil’s taksimler (Figure 4) with two taksimler by Tanburi Cemil Bey (Figure 5) reveals some differences. For this, we focus on the lags smaller than 1s, as according to Figure 2b for non-metered pieces these short period pulsations seem to be important. Tanbur Cemil Bey’s taksimler seem to contain strong pulsations concentrated at 0.15s and 0.3s, indicated by the maxima at these values in Figure 5. For Mesut Cemil’s taksimler, the peaks are clearly less concentrated which indicates a larger variation of the pulsations in his taksimler. Especially in the Hisarbuselik taksim, the leftmost peak (at 0.16s) is not accompanied by a second, harmonically related and clear peak. These aspects indicate a difference in the rhythmic content in the related pieces.

The pulsation profiles cannot tell us anything how pulsation develops throughout a piece. While the clear peaks for Tanburi Cemil bey imply strong pulsation, the lack of them for Mesut Cemil does not necessarily imply the absence of pulsation, but might as well indicate a high variation of pulsation tempi throughout a piece. In order to understand more about the temporal development, we need to look at the pulsation matrices of the pieces in question.

They are depicted in Figures 6 and 7 and reveal clear differences in rhythmic elaboration between the two taksimler by Mesut Cemil and the taksimler by Tanburi Cemil.

In the taksimler by Tanburi Cemil pulsations are maintained over large durations, especially in the example of the Rast taksim. This conclusion can be drawn by observing the bright horizontal line patterns in Figures 7a and 7b. In both figures, the second lines (from the top) of these patterns are graphically emphasized by overlaying them with white polygons. We can observe, that e.g. in the Rast taksim a continuous pulsation is established at about 20s, which is then increased in tempo until 70s, and then slowly fades out. The other depicted taksim by Tanburi Cemil does not have such a clear continuous development,
5. PROSODY OF TAKSIM

As we discussed in the previous section, some players, such as Tanburi Cemil bey, seem to emphasize pulsations of specific frequencies in their playing, which seems to make them differ regarding their style from other players. We were able to observe that this emphasis is expressed by a continuous pulsation of up to 50s for Tanburi Cemil bey, while Mesut Cemil seems not to elaborate rhythm in such a continuous way. There might be two reasons for such differences, the first simply being differences in individual playing style, and the second, a difference that is caused by the changed stylistic preferences of the society at different historic periods. The second hypothesis is attractive, because Mesut Cemil is widely known to have broken with many concepts of the court music tradition of the former Ottoman empire. He contributed to defining the new national identity of Turkish music by introducing chorus singing, and by banning styles such as the vocal improvisation gazel that were considered not to fit to an orientation towards Europe. However, while our results might indicate such a direction, other recordings from the final period of the Ottoman empire would have to be examined.

The peaks in the pulsation profiles, and their temporal continuity for some taksim motivates to ask if these phenomena evoke the impression of a tempo in the listener. We could ask if listeners can perceive a tempo development in a taksim that follows the shape of the patterns we observe in the pulsation matrices. It is difficult, however, to quantify the agreement of a listener with the measurements. Therefor, we might establish a tempo curve for a taksim, which follows e.g. the white shaded area in the Rast taksim by Tanburi Cemil bey depicted in Figure 7a. Then, a stimulus in form of a click sequence can be generated that follows this tempo curve, and the resulting click sequence can be superimposed to the sound of the taksim, to ask listeners regarding the relation between the click sound and the music. This way we could for the first time establish some rules how a tempo is established in taksim.

Obviously, a taksim is not based upon a musical meter. This is apparent for various reasons; First, musicians are absolutely clear in the differentiation of forms that follow a rhythmic mode (usul), and forms that do not have any usul, such as the taksim. Furthermore, in literature taksim was always referred to as free-rhythm. When intending to understand in more detail how rhythm in taksim is shaped, investigating relations to rhythm in speech might be helpful instead. Relations between musical expression and speech were frequently used in music seminars of Turkish makam music, which I attended. For instance, teachers might motivate their students to play a short phrase, or their names, on a musical instrument, expressing the sound of the name with the instrument. For that reason, it appears as an interesting question if the pulsation in taksim is in some way related to syllable and word rates in Turkish language. It is interesting to observe that the poetry of the Ottoman was mainly following quantitative meter, hence being based on schemes of syllable durations. This poetry, in the form of gazel, had surely an influence on artists like Tanburi Cemil,
while in the times of the Turkish republic a stronger emphasis was given on folk poetry with its qualitative meter. The discussed relations between poetry and taksim, as well as the potential perception of tempo in taksim can only be examined after a careful annotation of timing in related recordings. As a next step, we intend to manually annotate for some taksimler the time instances, at which the player hits the string. This will enable us to obtain more detailed insights into the rhythmic elaboration of the pieces. Furthermore, it appears meaningful to attempt the same for recitations of poetry or some free speech samples in Turkish language, to be able to eventually compare the occurring timing patterns.

6. CONCLUSION

By applying a simple signal processing approach, we were able to observe differences in the ways two renowned master players of Turkish makam music shape(d) rhythm in their free-rhythm improvisations. Differences are related to the continuity in which a pulsation is encountered over time. These differences might be related to personal style, or to style preferences of different historical periods. The following steps that will help to illustrate these aspects in more detail will lie in conducting some interviews with listeners, and by detailed manual annotations of onset instances in some of the taksim. We will have to address the question, if there are some general styles present in the prosody of taksim, and if the two examined masters might be representative for such styles.

7. ACKNOWLEDGEMENTS

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8. REFERENCES


