Proceedings of the

Second Symposium of the ICTM Study Group on Sound, Movement, and the Sciences (SoMoS)

26-28 October 2022
Barcelona, Spain

Editor
Filippo Bonini Baraldi

Publisher

inet MD
instituto de etnomusicologia
centro de estudos em música e dança

Hosts

Title	Proceedings of the Second Symposium of the ICTM Study Group on Sound, Movement, and the Sciences (SoMoS)
Editor	Filippo Bonini Baraldi
Publisher	Instituto de Etnomusicologia - Centro de Estudos em Música e Dança (INET-md), Faculty of Social and Human Sciences, NOVA University Lisbon, Portugal

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Lecture/Concert

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Justin Vali
Musician, Madagascar/France

Preface

The Second Symposium of the International Council for Traditional Music (ICTM)—in August 2023 renamed into International Council for Traditions of Music and Dance (ICTMD)—Study Group on Sound, Movement, and the Sciences (SoMoS) took place in a hybrid format between 26 and 28 October 2022, hosted by Universitat Autònoma de Barcelona and Universitat Pompeu Fabra, Spain.

The aim of this Symposium was to bring together scholars conducting research on sound and/or movement and deploying the multidisciplinary approaches incorporating the wide spectrum of different sciences in combination with ethnomusicology and/or ethnochoreology. As announced in the Call for Papers, the Program Committee welcomed proposals on any topic aligned with the aims and themes of the Study Group insofar as they combine ethnographic and science-based approaches, explore the issues involved in such endeavors or presented reflective discussions on relevant theories and methodologies. Considering that health issues are currently highly topical, the Call for Papers highlighted the interest in receiving contributions considering the relationships ongoing among sound, movement, emotions, and health in a large variety of cultural contexts. From the 28 submitted abstracts, the Program Committee selected 14 through a double-blind peer-review process and then published them online prior to the Symposium (https://ictm-somos.github.io/Symposium-2022/program.html#program).

The oral presentations took place in six sessions with each devoted to a specific sub-theme: 1) "rhythm and tempo", 2) "timbre and memory", 3) "varia", 4) "improvisation", 5) "dance", and 6) "voice". Two more sessions featured an exciting lecture/concert by ethnomusicologist Marc Chemillier with musician Justin Vali, and a thought-provoking keynote presentation by Bernd Brabec. I would thank the invited speakers and performers warmly for their precious insights into the themes of this Symposium.

The Symposium also featured an open session, intended as an opportunity to more informally share and discuss ongoing and future research projects related to the SoMoS themes. Similar to a poster session, participants were free to move around the room and meet the colleagues wishing to share their ideas, data or doubts. The presenters in charge of the open session, together with the keynote and lecture/concert speakers, were invited to submit an abstract on these proceedings in accordance with the same procedure of all other presenters.

The final session included discussion of the means for publishing the Symposium's Proceedings. Among the various formats referenced (book, abstracts, etc.), we chose to publish a collection of "extended" (approx. 1500 words) and "short" (approx. 300 words) abstracts. This mixed format is the same as that adopted by the *Proceedings of the First Symposium of the ICTM Study Group on Sound, Movement and the Sciences* (https://zenodo.org/record/5514167).

Thus, the following pages provide readers with the Symposium program, short biographic notes of the invited speakers/performers, and 19 abstracts (10 of which are "extended", and 9 "short"). All the extended abstracts submitted to these proceedings underwent a single-blind peer-review process. The short abstracts are published in their original version as submitted to the symposium. Instead of separating the texts according to their length, the original order of the Symposium program was maintained, thereby preserving the thematic grouping of the papers. I would like to warmly thank all the authors and reviewers who each gave their personal best to ensuring the high quality of this publication.

Lisbon, December 2023
Filippo Bonini Baraldi (Program Chair and Editor)

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Invited Speakers and Performers

Bernd Brabec (Keynote)

Institut für Musikwissenschaft, Universität Innsbruck, Austria

Bernd Brabec received his M.A. (Mag. phil., 2003) and Ph.D. (Dr. phil., 2012) in musicology from the University of Vienna. He worked for five years in the field among Indigenous People in the Peruvian lowland rainforests. After returning to Europe in 2006, he has been teaching and researching, among other institutions, at the Phonogrammarchiv of the Austrian Academy of Sciences, at the Department for social and cultural anthropology at Philipps-University Marburg, at the Centre for systematic musicology of Karl-Franzens-University Graz, at the Institute of musicology at the University of Vienna. Currently he holds a tenure track position at the University of Innsbruck, Austria. He published a couple of books, among them *Die Lieder der Richtigen Menschen* (Songs of the real people, 2015), *Sudamérica y sus mundos audibles* (South America and its auditory worlds, 2015), and *Auditive Wissenskulturen* (Auditory knowledge cultures, 2018), as well as research articles in the areas of Indigenous vocal music, medical ethnomusicology, sound perception, and auditory knowledge.

Marc Chemillier (Lecture/Concert)

École des Hautes Études en Sciences Sociales, France

Musician, computer scientist and anthropologist, Marc Chemillier studied jazz piano as a teenager, then mathematics at ENS Fontenay-aux-roses. He completed a PhD thesis in computer music. As an ethnomusicologist, he worked in Central African Republic (CD Music of the former Bandia courts, 1995), then on the zither of Madagascar. In 2000, he created the improvisation software OMax with colleagues at IRCAM. Director of studies at EHESS in Paris, he published *Les Mathématiques naturelles* in 2008 (Odile Jacob) and continues his research on computer-assisted improvisation and its anthropological and social issues. In 2021, he published the book-CD *Artisticiel: Cyber-improvisations* with Bernard Lubat and Gérard Assayag.

Justin Vali (Lecture/Concert)

Justin Vali ranks among the greatest living players of traditional Malagasy music on the *valiha*, a bamboo tube zither considered the national instrument of Madagascar. He also performs on the *marovany* box zither of central and southern Madagascar. Vali contributed to several compilations in the late 1980s before beginning to release his own albums in 1990. In 1994, he recorded *Ny Marina* (The Truth) at Real World Studios under Peter Gabriel's Real World Records. In 1999, he released *The SunshineWithin*, a collaboration with Paddy Bush (brother of Kate Bush). In 2008, he collaborated with Eric Manana and other prominent Malagasy artists to record an album as the Malagasy All Stars.

Extended and Short Abstracts

Music, Health, and Wellbeing: Methods for Bridging Science and Ethnography

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The study of music in the field of health and wellbeing is commonly either studied by anthropologists and ethnomusicologists when the field extends to non-modern societies, or by psychologists and social or medical scientists when it comes to modern biomedicine or music therapy. Although the latter may sometimes show interest in the field of the former, and vice versa, it is still unusual to find serious scientific studies of non-modern musical health practices or ethnographic studies of music therapy. Even less research is conducted with mixed quantitative-qualitative methods in the whole field. Based on a couple of examples in the contemporary study of musical health practices, I argue that this is due to communicative difficulties in interdisciplinary studies, especially regarding music. Both humanities and sciences have strong traditions in music studies, and traditionally often rather stand against than with each other. In order to bridge this divide, it is mainly necessary to empower—or even protect—humanities based ethnographic research as a valid complement and explanatory extension of scientific studies. Protection is needed because contemporary media coverage, public policy, and also project funding seems to favor science over humanities. On the other hand, many practitioners of music therapy or related health practices do not find access to or do not understand the methods and results of scientific studies and long for more personal, biographical, qualitative explanations about the power of music in health and wellbeing. I will end with some open suggestions for future research design in order to promote mutual acknowledgement and cooperation among humanities and science scholars.

NOTES

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Bi-musicality in the Age of Artificial Intelligence

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École des Hautes Études en Sciences Sociales (EHESS), France

The notion of bi-musicality was first introduced by Mantle Hood in his influential paper published in 1960 and this notion is still used and discussed today (Hood, 1960). The term itself, "bi-musicality", was coined on the model of bilingual, a word which is applied to somebody who is fluent in two languages belonging to different communities, and underlining how both music and language are attached to human groups or communities. Today, the term bi-musicality is now a taken-for-granted part of the ethnomusicologist's methodology (Rice, 2014, p. 21). However, in the era of globalization and post-colonial issues, some new perspectives have also arisen. When the term was first introduced over sixty years ago, what is today called World Music was not yet established. Nowadays, cultural boundaries have tended to blur and the idea of learning the music of non-Western cultures is no longer exclusively the preserve of ethnomusicologists. Furthermore, technology also raises new questions on this subject, particularly artificial intelligence and machine learning. Recent developments in computer science are beginning to give meaning to the notion of "artificial creativity" (Lubat et al., 2021). Therefore, it is natural to inquire whether a machine can also become bi-musical, and in what sense. This concert-conference explores such ideas in the case of a zither repertoire from Madagascar and illustrates them by live interaction between the computer and a Malagasy musician, the great Justin Vali.

SENSORS ON A MALAGASY *MAROVANY* ZITHER

This presentation is devoted to the repertoire of a *marovany,* a traditional zither from Madagascar. This instrument differs from the well-known tubular bamboo zither called the *valiha* because its soundboard is not a cylinder but rather a rectangular box. It is played for several hours at a time in *tromba* possession rituals. Studying the structuring of improvisation on this time scale led us to develop MIDI sensors for the zither. After testing several different pickups, we applied piezo pickups placed between the strings and the bridges. Although the *valiha* zither has already been studied by past research (Domenichini, 1984; Razafindrakoto, 1999), there are no transcriptions of the *marovany* repertoire except a few examples (Schmidhofer, 2005).

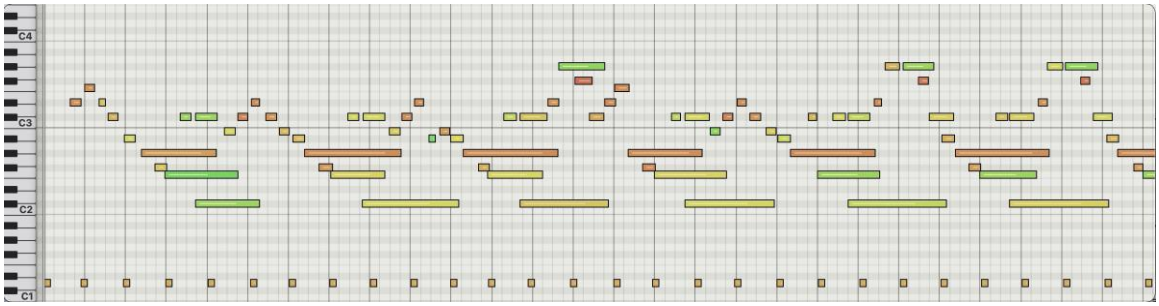

Fig. 1. Transcription of the beginning of "Sojerina" by zither player Velonjoro, with handclaps at the bottom (MIDI file computed by our detection program, piano-roll displayed by Logic Pro, beats indicated on the horizontal axis—note that Logic Pro's binary subdivision of the beat does not correspond to the ternary subdivision of zither playing, MIDI notes on the vertical axis).

The piano-roll reproduced in Figure 1 identifies the first notes in the piece "Sojerina" by Velonjoro, a virtuoso *marovany* player from southern Madagascar, recorded with our sensor-augmented zither in 2014. Since the musician played this piece by listening to a pre-recorded rhythmic sequence with hand claps and rattle, we know exactly where the pulses fall (represented at the bottom of the piano-roll in Figure 1). Thanks to these pulses, we can attribute the zither part with its correct rhythmic placement. Thus, we were able

to collect a large amount of MIDI data from the playing of this musician. For a more in-depth presentation of the methodology associated with this recording / transcription process, see Cazau et al. (2016), Cazau, Chemillier & Adams (2016).

SIMULATION WITH THE IMPROVISATION SOFTWARE "DJAZZ"

At IRCAM and CAMS (EHESS) in Paris, we have also developed a machine learning based improvisation software program called Djazz. Unfortunately, there is currently no general overview of Djazz written in English but such a document will soon be available as we are preparing to distribute this software for free, hopefully in 2023. In the meantime, interested parties might refer to either Lubat et al. (2021) who sets out an aesthetic and historical reflection on the subject or an older presentation of a previous version of the software illustrating the same principles in Nika & Chemillier (2012).

The Djazz software captures whatever a musician plays and then recombines the recorded sequences. Obviously, improvisers do not simply recombine sequences but learning to play patterns that they can reuse when improvising nevertheless represents an important aspect of practice. The software takes into account the beats on which the musician plays, and can also follow the harmonies. When the software makes recombinations, they remain consistent with these parameters despite the lack of any actual musical knowledge, following only a series of clicks and labels for the chords. This lack of musical knowledge means the software is adaptable to any musical style as long as the data applied to train the program belongs to that particular style.

Our improvisation system features two layers, one automatic and one manual. The recombination process coherent with the beats and harmonies takes place automatically. However, users can "perform" with the software, deciding which parts of the memory to apply in recombinations and which effects to add to the algorithm's output, such as looping a pattern, modifying the playback speed or transposing pitches in different registers. The software's degree of autonomy is limited to recombination and holds no long-term view. This aspect has to be handled by the user manually, who thus improvises with the software as a kind of intelligent instrument. In a given cultural framework, the challenge involves obtaining a result that is acceptable to the expert musicians of this culture. Indeed, as we shall see, the software is able to play in the style of a native Malagasy musician.

The software can produce hybrids by mixing various databases captured with several different musicians into its improvisation and thereby exploring many degrees of hybridization. One can thus inject into the Malagasy musical context solos generated within other traditions (for instance jazz) and study how they fit into the musical context according to the native musicians' point of view. We tested this approach with the Malagasy guitarist and singer Charles Kely Zana-Rotsy and his group. In his composition "Save The Earth," the computer injected at 04:11 a passage from a transcription of Brad Melhdau's solo on "The Falcon Will Fly Again" at 01:37 (from the album *Highway Rider*, 2010) represented in Figure 2.

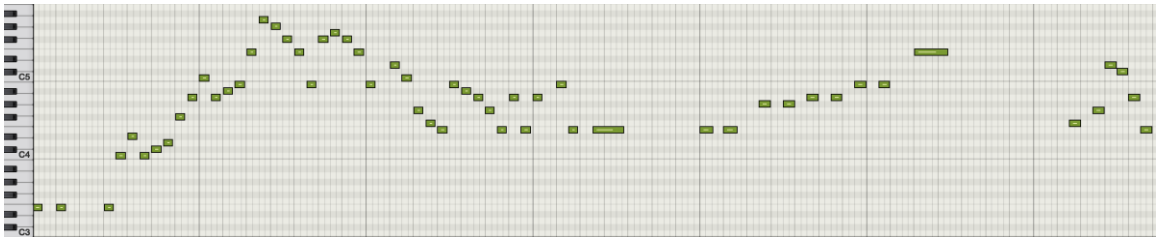

Fig. 2. Transcription of Brad Melhdau's solo on "The Falcon Will Fly Again" at 01:37 reinjected by the computer into Charles Kely Zana-Rotsy's "Save The Earth" at 04:11 (https://www.youtube.com/watch?v=tsTI2M0OBWg). MIDI transcription done by ear, piano-roll displayed by Logic Pro, seven beats per bar indicated on the horizontal axis, MIDI notes on the vertical one.

The software learned from the MIDI data captured by out sensors from the Malagasy zither. When he listened to the first improvisations generated by Djazz based on his own playing in July 2014, Velonjoro's reactions were quite positive. They seemed to mostly relate to the correct rhythmic placement of the motives played by the computer and indeed, the computer was playing with millisecond precision (Cazau et al., 2016; Chemillier, 2017). The full test of acceptability was to be able to duet with the musician, that is, to make the

computer bi-musical. The outputs of the program were good enough to allow duets with Velonjoro as took place in May 2016 (https://www.youtube.com/watch?v=xApyhRgMSFU) following a preliminary attempt to duet with this musician in July 2014 (https://www.youtube.com/watch?v=fJXLcTmDnXs). In this perspective, the musician's reactions to the outputs of the machine can shed new light on analysis of his repertoire. Indeed, by refining the generation parameters, we can move closer to an optimal characterization of the music studied.

LIVE DEMO WITH THE GREAT MALAGASY MUSICIAN JUSTIN VALI

Velonjoro passed away on January 10, 2017, at the age of 54, but his data lives on. In 2022, the world-famous Malagasy citharist Justin Vali listened to Velonjoro's data and was inspired to play with him. Resident in France, Justin Vali ranks among the greatest living players of traditional Malagasy music on the zither. He has recorded for the label Real World Records and played in World Music contexts with Peter Gabriel and Kate Bush.

Fig. 3. Portrait of Velonjoro in July 2014 in Mahajanga (photo by Marc Chemillier).

Fig. 4. Duet with Justin Vali playing a *valiha* zither and Marc Chemillier playing the Djazz software trained with a database from Velonjoro's *marovany* recordings, Paris, Luna Rossa Studio, February 20, 2023 (photo by Yuri Prado).

We played the database of Velonjoro recordings during the conference-concert at the second Symposium of the SoMoS Study Group in Barcelona on October 26, 2022, in a duet with Justin Vali who performed with the system (http://digitaljazz.fr/2023/06/19/videos-djazz-avec-justin-vali/#sojerina). During the rehearsal sessions before this performance at Universitat Pompeu Fabra, Justin Vali made the following comment on duetting with a computer playing Velonjoro's data:

> I'm going to work hard on this one. For me, it is not obvious [to play at Velonjoro's very fast tempo of 200 BPM], nor for all *valiha* players. Maybe even Vezo players [people from the South-West of Madagascar], for instance Bekamby [a great Vezo zither player], they don't play as fast as Velonjoro. […] Besides, it's my challenge. While I'm not yet completely old, I still want to exploit speed. […] Sometimes, when I'm in there, it goes by itself. But as soon as I start thinking, I completely miss it. [...] When he plays, in the photos it looks like he's laughing, he's like a machine. […] Maybe I need to ask his [Velonjoro's] spirit to help me a little bit with his piece because it's great (Justin Vali, October 16, 2022, see multimedia animation "Madagascar" for a video of this dialogue: http://digitaljazz.fr/multimedia/clesdecoute, Clés d'écoute, 2023)

The use of AI in a World Music context is open to accusations of imposing modern Western biases on this music. Therefore, it makes sense to ask whether Western AI algorithms can simulate musical styles from non-Western cultures. We have already seen that the software makes very few assumptions about the actual music it plays. In addition, Justin Vali's positive reaction showed that he considered the avatar played by the software as fully part of the Malagasy cultural context. In this sense, the computer becomes bi-musical.

There is another interesting idea in Justin Vali's quotation when he invokes the "spirit" of Velonjoro. In trance rituals, the spirit of the dead is believed to speak through the person falling into the trance. More generally in Madagascar, there is "no radical break between the living and the dead" (Decary, 1962, p. 8).

David Graeber talks about "the enduring presence of the ancestors" in everyday life (1995, p. 262). This conception of death is interesting to compare with current trends in AI concerning digital life after death. Nowadays, there is a "digital afterlife industry" (for instance Eter9, LifeNaut, Eternime), that produces "goods or services involving the online use of digital data from deceased persons to monetize deaths online" (Nakagawa & Orita, 2022) and we currently understand very little about "the impact of the creation of digital immortals on religious practices and grief management" (Savin-Baden, 2019).

The prospect of applying artificial intelligence to keep the dead alive may be puzzling. However, in a way, classic field recordings made in ethnomusicological approaches to conservation have already done something similar when founding recording archives to preserve a person's memory after death. In the same way, improvisation software maintains a trace of a musician's playing as a type of avatar with the simple difference that the software can imitate as if the musician were playing again postmortem. This raises numerous philosophical, ethical, artistic, and cultural aspects including the due caution and respect for the deceased and their cultural traditions.

CONCLUSION AND FURTHER DEVELOPMENTS

We have here described our analytical research into the repertoire of the Madagascar *marovany* zither. As this instrument is played for very long periods of time during trance rituals, we designed sensors adapted to the instrument in order both to make automatic music transcriptions of its repertoire and to collect MIDI data from the playing of Malagasy musicians. These data are then processed by a computer program designed to improvise and able to play in the style of these musicians. The program outputs are good enough to allow for duets between musicians and the computer. Thus, the scope for such duets involving the use of artificial intelligence may be regarded as an extended form of the notion of bi-musicality introduced by Mantle Hood. Furthermore, we may apply this system for artistic purposes in order to stage concerts with musicians such as Justin Vali, the great zither player from Madagascar. A new version of the software is being designed by Daniel Brown in Max/MSP with a library written in Python. In the artistic context, the role of the computer raises new questions to the fundamental issue of presence in live music, especially when databases of deceased musicians are incorporated, such as that of Velonjoro.

ACKNOWLEDGEMENTS

This research is supported by the European Research Council (ERC) REACH project (Grant 883313) and by French *Agence Nationale de la Recherche* (ANR) MERCI project (Grant ANR-19-CE33-0010).

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Measuring Tempo as a Methodological Approach: Case Studies of West African Drum Ensemble Music

RAINER POLAK[1]
RITMO Centre for Interdisciplinary Studies in Rhythm, Time and Motion - University of Oslo, Norway

The measurement of musical tempo is an approach rich in tradition in empirical musicology. A strong focus is on style-specific patterns of local variations in tempo and note durations (e.g., *rubato*, swing timing). Another more recent and much smaller focus is on automated data extraction and advanced computational analysis of large data sets, such as lists of tempo indications or audio recordings. Such corpus analyses deal, among other things, with statistical trends on the frequent occurrence of certain preferred tempo ranges in entire genres.

In this talk, I describe a methodological middle ground: manual annotation by tapping along with the main pulse and simple computer-assisted analyses of beat and subdivision rates in medium-sized corpora of audio recordings, focusing on global tempo curves across whole pieces. This approach assumes a good knowledge of the annotated repertoire, as is common in ethnomusicological research. It is technically very robust, as any measurement errors are automatically corrected by creating a reverse error in the following cycle and then compensated for by using running averages. The analysis requires only the simplest calculation methods, which can be easily mastered even by humanities scholars not trained in statistics.

The presentation describes published studies (Polak, 2017; Polak and London, 2022) of the performance practice of tempo in three different collections of field recordings of dance drumming from Mali and Ghana. This approach allows important insights into the psychological mechanisms of tempo perception, e.g. the important role played by the fastest pulse in addition to the often exclusively prioritized main pulse (tactus rate), as well as into the genre-specific generation and meanings of musical form. The presentation pleads for greater attention to the dimension of tempo in music research and illustrates that, contrary to widespread reservations, the integration of ethnographic and quantitative perspectives can sometimes—depending on research interest and choice of methods—be achieved quite easily.

NOTES

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Analysis and Documentation of Uruguayan Candombe Drumming: Overview of a Collaborative Research Project

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INTRODUCTION

This article presents an overview of the "Analysis and Documentation of Uruguayan Candombe Drumming" project carried out by the authors with a dual motivation: to document and preserve a rich intangible tradition and to analyze the rhythmic, technical, and musical features of candombe drumming.

The research team adopted an interdisciplinary approach: Luis Jure is a composer with a background in music theory. He has conducted research in candombe since the early 1990s, undertaking field and studio recordings of groups of drummers as well as producing transcriptions and analyses with a particular emphasis on the *repique* drum (Jure, 1992; 2013). In turn, Martín Rocamora is an electrical engineer specializing in signal processing and machine learning. He received his doctoral degree for a thesis about computational methods for percussion music analysis applied to candombe drumming (Rocamora, 2018).

These different—and complementary—backgrounds do not reflect any rigid separation of tasks between the researchers. Each holds a basic understanding of the other's area of expertise, and all aspects of the research were jointly discussed.

The team specializes in the field of computational musicology and, in the context of this research, developed new tools alongside the optimizing of existing tools for the extraction of meaningful musical information directly from audio—and in some cases, also video—recordings. Traditional digital signal processing and music information retrieval techniques, coupled with novel machine learning techniques, were deployed for automatic analysis and for data extraction and visualization in computer-aided analysis.

CANDOMBE DRUMMING

Candombe drumming constitutes one of the most defining features of traditional Uruguayan culture and an identity symbol of communities of African descent in Montevideo. While its cyclic, timeline-based rhythm shares many characteristics with other Afro-Atlantic world music styles, candombe also exhibits several unique and distinctive traits. Less well-known internationally than other Latin American music genres of African origin (such as Afro-Cuban or Afro-Brazilian), candombe drumming possesses considerable rhythmic wealth and deserves wider recognition. In 2009, in acknowledgment of its rich history and cultural value, UNESCO accepted it onto the Representative List of the Intangible Cultural Heritage of Humanity (UNESCO, 2009).

The essential manifestation of candombe drumming is the "*llamada de tambores*" (lit. "call of the drums"): a group of drummers playing while marching on the street (Figure 1). The characteristic candombe rhythm results from the interaction of the rhythmic patterns of three types of drums of different sizes and pitches called *chico*, *repique*, and *piano*. The rhythm cycle comprises four beats, each divided into four pulses, and the underlying timeline—occasionally made explicit by a pattern named *madera*, produced by hitting the shell of the drum with the stick—is isomorphic with the *clave* pattern of Afro-Cuban *son*. Candombe drumming also exhibits a style-specific microtiming profile that plays a structural role in the rhythm.

Fig. 1. Group of drummers or "*cuerda de tambores*" playing on the street. (Photo by Luis Jure).

DATA COLLECTION

Collecting audio and video recordings of candombe performances represents one of the most important components of this project as the quantity and quality of data are essential to the type of analysis performed. Furthermore, such recordings also in themselves hold intrinsic value, contributing to documenting and preserving a tradition of substantial cultural value. Parts of the collection have since been released and are available for researchers (Jure and Rocamora, 2015; Jure et al., 2020).

The collection of candombe recordings is an ongoing project that now spans 30 years, having started out in 1992. The collection presently includes more than 70 complete performances from 15 different studio sessions, totaling more than seven hours of audio. The group size varies between three and nine drums, involving more than 60 different players who represent several generations and different neighborhood styles (Figure 2).

For each performance, there are both multi-track (one drum per track) and stereo audio recordings as well as video recordings (Rocamora et al., 2015; Jure et al., 2020; Clayton et al., 2021).[2] There is also complete information about sessions and takes (date, location, performers, equipment utilized, etc.), as well as annotations of the metrical structure per take alongside timing onsets for each track. Both types of annotations were generated automatically before their manual verification (Figure 3).

Fig. 2. Audio and video recording session of a group of six candombe drummers. From left to right: *repique*, *piano*, *chico*, *piano*, *chico* and *repique.* (Photo by Diego Duarte).

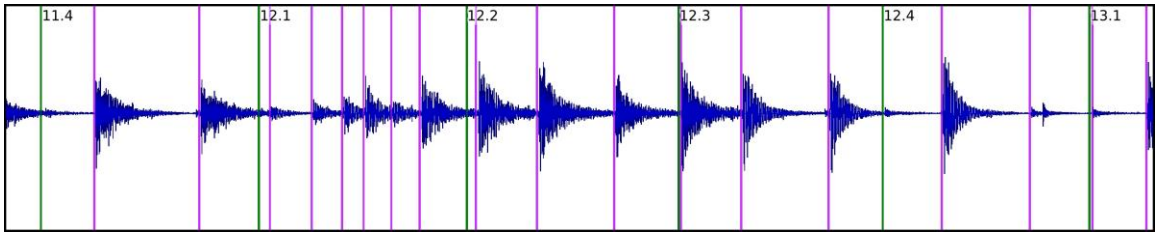

Fig. 3. Audio waveform of a single track with metrical annotations (measure.beat) in green and onsets in magenta.

COMPUTATIONAL ANALYSIS

The availability of a large collection of annotated recordings allows for several types of musical content analysis of the audio signal through computational tools. Within the project framework, we carried out several lines of research; a brief overview of two cases follows below.

Rhythmic patterns analysis

Analysis of the rhythmic patterns in the annotated audio begins by estimating what was termed "accentuation feature:" the measurement of energy level in each of the cycle's 16 pulses (Figure 4, box 1). Each cycle is then represented as a column in the feature map for the whole performance (box 2). Next, the patterns are automatically grouped into clusters according to the k-means method and reduced to three dimensions for the purpose of visualization through isometric mapping (box 3). Lastly, the centroid of each cluster is estimated to obtain the most representative form of each pattern. This approach served both to analyze the main patterns of the *piano* drum in a performance and to classify recordings by performer (Rocamora, Jure, and Biscainho, 2014) as well as to identify *madera* patterns in a collection of recordings (Rocamora and Biscainho, 2015).

Analysis of microtiming

In candombe drumming, fluctuations in tempo during performances are common (Jure and Rocamora, 2018), as well as deviations in the microtiming of events around the regular subdivision of the beat. To analyze microtiming, we only applied annotation files. The location of onsets is analyzed in relation to metrical points to determine the distribution of events within the normalized beat and inter-onset intervals (IOIs). The evolution of these factors with tempo is also of interest. We established a visualization model to represent these parameters (Figure 5). The vertical axis represents time in cycles while the three graphics depict tempo in beats per minute (BPM), onset location as a fraction of the normalized beat, and IOIs as a percentage of the beat.

This process thereby reveals some of the salient features of the characteristic microtiming profile of candombe. These include a general contraction in the pattern within the beat, with the last pulse approaching a ternary subdivision, and a typical variation of the microtiming pattern with tempo (Jure and Rocamora, 2016; forthcoming).

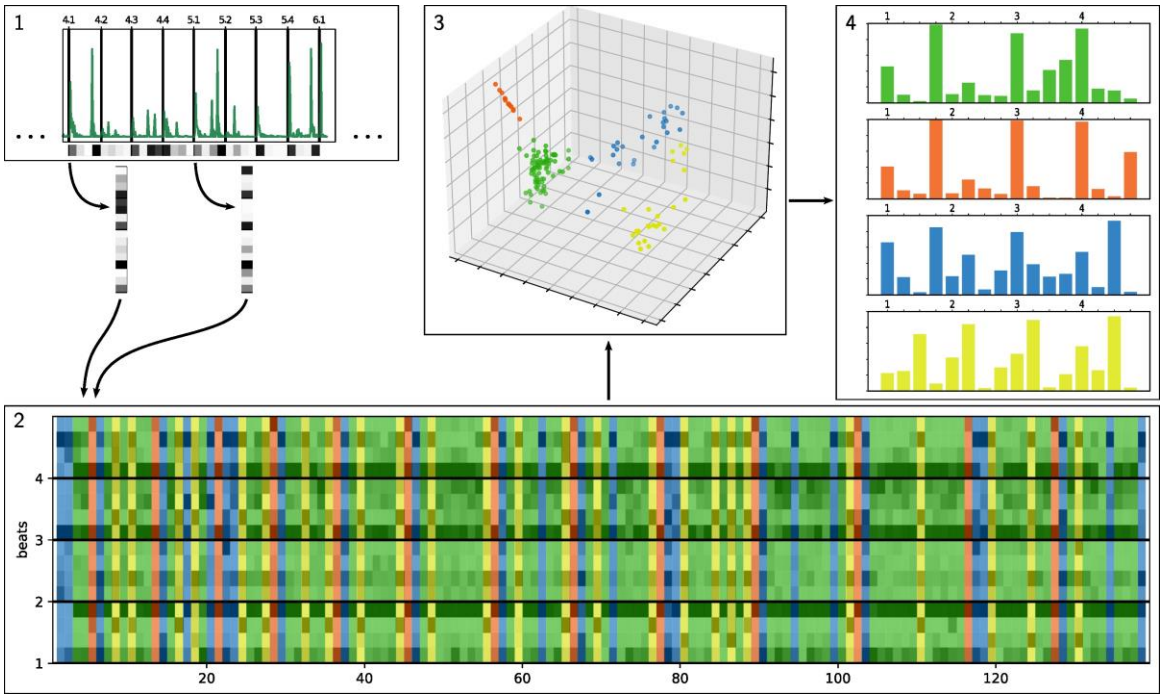

Fig. 4. Pattern analysis of annotated audio: the accentuation feature of each cycle (1), map of the whole performance with the x axis representing time in cycles (2), clustering and dimension reduction (3), centroid of each cluster (4).

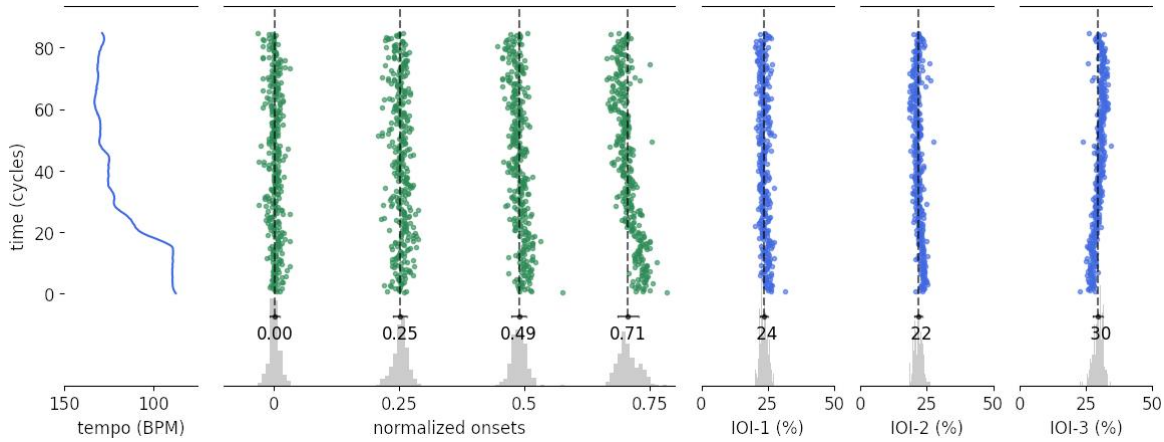

Fig. 5. Evolution in time (vertical axis) of tempo in BPM (left), onsets location within the normalized beat (center) and IOIs (right) of the *chico* drum during a performance.

THE `carat` TOOLBOX

In the framework of the project, there was the release of the Python `carat` (Computer Assisted Rhythm Analysis Toolbox) toolbox (Rocamora and Jure, 2019). One of the aims of this toolbox is to maximize its usability by the musicological community with a low barrier to entry for researchers in musicology with little or no background in scientific programming.

The toolbox implements functions for the different types of rhythm analysis performed in this research, like displaying audio waveform with annotations, tempo curves and microtiming patterns, accentuation features, and feature maps with clustering, cluster centroids, et cetera. It was released under the MIT license and is freely available on GitHub,[3] in conjunction with several notebooks that exemplify its use. As with data collection, `carat` remains an ongoing project and correspondingly subject to updates and expansion.

ACKNOWLEDGMENTS

This project was partially funded by the research agency of the University in Uruguay, Comisión Sectorial de Investigación Científica, Universidad de la República.

NOTES

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[2] Recent sessions include multi-camera HD video as well as high-speed video at 240 fps.

[3] https://github.com/mrocamora/carat

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Mimicking Timbre: Identifying Gestural Patterns and Sonic Similarities in Flamenco Flautists and Singers

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INTRODUCTION

This paper analyses the multi-modal nature of timbre in flamenco performances. Although timbre represents a fundamental facet of the flamenco experience, it is still relatively under researched. I present here examples of indigenous Andalusian perceptions of timbre in flamenco and their sociocultural significance. I also put forward a comparison of two videos, respectively featuring a concert by a traditional flamenco singer from Jerez de la Frontera, Spain, Jesús Méndez (available on YouTube), and one of my fieldwork recordings of flamenco flautist pioneer Jorge Pardo from Madrid. This comparison enables the identification and association of specific physical gestures in relation to acoustic timbral events, thus establishing a connection between sound and movement in traditional flamenco practice. This constitutes a novel research approach in flamenco studies and correspondingly requiring further expansion by future investigation. The aim is to explore the flamenco timbre as a holistic embodied experience that encompasses a series of modes of expressions such as movement, sound, and cultural and metaphorical discursive elements.

LOCATING TIMBRE IN FLAMENCO

In flamenco, timbre plays a key aesthetic role in vocal performance where it is indigenously understood to index meaning and reference culture. Thus, vocal timbre associates with an array of discursive elements and culture-specific metaphors deployed by practitioners and aficionados to express a series of concepts relating to affect, ethnicity, social extraction, or cross-modal associations deriving from the material world, tactile experiences and others (Cruces Roldán, 2002; Fales, 2002; 2019; Levin and Süzükei, 2006; Gamboa and Núñez, 2007; Díaz-Báñez, 2013; Mora, 2013; Eidsheim, 2019).

Singing occupies the highest rung in the hierarchy of traditional flamenco practices, *cante* (singing), *baile* (dance), and *toque* (playing), as the popular adage "*el cante manda*," (singing is boss) conveys. As the fieldwork interviews indicate, the flute is arguably the main non-traditional melodic instrument in flamenco. The flamenco flute primarily emulates singing, often substituting it and becoming the central melodic element in the performances in which it features. This reflects a certain degree of "voiceness" with the quality of the voice being a non-vocal instrument (Fales, 2019). Such emulation is achieved by specifically extended techniques (Dick, 1986) which consist of overblowing notes, bending pitches, or playing harmonics. These techniques have also been developed through mimicking a series of body movements in which flautists reproduce the traditional movements of *cantaores* (flamenco singers). For example, flamenco flautists anchor themselves, shrugging their shoulders and projecting themselves towards the ground in reproducing the movements of *cantaores*. The acoustic results are notes rich in harmonics with weaker fundamental frequencies for both singers and flautists.

TALKING ABOUT TIMBRE

My preliminary research suggested that timbre plays a key role in the flamenco aesthetic, particularly in relation to controversial notions around purity and authenticity (Cattaneo, 2021). However, my extensive fieldwork in Jerez de la Frontera, Spain, during 2017, revealed the difficulties that both aficionados and practitioners encounter when describing timbre. Recent studies on flamenco timbre have primarily focused on the physical, measurable aspects of the flamenco sound and emerging from the fields of mathematics and computational theory (Díaz-Báñez, 2013; Mora, 2013; Kroher et al., 2018). Research on flamenco voice quality in terms of the relationship with symbolic understandings and social systems of meaning, and the intersection with cultural narratives or movement, remains largely absent from the literature.

Indigenous perceptions of flamenco timbre mainly apply to the voice and are described utilizing a series of cross-sensorial metaphors, such as the tactile, the *voz rozada* (coarse voice). They may refer to the characteristics of a specific material, like *metal* (a word commonly used in flamenco to refer to timbre) or the highly valued vocal feature of *rajo* (rip or tear) in the *voz afillá*, proposed by many as the archetypal flamenco voice.

Other common metaphors employed by flamenco practitioners and aficionados connect the perception of sound with the realm of emotions and affect, such as despair, passion and sadness, for example, the *quejío* (from *queja*, complaint), and the incorrect reflexive use of the verb *dolerse* (to hurt, to hurt oneself, or literally to "make" oneself hurt). Metaphors describing timbre may also refer to ethnicity *sonar gitano* or *sonar payo*, to sound Gypsy or not Gypsy, which associate the timbral event with a sonic fingerprint understood as an ethnic identity marker.

METHODS: VIDEO ANALYSIS OF GESTURES AND THEIR RELATIONSHIP WITH TIMBRE

In this section, I shall compare two video extracts. The first is a recording of flamenco singer Jesús Méndez, at the Fiesta de la Bulería (the Bulería flamenco festival) in Jerez de la Frontera, Spain, in 2020 (Figure 1). The second is one of my 2017 field recordings of flamenco flute pioneer Jorge Pardo, who is a leading reference in flamenco flute playing, in Sanlúcar de Barrameda, Spain (Figure 2).

Jesús Méndez is a *cantaor* (traditional flamenco singer) from Jerez de la Frontera. He is a local practitioner who grew up in a traditional flamenco environment where he learned flamenco from a young age, through oral transmission in a domestic and social setting characteristic of the flamenco vernacular tradition. He is a member of the *gitano* (Gypsy/Roma) ethnic group, which is closely associated with the practice of flamenco throughout Spain, Andalusia and particularly in Jerez de la Frontera. Jorge Pardo originally started out as a jazz musician and learned flamenco as a (young) adult musician in a stage performance context. However, his formation happened through traditional oral transmission thanks to his proximity to some of the world's leading flamenco practitioners such as Camarón de la Isla, Paco de Lucía, and many others.

Here, I aim to analyze the audio spectrogram of the selected videos according to the SonicVisualizer software (Cannam et al., 2010) through comparing the moments in which specific, comparable timbres occur in both performances and thereby correlating the movements and gestures performed respectively by Méndez and Pardo.

FINDINGS

This comparison enables me to identify similarities between the types of physical gestures and bodily movements employed by both singer and flautist when specific timbral events occur. Singers generally move more freely as they are not limited by interacting with an instrument while in the case of flute playing, their hand gestures and facial expression are directly restricted by the instrument. The flute imposes certain limitations, for example, the hands are occupied fingering notes and holding the instrument while the mouth is making the embouchure. Nevertheless, comparative analysis identifies some general similarities for these two performers in both body movements and gestures in relation to the timbral events.

Analysis indicates that specific timbres in flamenco singing and flute appear to be instantiated by a similar set of embodied patterns characteristic of traditional flamenco. These patterns, which have not yet been classified in a flamenco context, include hand gestures, facial expressions, shrugging of the shoulders, and a downward projection of the upper body. Such patterns emerge even in the gestures employed in performances by musicians who learned as adults, but through traditional oral transmission, as is the case with Pardo who has integrated this set of gestures and codes of communication into his performance. These physical gestures, as this fieldwork reveals, are natively associated with traditional embodied perceptions of timbre. The two spectrograms allow me to compare the physical gestures employed by Méndez and Pardo in relation to the specific timbres produced. Both performers move in a similar fashion when making sounds natively understood as archetypal flamenco timbres. These sounds, described with words such as *rajo* (tear), display a higher intensity in harmonics and weakened fundamental notes (Mora, 2013).

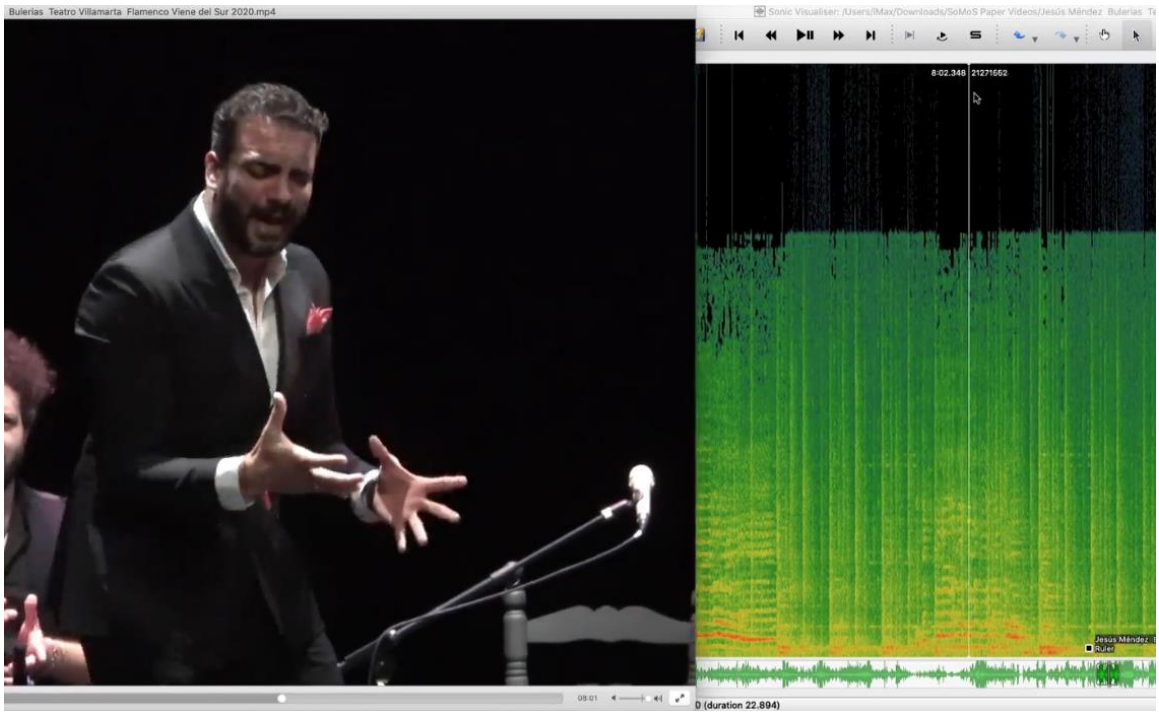

Fig. 1. Jesús Méndez in performance. Still from video performance (left), spectrogram of acoustic event (right).

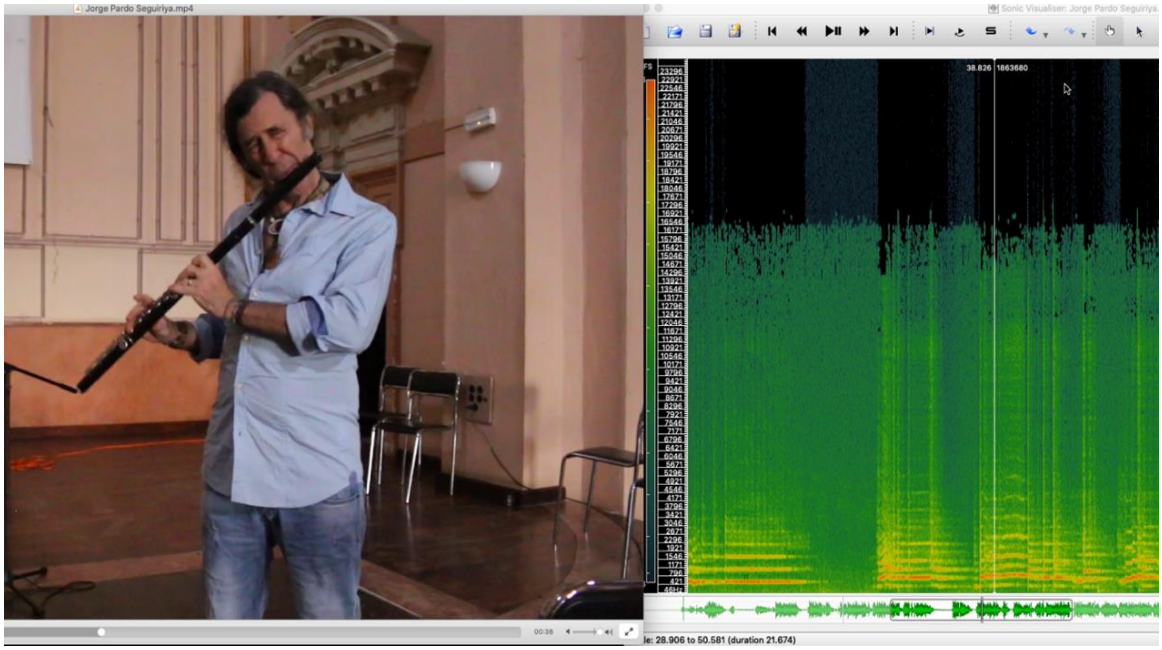

Fig. 2. Jorge Pardo in performance. Still from video fieldwork recording (left), spectrogram of acoustic event (right).

This paper provides only partial and initial analysis. A more thorough study of a larger sample of performances and greater consistency in settings, recordings and equipment would provide better material for analysis. Moreover, a more detailed classification of gestures, hand and body movements, and facial expressions would enable us to decode and codify the connections between movement and sound in the performance of traditional flamenco timbres. This might implement methods such as Laban Movement Analysis (LMA) as a tool to analyze and compare movement. Finally, more targeted fieldwork research,

involving questionnaires and focus groups, would enable us to elicit information regarding the perception of timbre and the gestures that instantiate it. Such research would allow us to identify flamenco specific gestures shared among flamenco players and also alongside idiosyncratic approaches that individual singers and flautists may employ when performing certain timbres. Further study may also enable us to identify potential correlations between gestures and patterns and their relationship to timbre across different musical traditions which might, in turn, produce applications beyond ethnomusicology and academic research.

NOTES

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Memorization of Repertoire in Trinidad & Tobago Steelbands: A Cognitive Approach

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This presentation focuses on the quick memorization abilities displayed by players of the steelpan, Trinidad and Tobago's famous melodic idiophone made out of between one and twelve second hand oil drums (Stuempfle, 1995; Dudley, 2008; Helmlinger, 2012). This instrument, invented at carnival festivities in the late 1930s and 1940s and later consecrated the "National Instrument of Trinidad & Tobago", has been institutionalized through the creation of various national competitions. At the "Panorama"—the largest musical event for steelbands where orchestras of up to a hundred players compete in a challenging music contest—seasonal players, playing for about one month a year, and sometime even beginners, are able to memorize and perform by rote a symphonic-like tune, with a lot of technical constraints, at an extremely fast tempo. Without the help of score sheets or the use of variation, at the same time they encounter the constraints of written and oral traditions.

Interweaving a classical anthropological approach and background (participant observation) with the input of the cognitive sciences—an oriented bibliography and methodology, I here propose a comprehensive analysis of the way these non-professional musicians retain the music in a challenging context. This involves the presentation of several hypotheses, supported both by fieldwork observations and the cognitive psychology bibliography: the memory of songs, the visuo-spatial memory and mental images, and an implicit understanding of the intervals on the instruments. Another hypothesis, the assistance of feeling the simultaneous performance of other players, was tested by an experiment inspired by cognitive psychology and successfully identifies a positive group influence on individual memory.

NOTES

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Collectively Classical: Social Connection at a Classical Concert

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Concerts are fundamentally social experiences in which an audience and musicians gather to witness and create an aesthetic experience. Live concerts are important sociocultural events that normally involve gathering at the same time and in the same space. In livestreamed virtual concerts, participants may gather in time, but not in space. Therefore, technological mediation permits manipulations that allow us to examine what contributes to the social experience of concerts. Our previous research indicated that livestreamed concerts promote more social connectedness and reduce loneliness more than pre-recorded concerts. Additionally, live, in-person concerts promote more movement than listening to recorded music in a group. However, to the best of our knowledge, a comparison between live and virtual concerts and their effects on motion and emotion has not yet been conducted.

The Danish String Quartet is an acclaimed classical music group who performed a concert to both live and livestreaming audiences. Audience members were invited to participate by downloading a smartphone application that records motion with their smartphones' inertial measurement unit sensors. Surveys collected information on participants' experience of the music, social connectedness, and the sociorelational emotion of feeling moved before the concert and after each piece.

Survey responses were collected from 91 participants in the live audience and 32 participants in the livestreaming audience. Motion data was collected from 82 participants in the live audience and 25 from the livestreaming audience. The live audience felt more connected to the other audience members than the livestreaming audience but there was no difference in the feelings of connectedness towards performers between the audience groups. The audience reported feeling moved more in the Folk, then the Beethoven, and then the Schnittke, though there were no differences in reports of emotions between audiences. When neighbors behaved in musically cooperative ways by moving more during the Folk but less during the classical pieces, then audience members reported more connectedness to the audience.

This research contributes to ethnomusicology by reinforcing the importance of the social nature of musical experiences. Performers could use livestreams to connect with their audiences all over the world. Greater understanding of the ways in which concerts influence social connection could help illuminate interventions for reducing loneliness and improving well-being.

NOTES

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Annotating Karnataka Music: Encounters Between a Musical Tradition and Computational Tools

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INTRODUCTION

Computational tools, such as automated motif-finding, have been designed for and used in musicological contexts. However, questions can be raised regarding the value and ethical implications of such computational approaches; can they contribute anything positive to the musical tradition being analyzed, and do they have the potential for causing harm? We take up such issues in the context of a specific case, the annotation of Karnataka music audio recordings for the development of motif-finding tools designed specifically for this South Indian music tradition.[2] From our perspectives as musicians and musicologists, we explore the processes involved, document issues that arose and make recommendations based on our experiences.

Although we draw on some music-theoretical sources in this paper, we deliberately adopt a performer-based perspective, founded on knowledge of how musicians learn and conceptualize the music. This is based on both authors' first-hand experience of learning the style and on one author's over twenty years of experience as a professional Karnataka musician, based in Chennai. Our wider concerns regard the social and cultural impact of the technologies to which we contribute and our approach is auto-ethnographic in that we reflect on the process of making the annotations, and more broadly on this encounter between Karnataka music concepts and the needs of Music Information Research (MIR).

The goal of the MIR task undertaken by researchers at Universitat Pompeu Fabra was to create computational tools to find motifs (short melodic phrases) in audio recordings.[3] In order to evaluate the results of this process they needed to be compared to a "ground truth", which in this case was a set of annotations made by an expert musician. Brindha Manickavasakan, a highly regarded professional Karnataka vocalist, created these annotations using ELAN annotation software (Lausberg and Sloetjes, 2009). During the course of this process, she had regular meetings to discuss issues arising with the other author of this paper, Lara Pearson, who has been collaborating with the Pompeu Fabra team since 2021. This paper is the outcome of these processes and discussions.

UNDERSTANDING KARNATAKA MUSIC CONCEPTS

We started the annotation process from the position that Karnataka music concepts should be central in the development of computational tools aimed towards the style, both for ethical reasons and for the tools to give meaningful results. Tradition-specific concepts need to be considered because there are features of Karnataka music that differ from styles that are more typically analyzed computationally, such as Western Art and Popular musics. For example, in Karnataka music, *svaras* (notes) are often performed with *gamakas* (ornamentation) that have a significant impact on the resulting musical sound, such as wide oscillations that don't rest on the svara pitch itself (Krishna and Ishwar, 2012; Pearson, 2016).[4] Furthermore, the concept of svara includes any gamaka performed on it, and so svaras are not like "notes", which are typically associated with a relatively static pitch. As gamakas are musically meaningful (*rāgas* with the same svaras can be differentiated based on the gamakas used) flattening out the gamaka curves during any transcription process would erase an important part of the musical meaning. For these reasons, the project at Pompeu Fabra starts from audio recordings rather than from simplified transcriptions, thereby taking into account both svara and gamaka combined into a unified whole, in line with understanding within the tradition (Viswanathan, 1977).

As the task "motif-finding" is framed using the English language musicological term "motif", we first need to understand how this relates to Karnataka performance practice and structural concepts, the most relevant of which we discuss briefly below.

Melodic Structure in Karnataka Music

In Karnataka music, a rāga is a melodic framework that comprises phrases, formed from a limited number of svaras (notes) that often incorporate gamakas (ornamentation) (see Ramanathan, 2020 for a detailed explanation). All of these elements reside in the collective living knowledge of the rāga, as expressed both in compositions and more extemporized formats performed by musicians.

Phrase Concepts: *Piḍi*, *Sañcāra* and *Prayōga*

The term piḍi ("hold" or "catch" in Tamizh) or "characteristic phrase" generally refers to a phrase that points clearly to one particular rāga, and that would not be found in another (Ramanathan, 2020). Sañcāra (from the Sanskrit सञ्चर्, meaning "to move") refers to a coherent segment of melodic movement that follows the grammar of the rāga. Defined in this way, unlike a piḍi, a sañcāra may be found in more than one rāga. Therefore, although piḍis are also sañcāras, not all sañcāras are piḍis. The term sañcāra is similar to the meaning suggested by the English terms "phrase" or "motif", but with the added requirement that it should conform to the grammar of at least one rāga.

Another commonly used term, prayōga, means "usage" or "practice". A gamaka prayōga, for example, is an instance of gamaka usage. In the context of rāga, the term prayōga often refers to a phrase (i.e., an example of melodic usage) and so the terms prayōga and sañcāra are frequently used interchangeably.

For this project, as we aimed to annotate from a tradition-oriented perspective, we chose to use Karnataka concepts when defining the phrase type. We annotated sañcāras in order to include a larger number of phrases than would be covered by the concepts of piḍi or characteristic phrase.

ISSUES ARISING DURING ANNOTATION

During the annotation process, issues became apparent regarding segmentation, similarity and transcription.

Segmentation

Segmentation of the melodic flow into sañcāras was not always straightforward due to there sometimes being more than one plausible option. In such cases, we found that the *sāhitya* (lyrics) could influence decisions regarding sañcāra starting and ending points. Namely, there was a tendency to prefer segmentation points that did not split words (see Figure 1, https://youtu.be/DzVRkvHROc8).

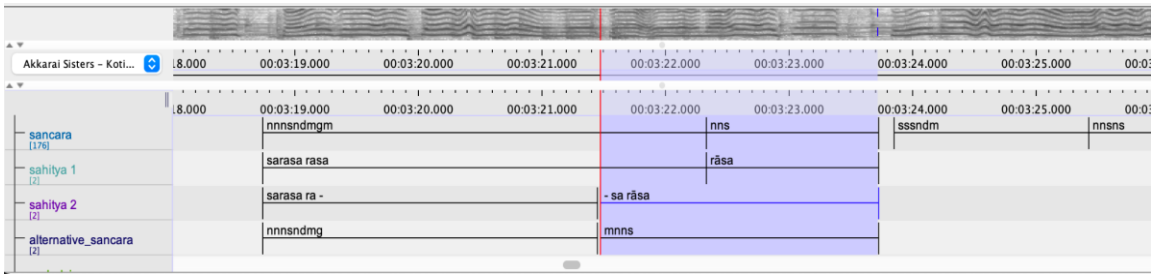

Fig. 1. Annotations in ELAN showing two possible segmentation points for the phrase "nnnsndmgmnns": one that aligns with the word breaks in the sāhitya (lyrics) and the other that does not. Both work musically, but we noticed that the word breaks can influence the choice of segmentation point. The letters used here to transcribe phrases, such as "nnnsndmgmnns" are from the traditionally used *sargam* notation – a form of solmization in which sa can be placed at any pitch from which the svaras ascend as follows: sa, ri, ga, ma, pa, dha, and ni. The letters used for the annotations in this project comprise the first letter of each of these svaras, so the sañcāra in question is actually "ni ni ni sa ni dha ma ga ma ni ni sa."

Furthermore, a given sañcāra may be part of a longer sañcāra. To take into account both the shorter and longer sañcāra we annotated two levels, namely "sañcāras" and "full phrases" (see Figure 2, https://youtu.be/yLXUcoV7NYo).

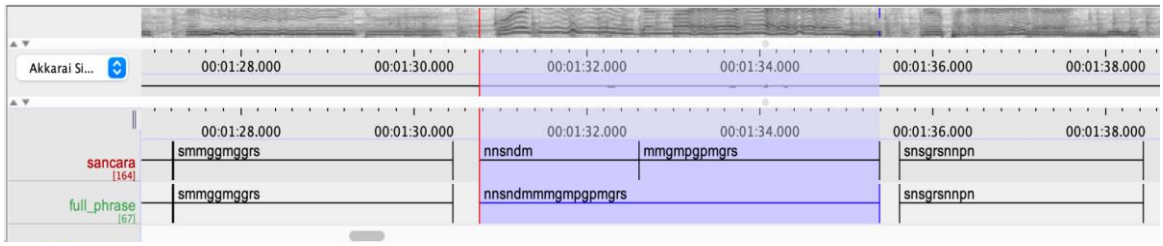

Fig. 2. Annotations in ELAN showing two hierarchical levels at which the melody could be segmented: a higher level of longer segments that we labeled "full-phrase" (often marked at either end by breaks in the vocal melody), and a lower level of shorter segments that we labeled as "sañcāra".

Existing literature on music annotation has similarly noted that ambiguity regarding optimal segmentation points often leads to differences amongst annotators (Bruderer et al., 2009; Ren et al., 2018). Surveying this literature and based on our own experiences, our recommendation would be to accept that this ambiguity is part of musical experience and find ways to embrace it. Possible approaches suggested include employing multiple annotators and creating hierarchical and weighted annotations (Nieto, 2015; Mcfee et al., 2017; Tomašević et al., 2021). Instead of forcing the idea that there is only one set of correct segmentation points, metrics can be employed that take differences in segmentation points into account (Nieto, 2015; Mcfee et al., 2017; Nieto et al., 2020).

Similarity

In Karnataka compositions, it is frequently the case that some sañcāras are later repeated with elaborations that include additional svaras and gamakas. In order to connect later elaborations to the sañcāra's first rendition, which is typically the simplest version, we also annotated "underlying sañcāra" and "underlying full phrase". This enabled us to indicate similarity between sañcāras that are related but not precisely the same (see Figure 3, https://youtu.be/58lNU1eAQqU).

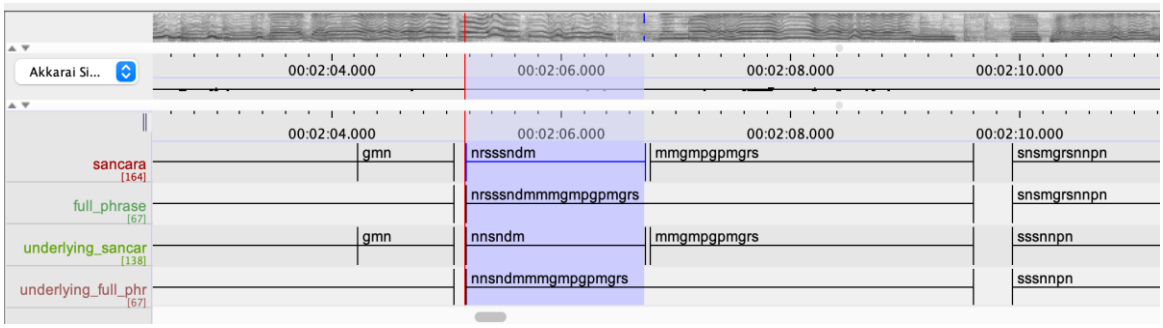

Fig. 3. Annotations in ELAN showing sañcāras, full phrases and the underlying versions of each, thus connecting elaborations on sañcāras back to the first, and typically simplest, rendition of that sañcāra.

Transcription

Transcription from audio into visual notation is notoriously subjective (England, 1964; Ellingson, 1992). Similarly, in Karnataka music there are often different, but still acceptable, ways to notate the same sañcāra (see: https://youtu.be/K6Oyjnyptls). Therefore, annotations by different musicians are likely to differ to some extent. Audio recordings can be transcribed with either more or less detail, and so decisions need to be made regarding the level of detail required (see: https://youtu.be/APrYUspi1xI).

RECOMMENDATIONS

In conclusion, we make four recommendations based on our experiences during this project, which combine ethical considerations with those relating to research relevance.

a) Understand and use practitioners' musical concepts

For both ethical reasons and to ensure that the research results are meaningful, it is important to create computational tools that take into account, rather than ignore or erase, musical concepts used by practitioners.

b) Clarity regarding the annotation process

In order to avoid misrepresenting the musical style, annotations should be based on concepts that are adequately described. This requires a thorough inquiry into the concepts, documentation of the definitions finally employed and the inclusion of such documentation together with the dataset. Proper documentation should help prevent misunderstandings and the propagation of errors in future research, which could be construed as harms to the tradition.

c) Incorporate naturally occurring ambiguity

Considering that musical segmentation, assessments of similarity, and transcription are all subjective to some degree, it would seem wise to accept this ambiguity and find ways to take it into account both in the annotation process and in the metrics used for evaluating results.

d) Create tools that contribute to the tradition

Computational tools should be designed to positively contribute to the tradition and to those who sustain the tradition through performing, teaching, audiencing and researching. Ideally, the tools created should be accessible to all. These should be genuinely usable by a wide range of musicians, listeners and musicologists, with opportunities for such individuals to provide feedback on the tools.

In these ways we increase the likelihood of creating and contributing to ethical computational tools that respect the tradition and are transparent regarding their assumptions.

NOTES

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[2] The full name for the style is Karṇāṭaka Saṅgīta. It is also referred to as Karnataka music, Karnatak music and Carnatic music.

[3] See https://github.com/MTG/searching_for_sancaras

[4] In keeping with APA style guidelines, non-English terms in this paper are placed in italics on first mention, and then without italics on subsequent mentions.

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An Interactive Animation of Maracatu de Baque Solto Collective Choreographies (Brazil)

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INTRODUCTION: MARACATU PERFORMANCES

Maracatu de baque solto ("free-rhythm" Maracatu), also known as *Maracatu rural* ("rural" Maracatu), constitutes a public performance of sounds, music, dance, oral poetry, decorated objects and costumes that takes place in the *Zona da Mata Norte* region of Pernambuco (Northeast Brazil) during the Carnival period. Maracatu groups[2] may differ in size (20 to 200 performers) but they always feature the same key components: 1 or 2 poet-singers (*mestres de apito*), 5 percussionists (*terno*), a small brass section (2 to 5 trumpets and trombones, called *músicos*), and several costumed dancers, representing various characters linked to the indigenous and Afro-Brazilian history and culture (*rei*, *rainha*, *caboclos de lança*, *baianas*, *dama do paço*, and others). Low-income rural workers, mainly sugarcane cutters, join these groups in keeping with their family ties, sense of belonging to their neighborhood, and/or out of a spiritual duty as Maracatu closely intertwines with the worship practices of the *Jurema* religion (see Guimarães de Salles, 2010). Maracatu groups perform in different contexts and periods of the year: from September to February, they "rehearse" (*ensaiam*) next to their own headquarters (*sede*); during the three days of Carnival, they "present themselves" (*se apresentam*) in the neighborhood towns and, on Fat Tuesday, they compete in the official parade organized in Recife, the state capital. Whether the performances are all-night long as in the former case, or of a shorter duration (15 to 30 min) as in the latter two cases, they always take place in a public arena, usually in a square or on a straight road. In some cases, the group starts at one point of the city and ends in another one, following a predetermined itinerary that passes by symbolic locations (e. g., the house of a deceased group member or that of a politician sponsoring the group).

THE *MANOBRAS*: COLLECTIVE MOVEMENTS IN SPACE

A Maracatu performance involves collective movements in space, called *manobras* (lit. "maneuvers", e.g., evolutions or choreographies), during which each group member occupies a precise position in relation to the others, and moves according to a common plan. Some *manobras* have precise symbolic meanings or functions: for instance, when the Maracatu traverses any crossroad, the group always turns in each direction (left and right, back and forth) before continuing on its path with these moves designed to "undo" (*desfechar*) witchcraft. This *manobra,* and a few others, are identical for all groups while others stem from the creativity of each group's lead dancer (*mestre caboclo*). In both cases, these collective movements are quite challenging, especially for large groups as performers do not retain their relative positions but rather continually change them while moving through space. For instance, two or four lines of male dancers (*caboclos de lança*), always positioned on the external flanks of the group, cross over whenever this changes direction. In another *manobra*, performers realize a spiral movement, called the *curupim*, revolving around the group's central nucleus (*miolo*). Moreover, even while realizing collective maneuvers, each performer has also to focus on his/her own individual movements, intended as "dance" (*dança*).

According to the local discourse, individual and collective movements are supposed to "animate the puppet" (*animar o brinquedo*), that is, to bring life to a holistic entity endowed with a spiritual substance and magical attributes; and to "close the Maracatu" (*fechar o Marcatu*), meaning to protect the group from eventual spiritual and/or physical threats emanating from rival competitors. A Maracatu group may only effectively become "animated" and "locked" whenever its members are both moving correctly and ensuring

their collective movements take place "in consonance" (*consonância*), hence, with a high level of interpersonal coordination, mutual understanding, and proper behavior (see Acselrad, 2013). In the opposite case, negative entities, aroused by the envy (*inveja*) of rivals, may "dismantle" (*desmantelar*) the group, breaking it up and causing individual health problems and interpersonal conflicts (see Bonini Baraldi, 2021; 2022). Grasping the cultural and social meanings underlying a Maracatu performance therefore requires describing the *manobras* and understanding how these should be performed.

AN INTERACTIVE ANIMATION OF THE MARACATU *MANOBRAS*

Standard videos of Maracatu performances might provide a useful tool for describing and analyzing the collective *manobras*. However, given the high number of people involved and the complex movements carried out, these images prove difficult to obtain. During my field research, I was able to capture the *manobras* of the Maracatu group *Leão de Ouro de Condado* ("Golden Lion of Condado") on many occasions, eventually choosing the highest filming position (e.g., the top floor of a nearby house) but I was never able to shoot footage including all of the performers. Thus, an alternative able to this limitation would involve depicting the collective movements in space by means of a computer animation in which the Maracatu characters are represented by simple icons that move bi-dimensionally (across the computer screen), hence, generating a bird's-eye view of the *manobras*. Within the framework of a graduate dissertation project carried out at the Polytechnic of Porto School of Engineering, we set out to implement such a project.

The platform was designed in HTML 5 as this provides specific multimedia controls. The animations are run by javascript through recourse to d3.js and anime.js. Figure 1 illustrates the pipeline for developing the final solution. For each actor, an icon was designed to provide some feedback on their respective roles (Figure 2).

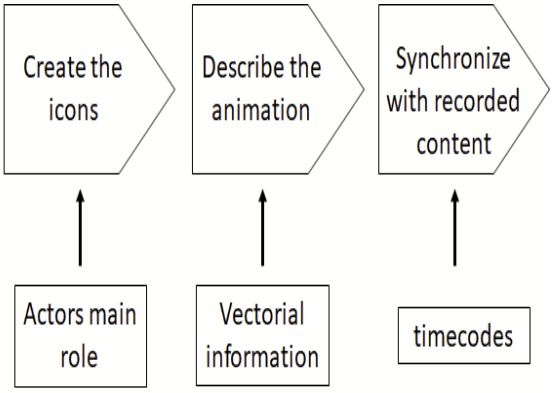

Fig. 1. Implementation pipeline.

Fig. 2. Icons representing each actor of the Maracatu group *Leão de Ouro de Condado.*

The application enables the reproduction of the actors and their movements in a two-dimensional format. To achieve this, each *manobra* is described as a vectorial representation of the actors' positions and the speed of their movements. The videos obtained in the field served as the references for correctly programming the movements of participants. The final animation enables a perception of how a *manobra* unfolds in time. Figure 3 displays a sequence of frames extracted from two animations, each representing a different *manobra:* the circular *curupim* and the back and forth change in direction. These two *manobras* are the most commonly performed by the Maracatu group *Leão de Ouro*. A prototype version of both *manobras* has since been uploaded online (https://maracatu.surge.sh/).

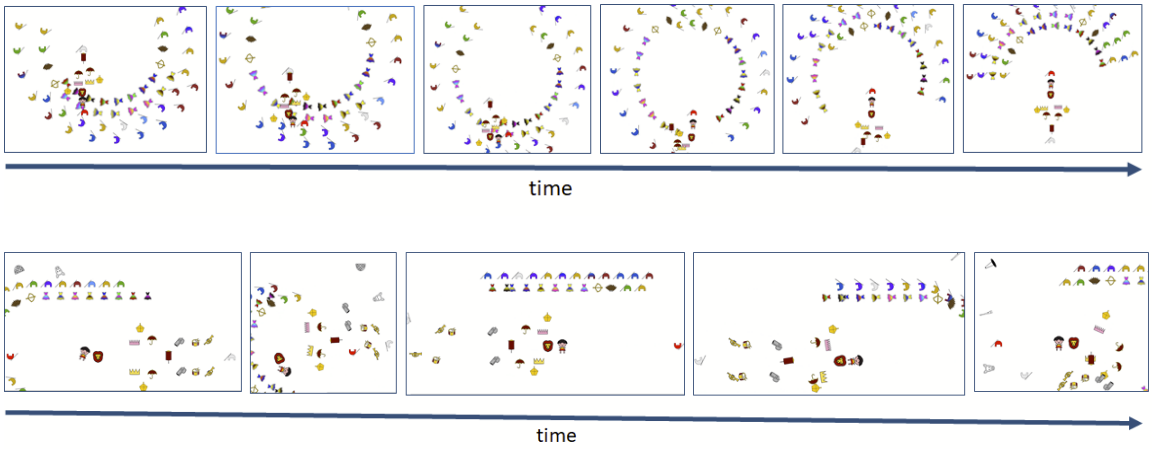

Fig. 3. Frames of the interactive animations of two different *manobras.*

To enable a still better understanding of the two *manobras*, the animation is synchronized with the audio and video captured in the field. Additionally, informative pop-ups about the characters provide basic insights in their roles (Figure 4).

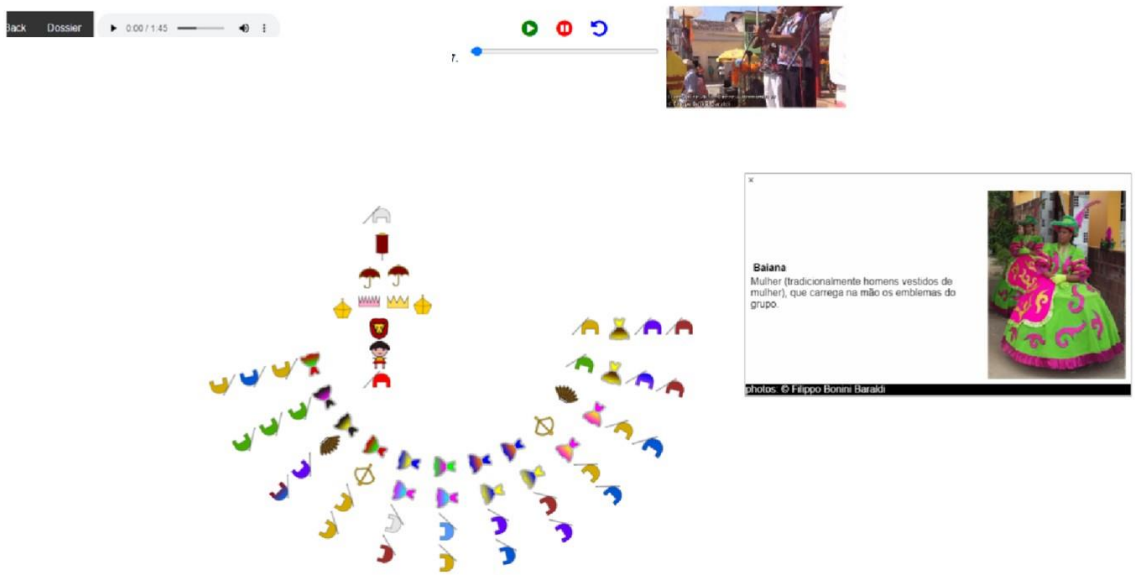

Fig. 4. Video captured in the field (up right) and corresponding animation. On the right, the informative pop-up window on one actor (*baiana*).

CONCLUSION

Interactive animations have proven worthwhile for describing various musical cultures worldwide, notably catering to non-specialist audiences. The French Society of Ethnomusicology website contains a section featuring several of such animations for screening (see https://ethnomusicologie.fr/category/plateforme-multimedia/).

The term "interactive" refers to how users are invited to play active roles, for instance by opening the pop-up windows, operating the multimedia controls or performing other similar actions. In the case of our project, the user is able to click on the icons and open pop-up windows with basic explanations of the different characters involved in Maracatu. Secondly, users can choose to observe the two animations at two

different speeds (standard and accelerated), which favors the understanding of Maracatu collective movements "in the blink of an eye".

The term "animation" reflects how some musical and/or danced processes are made explicit through various visual and audio effects. A musical transcription in which the user can follow a cursor moving along with the notes being played accounts for a simple example of an interactive animation. More elaborate animations, such as the "digital gamelan" (https://pad.philharmoniedeparis.fr/gamelan.aspx), enable the user to follow and understand the researcher's analyses of the rhythmical and melodic structure of a foreign musical culture (in this case, Balinese gamelan) in an intuitive and interactive approach. In our case, users are able to understand the functioning of Maracatu collective *manobras* simply by pressing the play button and observing the icons displayed on the screen.

Interactive animations may also prove useful as a means of supporting field research. Screening the animation with Maracatu performers stimulated a rich debate on just how the *manobras* should be performed, their symbolic meanings, the creative process behind them, etc. Ideally, such an animation would also serve as an inspiration for performers seeking to create new collective choreographies. However, the eventual limitations include the time-consuming aspect of programming such animations as well as the short lifespan of some coding languages.

ACKNOWLEDGEMENTS

This work is supported by Portuguese National Funds through the Foundation for Science and Technology (FCT), within the scope of the projects "The Healing and Emotional Power of Music and Dance" (PTDC/ART-PER/29641/2017, https://www.help-md.eu/) and CEECIND/02148/2021. We would like to thank all members of the Maracatu group *Leão de Ouro* (Condado, Pernambuco), as well as Eduardo Teixeira who programmed the interactive animation in the framework of his final work for his undergraduate degree in Electrical and Computer Engineering at the Polytechnic of Porto.

NOTES

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[2] In the *Zona da Mata Norte,* a region of 3,200 km² dominated by a sugarcane monoculture, there are currently around 130 active Maracatu groups.

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Grammatical Synthesis of Kendang Tunggal: Computer-Aided Ethnography of Improvisatory Balinese Solo Drumming

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INTRODUCTION

Kendang tunggal[2] denotes the Balinese improvisatory solo drumming tradition that mainly accompanies solo dances that are also of an improvisatory nature. In the context of Balinese dance, improvisatory means that a performance is not choreographed down to the last detail with dancers attributed a certain degree of freedom to shape a performance to their liking. When accompanying such a dance, drummers have to fulfill two main obligations: firstly, they need to appropriately respond to the movements of the dancer, and secondly, they lead the other accompanying musicians in the Balinese music ensemble (*gamelan*). As the sequences of movements in such dance performances vary between performances and individual dancers, drummers must be able to spontaneously compose sequences of previously learned drumming patterns in accordance with a dancer's movements when performing while also aligning the played patterns with the music's melody and colotomic structure (Sudirana, 2018, p. 8).

Balinese drummers often compare the improvised rhythmic patterns of *kendang tunggal* to the sentences of spoken language (Sadguna, personal communication, April 2018; Suweca and Surtaya, 2021) in consisting of several independent parts that can be reused and rearranged with different parts of other patterns whether to form variations or invent new patterns. To unravel the fundamental rules of this pattern-based mode of improvisation, I developed a computer program that became my main research tool in collaboratively analyzing the drumming of eight Balinese master drummers.[3]

This abstract describes the methodological approach applied in researching *kendang tunggal*, focusing on the computer program's functionalities and applications in the fieldwork. My research outcomes are therefore omitted.[4]

COMPUTATIONAL APPROACH

My computer program consists of five software tools—recorder, transcriber, analyzer, generator, and synthesizer—which provide the following core functions: recording and transcribing audio files, analyzing transcribed drumming patterns, producing new patterns from those analyzed, and generating audio files from transcriptions.

Recorder & Transcriber

The recording and transcription tool (Figure 1) served to create a corpus of drumming patterns for each drummer participating in my research project. During recording sessions, the recording tool allowed me to provide the drummer with selected, drum-less backing tracks, played on headphones worn by the drummer, while simultaneously recording their drumming with a field recording microphone connected to my computer. Each backing track contains only a single cycle of a composition's core melody and colotomic structure, allowing it to be looped indefinitely. The recording tool is also capable of adjusting a backing track's speed, which was sometimes necessary because of the different aesthetic preferences of the drummers. The preferred speed was always chosen and adjusted before a recording session.

The resulting drum recordings were then notated with the help of the transcription tool capable of converting an audio recording into a character string and applying different symbols to represent the different drum strokes/timbres as well as pauses. The character string generated thus provides a form of pulse notation, with each symbol spanning the same rhythmic duration. My transcription tool is purely sound based, meaning it only incorporates the sounds detected in a recording when generating transcriptions. It correspondingly

builds on the functions provided by the freely available software packages librosa (McFee et al., 2015) and scikit-learn (Pedregosa et al., 2011), given its capacity to classify the different drum strokes/timbres detected in an audio recording whenever first properly trained.

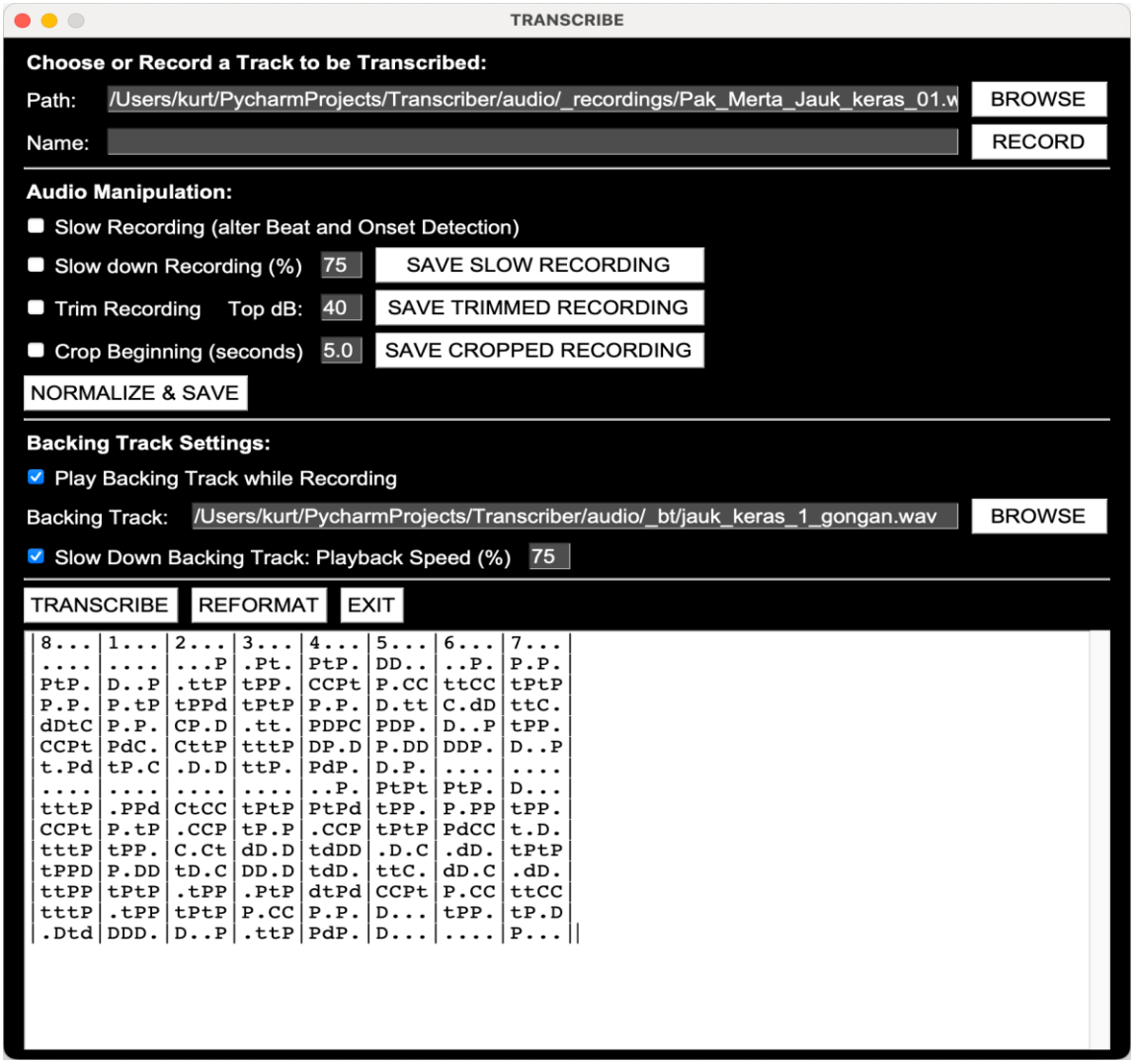

Fig. 1. The recording and transcription tool user interface.

Analyzer, Generator & Synthesizer

To collaboratively analyze the transcribed corpus of the drumming patterns of each drummer recorded, I developed a structural analysis tool (see Figure 2) allowing us to subdivide the *kendang tunggal* drumming patterns into sub-patterns and save this information in my program. Doing so produced a generative grammar of drumming patterns consisting of a dictionary of valid sub-patterns and pattern structures grouped by length and purpose. The sub-patterns obtained effectively depict the fundamental building blocks of this improvisatory drumming tradition while the pattern structures represent blueprint-like rulesets for building complete drumming patterns.

This information is then utilized by the generation tool which is capable of generating every possible pattern based on the previously derived sub-patterns when given one or several pattern structures as a template. This tool also enables the generation of pattern structures whenever the given template instead consists of a combination of several pattern categories.

A manual, rule-based approach to analyzing and generating drumming patterns was favored over a deep learning methodology as the former appeared to be the most appropriate approach to modelling the thought processes of my interlocutors when performing. Deep learning algorithms would not have been suitable for this task because they lack the scope to interpret their behavioral logic, a common criticism of such algorithms (Yin et al., 2023, p. 1791).

As *kendang tunggal* is an oral musical tradition, it was also of the utmost importance that the computer-generated patterns could be played back to my interlocutors so they could rely on their ears when validating the notated patterns. This task is handled by the *kendang tunggal* synthesizer, which can generate audio files from transcriptions that are either exported and saved or directly played back by the program. When generating an audio file, the synthesizer utilizes a collection of high quality *kendang tunggal* samples and backing tracks that have been especially commissioned and recorded for my research project.[5] The program can also adjust the speed and volume of the backing track, over the top of which the computer-generated drumming track is laid down.

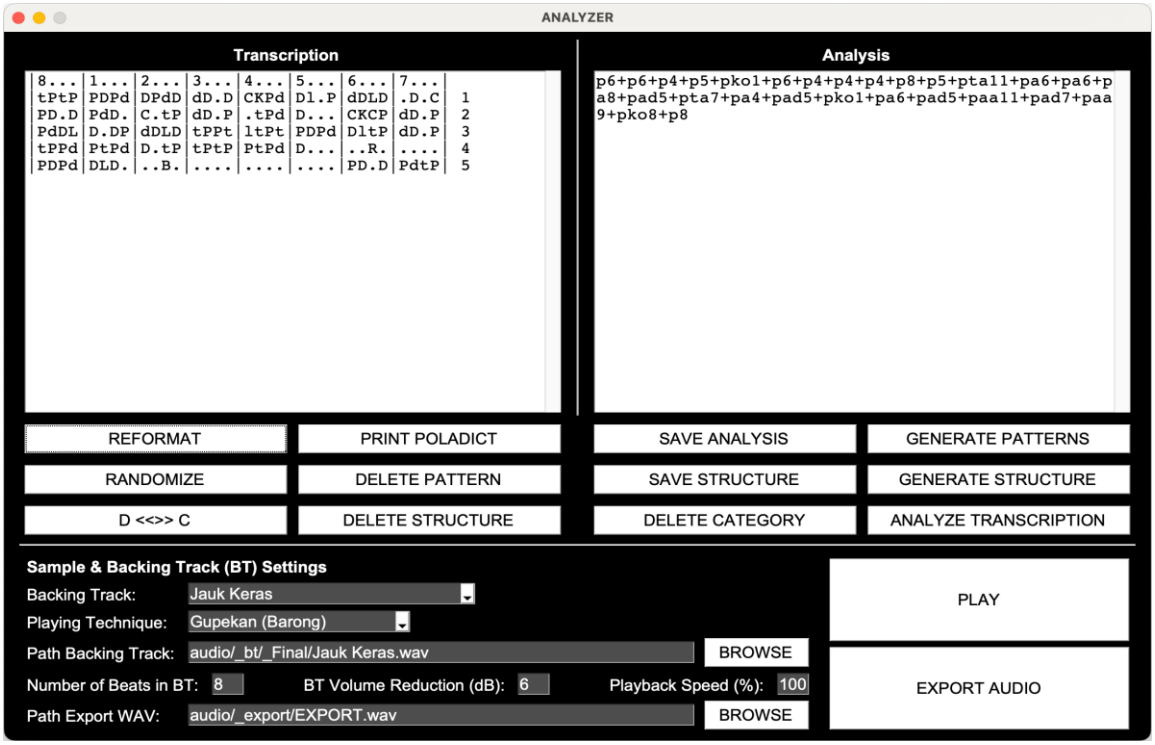

Fig. 2. The analysis, generation, and synthesizer tool user interface.

Research Design

The research for my project was carried out in two stages. In the first, I spent six months in Bali equipped with my recording and transcription tool with the goal of creating a moderately comprehensive corpus of *kendang tunggal* drumming patterns and familiarizing myself with this performance tradition. The knowledge and experience gained in this first stage enabled me to develop the analysis, generation, and synthesizer tool in my program.

Taking inspiration from the studies conducted by Bel and Kippen (1989) and Nierhaus (2015), I applied a recursive research design. Spending another three months in Bali, I revisited the recorded drummers to analyze their previously transcribed patterns alongside them and saving the analysis results in my program. To evaluate these results, I generated new patterns based on previous program analyses and played them back to the corresponding drummer. The drummer then critically evaluated the correctness, playability or likelihood for each of the generated patterns and pointing out mistakes in the analysis. We would then together correct the analysis mistakes and repeat the generation and evaluation steps until the drummer was

satisfied with the computer-generated patterns, leaving me with an algorithmic model of the drummer's pattern creation rules as applied when performing.

To better understand a drummer's thought processes while accompanying a specific dance, I made drum-less video recordings of two dancers[6] performing dances appropriate to my research project and digitally accompanying these video recordings by generating drum patterns with my program under the guidance of the drummers participating in my research project.

CONCLUSION

Conducting computer-aided fieldwork allowed me to gain deep insights into the practice of Balinese joint drum-dance improvisation that is *kendang tunggal* in a relatively short period of time. With my program as the research tool, I was able to converse with expert drummers in musical terms, unraveling the fundamental rules of *kendang-tunggal* drum-pattern creation by collaboratively analyzing the repertoire of my teachers. Through this process, we together explored to what extent patterns tailored to accompanying specific dance movements might be altered without losing their performance meaning or assertiveness. By digitally accompanying dance performances together with my teachers, I gradually came to understand their thought processes in choosing the appropriate pattern to play in specific situations, comprehending that deemed crucial when performing.

Through this collaborative research process, I became familiar with the discourse that surrounds *kendang tunggal* as well as with the myriad of technical terms that differed greatly between my respective teachers. It became clear to me that, when talking about *kendang tunggal*, there is no standardized vocabulary for referring to a single pattern or a sequence of patterns, and that dance and drum terminology overlap significantly. Gaining the opportunity to undertake my research with different expert drummers not only unveiled the high level of individuality in this performance tradition but also the value of developing one's own performing style.

NOTES

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[2] The compound term *kendang tunggal* can be translated as "solo drum." The word *kendang* is an umbrella term referring to various kinds of Indonesian drums while *tunggal* translates as "solo," "single," or "one."

[3] The Balinese artists participating in my research project are I Ketut Cater, I Nyoman Kariasa, I Ketut Keplug, Pande Gde Eka Mardiana (Yande King), I Wayan Merta, I Dewa Putuh Rai, I Wayan Sudirana, and I Wayan Eka Putra Udyana.

[4] For information on the project's research outcomes, please contact the author directly.

[5] The necessary drum samples were recorded by I Wayan Eka Putra Udyana and Pande Gde Eka Mardiana and digitally post-processed by I Wayan Eka Putra Udyana. All backing tracks for my research project were created by I Wayan Eka Putra Udyana.

[6] The dancers participating in my research project are I Made Suteja and I Kadek Pasek.

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Exploring Taksim Improvisation: The Challenges of Analyzing "Free-Rhythm" Music

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Taksim improvisation represents a vital practice within the different traditions connected with Makam music. Despite the literature recognizing its significance, musical analyses of this phenomenon are hindered by its free-rhythm features (the term free-rhythm is applied here as no metric framework seems present in performances). The existing literature suggests this free rhythm characteristic is responsible for the expressive features of these practices and urges study of its rhythmical features.

This paper discusses components of a methodological proposition for analyzing the rhythmical aspects of taksim improvisations. This methodology combines the following features: (a) interviews with musicians; we consulted experts in taksim improvisation to understand how they perceive rhythm in the teaching and performing of free-rhythm taksim. These conversations presented diverse opinions and strategies for teaching taksim, including discussions around the idea of the pulse within taksim and the recognition of musical phrases as generating the fundamental unity of expression. (b) Computational analysis; taksim recordings were segmented into phrases (in accordance with how the musicians understand these phrases). Subsequently, the R script "onsetsync" served to extract measures such as tempo estimates and the phrase periodicity, allowing for precise observation of some of the basic rhythmical features of the taksim style.

By continuing with the methodology proposed, we aim to arrive at a typology of rhythmical procedures that characterize "free rhythm" within taksim improvisations through an approach susceptible to utilisation for the study of other genres of music with similar characteristics.

NOTES

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Synchrony and Solidarity in the Sitting Dances of Aceh, Indonesia

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INTRODUCTION

From traditional origins in coastal Aceh and the Gayo highlands, the sitting dances of Aceh, the westernmost province of Indonesia, have exploded in popularity and acclaim, spreading to schools, universities, embassies, and festival stages across Indonesia and the world (Kartomi, 2006; Ishiguro, 2019). They require intense rhythmic co-ordination between participants, who synchronize singing, body percussion and dance movements. In these dances participants generally kneel close together in a tightly-packed line, executing arm, head and torso movements in sync and producing body percussion by clapping or striking the thighs or chest while singing songs about religious values, relationships, nature and daily life (Kartomi, 2010, p. 90).[2] The dances are said to represent or express cohesiveness, and participants report experiencing heightened feelings of togetherness while performing. This paper presents findings from my ethnographic research with sitting dance participants, in which the embodied experiential knowledge shared by these "dancer-musicians" (Kartomi, 2004, p. 1) is brought to bear on issues which have more often been examined using cognitive sciences methodologies.

BACKGROUND

The displays of unity found in the sitting dances of Aceh are traditionally linked to the famously strong social ties of Acehnese and Gayo society. A key challenge facing Indonesian governments, administering 17,000 islands resident to 300 distinct ethnic groups, lies in maintaining a shared sense of national unity, and regional arts like the sitting dances provide a set of traditions and symbols that political leaders use "to forge national identity and foster a sense of community" (Dahles, 2001, p. 2). The use of these dances to promote Indonesian national identity rests on "exploitation" of the "simultaneous movement" of the group, which the synchronized movement being "a metaphor for Indonesian nationalism itself […] moving in harmony with one another in an effort to achieve a common goal" (O'Sullivan, 2011, p. 55).

In discussion of the different genres of sitting dance, participants in this research often said that they require, express and/or embody *kekompakan*, from the root word *kompak* (borrowed from the Dutch or English "compact"), often translated as "cohesiveness" or "harmony." The derivation of this term follows the same logic as the English word "solidarity;" a spatial term referring to density (solid) turned into a metaphor for social cohesion. Achieving *kekompakan* in performance—keeping movements precisely in time and with the same emotional intention and level of energy—is said to have a mutually reinforcing relationship with feelings of unity experienced by participants. Other local concepts like *gotong-royong* (mutual assistance, see Bowen, 1986) and *silaturahmi* (strengthening ties of friendship, see Seise, 2021) were also said to be important, as were more universal concepts like togetherness (*kebersamaan*), unity (*kesatuan*), uniformity (*keseragaman*), and harmony (*rukun/keselarasan*).

Scholars working in disciplines such as history, psychology, neuroscience, and behavioral biology have identified a pro-social effect of synchronous, i.e., entrained, rhythmic movement (e.g., McNeill, 1995; Hove and Risen, 2009; Trost et al., 2017; and Launay et al., 2016, respectively). A recent meta-review by Mogan et al. (2017, p. 18) found that synchronous movements and vocalizations "increase prosocial behaviors" and "enhance perceived social bonding." Many scholars have posited that entrainment is central to musicking's ability to enhance social bonding (e.g. Freeman, 2000; Tarr et al., 2014; Kim et al., 2019; Grahn et al., 2021). Questions around the precise nature and origins of music's relationship to social bonding have recently attracted increased attention and robust debate in two linked papers by Savage et al. and Mehr et al. published in a special 2021 issue of *Behavioral and Brain Sciences* (Mehr et al., 2021a; Savage et al., 2021a). These authors disagree over whether synchrony between participants is responsible for music's social bonding effects, Savage et al. (2021b, p. 135) arguing that mutual entrainment is "a key mechanism by which

music confers its effects on social bonding," where Mehr et al. (2021b, p. 145) see behavioural synchrony as "a proximate mechanism employed in the service of signaling a bond, but not actually creating it."

While some recent studies have included more "naturalistic" settings of dance and musicking (e.g., von Zimmermann et al., 2018), most of the evidence used to inform the aforementioned debates comes from studies using traditional psychological and cognitive science methodologies with heavily abstracted experimental setups. Clayton (2013, p. 31) argues that ethnographic engagement is needed with settings of "real-life music making" to progress entrainment research. Investigating links between entrainment and cohesion ethnographically can provide richer and more nuanced evidence than more impersonal methods, and Clayton et al. argue that ethnography is necessary to go beyond simple description and allow us to investigate "how entrainment feels" (Clayton et al., 2005, p. 23).

METHODS

I conducted participant-observation with Murtala S. Sn, M Sn and Alfira O'Sullivan's group Suara Indonesia in Sydney, Australia, and recorded 65 conversations involving 91 dancers, teachers, students, choreographers, group leaders, musicians and administrators in Aceh, in Jakarta, and in Sydney and Melbourne, recording participants describing personal experiences of rehearsing, teaching, and performing and gathering insights into the psychological moment of group mutual entrainment. This "multi-site" ethnographic project (Marcus, 1995) investigated a representative sample of the contexts in which the sitting dances are today being performed, across Aceh, elsewhere in Indonesia and in diaspora communities abroad. During these conversations we moved from general questions about the dances, participants' experiences and their motivations for taking part to questions reflecting directly on the relationship between synchrony and cohesion.

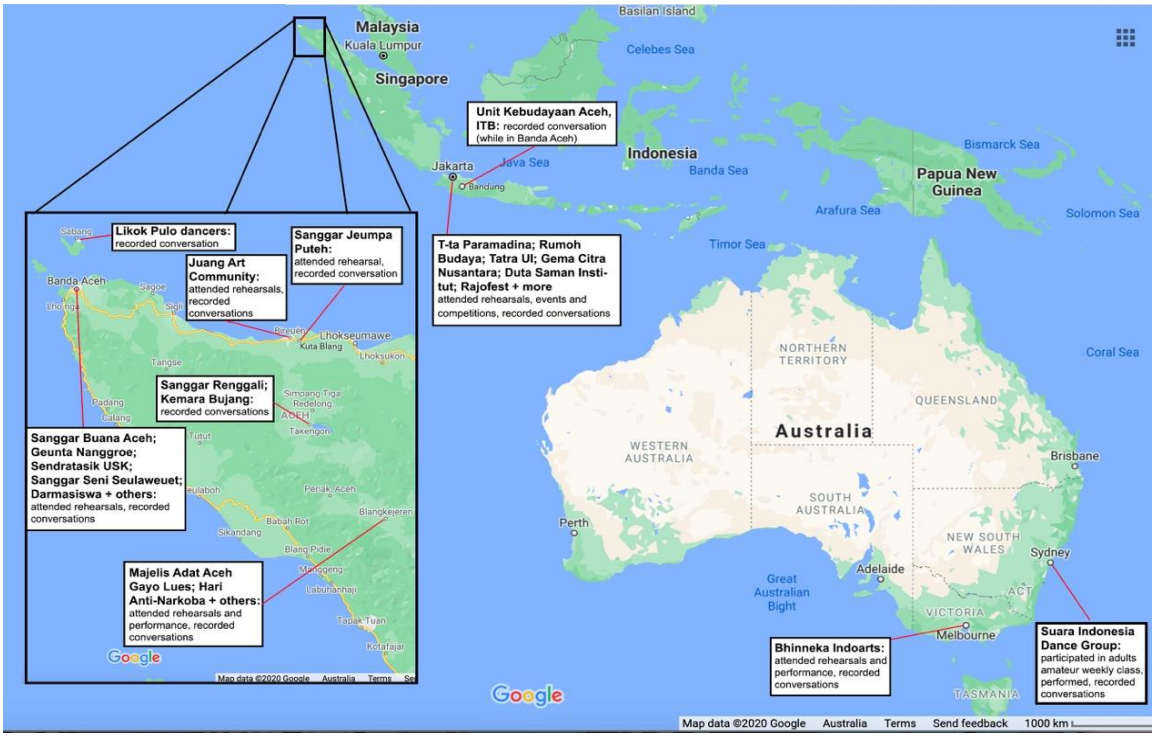

Fig. 1. Map showing the sites where this research took place in 2018–2020, including groups I worked with in each location and the research activities performed.

Analytical methodologies developed in discourse analysis can be helpful to ethnographers (Hammersley, 2005, p. 15), and in this work I used the process known as "coding" where segments of text are sorted into categories and tagged (e.g., see Saldaña, 2013). While such methods allow important local concepts like *kekompakan* to be identified and understood, Agawu (2017, p. 50) cautions that such terms should be discussed as "parts of a larger theoretical effort, not as items in a separatist category," urging "a

cosmopolitan approach that incorporates insights from both local and global theory." This research is informed by music-psychological and other work theorizing a link between entrainment and social bonding, but is grounded in the analysis of such local concepts and relies on the explanatory power of testimony provided by individual participants, acknowledged by name. A small range of examples appear in the following section.[3]

DISCUSSION

Getting closer

One part of my approach was to ask participants directly about conclusions of the studies mentioned in the above section and their applicability to their experience of Acehnese sitting dances. In 49 of the recorded conversations, involving 70 of the individual participants, I asked whether dancing together could make people feel closer to each other, and there was universal agreement. For example, Yusri Saleh aka Dek Gam, the head teacher of Rumoh Budaya in Jakarta, said that dancers "develop friendships" and that his *ratoh jaroe* dance promotes "unity" (*persatuan*) and "harmony" (*kekompakan*). Others, like *didong* dancer Teuku Aga Diwantona of Sanggar Renggali in Takengon, said that dancing together "can make us have stronger relationships" and that dancers "become family," which was also echoed by many others. Imam Juaini, a teacher, choreographer and researcher in Banda Aceh, said that becoming closer is "automatic" when the dancers "join together as one" (*satukan*), and that "one becomes everyone, everyone becomes one."

One body

This image of a group merging together was something Murtala had described to me early on, and it was a common way for sitting dance practitioners to conceptualize the effects of *kekompakan.* Making use of this familiar imagery, in 37 conversations involving 48 individual participants I said that I had heard that "the dancers must move as if they were one body" and asked if this was true, meeting with universal agreement. For example, Alimuddin, a senior Gayo *saman* dancer in Blangkejeren, called this "the essence" (*intinya*) of *saman* dance, and said that if dancers can "be cohesive" (*kompakkan*) outside of the dance then "automatically at the dance they are always in 'harmony together' (*selalu kompak*)." Also responding to this question, Indra Maulana, an Acehnese teacher in Jakarta, said the dance will only be good if there is "one feeling, one soul" among the group, and Jufrizal aka Alex Aceh, also a teacher In Jakarta, agreed, saying that dancers must learn not to have ego or "'the harmony' (*kekompakan*) that they are creating is not going to be there."

Syncing up

Another way I sought to expand on the hypotheses linking synchrony and cohesion above was to ask participants directly about synchronization of movement, and all agreed that it was important in the sitting dances. For example, Maat Sabri Porama, a senior Gayo *saman* dancer in Blangkejeren, said that synchronization was "necessary" and "important," and "we must be as one, in harmony (*kompak*)." Surya Darma, a teacher in Jakarta, said that being synchronized is an "obligatory" part of how they "work together to become a close-knit team," and Jufrizal said that being synchronized is "very important" so the dance "has a togetherness, and is as one." Miranda Anwar, the leader of Bhinneka Indoarts in Melbourne, described the group experience as like an "adrenaline rush" and identified the "synchronicity" of the fast and complex movements as a key driver of a unifying effect, with "everyone having the same brain instead of being different people."

Harmony in movement

Many participants alluded to uniformity of movement and unity of feeling going hand in hand, and some of their responses made this link explicit. When asked how it feels to dance with the group, Natasha Amanda Zulharmen, a student member of Bhinneka, described it as "being in harmony" with the other dancers, and singled out the "beat of the claps" as what made her "closer with everyone." Ronald Firdaus, of Geunta Nanggroe in Banda Aceh, said "the form of the movements, of the rhythms, it represents cohesiveness

(*kekompakan*)" and that this is "the meaning of the philosophy" of the sitting dances, whereas Rilky Trianov of Geunta Nanggroe said that dancers "are attached by feelings of unity; namely being in harmony (*kekompakan*)" due to the "movements in unison." Finally, Fadlan, a teacher with Rumoh Budaya in Jakarta, said that moving together in unison can increase friendships, and that "getting closer with those movements being done in unison… that is what is called being 'in harmony' (*kekompakan*)."

CONCLUSIONS

The sitting dances of Aceh involve unusually complex and demanding rhythmically synchronized, or "entrained," movements and singing that serve as displays of unity and togetherness and encourage such feelings in participants. Testimony of participants in this research indicates that:

- dancers perceive that dancing together can bring sitting dance participants closer to each other and improve their relationships;
- the merging of individuals into a unified group is understood to be an important part of achieving a successful performance;
- synchronization of movement is important in the sitting dances and it is seen to encourage feelings of unity;
- unity of feeling and uniformity of movement are closely connected to each other and to the solidarity represented and encouraged by the sitting dances in the minds of participants.

The subjective experiences of these sitting dance participants, and concepts like *kekompakan* used to conceptualize the effects of such practices, hold relevance for our understanding of a proposed pro-social effect of mutual entrainment in musicking.

ACKNOWLEDGEMENTS

Thank you to all of the participants in this research for their invaluable contributions. Thank you to Murtala S. Sn, M Sn and Alfira O'Sullivan (Suara Indonesia), and to Dr. Ari Palawi (Universitas Syiah Kuala), for facilitating my introduction to many of the participants. Thank you to Arie Riswandy for transcription of the conversations and to Christine Berry for translation. Thank you to the reviewers for their helpful comments.

NOTES

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[2] For an example, view this video of a *saman* dance recorded by the author in Blangkejeren in June 2019: http://catalog.paradisec.org.au/collections/NEF02/items/2019Saman3

[3] All excerpts are from conversations conducted in Indonesian with translations performed by NAATI-certified Indonesian to English translator Christine Berry, except for conversations with Miranda Anwar and Natasha Amanda Zulharmen which were conducted in English.

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Exploring Sonification as a Tool for Folk Music-Dance Interactions

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In this paper we present ongoing work on the sonification of movements by dancers and players in Swedish folk music, with the aim to develop oral music theory tools for artistic and pedagogical purposes.

An advantage of using sonification in the exploration of dance and music interaction is that it places dance movements within the same sensory domain as music - sound. In general, human beings are more accurate in perceiving time differences with auditory than visual stimuli, and the ability to listen to the dance movements can facilitate a more precise understanding of the complex temporal relations between movements and music. Sonifying dance movements extend traditional music and dance practices into an artificially created sonic world. With sounding dance movements, the roles in the interaction of dancers and musicians become entangled, which can allow new ways of artistic expression.

This work aims at sonifying movement patterns in the dance in ways that 1) correspond to the embodied experience of the performers, 2) make the experience of how rhythms and meter interact in dancing and playing more tangible and, 3) allow for artistic explorations of performing with sonifications of dance.

As a first step we explore sonifying motion capture data of dancers and musicians performing together and sonify movements that are relevant to the rhythmic and metrical patterns of the music and dance forms. This initial focus on recorded data facilitates a sound design that involves first-person perspectives. To this end, we invite expert dancers and musicians to contribute to the design process. We sonify using WebaudioXML (Lindetorp and Falkenberg, 2021) to facilitate accessible interactions in this process, through a web interface, and we will present the insights from our ongoing design process. In future extensions we aim to explore using real-time sensors to allow live interactions between sonified dancers and musicians.

NOTES

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Why They Don't Step on Each Other's Toes: Motion Capture Analysis of Backward Tango Steps

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Tango argentino is an improvised couple dance in which one person takes on the role of couple leader with the other being the follower. Both move together building on a learned movement repertoire, both limited so as to allow dancing with any other person also trained in this movement repertoire and yet flexible enough to always create new dance experiences through improvisation.

One of the basic rules of tango movement is that the couple progresses counterclockwise on the dancefloor with the leader walking mostly forwards and the follower backwards. The dancers walk in close proximity and in front of each other because of their close embrace hold, therefore their steps overlap in space; where the follower's foot was just situated, the leader's foot is now headed. For beginner dancers, this is a great challenge to master, and stepping on each other's toes is often enough part of the learning process. For myself, as a tango dancer who has gone through decades of learning, the question is which movement techniques tango dancers deploy to avoid toe collisions while simultaneously making it look so effortless.

RESEARCH APPROACH

This research falls within the scope of a larger project entitled "Tango Danceability of Music in European Perspective," sponsored by the Austrian Science Fund FWF (project V423). The project lasted from 2015-2019 and aimed at exploring the relations between tango music and dance from a transdisciplinary perspective. Data was collected through observing participation, formal and informal interviews, an online survey, and several experiments. To determine the basic principles of *tango argentino* movements, we worked with three professional tango dance couples with each well-known for their distinctive dance styles. Their movements were recorded with an optical motion capture technique and analyzed with MATLAB. We mainly deployed the Mocap Toolbox (version 1.5) by Burger and Toiviainen (2013). An important foundation for exploring the relations between music and movement involved analyzing the tango movement repertoire to further understand the limits and options tango dancers have in their embodied movement system.

MOVEMENT PRINCIPLES IN TANGO

The tango movement repertoire is based on simple concepts. While connecting through a held embrace, the dancers combine steps (forwards, backwards, sideways) and pivots into an almost unlimited number of step-turn combinations. Some of these possible combinations have become standard basics and been labelled with names like "*ocho*" (eight) (see Stepputat, 2021). Though the combinations can be quite complex, they are always assembled out of simple steps and pivots as the locomotive basics. This ensures dancers enjoy a high level of freedom for improvisation while simultaneously enabling embodied communication between the partners based on the joint movement repertoire (see also Kimmel, 2019).

My research was able to demonstrate how a tango forward step is carried out differently to regular walking forward steps. Dancers actively move their free leg into a fast acceleration and slow down towards the floor contact. This contrasts with regular walking where the free leg swings dynamically to minimize the effort expended (see Levine, Richards and Whittle 2012). At the same time, the root speed (the horizontal torso velocity) remains more stable, which is in accordance with the aesthetic tango movement ideal of a gliding, smooth horizontal movement through the dance space. These two short films[2] show a visual impression of tango walking with Yanina Quiñones demonstrating both forward (*adelante*) and backward (*atrás*) tango steps. In the following, I set out how the technique for forward steps and backward steps differs to thereby enable collision-free walking even within the limited space provided within the couple in close embrace, while progressing smoothly forward over the dancefloor.

STEP TECHNIQUE ANALYSIS

Figure 1 below displays the visualization of the motion capture data for backward step gait cycles for the three followers (Yanina, Cristina, Maja) in the top row, and the data for the forward step gait cycles of the respective leaders (Neri, Homer, Marko) in the bottom row.[3] The figures in the top and bottom row vertically align by the smallest ankle distance, which is the point at which a tango step starts (thus, with the feet closed).[4] The grey line and area show the ankle distance throughout one gait cycle with the blue line and area depicting the heel speed. The figure conveys how the heel speed graphs of the three followers are similar in shape. Likewise, the graphs of the three leaders bear strong similarities in shape. However, there is an obvious difference between the graphs of the forward steps (executed by the leaders) and those of the backward steps (by the followers), particularly concerning the moment of maximum acceleration. Followers reach their maximum acceleration at 58, 59 and 61% whereas the leaders attain their maximums considerably later at 85, 86 and 87% of the gait cycle. These differences in acceleration times result from a change in the distance between the leader's and the follower's free foot: Followers accelerate earlier in their steps and slow down later, hence, creating more space between their free foot and the free foot of the leader during the step's swing phase. Towards the end of the step—the next floor contact—the leaders catch up. Through this delayed acceleration, they leave as much spaces as possible, and for as long as possible, to enable the follower to move their free foot away from the very same space where they are about to place their foot.

The motion capture data, here visualized as film in Mokka,[5] show Homer Ladas (leader) and Cristina Ladas (follower) demonstrating tango walking in a couple. The same recording is seen in both films, once with all the markers and once with only the four toe markers. The recording clearly portrays how the distance of the toe markers changes from the smallest distance when the feet are on the floor to the longest distance at around the middle of the swing phase.

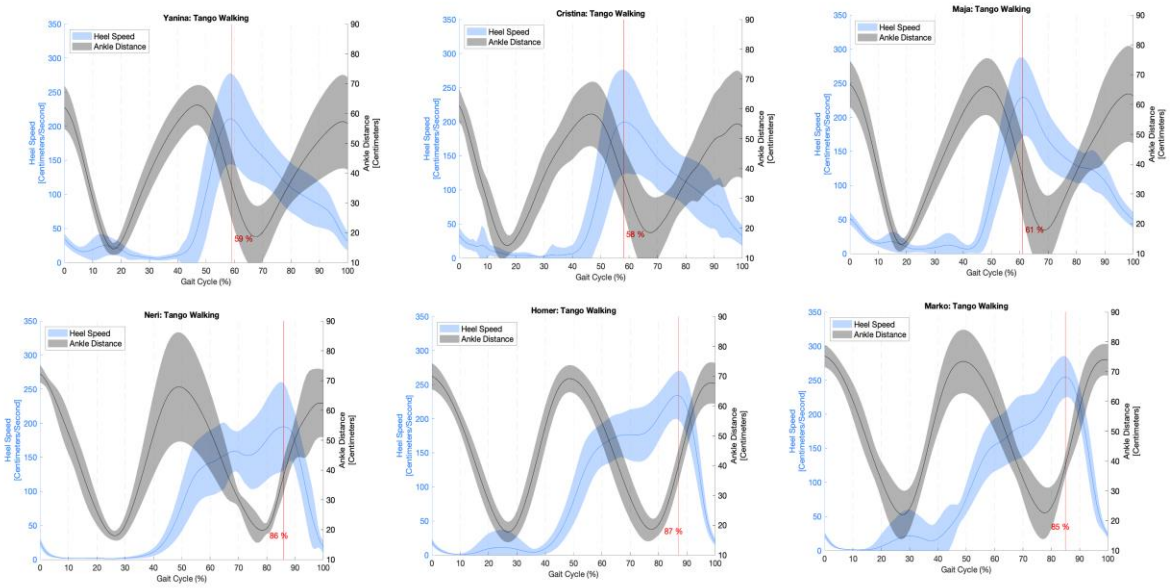

Fig. 1. Graphs detailing the ankle distance (grey) and heel speed (blue) of the backward steps of the three followers (top row) and the front steps of the respective leaders (bottom row). The figures of the leader and corresponding follower are vertically aligned at the smallest ankle distance (beginning of a tango step). The red vertical line indicates the moment of reaching maximum heel speed. All graphs display one gait cycle performed by one leg. Graphic by Kurt Schatz.

CONCLUSION

Tango dancers embody the movement repertoire to the extent that they are able to undertake even simple steps in ways that suit both tango aesthetics and the pragmatic considerations necessary to avoiding collisions while walking in a couple. Hence, the forward and backward steps in tango are carried out in ways that create a maximal distance between the free feet in the swing phase and return to the shortest distance when the feet have floor contact. This difference in distance is achieved by heel speed variation: followers train to accelerate quickly ("get out of the way") while leaders learn to accelerate later ("catching up").

Through my motion capture analysis of the backward and forward step movement technique, I was able to convey how tango walking is not "just walking" but rather a meticulously trained way of walking. For myself as a researcher, understanding the mechanics of tango forward steps and backward steps sheds light on how movement aesthetics and pragmatics in tango overlap. For myself as a tango dancer and dance teacher, understanding how the forward and the backward step complement each other helps to focus on relevant aspects of the technique I practice, thereby enabling better and eventually—while learning and teaching dance—faster access to collision-free tango walking in a couple.

ACKNOWLEDGEMENTS

I would like to thank my primary project collaborators Christopher Dick and Kurt Schatz for their support and valuable contributions throughout. I also highly appreciate the enthusiasm the professional tango dancers Yanina Quiñones, Neri Píliu, Cristina Ladas, Homer Ladas, Maja Petrović and Marko Miljević brought into the motion capture lab. I thank the Austrian Science Fund FWF for funding the project and the University of Music and Performing Arts, Institute for Ethnomusicology and Institute for Electronic Music for providing the necessary infrastructure.

NOTES

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[2] Yanina Quiñones demonstrates forward (*adelante*) (https://phaidra.kug.ac.at/o:121096) and backward (*atrás*) tango steps (https://phaidra.kug.ac.at/o:121097). Both filmed and edited by Neri Píliu, 2021.

[3] The visualized averaged gait cycle of each dancer is based on the detected number of steps from four recordings after having been requested to walk with simple tango steps: Cristina: 9,12,13,11; Maja: 24,41,41,44; Yanina: 6,21,12,24, Homer: 18, 24, 16, 28; Marco: 20, 35, 41, 37; Neri: 1, 5, 2, 4.

[4] Note that the figures of leader and corresponding follower identify how the followers reach the maximum ankle distance shortly after the leaders (approximately 10%). This is caused by the followers' high heeled shoes: even when already in contact with the floor via the balls of their feet, the heel (and thereby the ankle) keeps moving slightly longer.

[5] Excerpt from a recording session in Graz in August 2017. Recording by Christopher Dick, recording visualized in Mokka (https://biomechanical-toolkit.github.io/mokka/), edited by Kendra Stepputat September 2022. All markers: https://phaidra.kug.ac.at/o:129702. Toe markers: https://phaidra.kug.ac.at/o:129703.

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Mugham Singers' (*Khanende*) Vocal Sounds, Voice Health and Wellbeing: Outline of a Research Project in Musician Medicine

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The traditional vocal-instrumental *mugham* of Azerbaijan holds a significant cultural value and is widely regarded as a national treasure. This expressive music, typically performed by a trio, features a *khanende* (*mugham* singer) who improvises on melodic themes while playing the *gaval* (a tambourine-like percussion instrument), accompanied by two instrumentalists: one playing the *tar* (a plucked string instrument), and the other—the *kamancha* (a bowed instrument). "For the Azerbaijani people, *mugham* is music, philosophy and a kind of meditation, which helps to uncover spiritual bases in people, having a healing effect on the soul and mind" (National Commission of the Republic of Azerbaijan for UNESCO, n.d.).

The art of *mugham* singing demands a high level of technical skill and vocal control. *Khanendes* typically commence their performance in the low-pitched range, referred to as the "*bam*," which requires a softer and more contemplative chant-like vocalization. Subsequently, the singers progress to the high-pitched range, known as the "*zil*," wherein they generate a robust and emotionally charged sound (Sultan von Bruseldorff and McCoy, 2014). Azerbaijani *mugham* singers are renowned for their exceptional vocal abilities, which are characterized by powerful and expressive voices that convey a distinct shimmering quality to the music. These vocal abilities are achieved through the utilization of various vocal techniques, such as melismas, bending and stretching notes to create subtle variations in pitch. Another technique commonly employed by *mugham* singers is *zengule,* which involves rapidly alternating between two adjacent notes, creating a trilling effect (Mugham Encyclopedia, n.d.).

Mugham singers face vocal fatigue and wear and tear due to their strenuous training and schedules. This research thus aims to identify healthy vocal practices, understand the *mugham* singing biomechanics, and define the specific *vocal modes* deployed in Azerbaijani vocal-instrumental *mugham*. "Vocal modes" are distinct physiological configurations that involve positioning the larynx and surrounding muscles in different ways in order to shape the color and acoustic effects of the voice (Brixen et al., 2012).

To address these challenges, otolaryngologists, phoniatricians, acoustic specialists, and the author collaborated to create *mugham*-specific vocal rehabilitation techniques and establish a Voice Research Scientific Laboratory at the Azerbaijan National Conservatory.

This joint effort emphasizes the importance of recognizing the symptoms of functional voice disorders and taking care of the voice, and the entire vocal mechanism to maintain good vocal health and prevent voice-related issues. This approach is first applied to the musical science of Azerbaijan as part of an ongoing multidisciplinary doctoral dissertation entitled "Research of acoustic and physiological properties of the vocal apparatus of Azerbaijani *mugham* performers (*khanendes*)."

METHODS

Physiological Research: Magnetic Resonance Imaging (MRI)

As part of her doctoral research in 2019, the author, accompanied by two professional mugham singers—Mansum Ibrahimov and Sedef Budagova—traveled to the University Medical Center Freiburg, Germany. The objective was to investigate the vocal apparatus physiology of Azerbaijani *khanendes* utilizing real-time Magnetic Resonance Imaging (MRI). The MRI procedures were carried out under the guidance of medical experts from Germany, including Jurgen Hennig, the Scientific Director of the Department of Diagnostic Radiology, along with Maxim Zaitsev and Martin Büchert.

The *mugham* singers had to perform seven sections of the *Bayaty-Shiraz mugham* and five sections of the *Mahur-Hindi mugham* in a closed MRI pressure chamber while lying prone (Figure 1). The singers performed *mugham* in 2-minute intervals to stabilize their working larynx. Headphones served to convey the initial tones of each musical piece every 2 minutes. This setup created unique challenges for the singers, considering the confined space and the presence of the MRI machine noise. However, despite these

unconventional conditions, the singers were still able to utilize traditional vocal techniques and preserve the tonal purity of the sound.

Fig. 1. Radiologists in Freiburg, Germany preparing the Azerbaijani *mugham* singer Mansum Ibrahimov to record his vocal tract while singing using real-time MRI technology (2019).

The captured real-time MRI images were overlaid with synchronized audio recordings by specialists at the same Department of Diagnostic Radiology in Germany. The purpose of this fusion was to create a comprehensive representation of the vocal process by linking the MRI based visual data with the corresponding sound produced during vocalization. As a result, seven MRI videos of the *Bayaty-Shiraz mugham* and five MRI videos of the *Mahur-Hindi mugham* underwent a quantitative evaluation by the author upon returning to Baku, Azerbaijan. Nevertheless, within the confines of this scholarly article, the third MRI video out of the seven, capturing the rendition of the *Bayaty-Shiraz mugham* by Mansum Ibrahimov, is presented as an example. The analysis took place with the assistance of radiologist Farkhad Garayev from Azerbaijan. Using *Medixant RadiAnt DICOM Viewer*, this process focused on specific footage to measure lip opening, pharynx width, and larynx position during singing of the *mugham* (Figure 2).

Physiological Research: High-Speed Video Endoscopy and Fiberoptic High-Speed Video Nasolaryngoscopy

Besides real-time MRI, the singers underwent high-speed video endoscopy and fiberoptic nasolaryngoscopy guided by Bernhard Richter, Director of the Freiburg Institute for Musicians' Medicine, and phoniatrician Fakhriya Asadova from Azerbaijan (Figure 3).

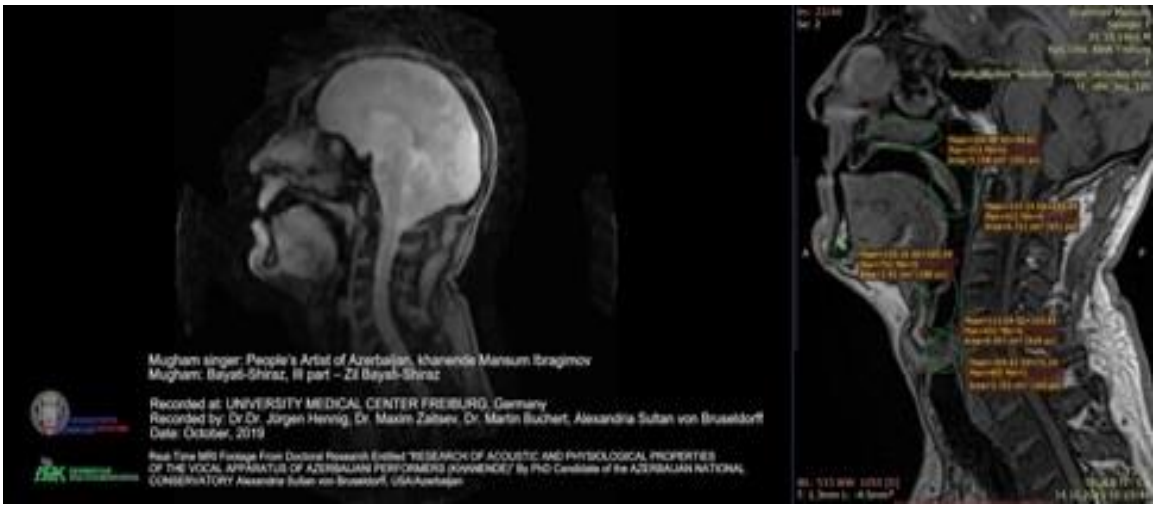

Fig. 2. Real-time recorded MRI image of *khanende* Mansum Ibrahimov singing the *Bayaty-Shiraz mugham* produced in Germany, 2019 (left), and the process of measuring the lip opening, the width of the pharynx, and the position of the larynx using *Medixant. RadiAnt DICOM Viewer [Software] Version 2021.1.* produced in Azerbaijan, 2020 (right).

Fig. 3. *Khanende* Mansum Ibrahimov singing *Bayaty-Shiraz mugham* while undergoing fiberoptic high-speed video nasolaryngoscopy (upper left) and the image of the back of his throat, including his voice box (larynx) and vocal cords in the process (lower left). *Khanende* Alim Qasimov vocalizing *Rast mugham* while undergoing high-speed video endoscopy (upper right) and the image of the back of his throat, including his voice box (larynx) and vocal cords in the process (lower right).

Acoustic Research

Audio recordings were produced at the International Mugham Center of Azerbaijan in a soundproof studio with a calibrated NEUMANN U87 Ai omnidirectional microphone at 48000Hz. The microphone was positioned 25 cm from the lips, 3 cm below the chin, at a 0º angle. Long-term average spectrum (LTAS) analysis was deployed to examine the energy distribution across frequency spectrums and the presence or absence of a *singer's formant*— "a prominent spectrum envelope peak near 3 kHz, typically found in singing voices of classical operatic singers. It is mainly a resonatory phenomenon produced by clustering of formants 3, 4, and 5" (Sundberg, 2001, p. 176).

These recordings were then converted to 16000 Hz WAV files and analyzed with *Sopran* software, applying its *Spectrum, Spectrogram*, and *Oscillogram* subroutines. The author then transferred the data obtained from the analysis to an Excel sheet before superimposing the resulting curves (Figure 4) to determine the differences and similarities in the patterns.

The vocal profiles of opera singers and accomplished *mugham* singers revealed discernible clustering within the 3rd, 4th, and 5th formant frequencies, thereby substantiating the existence of a singer's formant. However, certain *mugham* singers were found to lack singer's formant. Audibly, the timbral quality exhibited a heightened degree of mellowness and expansiveness, akin to the sonorous attributes characteristic of operatic renditions, concomitant with an anatomically elevated laryngeal position.

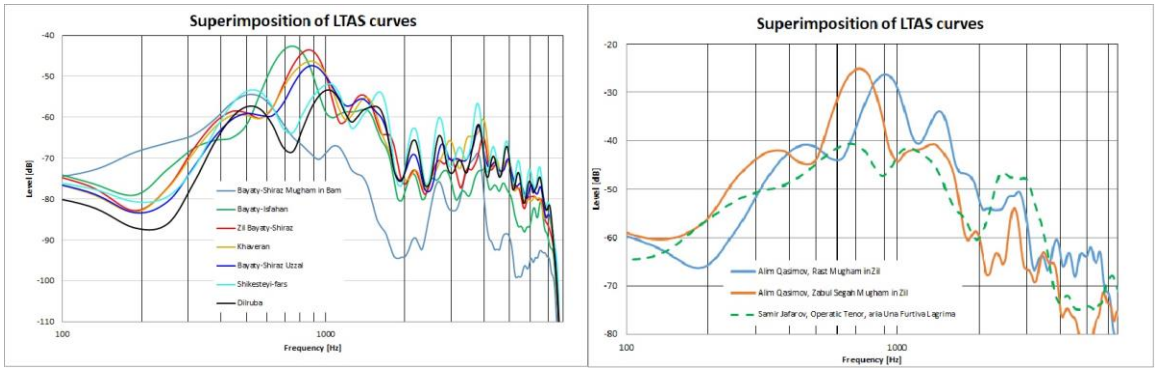

Fig. 4. Left: Superimposition of LTAS curves from various segments of Azerbaijani *khanende* Mansum Ibrahimov's rendition of the *Bayaty-Shiraz mugham*, illustrating shared energy distribution patterns and the presence/absence of singer's formant. Right: Superimposition of LTAS curves of the *Rast* and *Zabul Segahi mughams* performed by *khanende* Alim Qasimov, and aria *Una Furtiva Lagrima* sung by operatic tenor Samir Jafarov, illustrating shared energy distribution patterns and the presence/absence of singer's formant.

FINDINGS

During *mugham* performances, professional *khanendes* start in the low-pitched *bam* range using the chest register with the thyroarytenoid (TA) muscle. As they ascend into the head voice range, they decide whether to continue with the TA dominant approach or transition to male falsetto using the cricothyroid (CT) muscle or to combine both registers (TA and CT muscles). Unlike typical vocal transitions, *khanendes* maintain a chest-dominant vocal production in the powerful climax of the *zil* portion, deploying a TA dominant muscle position even in the high range with an extremely high larynx position.

High-speed video endoscopy and flexible fiberoptic nasopharyngolaryngoscopy revealed vocal tract changes. In the low *bam* range, slight pharynx constriction and vocal fold shortening enhanced chest resonance, creating a "speech-like" quality. Transitioning to the head voice, the vocal folds stretched and stiffened. In the high *zil* range and *zengule* technique, *khanendes* exerted maximum muscular effort in the head and neck for heightened emotions, involving intense constriction of vocal muscles, including the ventricular folds. The *zengule* technique featured unique vocal fold adjustments, applying partial falsetto for specific notes.

Excessive and sustained usage of maximal muscular effort to convey emotional lyrics can ultimately result in detrimental effects to vocal health, including issues such as hoarseness, throat discomfort, vocal cord nodules, and irreversible loss of vocal range and timbre. Professional *khanendes* prioritize appropriate singing

techniques, proficient breath management, and seamless transitions in their artistic presentations. In contrast, young *khanendes* often run the risk of vocal strain.

CONCLUSION

Based on the results obtained from physiological and acoustic research, the author aims to produce a tailored guidebook for aspiring *mugham* singers, allowing them to gain comprehensive knowledge encompassing the anatomical, physiological, and acoustic intricacies inherent to their vocal capacities. By understanding how the voice works at a physical level and how it produces sound, singers and vocal professionals can make informed decisions about their vocal techniques and habits, encompassing aspects such as muscular engagement and respiratory practices.

The establishment of the Voice Research Scientific Laboratory within the Azerbaijan National Conservatory was prompted by the aforementioned circumstances and now promotes voice health, vocal hygiene, and well-being for *mugham* singers. The laboratory's advanced facilities and experienced staff play a crucial role in raising awareness about vocal health and providing singers with access to medical expertise and tailored training programs.

Through lectures and seminars (Figure 5), the laboratory has disseminated essential knowledge about vocal health to a wider audience, leading to the development of new techniques and practices to safeguard the vocal well-being of *khanendes*.

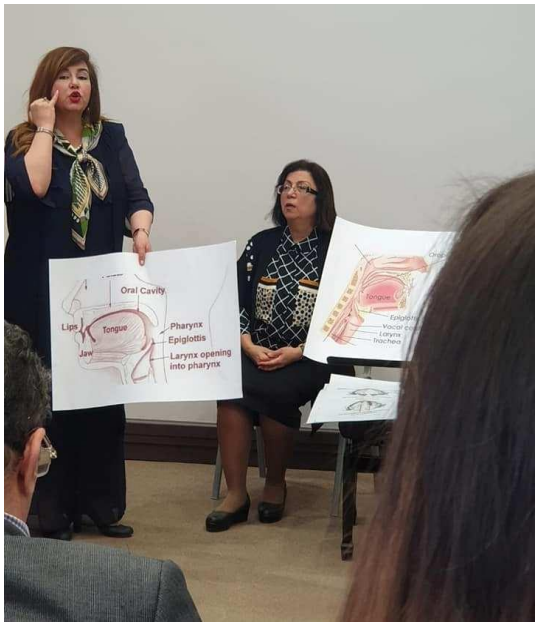

Fig. 5. A seminar given by the author at the Azerbaijan National Conservatory in 2022 based on research findings that focus on the *vocal mode*, voice health, vocal hygiene, and well-being of Azerbaijani *mugham* singers (*khanendes*).

ETHICAL CONSIDERATIONS

This study prioritized collaboration and ethical principles, with official approval from the Vice-Rector of the Azerbaijan National Conservatory. Participants were fully informed about the study, their rights, and willingly provided written consent. They had the freedom to withdraw at any point. Participant identities were disclosed with explicit consent for transparency. The invasive procedures involved a separate consent process, ensuring the complete understanding of what to anticipate during the procedures. These invasive procedures were undertaken by qualified medical professionals within medical facilities, with participants fully informed about the procedural details and any potential discomfort.

ACKNOWLEDGEMENTS

I extend my sincere thanks to all the erudite scholars and singers who contributed to this research.

NOTES

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The VocalNotes Project: Investigating (Dis)agreement Among Expert Transcribers in Different Cultures

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It has been argued that our vocal musical production is less precise than that of our instruments (Pfordresher et al., 2010, 2017; Hutchins et al., 2012). Whereas a f0 visualization of an instrumental performance usually consists of well-defined segments, the curve is quite difficult to segment for vocal performances due to voice characteristics, such as vibrato, glides, embellishments (Mauch et al., 2014).

How then do we make sense of vocal performances? How do we perceptually segment a vocal audio stream into the discrete units we call notes? How do we assign them to categories such as pitch classes?

This project started out from a pilot study of traditional Russian vocal music and then extended to four other teams led by ethnomusicologists studying the Chinese, Japanese, Jewish, and Alpine yodel traditions. We examine the disagreements between expert transcribers as the consequences of perceptual differences. The experts independently segment real-life recordings of vocal performances in accordance with the Tony software (Mauch et al., 2015), which neither constrains the note pitches to equal temperaments nor does the software force the note onsets into a metrical structure. Figure 1 reports the typical differences occurring during the segmentation phase.

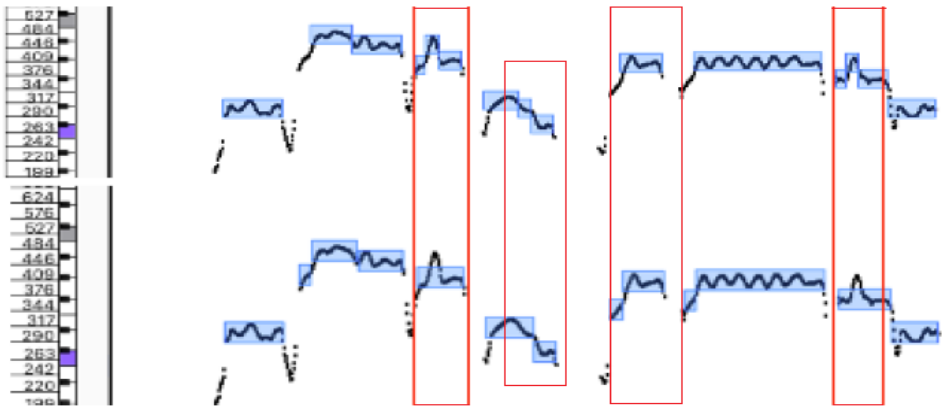

Fig. 1: An excerpt from two independent transcriptions in the Tony format.

The first phase of the VocalNotes project consists of both independent expert transcriptions within the teams and cross-cultural analysis of the musical contexts of the disagreements. The second phase investigates how expertise in a culture affects transcription. In the third phase, we aim to estimate variability in human transcriptions, as compared with the automated methods of music notation developed in Ozaki et al. (2021) and Holzapfel et al. (2021). The next step involves the annotation of the descriptive scales in vocal performances (McBride and Tlusty 2021). The dataset including the audio fragments and annotations produced by the project will be published for replication and for follow-up and new research.

NOTES

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[2] During 2021-22, Polina Proutskova and Olga Velichkina have made several communications about the project at conferences, including: Singing Voice and Artificial Intelligence Forum (January 2021), Joint International Conference for Music Perception and Cognition/European Society for the Cognitive Sciences of Music (ICMPC 2021), Third Symposium of the ICTM Study Group on Music and Dance of the Slavic World.

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The Spread of Steelpans Layouts: A Comprehensive Study of Ergonomic Choices

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A remarkable aspect of the naturalistic and cognitive paradigm in anthropology is probably its potential for producing a causal understanding of the culture rather than taking the culture as explanation (Atran, 2003, p. 137). Beyond accessing local mental representations, anthropology can, through a cognitive and naturalistic approach, allow for the building of explanations of the observations made (Sperber, 1996; Boyer, 2001; Atran, 2004; Morin, 2011).

In ethnomusicology, such an approach can be fruitfully applied to studying performance. Trinidad and Tobago steelbands, for instance, have been well studied in terms of their social and political history (Stuempfle, 1995; Dudley, 2008). However, their very rapid spread—they now exist in around 50 countries since their invention in the 1940s—needs systematic analysis. I have demonstrated how their organological particularities generate advantages for the memories of players (Helmlinger, 2012), and probably explains their success.

Nevertheless, this spread also raises other co-related questions: which steelpans (struck idiophones), the melodic instruments in steelbands, are adopted? One of the most interesting aspects of steelpans is their very original and rich ergonomy: they are an entire family of instruments, and only partially standardized. Acoustical constraints (small intervals like semitones are placed apart while larger intervals, such as fifths and octaves, are located in close vicinity), combined with the concave shape of the playing surfaces and the number of oil drums used for each instrument (from 1 to 12), ensures a large variety of very original note layout settings. They therefore create a variety of "public representations" of the musical scale on 2 to 3 dimensional patterns.

The "Pan-e-Pedia" project produced a large-scale study of the spread of the steelpan with the objective of adapting a phylogenetic approach to organology: a database of vectorial images of the layouts to enable systematic comparisons of the interval settings in order to better understand the choices in terms of musical ergonomy in steelbands.

NOTES

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Machine-Musician Co-improvisation: A *Djazz* Incursion into Flamenco

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INTRODUCTION

Flamenco is a traditional music and dance practice originating in Andalusia, Spain (Bermúdez and Pérez, 2009; Cuellar-Moreno, 2016). It combines singing, guitar playing, dancing and rhythmic handclapping. While flamenco music is highly codified and structured (Flores, 2008; Foggo, 2021), this structure nevertheless includes many improvisational elements and variations (Baena-Chicón et al., 2023; Flores, 2008). The AI Djazz software (Nika et al., 2016)—originally designed to generate improvised jazz music—has previously been adapted to traditional Madagascan music (Chemillier, 2018). The questions raised in those experiments arise from whether Djazz is able to provide "acceptable" pieces in a given musical idiom, and whether musicians can co-improvise and co-create new musical patterns under the influence of Djazz. This study represents the first attempt to apply Djazz to the flamenco style.

Flamenco is composed of a number of musical forms, or "*palos*" (Bermúdez & Pérez, 2009), which are classified according to their melodic and rhythmic patterns as described in the literature (Guastavino et al., 2009; Gómez and Bonada, 2013; Toussaint, 2019). One key feature of flamenco is the "*remate*," which serves to close a piece of music. All musicians (including dancers) play in ways that increase the tension, which is then resolved, before the end, in a moment of great tension release. The typical *remate* signature incorporates an increased number of beats per pulsation, which indicates resolution.

In the present study, we focus on the ability of Djazz both to reproduce the *palos*, and to respect the *remate* signature.

METHODOLOGY

During concerts with Djazz, there are typically one or more musicians playing with an operator directing the computer in real time. What a musician plays is captured in real time by Djazz, and then the software can improvise with these data by recombining various motives. As musicians are not always available, recordings may instead be used as a database. Audio and tempo are delivered to Djazz through a DAW and a virtual microphone. Subsequently, improvisations are calculated according to different parameters. Here, we set out examples of the influence of the "grid." The "grid" represents a sequence of symbols capable of constraining the recombination process (see Nika et al., 2016) for further explanation.

RESULTS

Djazz tests with pre-recorded sources: *Palmas por bulerías*

The data are sourced from an audio file of *palmas* (hand clapping) *for bulerías* to carry out rhythmic tests. This contains 8 measures of 12 beats (1-2-**3**-4-5-**6**-7-**8**-9-**10**-11-**12**), the *palo* of *bulería* consisting of 12 beats with the accent on the 3, 6, 8 10, 12 beats (2-ternary and 3 binary). The *palmero* (*palmas* player) was asked to perform "standard*"* *palmas* before providing some variations. Fig. 1a displays the results of statistically analyzing the *palmero's* production. We may recognize strong beats at times 12 and 3 and an increase in the beat number (occurrence of upbeats) between beats 8 and 10, the signature of the "*bulerías remate.*"

On this basis, Djazz performed improvisations. Several grids were compared, i) the "free" grid (no constraints), ii) the "*abcdefabcdef*" grid where the measure is divided into two equivalent parts of 6 beats, and iii) the *abcabcdedefg*, which considers the entire measure and respects a 2-ternary and 3-binary scheme. This grid also indicates that the first 6 beats (2-ternary) share nothing in common with the next 6 (3-binary) while respecting the difference between the 3 parts of the ternary block and the 2 parts of the binary block. Moreover, the last binary block is differentiated from the others and therefore becomes less easily substitutable than the others.

The statistical analysis of the occurrence and intensity of beats was applied to the Djazz productions and compared to the reference (the *palmero* performance). Figure 1 provides some of the results. In the absence of any constraint (free grid), the *bulería's* signature is lost. The *abcdef* grid attains some improvements as regards the free grid: the most important strong beats 12, 3 are marked by Djazz. However, beats 1 and 2 are also enhanced, and this introduces confusion to the pattern, and again, losing recognition of the *bulerías*. The *abcabcdedefg* grid returns the most satisfying results with the conservation of the most important features, and the occurrence of variations that make the pattern understandable but not overly similar to the reference.

Musicians-Djazz interaction

We then carried out an experiment with three musicians, one guitarist (www.cristobal-corbel.com), one singer (https://www.garciaalberto.com/) and one dancer (https://www.flamencoenfrance.fr/professeurs/sophia-sena). We chose to focus on the binary *palo* "tangos." Without any preliminary testing, we adapted the conclusions of the *bulerías* study to tango, hence, we deployed the *abcdabce* grid which, as in the *bulerías*, identified the *remate*. We performed three types of tests: improvisation with guitar, singing and dance.

We received the following feedback from the musicians: the Djazz productions are not acceptable for the song. There is a total loss of coherence. In the case of the guitar, the result is more audible but, at particular points, the melodic purpose is broken by either transitions or conclusive parts for which no musical logic is understandable. As for the dance (*zapateados*), they are the most acceptable (because there is less melodic pattern) although the occurrence of "strange beats" might appear as interesting proposals. The guitarist could improvise above and with the Djazz proposed feet.

However, according to these musicians, the main drawback to Djazz stem from how, even when susceptible to accompanying by guitar or feet, there remains a lack of musical intention and purpose that would turn it into "true music" and "go somewhere."

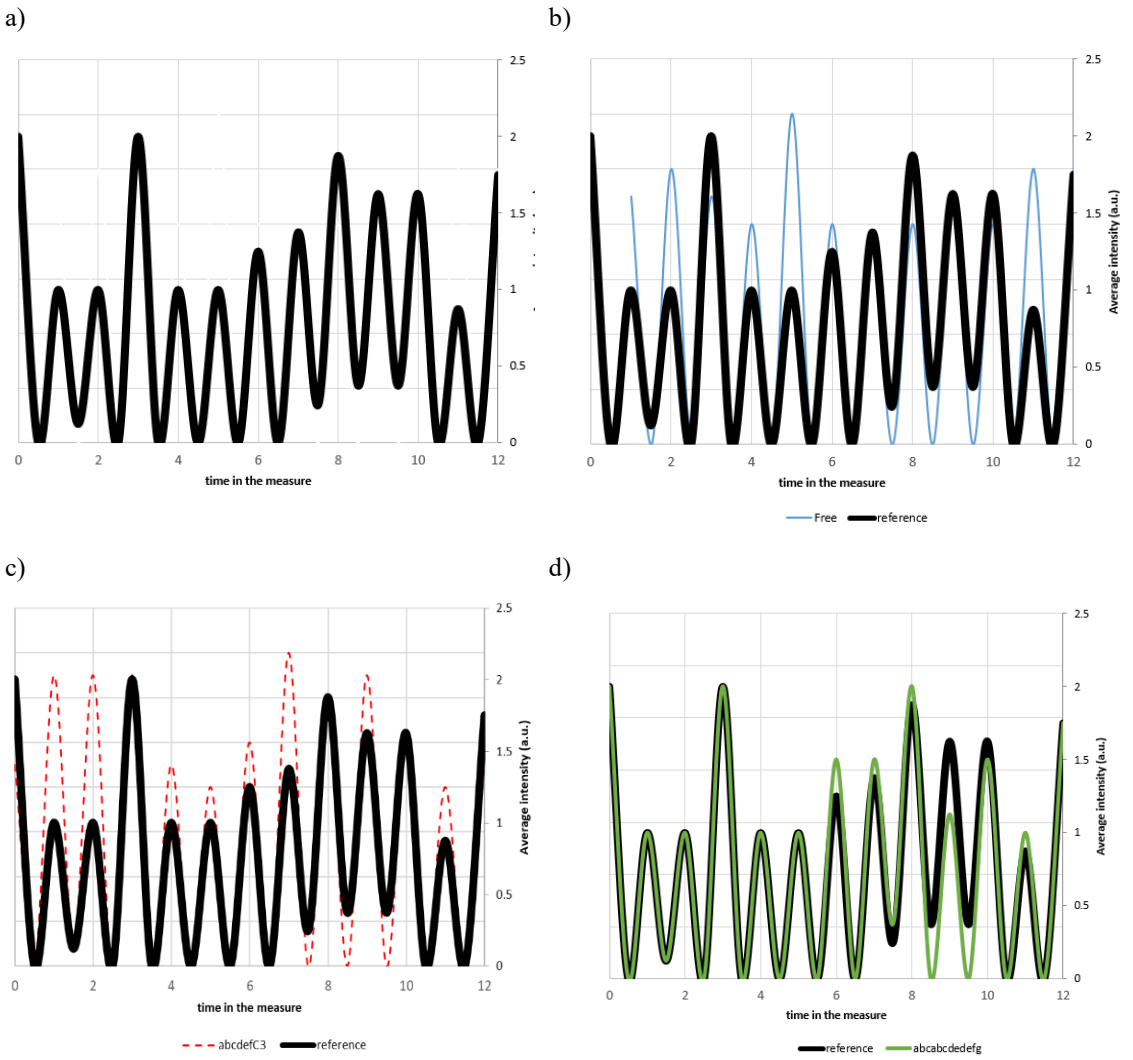

Fig. 1. Statistical analysis (average beat intensity in the measure of 12 pulsations) of the *palmas por bulerías*. a) Original *palmas* performed by the *palmero*; b-d) Djazz production and comparison with the original (reference) piece: b) "free" grid (no constraints); c) "*abcdef*" grid: measure divided into two equivalent 6-beat parts; d) *abcabcdedefg* grid which respects the 2-ternary and 3-binary scheme.

CONCLUSIONS AND PERSPECTIVES

Thus, we were able to produce improvisations that respect the rhythmic pattern and the strongest beats of *bulerías* and *tangos*, the two main flamenco *palos*. In the future we aim to improve those aspects of Djazz that are less satisfactory at present, for example, the melody and anticipation of the *remate*.

ACKNOWLEDGEMENTS

This research is supported by an ERC REACH action supported by the European Research Council under the Horizon 2020 program (Grant 883313), and by Agence Nationale de la Recherche (ANR) project MERCI (Grant ANR-19-CE33-0010). This furthermore acknowledges financial support from "L'OiseauRoc Flamenco." We would especially thank the artists for their participation and advice. The Djazz productions available on request at flamencoloiseauroc@gmail.com

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Some Recently Developed Open-Source Tools for 3d Motion Tracking from Video

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Over recent years there has been significant progress in tools available for human pose motion tracking from video, based on free and open-source frameworks such as OpenPose and MediaPipe. Following this, tools for combining pose tracking data from two or more camera angles have been developed, including FreeMoCap a project led by human movement researcher, Jon Matthis (see: https://github.com/jonmatthis). In this open session I will demonstrate some of these open-source tools, and discuss their application in the analysis of co-musicking body movement.

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