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Analysis of Expressive Microvariations in Oral Tradition Music: Two Studies from Romania and Brazil*

Keywords: music and emotion, microtiming, empirical ethnomusicology, Transylvania, *Maracatu de baque solto*, *aksak*

Introduction

In this paper, I pay tribute to Speranța Rădulescu by discussing two fundamental aspects of the ethnomusicological research that Speranța cultivated throughout her career: the recording of oral tradition musicians and analysis of their repertoire. My aim is to present a few thoughts on how these two issues have evolved, in particular when carrying out research on musical emotion – as in my case.

Firstly, I will briefly outline the challenges of ethnomusicological research on musical emotion. As there is no single methodology, I here describe my own choices and strategies, stressing the need for an interplay between ethnographic field research and empirical laboratory measures. I then present two studies: one on rural string music from Transylvania (Romania) and one on carnival percussive music from Pernambuco (Brazil). In the first case, we[1] applied multi-track and motion capture (mocap) technologies to measure the asynchronization between a violinist and a *bracist* (three-string viola player). In the second case, multi-track recordings and

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[1] Both studies were carried out by interdisciplinary research teams (see acknowledgments).

automatic onset detection algorithms allowed us to analyze the micro-deviations in time (microtiming) in a group of five percussionists performing *Maracatu de baque solto*.

In the final section, I will advance a few considerations on the benefits and challenges of multimodal recordings and analysis of expressive microvariations in oral tradition music. In particular, I argue that these research topics and methods, combined with long term field research, enable the highlighting of ensemble playing strategies that may differ subtly from those used by performers of the so-called written tradition of music.

Ethnomusicological research on music and emotion: from the laboratory to the field and vice-versa

In the introduction to *Roma, Music and Emotion* (Bonini Baraldi 2021a), I argue that research on musical emotion should move from the laboratory to the field. With this expression, my aim was to draw attention to the following: while sophisticated experimental procedures have been developed in the domain of experimental psychology, neurosciences, computational musicology, and other fields of science to study the emotional power of music (for a review, see Sloboda and Juslin 2010; Cochrane, Fantini, and Scherer 2013), ethnomusicologists have left this research task aside (with certain exceptions), even though they have widely acknowledged its importance. Starting out from this simple assumption, I stood up in favor of the development of ethnographic accounts of music and emotions that has more recently resulted in growing interest among French ethnomusicologists, as reflected by the publication of a collective volume on this subject (*Cahiers d'ethnomusicologie* 2010). However, given the general nature of the topic and the specific characteristics of each musical culture, we do not yet have any general methodology, a sort of "handbook", for studying musical emotion in the field. Each researcher needs to develop his/her own methodological *bricolage*, depending on the particular cultural and musical context studied, along with his/her skills and personality. I shall briefly outline my own choices here, developed both during my field research in Romania (2004-2010) and Brazil (2014-current), which incorporate a close interplay of field research and experimental laboratory procedures.

Firstly, I believe the ethnomusicological study of musical emotions only makes sense when we share the life of the community we are studying, observing the daily events that move people toward a particular emotional sphere, the actions and social interactions that reveal specific emotions, the subtle bodily movements, facial expressions, the vocal inflections that unveil one's feelings.[2] Secondly, analysis of the local vocabulary of the emotions provides an entry point into how feelings are locally conceptualized, and indeed this represents one of the first "hooks" for anthropologists striving to study how other people feel (Lutz and Abu-Lughod 1990). Once local concepts, words, and expressions come to the surface, we are able to focus on particular emotional registers, specifically those that seem more directly associated with the musical activity. Thirdly, ethnographic analysis of music performances (rituals, processions, parties, concerts, etc.) aims to describe how music drives the emotions of participants, guiding them through a precise "emotional contour" (Wolf 2001) or, conversely, how a specific emotional atmosphere gives rise to musical actions. Fourthly, as "ethnomusicologists of emotions", it is our duty to look closely at how, in a given community, people associate, more or less explicitly, specific sounds, musical structures, ways of playing or singing, to specific feelings.[3] The aim here is to ascertain the large-scale relationships, hence, between the musical parameters (modes, harmonic progressions, timbres, rhythms, etc.) and emotional registers. When accomplished in the many different parts and contexts of this world, this research on local aesthetics would allow us to advance more general hypotheses on the relationship between music and human emotions.

In addition to all these research tasks, one more level of analysis should draw our attention: that of the microvariations that musicians introduce for expressive purposes. In keeping with Gabrielsson's (1995) term "expressive microvariations" I refer to those slight variations – in relation to the expected, nominal values of one or more musical parameters – that musicians introduce in order to impress an emotional quality onto the sounds they are producing. In the case of Western classical music, how a single interpreter produces variations to the referent values of parameters such as tempo, intensity, articulation, and timbre for communicating his or her expressive intentions has been empirically demonstrated (among many others, see Bonini Baraldi, De Poli, and Rodà 2006). More recently, empirical research has focused on how performers jointly produce expressive microvariations in terms of interindividual covariation, thus how they "coordinate their actions to bring about the optimal covariation of expres-

2 This might seem obvious but is always worthwhile stressing as long term field research no longer seem as steady a point in the discipline as in past decades.

3 To provide just one example from outside the Western classical tradition, one may refer, for instance, to Hindustani musical treatises on the associations between *raga* (a melodic framework for musical improvisations) and *rasa* ("feeling", "affect", "mood"; see Benamou 2010).

sive performance parameters" (Keller 2014: 260). Research on interindividual covariation has focused mainly on the temporal dimension, i.e., how musicians jointly produce microvariations in timing. In Western classical music, the basic assumption states this optimal covariation tends toward perfect synchrony in the musical parts. For example, when the lead violin in a string quartet is lengthening or shortening a tone duration, the other musicians are to apply the same variations in order to maintain the parts in synchrony (Wing et al. 2014).

However, the way musicians conceive of time asynchronies depends on many factors, including musical style and cultural context. In some cases, an effort is made to keep the parts separate in time, rather than synchronized. The case of jazz and some popular music styles such as hip-hop and funk demonstrate the effect commonly known as "swing" or "groove" that seems interrelated to a slight asynchronization among the parts (see Benadon 2006; Hove, Keller, and Krumhansl 2007; Butterfield 2010; Dittmar et al. 2018). Ethnomusicologist Charles Keil (1987, 1995) proposes the expression "participatory discrepancies" to name these "inflections" voluntarily introduced by musicians in order to obtain a "productive tension" or "drive" that generates a sense of swing or groove. According to Keil, participant discrepancies exist in many musical cultures around the world and are of great importance to music being perceived as emotionally charged, a hypothesis finely expressed by the famous sentence: "music, to be personally involving and socially valuable, must be 'out of time' and 'out of tune'" (Keil and Feld 2005 [1994]: 96). As he had foreseen, empirical research on expressive timing microvariations has later expanded into other global musical traditions, and particularly central and south-American cases such as Cuban rumba (Bilmes 1993), Uruguayan candombé (Rocamora 2018; Fuentes et al. 2019), and Brazilian samba (Naveda et al. 2011).

The analysis of timing microvariations requires special audiovisual recording techniques capable of detecting a high number of musical events in a small period of time. In particular, this needs to precisely determine the onsets (the moment when a sound event, as a note, begins), and the inter-onset intervals (the amount of time between one onset and the next), of several instruments playing simultaneously. The recording of several musicians onto the same audio tracks – a technique commonly deployed by ethnomusicologists in the field – makes it difficult to precisely determine the note onsets. Multimodal recordings may offer several advantages in this direction. By the term "multimodal recordings", I refer to recent techniques and technologies enabling the simultaneous recording of several aspects of a musical performance: the audio in stereo and in separate tracks, as well as the musicians' and dancers' gestures in video and with a motion capture capability. As I set out in the following sections, when these techniques allow to obtain precise measures, the results should be interpreted in light of ethnographic observations in a back and forth movement between the laboratory and the field, between empirical and qualitative analysis.

Study 1: Transylvanian string ensembles

"Sweetness" in "sorrowful" Roma tunes

In Ceuaș, a small Hungarian and Roma village of central Transylvania where I carried out my field research (Bonini Baraldi 2017, 2021a), two musical genres, called *doină* and *meseliecri* or *de masă,* are explicitly associated with the emotion of "sorrow" (*jale*). In the case of vocal music, the *de jale* repertoire takes its name from the plaintive content of the lyrics that emphasize painful experiences. However, the phrase *muzică de jale* does not necessarily refer to a song repertoire: it also designates certain instrumental tunes, pertaining to the same genres of *doină* and *de masă.* These genres do not seem to display any defining harmonic and melodic structure: their tonality, ambitus, cadences, chords, and melodic contour can vary from one tune to another. Moreover, even while most *doină* and *de masă* tunes are in a minor key with an accompaniment in the major key, this is also true of many *csárdás* (couple dance tunes). In the case of instrumental music, the aesthetics of sorrow seem mainly associated with three interrelated musical parameters: the unmeasured rhythm of the *doină* or the irregular *aksak* of *de masă* tunes; the swinging effect created by the slight asynchrony between the melody and the accompaniment; and "sweetness" (*dulceață*), a quality of interpretation related to complex elaborations of the melodic line.

While the first two parameters are not explicitly verbalized, the notion of "sweetness" (Romanian: *dulceață*, Romani: *gulybó*)[4] regularly came up in my conversations with musicians and non-musicians alike, and often in the context of debates on the emotional quality of a particular musical interpretation. Thus, one often hears that when musicians draw tears from their audience, this happens because they play "with sweetness"; conversely, those "who do not know sweetness" induce laughter (*a face să râdă*). Although the musicians themselves all have their own way of describing this sweetness, they all emphasize the same idea: playing "with sweetness" is a specifically

[4] Literally, the word for sweet things commonly given to children, such as chocolate, candies, jam, etc.

Roma attribute; it does not simply mean playing "right" as opposed to "wrong", i.e., in tune (*curat*) as opposed to out of tune (*fals*), but going the extra mile and "doing something more, adding something" (*mai faci, mai pui*) to the music. Emblematic of the style and creative freedom of the *primaș* (lead violinist), sweetness is therefore understood as what "brings the music to life" (*bagă viață în ea*, see Bonini Baraldi 2015). At a simple listening, it fashions the timbre, the phrasing, the microvariations of the melodic line, and the ornaments. In order to precisely determine what musicians do to impress this emotional quality onto the music, I made various recordings and attempted to "translate" the concept of sweetness according to the terms of musical analysis.

Recordings

I conducted the first recordings in the field (Ceuaș, September 2006), at the house of Sanyi, a violinist widely cherished for having "great sweetness in his fingers". I asked him to play the same *de masă* tune twice: first "without sweetness" (*fără dulceață*), then "with sweetness" (*cu dulceață*).[5] Throughout the session, Sanyi's son Alin accompanied him on his *contră* (three-string viola). I used an ordinary video camera to film Sanyi's left hand, framing the shot at a high angle over his left shoulder and pointing the camera down in order to focus on the movement of his fingers. These recordings allowed me to produce a musical transcription that highlights the differences between the melodic line played "with sweetness" and "without sweetness" (see Fig. 1).

The second recording session was carried out in July 2007, when Sanyi and his brother-in-law Csángáló were invited to give a workshop at the *Cité de la musique* in Paris. On this occasion, we organized a recording session in the fully equipped *Cité de la musique* music studio. The two musicians were placed in two separate rooms; they could see each other through a glass window and hear each other through headphones. This procedure, generally used by professional musicians for their studio productions, allowed us to obtain high quality waveform signals in separate tracks, facilitating the precise measurement of onsets and timing durations for both the *contră* and the violin. Among many other tunes, we recorded the same "song of sorrow" in Fig. 1, played "with sweetness" and "without sweetness".

[5] Although asking Sanyi to play "without sweetness" placed him in a rather artificial position, he seemed neither surprised nor disturbed by my request: on the contrary, he appeared to have a clear understanding of the purpose of my study.

Fig. 1. *Musical transcription of the same* de masă *tune performed by violinist Sanyi "with sweetness" and "without sweetness".*

The third recording session took place at the University of Burgundy (Dijon) in July 2007, and involved the same two musicians. The procedure was the same as in the previous studies: to record the sound and images of a *de masă* tune and a *doină* performed "without sweetness" first, and then "with sweetness". However, in this case, we were able to apply motion capture technologies in order to study two types of gestures: the macroscopic movements of Sanyi and

Csángáló, and the movements of the violinist's left hand, positioning smaller markers on each phalanx.[6] The sound was recorded separately, and the session filmed with two additional standard cameras. We obtained synchronization between sound and image by deploying a clapper board equipped with two additional retro-reflective markers. This motion capture recording resulted in the production of a mathematical model of the musicians' gestures through the spatial trajectories of the markers, which is then viewable in three dimensions through "SMART Viewer" software.

These three recording sessions were realized in contexts of increasing artificiality, when compared to the situations in which these musicians usually perform (weddings, funerals, balls, etc.). However, since Sanyi and Csángáló are professional musicians with previous experience of studio recordings for producing their CDs, I can affirm that the studio and laboratory settings did not cause any apparent discomfort nor did it significantly alter their playing style. Conversely, the three recording sessions present increasing advantages for onset detection and the quantitative measuring of timing microvariations.

Onset detection

The audiovisual recordings obtained at Sanyi's house allowed me to observe the violinist's melodic variations (see Fig. 1), but they did not enable precise onset detection either for the violin or for the *contră*. The studio recordings on separate tracks realized at the *Cité de la musique* partially allowed for onset detection. However, this was only partially the case because of the well-known problem of onset detection for string instruments (i.e., the problem of how to choose the points in the audio signal that best correspond to the beginning of each note) could not be avoided. As shown in Fig. 2, I therefore considered three possible choices for manually determining the starting and ending point of each rhythmic unit played by the *contră*.[7] A first possibility consisted

[6] The two musicians were standing at the center of a circular region of 2.5 m radius, surrounded by the six infrared-emitting cameras attached to six tripods, 2 m from the ground on each side of the subject, at a distance of 3 m from each subject's body. The movements of 38 retro-reflective markers (15 mm in diameter), placed at various anatomical locations on the body and on the instruments, were measured using an optoelectronic device (SMART-DX, BTS Bioengineering, Milan). Kinematic parameters in three dimensions (X, Y, and Z) were calculated from successive frames taken at 10 ms intervals. Kinematic variables were lowpass filtered through a digital second-order Butterworth filter at a cutoff frequency of 5 Hz.

[7] In the case of the *de masă* tunes, the *contră* plays "Short" (S) and "Long" (L) rhythmic units in an approximate temporal ratio of S:L = 2:3, following a regular S – L – S – L pattern.

of choosing the points of highest amplitude in the *contră*'s waveform signal, which would correspond to the accents played by the musician at the beginning of each new rhythmic unit. This measure is presumably consistent with the way the musician thinks the rhythm but is hard to obtain with any great precision. The second possibility involved choosing the lowest amplitude points, which corresponds to the moment in which the bow changes direction. This measure is easy to obtain with high precision but does not correspond to the exact moment in which the beginning of a new rhythmic unit is perceived. The third possibility was to choose the starting and ending points for the S and L rhythmic units on the basis of perception, hence, manually placing time markers on the waveform signal when perceiving the beginning of a new unit. In order to ensure a high degree of precision, I performed all three types of measures, and calculated the average for the three. In all three cases, I assumed the ending point of one rhythmic unit corresponded to the beginning of the next rhythmic unit. Time markers were placed on the waveform, and then the running time code was extracted by using the Audacity "extract markers time codes" option.

The motion capture recordings enabled an alternative method for onset detection. Indeed, by tracking the spatial trajectories of the reflective markers positioned at the top of the bows, it became possible to determine the precise moments when these change directions. As the local technique involves the use of distinct bow strokes for (almost) each single note, the moment when the bow changes direction corresponds to the beginning of a new note, i.e., an onset.[8] For each tune recorded, the timecodes of the violin and *contră* onsets, corresponding to the superior and inferior peaks of the curve representing the bow trajectories (Fig. 3), have been then extracted manually by recourse to "SMART Viewer" software.

[8] It could be argued that this method does not take into account the fact that the musicians' body movements may introduce irregularities in the trajectory of the bow, which in turn would make it difficult to precisely measure the timing durations of S and L rhythmic units. For example, if the musician bends his trunk while playing, the bow trajectory would change, and this would not allow a precise measure in time domain. Nevertheless, in order to be sure that the viola bow's movements give a precise indication of S and L timing durations, measures obtained with mocap technologies were compared with those obtained on the same recording with the sound signal method. The mean S, L, and S:L ratio, calculated over 12 periods are very similar, which suggests that the mocap measures can be taken as a reliable alternative method to sound analysis.

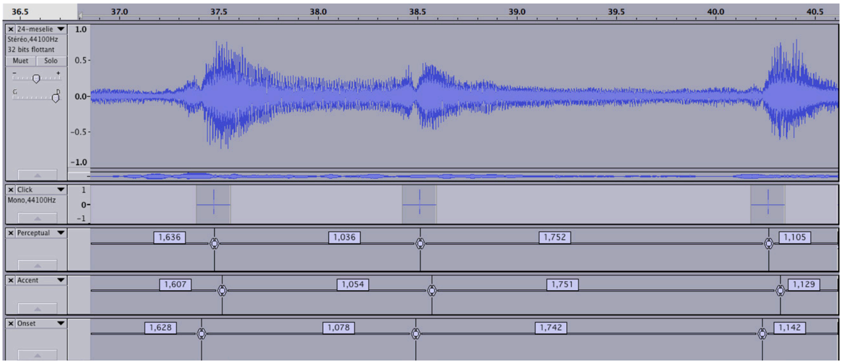

Fig. 2. *Detection of the* contră *(viola) onsets: screenshot of Audacity software (ver. 2.0.6). The upper part shows the* contră *wave signal of the Romani song of sorrow transcribed in Fig. 1 and recorded in separate tracks at* Cité de la musique. *The bottom part shows three different possibilities for determining the onsets of the rhythmical units Short and Long, named respectively "Perceptual Onset" (PO), "Peak Amplitude Onset" (PAO), and "Minimum Amplitude Onset" (MAO).*

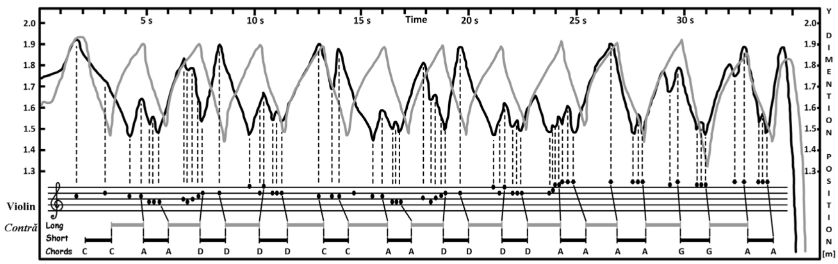

Fig. 3. *Detection of timing asynchronies between violin and* contră *(viola) by using mocap technologies. Top: movements of the markers placed at the top of the bows (violin, black;* contră*, gray). The horizontal dimension of the plot represents time (in seconds, resolution 7 ms), and the vertical dimension represents the position of the markers in space (meters from the ground, resolution 2 mm). Bottom: transcription of melody (violin) and harmonic-rhythmic accompaniment (*contră*) obtained (manually) from changes in bow directions. The lines linking melody to accompaniment highlight the asynchronies between the two performers.*

Results

Audio, video, multi-track and motion capture recordings provide different levels of understanding of what "playing with sweetness" precisely means.

Field recordings allow for highlighting the importance of so-called "ornaments" in interpretations performed "with sweetness": turns, mordents, *glissandi*, passing notes, etc. are ubiquitous (Fig. 1). This complex elaboration of the melodic part, freely introduced by the violinist, produces asynchronies with the harmonic-rhythmical accompaniment provided by the *contră*. As clearly emerged from the motion capture recordings (Fig. 3), the *contră* sometimes anticipates the violin, and sometimes it is the other way around. Manual onset detection precisely measured the type and amount of these asynchronies.[9] Statistical analysis performed on eight different tunes suggests that two different types of asynchronies are present: "small-scale" asynchronies (approximately 10% of the beat duration), which are very subtle and harder to perceive; and "large-scale" asynchronies (approximately between 20% and 50%), clearly audible even by a listener who is not familiar with the musical style. Large-scale asynchronies may closely relate to the musical structure of the tune, hence, to the way musicians conceive the melodic line in relation to the harmonic accompaniment. Indeed, comparison of two different takes of the same melody played with the same expressive intention, showed that large-scale asynchronies are relatively stable among different interpretations of the same melody. This suggests that musicians assign a clear place to a tone in the melody in relation to the accompaniment, and this place is often before the corresponding chord. Conversely, small-scale asynchronies vary from one take of a tune to another, which suggests that these are less related to the musical structure, and more dependent on each particular interpretation and on the individual style of the *primaș* (lead violinist).

The precise measurement of onsets and timing durations of the violin and *contră*, derived from the multi-track audio and mocap recordings, returned another important result. In the slow *de masă* tunes, playing slightly "out of step" produces variations in the rhythmical pattern of the *contră*. The precise analysis of S:L proportions in eight different *de jale* tunes indicates that this pattern is neither an "orthodox *aksak*" (S:L = 2:3) nor a "heterodox *aksak*" (S:L = 3:4, see Bouët 1997), but rather an *aksak* that is "in between the two", as it is characterized by the formula 2:3 < S:L < 3:4. Should we present the Short rhythmic unit (S) with a quarter note, as in the

[9] For a complete analysis of timing asynchronies, see Bonini Baraldi, Bigand, and Pozzo (2015).

aksak convention, the average duration of the Long (L) is slightly shorter than a dotted quarter note. This result may suggest that the musicians conceive two "blocks" of durations (S and L), which are largely independent of one another, that is, they do not rely on a common underlying pulse. In other words, the *aksak* rhythm – or at least, this Transylvanian version of *aksak* – should be regarded in terms of two independent duration units, as proposed by Brăiloiu (1951), rather than in terms of a unique smaller subpulse, as suggested by other scholars such as Arom (2004).

Study 2: Brazilian percussion ensembles

The concepts of "closure" and "consonance" in *Maracatu de baque solto*

Maracatu de baque solto ("free-beat" Maracatu) is a Carnival performance that occurs in the *Zona da Mata Norte* region of Pernambuco state (Brazil). Each Maracatu group has its own headquarters and may feature up to 200 members: a board of directors; tens of masqueraded dancers (*caboclo de lança, baiana,* and other characters); two poets (*mestres de apito*) improvising short, chanted verses; a brass section formed by two to four musicians (*músicos*) playing trumpets and trombones; and a group of five percussionists called *terno*. Members of Maracatu groups, mostly rural workers, invest a considerable amount of time and money in preparing for Carnival performances, imbued with a strong spiritual meaning and connected to the worship of *Jurema*, a local afro-indigenous religion (see Garrabé 2010).

While an external observer would tend to associate Brazilian Carnival with positive emotions (happiness, fun, excitement, etc.), *Maracatu de baque solto* involves more complex and varied emotional experiences. In Condado, the small city where I developed my fieldwork, jealousy and envy (*inveja*) seem to come to the fore in interpersonal relationships, before and during Carnival, both among members of different Maracatu groups or of the same group. Here, as in many other places of the world, envy is synonymous with the evil eye (*olho grande* or *olho gordo*), a dangerous attribute that might negatively affect the people's bodies, causing sickness. As such, Maracatu performers say that, in order to perform carnival safely, you need to "close your body" (*fechar o corpo*). According to my interpretation, sounds, among other aesthetic elements and ritual practices, are conceived as a means to close – i.e., to protect – Maracatu performers (see Bonini Baraldi 2021b, 2022; Bonini Baraldi and Viana 2023 in press).

Indeed, the concept of "closure" is explicitly used by Maracatu performers when discussing how the *terno*, the nucleus of five percussions, should sound. The local expression signifying aesthetic appreciation is "to hit the *terno* closed" (*batendo o terno fechado*), as opposed to "the *terno* is pierced" (*o terno esta furado*). What counts in the production of these short, fast and loud rhythmical sequences is the precise coordination among the five percussionists, as it is said that the "holes" (*furos*) appear when this coordination briefly runs off. More generally, the Maracatu group is effectively "locked" only if collective actions (playing, dancing, etc.) are realized "in consonance" (*consonância*), that is, with a high level of interpersonal coordination, mutual understanding, proper behavior. In the opposite case, negative entities, aroused by the rivals' envy, may enter the group and "dismantle it", breaking it up (*desmantelar*, see Acselrad 2013). While it is thus not surprising that high interpersonal coordination is valued – this is the case in many other musical traditions –, the local concepts used here deserve special attention. Specifically, one question arises: how far are the concept of "closure" and "consonance" related to expressive intentions, or more broadly, to the emotions involved in Maracatu? This is still an open research question and, for the moment, I can only advance a few hypotheses.

Both the notions of closure and consonance seem to relate to the idea of "groove", a concept that in its basic sense means "to blend", "match", "coordinate", "balance", "harmonize", and that points to a harmonic interlocking of parts forming "a pleasing relationship" (Merriam-Webster Online Dictionary). Furthermore, groove is what stimulates a desire to move along with music (Keil and Feld 1994). In *Maracatu de baque solto*, a closed, consonant, groovy *terno* puts the dancers' bodies into motion through repeated sequences of about one minute, spaced out by the poet's improvisations during which all dancers stand still. During an entire Maracatu performance, repeated motion for several hours allows dancers to achieve an altered corporeal state and a feeling of heightened interpersonal connection, ultimately resulting in the emotion of "happiness" (*alegria*). The feeling of performing with a "closed" body and of being interpersonally coordinated – only possible if the *terno* plays "closed" – is what gives protection against envy, a force that tends toward the opposite extreme, that of bodily sickness and uncoordinated, dismantled interpersonal relationships.

My aim is to understand how this high level of acoustic and choreographic coordination is achieved in Maracatu performances. In conjunction with extensive field research, I therefore completed several recordings with the purpose of translating the concepts of "consonance" and "closure" at the formal level of music and dance analysis.

Recordings

Following several research trips to Condado, in December 2019 I invited 13 performers of the group *Maracatu Leão de Ouro de Condado* to Lisbon for a 10-day residence.[10] Besides other activities (workshops, public presentations, round-tables, etc.), we staged two recording sessions of Maracatu music and dance: the first during a live performance in the city's historical center, and the second in a laboratory room in the Faculty of Human Kinetics of the University of Lisbon.

In the first session, the percussionists played in a fixed location; however, their proximity and their loud and fast playing style did not allow for isolated recordings made per instrument by conventional microphones. We therefore recorded the audio of the five *terno* instruments and the trumpet on separate tracks, with Schertler Basik Set universal contact microphones, which provide high-quality audio recordings with minimal spillage and distortion. We placed two pickups (less than 1 cm in diameter) on the *gonguê* (one per bell), two on the *bombo* (one per skin) and a single pickup for *tarol*, *porca*, and *mineiro* (Fig. 4). The eight contact microphones were connected with cables to an eight-channel USB audio interface for synchronous signal acquisition.[11] Over the total performance duration of 48 minutes, we recorded 34 extracts of the two main Maracatu rhythmic genres (28 *marcha* and 6 *samba*), with a mean duration of 39.4 seconds. The performance was also filmed on a portable Sony video camera.

Two days later, we organized a multimodal recording at the Faculty of Human Kinetics. In a laboratory room equipped with motion capture cameras, we simultaneously recorded the five percussionists on separate tracks and in stereo; the musicians' gestures with the Qualisys mocap optical system; the dancers' movements with Xsens mocap kinematic system; and the images of all performers with a standard Sony portable camera. We placed a total of 173 reflective markers (25 mm diameter) on each instrument (three to five markers), drumsticks, and on specific anatomical landmarks of each of

[10] This invitation was possible thanks to a project funded by the Portuguese Foundation for Science and Technology (FCT). The Maracatu members invited were: one director, one poet, two musicians, five percussionists, and four dancers. The recordings and analyses of the *terno* summarized here have involved several people and have been previously presented in various collective articles (see acknowledgments and references).

[11] Each microphone includes a phantom-power adaptor box which delivers a line-level signal, with a 60 Hz – 15 kHz frequency response. The sensitivity on the instrument is 34 dB (time-averaged sound level). We used a Motu UltraLite-mk3 Hybrid (USB/Firewire) soundcard, and Pro Tools 2019 software (44.1 kHz, 16-bit).

the five musicians (28 to 30 markers for each musician).[12] The virtual reconstruction of the musicians' movements was successful, with minimal loss of information on the markers. With this setup, we recorded a total of 17 pieces (11 *marcha* and 6 *samba*). We also recorded the sounds and movements of each percussionist playing alone, then in all combinations of two, three, and four instruments playing together. Simultaneously, we recorded the movements of three different dancers (one at a time) by applying a different motion capture technology, a full-body IMUs (Inertial Measurement Unit suit, Xsens MVN Link System). As *Maracatu* performances often feature a sort of "battle" between two dancers, we also recorded the movements of one dancer wearing the Xsens suit while "fighting" with another, not wearing the suit. The dancer's Xsens recordings were synchronized in time with the musicians' Qualisys recordings using an external trigger button (Qualisys AB). The post-recording synchronization with the audio capture was made possible through the dancer's initial single clap.

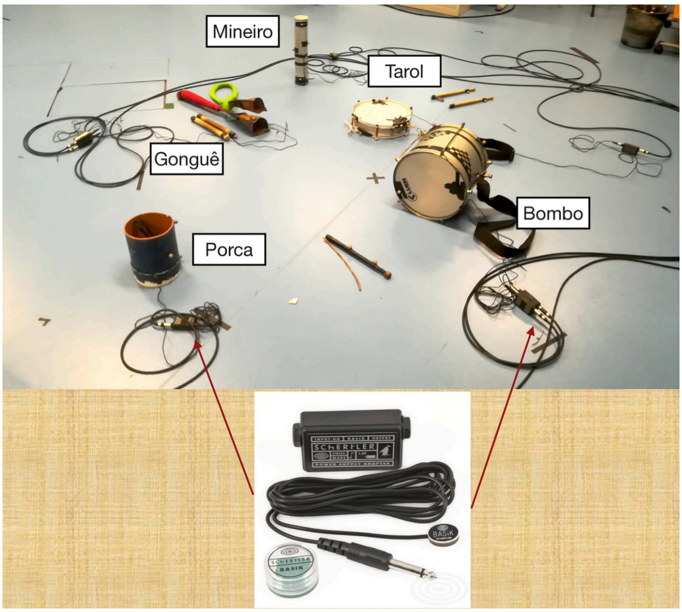

Fig. 4. *The instruments of the* terno *including the connection of the contact microphones.*

[12] The upper body kinematics of the five percussionists were recorded with an optical system of 14 infrared high-speed cameras (Oqus 300, Qualisys AB) and two video cameras (Oqus 210c), using the Qualisys Track Manager software.

Onset detection

The live recordings of the *terno* on separate tracks provided very "clean" sound waves for each of the five instruments, facilitating manual detection of the onsets, for instance by using the Sonic Visualizer software (Fig. 5). However, given the dense rhythmic structure of Maracatu, a very high number of annotations would be necessary even for a short sound event (51 onsets in 2 seconds). For a 22-minute recording with seven contact microphones (excluding that for the trumpet), this would mean annotating tens of thousands of onsets.

An alternative solution consists of applying computational approaches within a semi-automatic framework in which the automatic estimates are subsequently verified and corrected manually. As we here have largely isolated signals which are percussive in nature, one might assume the task of automatic onset detection would be relatively straightforward. However, our initial experimentation with existing onset detection methods (see Davies et al. 2020) provided somewhat mixed results, with a noticeably poor performance on the *gonguê* and *porca*. We finally developed an instrument-specific approach to onset detection by taking an existing deep neural network (Davies and Böck 2019) and retraining it specifically to each individual instrument of the *terno* (see Fonseca et al. 2021). This use of "instrument-adapted" networks drastically reduced the number of missed and erroneous detections. However, even after applying these instrument-adapted networks, some manual correction was still required, both to contend with issues of temporal localization as well as surplus and missed detections.

The final output was obtained using the open-source software Sonic Visualiser. Over the 34 pieces of live performance, we annotated 45,000 onsets across the four instruments in the *terno*: the *tarol*, *bombo*, *porca* and the low bell of the *gonguê*. We excluded the *mineiro* from further analysis since it was extremely challenging to annotate it consistently, even manually, due to the lack of any well-defined attack in the waveform. The data obtained with motion capture technologies were not (yet) used for onset detection. In future research, these data might provide complementary information on the *terno* onsets as was the case for the Transylvanian instruments (see Fig. 5).

Results

The recordings of the *terno* on separate tracks proved useful for describing the rhythmic patterns and macrovariations of the five percussionists as well as for detecting their microvariations.

The basic rhythmic patterns of all instruments in the *terno* jointly performing *marcha* are indicated in Fig. 6. The macrovariations in this basic pattern are limited, and globally consist of a change in the accents played by the *tarol*, and a few variations in the *bombo* and the *gonguê* high pitch bell patterns.[13] The low-pitched bell of the *gonguê*, the *porca*, and the *mineiro* never change pattern; as they play regular beat subdivisions, they might be considered as timekeepers (see Fig. 6).

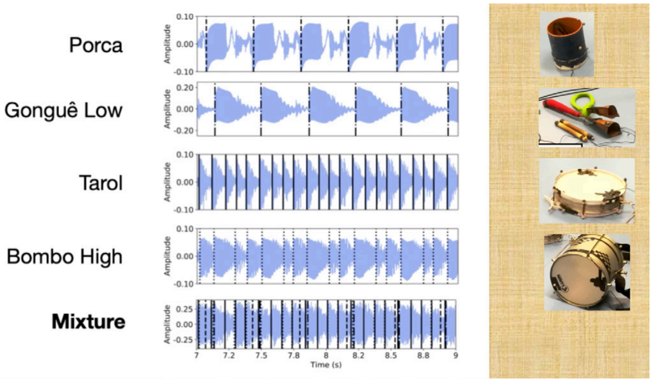

Fig. 5. *Wave signals of four instruments of the* terno *with annotated onsets (lines) in approximately one bar.*

Fig. 6. *Basic rhythmical pattern performed by the five percussionists of the* terno *of the group* Maracatu Leão de Ouro de Condado.

[13] For space reasons, the "macro" analysis of these rhythmic patterns and variations has not been presented in this paper.

Future field research will explore to what extent the macrovariations of the rhythmic patterns relate to the concepts of "closure" and "consonance". These same aesthetic values might be related to musicians' actions at a micro-temporal level, rather than at the level of rhythmic macrovariations. However, unlike the Transylvanian study on sweetness, it seemed quite artificial to ask Maracatu musicians to perform according to different expressive intentions, such as "play locked" or "play pierced". As the recordings were obtained from a live public performance, we assume the musicians always attempt to play *terno fechado* ("closed"). Starting out from this hypothesis, we analyzed the microtiming behavior of the *terno* instruments with the aim of understanding if and how microvariations in time were systematically introduced by musicians.

Considering the *tarol* (snare-drum) rhythmic pattern shown in Fig. 6, if we assign a normalized proportion of 100% to each beat, four sixteenth notes equally distributed within the beat would occur at normalized positions of 0%, 25%, 50%, and 75%. Analyzing the *tarol* onsets extracted from one recording (*marcha* 28), we detected a slight anticipation of the third and fourth sixteenth notes. Across the entire set of recordings of the live performance, the median profiles returned were 25%, 47%, 71.5%, confirming the previous result.[14] The microtiming behavior of the *tarol* can also be determined in relation to the beat provided by another *terno* instrument rather than in relation to its own beat. This "between-instruments" microtiming analysis (as opposed to the "within-instrument" analysis of the previous case) revealed that the microtiming profile of the *tarol* in relation to the *gonguê* beat for one piece (*marcha* 28) respects the following proportion: 1%, 27%, 48%, 74%. We can therefore assert that some consistent deviation from quantized positions is occurring, with the second sixteenth note slightly delayed and with the third and fourth slightly anticipated.

The same analysis applies for the *bombo*. In terms of beat proportion, the normalized sixteenth notes would be at 0%, 50% and 75% of the beat duration as the second sixteenth note is not played (see Fig. 6). Across the entire set of recordings, we found an explicit presence of within-instrument microtiming, with the third and fourth sixteenth notes clearly anticipated according to a proportion of 46%, 69%. A similar microtiming behavior, with anticipation of the third and fourth sixteenth notes, is obtained when adopting the *gonguê* as the reference beat.

14 Figures illustrating the microtiming profiles have been published in Davies et al. (2020).

Interestingly, when applying the beat of the *porca* as the reference for determining the microtiming profiles of both the *tarol* and the *bombo*, a dynamic usage of microtiming emerges. This reflects how musicians begin a *marcha* slightly asynchronized in one way and then modify their collective synchronization along the short performance of less than one minute. Indeed, the beats of the *porca* are played ahead of the beat and slowly aligning in phase by the end. At this stage of the analysis, it is not clear whether this clear anticipation of the *porca* beats and this tendency toward synchronization at the end of the piece holds any expressive function.

Obtaining microtiming profiles constitutes just a first step towards understanding what "to hit the *terno* closed" (*bater o terno fechado*) actually means. A further research task will be to present these same recordings to the Maracatu performers and ask them if (and where) they perceive "holes" (*furos*), and later verify how these "holes" relate to microtiming deviations. The audio recordings on separate tracks makes it possible to present manipulated musical extracts in which the temporal coordination among instruments is artificially modified. Furthermore, the motion capture recordings of the musicians' gestures may help to precisely understand what "being in consonance" and "playing closed" means in terms of bodily behavior, thus enabling the definition of a gestural grammar of the optimal ensemble coordination.

Conclusion: Recording and analyzing expressive microvariations in oral tradition music

In my research with Roma string musicians from Transylvania and with Maracatu percussionists from northeast Brazil, I followed a similar methodology for exploring the complex relationship between music and emotions. This methodology is rooted in long-term field research, a crucial task for discerning local feelings, uncovering emotional concepts, and seizing affective interactions, especially those that come into play in musical activities. Observing, participating in, and analyzing musical performances allows one to understand how sounds, music, and dance relate to people's emotional life. Exploring the local aesthetics – i.e., how people associate specific musical structures to specific feelings – represents another fundamental step in developing an ethnomusicological perspective on musical emotion.

In this paper, I suggest that, besides all these research tasks, ethnomusicologists should also pay close attention to the systematic, voluntary, small-scale actions that musicians jointly introduce in order to impress an expressive quality on the sounds they are producing. Indeed, it has been widely demonstrated that these "expressive micro-deviations" (Gabrielsonn

1995), or “participant discrepancies” (Keil 1987), are of great importance to the perception of music as emotionally valuable. When they concern the temporal domain, these expressive micro-deviations are often related to concepts such as “swing”, “groove” (see Davies et al. 2013), “vital drive”, or to the idea of a “semiconscious or unconscious slightly out of syncness” (Keil and Feld 2005 [1994]: 96). Special recording technologies, empirical methods and quantitative measures are needed to precisely describe small-scale timing variations as these often only emerge through the statistical analysis of precise temporal events (such onsets and inter-onset intervals). However, from the perspective of an ethnomusicologist accustomed to recording and analyzing live performances in the field, this whole research domain raises a certain number of questions and implications that I shall discuss in this final section.

A first topic of reflection concerns how to record musicians in ways that allow for analysis of micro-temporal events but preserve the ecological validity of the musical performance. Standard audiovisual recordings, such as those commonly realized in the field, do not always provide a precise (and ideally, automatic) detection of note onsets. Recordings musicians on separate tracks is technically more complex and invasive and requires several microphones, cables, sound cards, etc. This is more easily achieved in a controlled environment, such as a music studio or a laboratory room, but with the recordings consequently lacking ecological validity. When the aim is not to produce an album but rather to record musicians for analytical purposes, contact microphones represent a good compromise. With this equipment, it is possible to record musicians on separate tracks, with little interference between them, while playing together in live performances. Given their small dimensions and light weight, contact microphones can be used in the field, thereby boosting the ecological validity of the recordings. Motion capture technologies are also relevant for music (micro-)analysis, as has been the case for the detection of asynchronies in the Transylvanian *de jale* repertoire, obtained by looking at the different bow directions. The increasing affordability of all these technologies allows one to hope that in the future we will be able to realize multimodal recordings of oral tradition songs – thus, the simultaneous recording of musicians’ audio in stereo and on separate tracks, the gestures of musicians and dancers on video and with motion capture technologies, possibly during live performances and ideally in the field. In addition to the case studies provided in this article, a project featuring multimodal recordings in Mali is currently under development by the German ethnomusicologist Rainer Polak (see: https://www.uio.no/ritmo/english/projects/djembedance).

A second topic of reflection arises from how to precisely detect the note onsets from audio, video, and/or motion capture recordings. As previously shown, this is a crucial task for analyzing microtiming deviations. However, when carried out manually, this becomes a very time-consuming activity. Engineers working within the field of music information retrieval (MIR) have developed computational approaches for the extraction of information from musical audio signals, including automatic onset detection. However, the tools currently available do not easily apply to music instruments played in other musical traditions, such as *mineiro*, *porca*, or *gonguê*. Instruments with different acoustic characteristics (compared to the Western ones) pose new challenges to the music information retrieval community and encourage the development of hybrid methods for onset detection in which automatic extraction is coupled with manual annotation. Motion capture technologies also contribute to onset detection, providing a different level of information, arising from bodily behaviors rather than from acoustic signals. These methods can be coupled with audio recordings for more complete analysis of macro and micro timing patterns.

A third topic of reflection stems from the specific challenges of studying expressive micro-deviations in oral tradition music. In this case, the notions of "deviations" and "referent values" (see Gabrielsson 1995), do not apply in the same way as for written repertoires. By definition, in oral tradition tunes, there are no written instructions informing on how instruments should be temporally coordinated, something that we would call a "norm". In the case of Transylvanian *de jale* songs and of Brazilian *marcha*, I considered asynchronies as timing deviations from *hypothetically* synchronous sounds, even if there is no underlying fixed reference (such as a musical score) stating these sounds "should be" played together. Secondly, while in Western classical music, we are accustomed to relating timing deviations (*ritardando*, *accelerando*) to the performer's expressive intentions, timing deviations are not necessarily related to expressivity in other musical genres. In Transylvania, given the impressive size of the repertoire musicians have to know by heart, playing slightly after the melody is for the accompanist an important mnemonic simplification, as he/she is not obliged to memorize the harmonic development of each tune. On the other hand, if the *contră* player knows where the melody "goes", he/she may voluntarily anticipate the violinist, and this is a pure and simple way of pointing out who is in charge of the ensemble, expressing the social status of musicians rather than their personal feelings. The results obtained by empirical methods should therefore be associated with ethnographic research as only deep knowledge of the context and music allows one to understand what a "norm" is, what a "deviation" is, and which deviations hold an expressive function.

Finally, while research in jazz suggests that expressive timing asynchronies are rather systematic – that is, one part is constantly ahead of the other parts, or conversely, after the other parts (Keil 2005 [1994]) – other music styles may portray a different picture. Indeed, Transylvanian Roma musicians generate asynchronies in a rather unpredictable way, and the ambiguity in the placement of the melody in relation to the harmonic-rhythmic pattern is precisely what characterizes this repertoire. Having observed many different musicians playing together, I may affirm that a good performance occurs when a certain degree of equilibrium is achieved, hence, when both violinist and violist take the liberty of altering their note durations in order to produce this "out-of-synch" effect that constitutes the aesthetic of the Romani songs of sorrow. In my opinion, this explains why different types of asynchronies may be present in different performances of the same song, and why the *aksak* S:L proportions may vary widely over the course of the same performance.

In the case of the *terno*, the percussive "gear" of *Maracatu de baque solto*, more research is needed in order to precisely understand how the observed microtiming patterns relate to the concepts of "closure" and "consonance". What can thus far be stated is that microtiming patterns are consistently introduced by performers, i.e., the timing proportions show a systematic tendency toward slight anticipations of some beat subdivisions. However, the measurement results obtained highlight the presence of dynamic microtiming: profiles that change dynamically within given pieces of music, and between pieces of music. In other words, in the course of one minute, musicians start in a given joint rhythmic configuration and finish in another. Thus, the notion of a single and characteristic microtiming profile appears not to apply to the set of Maracatu recordings studied here and this might correspondingly represent a specificity of this particular music genre.

In conclusion, the empirical study of micro-deviations in a particular musical culture makes it possible to highlight ensemble playing strategies that may differ subtly from those used by performers in other cultures, and particularly in the Western tradition of classical music. In the case of oral tradition music, this micro-level of musical analysis, when included in long-term and extensive ethnographic research, might allow a better understanding of how musicians impart an emotional power to their music, whether making one able to cry or to dance.

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