12-14 2013 SEPTEMBER

Casa Paganini - InfoMus
Genova (Italy)

SysMus13

Sixth International Conference of Students of Systematic Musicology

PROCEEDINGS

Edited by

Donald Glowinski
Giacomo Lepri
Andrea Pedrina

SysMus13

Sixth International Conference of Students of Systematic Musicology

Genoa, Italy September 12-14, 2013

Proceedings

Edited by Donald Glowinski, Giacomo Lepri and Andrea Pedrina

Donald Glowinski, Giacomo Lepri and Andrea Pedrina (editors)
Sixth International Conference of Students of Systematic Musicology (SysMus13): Proceedings
Cover design: Andrea Pedrina
Publisher: Casa Paganini-InfoMus Research Centre, DIBRIS-University of Genoa, Italy
ISBN: 978-88-909096-1-0 Copyright 2014 by the editors

The enaction of conduction: conducted improvisation as situated cognition

Gabriele Marino and Vincenzo Santarcangelo

University of Turin, Italy

Nonverbal communication of emotion through sound and gesture: A preliminary performative testing

Tobias Neuhold

Department of Musicology, University of Graz, Austria

Analysis of Jaques-Dalcroze compositions

Elisabetta Piras

Independent scholar, Italy

Evaluation of individual contributions in a group estimate of the position of a moving point of common interest

Davide Punta, Giulio Puri, Fabio Tollini, Giorgio Gnecco, Marcello Sanguineti and Antonio Camurri

Department of Informatics, Bioengineering, Robotics and Systems Engineering (DIBRIS), University of Genoa, Italy

Perception of Pitch Organisation in Equitone Music: Implications for Psychology and Ethnomusicology

Barry Ross and Sarah Knight

Centre for Music and Science, University of Cambridge, United Kingdom

Pictorial structure of M.K. Čiurlionis's aphoristic piano compositions

Paweł Siechowicz

College of Inter-Faculty Individual Studies in the Humanities, University of Warsaw, Poland

Perceiving rhythm complexity under different body movements: Can people tell the difference between each rhythm?

Li-Ching Wang

Centre for Music and Science, Faculty of Music, University of Cambridge, UK

Introduction

It is our pleasure to introduce the proceedings of the Sixth International Conference of Students of Systematic Musicology (SysMus13) that took place in the Fall of 2013 at Casa Paganini, University of Genoa, Italy.

Contribution to the proceedings are voluntary and we offered authors the possibility to introduce their study with either an initial abstract with a more extensive introduction reviewing or, alternatively, participants could briefly discuss their background, aims and methods before presenting an extensive report of their research.

These proceedings give another nice illustration of the variety and quality of the disciplines gathered in the systematic musicology, from disciplins ranging from psychology, performance studies, engineering, and musicology.

We wish you an excellent reading.

Donald Glowinski, Giacomo Lepri and Andrea Pedrina, co-editors

The enaction of Conduction
Conducted improvisation as situated cognition

Gabriele Marino
Doctoral School in Humanities, University of Turin, Italy
gaber.en_at_libero.it - http://gabrielemarino.it/

Vincenzo Santarcangelo
LabOnt-Laboratory for Ontology, University of Turin, Italy
vincenzosantarcangelo_at_yahoo.it - http://labont.it/people/vincenzo-santarcangelo

In: Glowinski, D., Lepri, G., & Pedrina, A. (Eds.)
Proceedings of the Sixth International Conference of Students of Systematic Musicology (SysMus13)
Genoa, Italy, 12-14 September 2013, http://www.infomus.org/Events/SysMus13/index.php

Background. Enactivism represents a paradigm shift in the field of cognitive science; it is a multidisciplinary set of studies gathered under the name of "embodied cognition", focusing on the hypothesis that mind is not an isolated system coinciding with the brain, but a complex object that must be investigated in its essential relations with the body and the environment which the organism is *situated* in (Gibson, 1979; Varela, Thompson, et al., 1991; Clark & Chalmers, 1998; Santarcangelo, forthcoming). Noë's work, in particular (2004, 2009, 2012), proposes a dynamic model of interaction wherein perception is intrinsically connected to the explorative activities exercised by the body in motion. Noë and Gallagher's notion of "body schema" (Cole & Gallagher, 1995; Noë, 2004; Gallagher, 2005) does nothing but confirm the obvious; it is not necessary to pay attention to one's body parts, in order to use them efficiently. Likewise, a performance would be negatively affected if an expert performing a practical activity focused his attention on the mechanic of the task, instead of participating in the activity as a whole. A leader conducting a number of performers is a typical example of an expert engaging in a practical and embodied activity. "Conducted improvisation" (Salvatore, 2000; Marino, 2013) is a form of organized musical improvisation wherein the figure of a "conductor", who delivers instructions to the performers (mainly via gestures and graphic scores), is established.

Aims. Conducted improvisation is set within the enactive paradigm, by labelling this form of musical performance as an enactment-driven practice, and by defining it as a metaphor of the enactive process itself.

Main contribution. Butch Morris' Conduction® is taken as a case study, wherein "various semiotic resources […] are 'laminated' […] and mutually elaborate each other" (Veronesi, 2012). Conduction employs a set of "metaforms", namely gestural metaphors and metonymies, or gestural "plastic formants". Conducted improvisation establishes a type of performance and of environment which is challenging for the involved subjects: the performers have to learn entire sets of body schemas in a short term; the conductor has to consider the feedbacks coming from the performers, in order to deliver the subsequent instruction. Conducted improvisation, *de facto*, provides the actantial positions implied – and, normally, un-staged – in musical improvisation with physical actors. In other words, the conductor, delivering the instructions to the performers, embodies and makes the constraints that are working underneath the musical practice (e.g., architextual, stylistic and conversational norms) visible.

Implications. By showing the existence of rules and the asymmetry of relations, these practices stage the "behind the scenes" of musical improvisation (and of musical performance in general), stressing the intersubjective and contractual character of cognition and signification. Due to its autopoietic, cooperative and didactical nature, conducted improvisation can find a significant field of application in educational, rehabilitational and musicotherapical contexts. Enactivism is little employed as a theoretical framework in dealing with aesthetic subjects, and music in particular, still representing, in this perspective, a whole fertile field to be explored.

Introduction

The present paper is not the account of any empirical experiment, but it displays the very first steps of a theoretical proposal, which tries to join two different approaches (namely, the post-cognitive paradigm named enactivism, and sociosemiotics) together, by focusing upon the matter of concern which is identified in the title (that is, conducted improvisation). The idea is to employ enactivism in order to give conducted improvisation a theoretical framework and an operative label (or, in other words, to exemplify the paradigm), and to employ conducted improvisation not only as an example of enactivism, but also as a metaphor of it, capable to make it better understandable[i].

The enactive paradigm

The roots of the enactive paradigm lie in Bruner's (1966) proposal of three modes of representation:

- The symbolic one (based upon language)
- The iconic one (based upon visual perception and images)
- The enactive one (based upon action; it is the kind of knowledge coming through and from movements, so that "the Body shapes the Mind"[ii]).

Enactivism represents a true paradigm shift in the field of the history of cognitive science. This approach, an alternative to the naturalistic one held by materialists and functionalists, is a multidisciplinary set of studies gathered under the name of "embodied cognition", developed around the anti-dualistic hypothesis that mind is not an isolated system coinciding with the brain, or anyway implemented by it, but rather a complex object that must be investigated in its essential relations with the body and the – biological, social and cultural – environment which the organism is *situated* in (see Gibson 1979; Varela, Thompson et al. 1991-1993; Clark & Chalmers 1998; Santarcangelo forthcoming[iii]).

Enactivism, unlike classic cognitivism or recent forms of materialism, is focused on the contribution of bodily sensory-motor processes and environmental factors to the definition of cognition: namely, on the relations established by the agent with the surrounding space. Starting from this kind of perspective, Noë's work, in particular (see Noë, 2004; 2009; 2012), aims at investigating notions such as "consciousness" and "perception" on the basis of a dynamic model of interaction involving not only the brain, but also the body and the surrounding environment. According to the sensory-motor or enactive approach, "perception" is not an internal process based on the computational elaboration of information-stimuli deriving – in a static way – from the external environment, but it is intrinsically connected to the explorative activities exercised by the body in motion.

In other words, "cognition is not the representation of a pregiven world by a pregiven mind but is rather the *enactment* of a world and a mind on the basis of a *history of the variety of actions* that a being in the world performs" (Varela, Thompson, & Rosch, 1991, as quoted in Reybrouck, 2011; our italics). This "mémoire", this "history of past actions", is what it has been called "body schema" (see Head & Holmes, 1911), a notion employed in psychology to refer to the implicit and practical "body map" that makes it possible to efficiently use our body in motion and action.

Noë and Gallagher's recovery of the notion of "body schema" (see Cole & Gallagher, 1995; Noë, 2004; Gallagher, 2005) does nothing but confirm the obvious; it is not necessary to pay attention to one's body parts in order to use them efficiently. In the same way, a performance would be negatively affected if an expert performing a practical activity focused his attention on the bodily mechanic of the task instead of participating in the activity *as a whole.* As an example, one might refer to the very different actions simultaneously implemented by a drummer in a very single measure – e.g., to kick the bass drum, to keep the beat on the hi-hat or on a cymbal, to hit the snare with the stick – and to the implied notion of "drum independence".

A leader conducting a certain number of performers is a typical example of an expert engaging in a practical and embodied activity, whereas gestures are a typical example of embodied cognition (see Kendon, 1980; Streeck, 2009).

Conducted improvisation

"Conducted improvisation" ("improvvisazione eterodiretta", in Italian, according to Salvatore's 1997 neologism; see Salvatore, 2000[iv]) is a form of organized musical improvisation wherein the figure of a "conductor", who delivers instructions to the performers, mainly using gestures and graphic scores, is established.

The main difference between "collective improvisation" (e.g., Ornette Coleman's *Free Jazz*) and conducted improvisation (which may be considered as a particular type of the first category) lies in the systematic nature of the latter. Conducted improvisation enduringly employs a specific and – locally, or globally – shared lexicon, through which codified ways of interactions between the involved subjects (i.e., between the conductor and the ensemble, between the conductor and the single musician, and between the musicians themselves, both as singles and as part of sub-groups in the ensemble) are established. Feedbacks (i.e., the performer's acceptance or refusal of the instruction delivered by the conductor) play a key role in the construction of the performance.

A partial historical outline of conducted improvisation – a category that has never been employed as an umbrella term, neither eticly, nor emicly, before (for such a proposal, and for an introductory overview, see Marino, 2013) – might include:

- Luigi Russolo's *noise intoners* orchestra
- Karlheinz Stockhausen's *Intuitive Musik*
- John Cage's *event music*
- Earle Brown's *open form*
- Christian Wolff's *cues* and *game pieces*
- Iannis Xenakis' *stratégie musicale*
- Sun Ra's Arkestra performances
- Miles Davis' *silent way* (see the eponymous album)
- Frank Zappa's Mothers of Invention *musical theatre*
- Walter Thompson's *Soundpainting*
- Butch Morris' *Conduction*®[v]
- John Zorn's *game pieces*[vi].

The two latter cases represent the most systematic and documented examples of conducted improvisation. The following proposal focuses on Morris' Conduction only, but it still claims to be applicable to conducted improvisation in general.

Butch Morris' Conduction

Drawing inspiration from a body of works by musicians who had enduringly worked with ensembles[vii], Lawrence D. "Butch" Morris (Long Beach, CA-US 1947-2013) started to develop a method for live *composing improvisations* in the Seventies; the first public performance of what he had called "Conduction"[viii] took place in 1985 (being published in 1986 with the title *Current Trends in Racism in Modern America*).

Morris, who had started his career as a jazz cornetist with bandleaders Horace Tapscott and David Murray, devoted most of his life to the worldwide diffusion of his method; 199 Conduction performances are officially counted, most of which preceded by rehearsals or longer workshops, involving musicians he had never met before. The gestures he employed, an expansion of those of traditional conducting, actually constituted a codified and coherent lexicon, by the means of which he intended to join the traditions of European classical music and Afro-American jazz together (for an introductory overview to Morris and his works, see Stanley, 2009).

Morris defined Conduction as it follows: "Conduction (conducted Improvisation) is a means by which a conductor may compose, (re)orchestrate, (re)arrange and sculpt with notated and nonnotated music. Using a vocabulary of signs and gestures, many within the general glossary of traditional conducting, the conductor may alter or initiate rhythm, melody, harmony, not to exclude the development of form/structure, both extended and common, and the instantaneous change in articulation, phrasing, and meter. Indefinite repeats of a phrase or measures may now be at the discretion of the new Composer on the Podium. Signs such as memory may be utilized to recall a particular moment and Literal Movement is a gesture used as a real-time graphic notation" (in Graubard & Morris, 1995).

Conduction as a complex term

Being the composition of an improvisation, conducted improvisation stands as the *complex term* within the opposition "composition vs. improvisation" (at the basis of the consequent semiotic square), deconstructing both habitual contexts of music playing (i.e., composition and improvisation), their organizational models, and underlying values.

Conducted improvisation builds up a type of performance – and a type of environment (Morris defined Conduction as the "art of environing"[ix]) – which is challenging for the subjects involved in the process: the performers have to learn entire sets of *body schemas*, which are completely new to them, in a short term (during the workshops preceding the on-stage performance); the conductor has to consider the feedbacks coming from the performers, in order to deliver the subsequent instruction.

The enaction of Conduction

It is possible to set conducted improvisation within the enactive paradigm, in two ways:

- By labelling this form of musical performance as an enactment-driven practice
- By defining it as a metaphor (properly, a prosopopoeia[x]) of the enactive processes themselves.

The "lexicon" of Conduction (formerly, "vocabulary"; an abstract of which is available in Graubard & Morris, 1995, pp. 6-7) is being systematically studied by Veronesi (see 2009; 2011; 2012), a linguist, who had also collaborated with Morris as an interpreter during his Italian residencies. Veronesi backs a pragmatic perspective, with the aim to enlighten the multimodal features of this practice.

Conduction workshops, indeed, employ "various semiotic resources (talk, gestural imitation of instrumentalists' actions, vocal exemplifications, verbal and bodily *enactments* of directive sequences […]) [which] are 'laminated'[xi] […] and elaborate each other" (Veronesi, 2012; our italics). Therefore, Conduction performances employ a set of what Danesi & Sebeok (2000) call "metaforms"[xii], namely gestural metaphors and metonymies (Veronesi, 2009), or gestural "plastic formants" (Greimas, 1984)[xiii].

It is worth quoting the description of a typical Conduction instruction: "*Expand* is used to develop a phrase or area, then to bring it back. This is done by placing both hands in front of the body (extended arms) together (for the phrase) then separating the hands for the development" (Graubard & Morris, 1995, p. 6).

Conduction, *de facto*, provides the *actantial positions* implied – and, normally, un-staged – in musical improvisation (and in musical performance in general) with *physical actors*; here lies its metaphorical value, towards the enactive cognition. In other words, the conductor, delivering the instructions to the performers, *embodies* and makes the constraints that are working underneath the musical practice (e.g., architextual, stylistic and conversational norms) visible.

Conclusions and hints for further studies

By explicitly showing the existence of rules, the asymmetry and the fragility of relationships, these practices stage the "behind the scenes" of musical improvisation – we can think of them as a form of "Ur-Improvisation" – and of musical performance in general, stressing the intersubjective and contractual character of cognition and signification. Conducted improvisation is the staging, the enactment of enaction itself (of the embodiment of musical knowledge).

Due to its autopoietic nature (Maturana & Varela, 1980), and its cooperative and didactical component (Veronesi, 2011), conducted improvisation can find a significant field of application in educational, re-educational, rehabilitational and musicotherapical contexts.

The enactive paradigm is little – but increasingly – employed as a theoretical framework in dealing with aesthetical objects, and with music in particular (see Reybrouck, 2001; Luciani, 2009; Peters, 2010; Matyia, 2012; Noë, 2012; Lopez-Cano, 2013), still representing, in this perspective, a whole fertile field to be explored.

Acknowledgments. The Authors would like to thank Prof. Daniela Veronesi (Free University of Bozen, Italy), and Prof. Roberto Doati (Nicolò Paganini Academy of Music, Genoa, Italy), for their useful remarks, and their kind feedbacks.

References

Bruner, J. (1966). *Toward a Theory of Instruction*, Cambridge (MA): Belkapp Press.

Clark, A., & Chalmers, D. (1998). The Extended Mind. *Analysis,* 58(1), 10-23.

Gallagher, S. (2005). *How the Body Shapes the Mind*. Oxford: Oxford University Press.

Gallagher, S., & Cole, J. (1995). Body schema and body image in a deafferented subject. *Journal of Mind and Behavior,* 16(4), 369–390.

Gibson, J. J. (1979). *The Ecological Approach to Visual Perception*. Boston: Houghton Mifflin.

Goffman, E. (1981). *Forms of talk*. Philadelphia: University of Pennsylvania Press.

Goodwin, C., & Duranti, A. (1992). Rethinking context: An introduction. In Id. (Eds.). *Rethinking context: Language as an interactive phenomenon* (pp. 1-42). Cambridge (MA): Cambridge University Press.

Graubard, A., & Morris, B. (1995). Liner notes to *Butch Morris, Testament: a Conduction Collection*, New World, CAT 80478-2; online http://www.newworldrecords.org/liner_notes/80478.pdf.

Greimas, A. J. (1984). Sémiotique figurative e sémiotique plastique. *Actes Sémiotiques,* 60 (Documents).

Head, H., & Holmes, G. (1911). Sensory disturbances from cerebral lesions. *Brain*, 34 (2-3), 102-254.

Kendon, A. (1980). A description of a deaf-mute sign language from the Enga Province of Papua New Guinea with some comparative discussion. Parts I, II, III. Respectively: *Semiotica,* 31(1-2), 1–34; *Semiotica,* 31(1-2), 81–117; *Semiotica,* 32(3-4), 245-313.

Lopez-Cano, R. (2013). Music, cognitive enaction and social Metabody. Paper presented at Multiplicities in *Motion: Affects, embodiment and the reversal of Cybernetics. 3.000 years of posthuman history*, Medialab Prado, Madrid, July 27.

Luciani, A. (2009). Enaction and Music: Anticipating a New Alliance between Dynamic Instrumental Arts. *Journal of New Music Research,* (38)3, 211–214.

Marino, G. (2013). Musichaosmos: Intersoggettività, gioco e costruzione del senso nell'improvvisazione eterodiretta. In Mangano, D., & Terracciano, B. (Eds.), *Il senso delle soggettività. Ricerche semiotiche*. Proceedings of the XL congress of AISS-Italian Association for Semiotic Studies, Ateliers panel, «E/C» monographic issue (pp. 101-110).

Maturana, H. R., & Varela, F. J. (1980). *Autopoiesis and Cognition: The Realization of the Living*. Edited by R. S. Cohen & M. W. Wartofsky. Boston Studies in the Philosophy of Science, 42. Dordecht: D. Reidel Publishing Co.

Matyja, J. K. (2012). Review of Clarke, D., & Clarke, E. (2011, Eds.). Music and Consciousness: Philosophical, Psychological, and Cultural Perspectives. New York: Oxford University Press. *Constructivist Foundations,* 8(1), 129–131.

Noë, A. (2004). *Action in Perception*. Cambridge (MA): MIT Press.

Noë, A. (2009). *Out of Our Heads: Why You Are Not Your Brain, and Other Lessons from the Biology of Consciousness*. New York: Hill & Wang.

Noë, A. (2012). *Varieties of Presence*. Cambridge (MA): Harvard University Press.

Peters, D. (2010). Enactment in Listening: Intermedial Dance in EGM Sonic Scenarios and the Bodily Grounding of the Listening Experience. *Performance Research,* (15)3.

Reybrouck, M. (2001). Biological roots of musical epistemology: Functional cycles, Umwelt, and enactive listening. *Semiotica*, (134)1-4, 599–633.

Salvatore, G. (2000, Ed.). *Frank Zappa domani: Sussidiario per le scuole (meno) elementari*. Roma: Castelvecchi.

Santarcangelo, V. (forthcoming). Introduzione. In Gibson, J. J. *L'approccio ecologico alla percezione visiva*. Milano-Udine: Mimesis.

Stanley, T. T. (2009). *Butch Morris and the art of Conduction®*. Dissertation submitted to the Faculty of the Graduate School of the University of Maryland, College Park, in partial fulfillment of the requirements for the degree of Ph.D.

Streeck J. (2009). *Gesturecraft: The Manu-facture of Meaning*. Amsterdam: John Benjamins.

Varela, F. J., Thompson, E., et al. (1991-1993). *The Embodied Mind: Cognitive Science and Human Experience*. Cambridge (MA): MIT Press.

Veronesi D. (2009). The guy directing traffic: Gestures in conducted improvised music between metaphor and metonymy. Paper presented at the RaAM Workshop *Metaphor, Metonymy & Multimodality*, Amsterdam, June 4–5.

Veronesi D. (2011). La traduzione non professionale come co-costruzione: Osservazioni sull'interazione in contesti musicali didattici all'intersezione tra codici semiotici. In Massariello Merzagora, G., & Dal Maso, S. (Eds.). *I luoghi della traduzione: Le interfacce*. Proceedings of the XLIII International Congress of SLI-Italian Linguistic Society (vol. I, 89–102). Roma: Bulzoni.

Veronesi D. (2012). Formulating music, laminating action: Instruction and correction in ensemble music workshops. Paper presented at *The Linguistic Anthropology Laboratory*, University of California, San Diego, May 21.

---

[i] The paper has been conceived and written in cooperation by the two authors; for the legal exigences of publishing attribution, the "Introduction", the first paragraph and the "Conclusions" should be ascribed to Vincenzo Santarcangelo, while the other paragraphs to Gabriele Marino.

[ii] According to Gallagher (2005).

[iii] Authors like Bateson and Merleau-Ponty are other key references for the origins of the enactive paradigm.

[iv] Differently defined, in literature, as "controlled", "structured" or "composed" improvisation.

[v] "Conduction" is a trademark; the symbol "(R)" is not being displayed in the paper anymore.

[vi] His most famous one is *Cobra*; composed in 1984, recorded between 1985 and 1986, first published in 1987.

[vii] Such as Charles Moffett, Jackie Hairston, Sun Ra, Frank Zappa, Lukas Foss' Improvisation Chamber Ensemble, Leonard Bernstein (*Four Improvisations by the Orchestra*), Earle Brown, Alan Silva and Doudou Ndiaye Rose; see Graubard & Morris (1995).

[viii] A portmanteau word – explicitly modelled upon the homonymous word from Physics – with a deconstructionist flavour, made up with "conducting" and "improvisation"; Morris employed the word "comprovisation" too ("composition" plus "improvisation").

[ix] A typical gibsonian concept (see Gibson, 1979), that of "environment" is employed by Morris to describe his musical practice as the organization of the surrounding things, conditions, and influences. Morris claimed he wanted to *make* the "surroundings", the environment of the Conduction (i.e., the actual place where he was working, and the actual musicians with whom he was working), *music*; he wanted to translate the "character of the environment" (Graubard & Morris, 1995, p. 4) into sound. In this perspective, a circular feedback circuit is established; the environment affects the direction, and the direction manipulates the environment.

[x] I.e., personification, in rhetorics.

[xi] I.e., "simultaneously layered" (see Goffman, 1981; Goodwin & Duranti, 1992).

[xii] A metaform is any form that connects two different domains; generally, a metaform connects an abstract notion to a concrete source (e.g., the usage of the verb "to see" to refer to the notion of "thinking"). A metaphor is a typical metaform.

[xiii] A plastic formant is the basic unit of visual/plastic semiotics; a gestural plastic formant is each single, recognizable, meaningful gesture.

Nonverbal communication of emotion through sound and gesture: A preliminary performative testing

Tobias Neuhold
Department of Musicology, University of Graz, Austria
tobias.neuhold_at_edu.uni-graz.at

In: Glowinski, D., Lepri ,G., & Pedrina, A. (Eds.)
Proceedings of the Sixth International Conference of Students of Systematic Musicology (SysMus13)
Genoa, Italy, 12-14 September 2013, http://www.infomus.org/Events/SysMus13/index.php

Abstract. Anguished cries or crows of delight as examples for emotional expression as an evolutionary process and effect of the interaction between humans and their environment provide the basis for the emergence of its cultural formation music. The usage of nonverbal communication of emotions consisting of prosody, gesture and sound in musical expression is observed in an experiment. The generation of basic patterns for the emotions fear, happiness, sadness and anger, based on consisting empirical knowledge and on results achieved through a performance experiment, provided the observation of emotional connotations of nonverbal emotional expression through sound and gesture, as measured by the semantic differential, in different viewing conditions (audio and audio-visual) and varied in sound. The result achieved displays that the different emotions are represented in perception measured against the connotations on the factor activity. The additional testing of the emotional communication via rating scales on the level of language achieved no significant effects. The nonverbal communication of emotions by the means of gesture and sound has successfully, even though just partly, been observed and provides a starting point for more empirical observation.

Music was often stated to be the language of emotions. The relationship between music and emotion has been a topic of interest since the ancient greeks. It has many facets and perspectives with can be traced in the numerous publications with different or multiple scientific backgrounds. This research focuses on a basic level of nonverbal emotional communication through sound and bodily expression. Based on an anthropological framework a empirical testing method is established to grasp basic patterns of nonverbal emotional expression.

Theoretical Background

Anguished cries or crows of delight are examples for emotional expression as an evolutionary process and effect of the interaction between humans and their environment (Knepler 1972, Blacking 1977). These perspectives, developed in the seventies, deal with the origin of music and its evolutionary function, which is closely connected with the offspring of language. The relation between music and language is discussed at large and features many perspectives of which came first or conditions the other. Crucial for this underlying theoretical framework is the evolutionary perspective that music originates from the emotional interaction of humans with their environment (Knepler 1972, Blacking 1977). Language provided a system for a cognitive interaction; Music, or more detailed, its predecessor emotional expression, like shouts of anger or crows of delight, made emotional coherence between humans available. Music therefore can be seen as a cultural and a social extension of bodily expression of emotions. In other words, this bodily interaction therefore provides the basis for the emergence of its cultural formation music (Brown 2001, Mithen 2010).

But let’s focus on the level of emotional expression and make an tangible argument. If such emotional expressions according to theories of basic emotions incorporate distinct and distinguishable patterns, for example in the case of anger high amount and speed of movement, are these features traceable in musical expression of emotions? In other words: Do angry cries, as an example of emotional expression consist of features that can be traced in musical expression of emotions? Juslin from a music-psychologist perspective gives us a further direction with the following assumption: „Some aspects of music (e.g., tonality, melody, and harmony) are relatively more culture-specific, whereas other aspects ... are more culture-independent

Emotions	Body movements		Acoustical characteristics			
	Amount, dynamics and intensity	**Quality**	**Amplitude**	**Tempo, -variation**	**Articulation**	**Melody-contour, complexity**
Anger	high, plenty alterations, high intensity and activity	fast, jerky, erratic	high	fast, many variations	staccato	high pitched, ascending
Happiness	high, plenty alterations, variable intensity and activity	fast, dynamic, away from the body	high	fast, many variations	staccato	medium, ascending
Sadness	low, few alterations, low intensity and activity	slow, soft, fluent	low	slow, few	legato	high, descending
Fear	low	near the body	low	fast, many variations	staccato	high

Table 1. Table of basic characteristics of nonverbal emotional expression for four basic emotions

(because they are based on nonverbal communication of emotions.)." (Juslin 1997: 248; cited after Sloboda & Juslin, 2005: 813). This statement enforces the question, but also leads to a necessary theoretical split between primary and secondary emotions, as Damasio (2004) proposed it. This does not allow negating a further processing of emotions in music on a more complex cognitive level. This anthropological framework allows to search for an underlying patterns of emotional expression through sound and gesture. Overall Ekman (2003) studies on mimics give evidence of the universality of nonverbal communications of basic emotions. On the other hand few studies exist which deal with posture or gesture, and even if, their results showed that not all emotions in research were communicated significantly (Gross, Crane, & Fredrickson, 2010; Wallbott & Scherer, 1990). In addition to these studies various research fields were taken into account that deal with nonverbal expression of emotions: 1. intercultural studies in emotions in music (Balkwill & Thompson 2010), 2. prosody (Juslin & Laukka 2003), 3. general studies on posture and gesture (Dael et al. 2012, MEGA Project Camurri et al. 2005; Camurri et al. 2003), 4. bodily movements and dance studies (Camurri et al. 2003, Laban 1956) and 5. studies on nonverbal emotional communication in music performance (Dahl & Friberg 2007). Studies from the field of music performance were selectively taken into account, because the research hypothesis wants to focus on emotional expression in general and not on performers with high expertise. These studies were excluded due to the factor concerning the tradition of stylistic emotional expression, which would be more cultural dependant in terms of Juslin´s (1997) statement. Furthermore I do not claim to provide a detailed overview of each research fields, but a basic table (compare table 1) describing the four basic emotions (anger, fear, happiness and sadness) due to their characteristic body movements and sound parameters has been set up. For example anger is an emotion that features high tempo and loudness variations and fast, sudden, and elaborate movements. Nevertheless these research fields provide an empirical basis for basic patterns and their characteristics for the four basic emotions: 1. anger, 2. fear, 3. happiness and 4. sadness.

Aims

Based on the theoretical assumptions and the empirical evidences, I formulated the general research hypothesis as follows: Basic patterns of nonverbal emotional expression can be extracted and communicated.

And stated three specific sub-hypothesis:

1. The variation of the emotions shows an effect on the connotative qualities, measured by the semantic differential.
2. The variation in sound has an effect on the connotative qualities, especially on the activity.
3. The emotions can be communicated via discrete verbal terms and the variation of sound has no effect on it.

The extraction and generation of nonverbal patterns, consisting of a conglomeration of sounds and gestures, for basic emotions is the first aim of the study. The second stage observes the communication of these extracted patterns.

Main contribution

Method

The first experimental stage dealt with the generation of basic patterns. A simple performative approach was chosen, that observed, how people express the four basic emotions via gesture and sound. The developed setup can be compared to the usage of Clynes Sentograph (1978), which measured the pressure and direction of finger resting on a knob as a result of emotional induction and expression. His research has been criticized, approved and still provokes a lot of discussion and therefore the results must be taken critically. He also captured basic patterns for various emotions (love, hate, reverence, grief, anger, joy, sex and no emotion), which he refers to as sentics of touch. The theoretical paradigm of Clynes is not as essential as his effort to measure emotional expressions.
The setup in use was a two dimensional space programmed in Max/MSP which can be entered through a Jazzmutant Lemur Interface, a programmable touchpad. This interface as measurement tool allows interactions through the touch screen, which describes the two dimensional space (y= continuous pitch, x=time) and at the same time captures the bodily gestures of emotions. The interface itself was black, only the touch was visualized via a circle around the point where the finger touched the surface.

The sound was generated through a simple additive synthesis and consisted of a sinusoid frequency with nine partial, linear decreasing in their amplitude by numerical value. The sound was chosen to avoid association with existing instruments and to be easily manipulated in a later stage. Possible association were compiled in a post interview with each participant using the interface. The sound itself was evaluated as not pleasant by nearly all participants.

First each participant got to use and familiarize with the interface. To test its functionality and parameters. Afterwards they were instructed by printed text to express each of the four emotions from left to right in one gesture. A trial stage was given and each participant decided when each emotion could be separately recorded. These curves (compare graphic 1), visually presented by a simple black line, for each emotion were quantitatively analysed by a framework. Dahl & Fridberg (2007) movement descriptions in combination with Laban's theory of effort (1956), set up the following analysis framework: 1.) direction, 2.) amount, 3.) quality, 4.) time and acceleration. The patterns of each emotion were put on top of each other and compared for similarities and differences concerning the analysis framework. The space was divided into equal squares and thereby their direction and amount of the patterns were comparable. The parameter quality described the shape, for example edgy or round flow, of the pattern. The resolution (dots per second) of the recorded lines provided an implication concerning the factors time and acceleration. Fast movements travel more distance between each sample rate and therefore feature more straight lines. A relative comparison was thereby made possible. Repetitions of gestures were eliminated, because based on theoretical assumptions they are assumed to be intensifications.

The resulting parameters for each emotion were contrasted with the set of empirical evidences (compare table1) and afterwards were rendered manually by using the interface itself to keep the generation as valid as possible (compare figure 1).

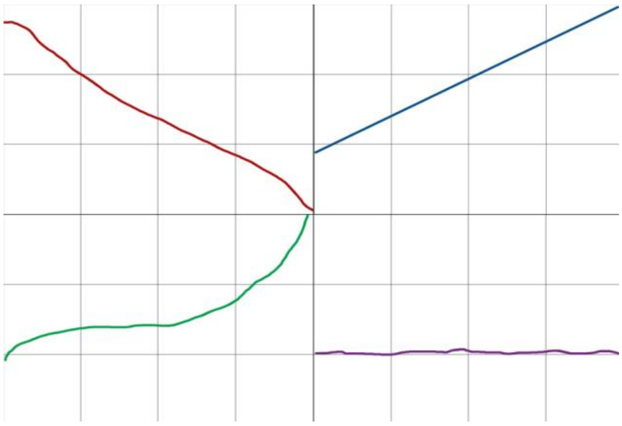

Figure 1. Generated patterns for the basic emotions: red: sadness, blue: anger, green: happiness and violet: fear.

In the second stage of the experiment the basic patterns were presented in different presenting conditions (audio, audiovisual and visual) and in variations of sound quality (sharpness, relative amplitude of the partials, sinusoid) again to non-musicians (n=30). The sound variable was introduced in three classes, that varied in their sharpness (energy distribution over the partials), that is connected to the connotation of activity (Flath 2009) and excitement. Basically more sharpness causes more activity and excitement.

The experimental setup was semiautomatic, that allowed each participant to go through the stimuli on their own pace, but each stimulus was only presented once. The participants were instructed in the first set to spontaneously and quickly fill out a semantic differential consisting of 15 bipolar adjective scales and then to rate the second set of patterns on a seven point Lickert rating-scales for each emotion. Afterwards a post-hoc survey was handed to the participants. Additional to the demographic data (age and sex) and musical and graphic expertise open questions about the experiment its perception and assumed purpose were asked to gain insights into strategy and/or theory production during the experiment by the participants.

Results

The material itself was perceived as ugly, not pleasing, bright, active and clear. This BIAS of the material perception was predicted due to the minimalistic visual representations and the use of additive synthesis. The factor analysis reduced the material to three dimensions (explaining 65,93% of the variations). These dimensions were labelled after their marker scales 1.evaluation/potency, 2. activity and 3. structure. An analysis of variance of the factor scores showed a significant result between the emotions on the dimension of activity. Anger had the highest activity and sadness the lowest. A tendency occurred on the factor activity, where the score for the sound classes (amplitude and timbre) were higher than for the class (sinusoid). The results showed furthermore on the factor evaluation/potency a significant difference between the sound classes. The sinusoid tones were rated as more pleasant, nice, soft, and fine as the classed timbre and amplitude, which nearly had similar ratings. There were no second order effects. The perception separated in the different presenting situations, showed no difference between audio and audio-visual. The analysis of the rating-scales showed some tendencies, but fear was significantly not perceived as such. This has been expected, because fear had low rates of perception in similar experiments (Dahl and Friberg 2007). Happiness often got confused with anger, except the sinusoid pattern of happiness had overall higher ratings. Sadness showed higher ranking in the classes sinusoid and timbre. Anger was confused as happiness in all conditions. Post-hoc interviews showed that participants often thought, that there were repetitions of stimuli, which leads to the interpretation that the cutting-scores for the sound classes were not adequately chosen. Furthermore 30% of the participants mentioned in the post experiment interview, that they had trouble to match these abstract patterns to discrete emotional labels.

Conclusions

Strictly speaking the hypothesis had to be dismissed, except the effects on the activity dimension show a fruitful tendency. Although other factors are necessary to describe nonverbal patterns of emotions. One need to take into consideration, that this was just a preliminary series of tests with a low number of participants (30), but the results for activity point in the right direction. The variable sound and its classes seemed to be inadequately set and therefore had no consequence in their variation. This can be seen not only in the nearly equal ratings, but also in the post-hoc interview data.

Nevertheless the experimental setup proves to be worthy to elaborate. Special interest in the future lays on the induction of the emotions and a more adequate operationalisation of the variable sound in its classes. One possibility could be to give the participants in the setup an option to choose the sound themselves out of a pool, so that the sound itself can be connected to the emotion expressed

Implications

The use of a performative testing environment opens up new ways and options in the research on nonverbal emotional expression also secludedly from high musical expertise and especially for music interfaces. The insights into the general functionality of emotional expression can be applied for affective computing, pedagogical purposes, or in psycho-therapeutical therapies.

References

Blacking, J. (1977). Towards an Anthropology of the body. In J. Blacking (Ed.), The Anthropology of the body (pp. 1–28). Academic Press.

Brown, S. (2001). The "musilanguage" model of music evolution. In N. L. Wallin, B. Merker, & S. Brown (Eds.), The Origins of Music (pp. 271–300). MIT Press.

Clynes, E. M. (1978). Sentics: The Touch of Emotions. New York: Anchor Press/Doubleday.

Dahl, S., & Friberg, A. (2007). Visual perception of expressiveness in musicians' body movements. Music Perception, 24(5), 433.

Ekman, P. (2003). *Unmasking the face*. Cambridge MA: Malor Books.

Damasio, A. R. (2004). *Looking for Spinoza*. Random House.

Gross, M. M., Crane, E. A., & Fredrickson, B. L. (2010). Methodology for Assessing Bodily Expression of Emotion. *Journal of Nonverbal Behavior*, *34*(4), 223–248.

Wallbott, H. G., & Scherer, K. R. (1990). Ausdruck von Emotionen. (Expression of emotion) (pp. 345–422). Göttingen: Hogrefe.

Thompson, W. F., & Balkwill, L. L. (2010). Cross-cultural similarities and differences. In *Handbook of music and emotion: theory, research, applications* (pp. 755–788). Oxford University Press.

Juslin, P. N., & Laukka, P. (2003). Communication of emotions in vocal expression and music performance: Different channels, same code? Psychological Bulletin, 129(5), 770–814.

Dael, N., Mortillaro, M., & Scherer, K. R. (2012). Emotion expression in body action and posture. *Emotion*, *12*(5), 1085–1101.

Camurri, A., Lagerlöf, I., & Volpe, G. (2003). Recognizing emotion from dance movement: comparison of spectator recognition and automated techniques. *International Journal of Human-Computer Studies*, *59*(1-2), 213–225.

Camurri, A., Camurri, A., De Poli, G., De Poli, G., Friberg, A., Friberg, A., et al. (2005). The MEGA Project: Analysis and Synthesis of Multisensory Expressive Gesture in Performing Art Applications. *Journal of New Music Research*, *34*(1), 5–21.

Flath, B. (2009). *Sound und Image. Eine experimentelle Untersuchung zum Einfluss von Klangqualitäten auf die Wahrnehmung eines Produktimages im Kontext von Fernsehwerbung.*(Disseration. pp. 1–151). Graz: Universität Graz.

Knepler, G. (1977). Geschichte als Weg zum Musikverständnis. Zur Theorie, Methode und Geschichte der Musikgeschichtsschreibung. Leipzig: Reclam.

Laban, R. (1956). Principles of dance and movement notation. London: MacDonald & Evans.

Mithen, S. J. (2006). The singing neanderthals: the origins of music, language, mind, and body. Cambridge, Mass.: Harvard University Press.

Sloboda, J. A., & Juslin, P. N. (2005). Affektive Prozesse: Emotionale und ästhetische Aspekte musikalischen Verhaltens. In H. T. Stoffer & R. Oerter (Eds.), Enzyklopädie der Psychologie, Musikpsychologie, Bd. 1: Allgemeine Musikpsychologie. Göttingen: Hogrefe.

Analysis of Jaques-Dalcroze compositions

Elisabetta Piras
Indipendent scholar, Italy
angheloruiu_at_yahoo.it

In: Glowinski, D., Lepri ,G., & Pedrina, A. (Eds.)
Proceedings of the Sixth International Conference of Students of Systematic Musicology (SysMus13)
Genoa, Italy, 12-14 September 2013, http://www.infomus.org/Events/SysMus13/index.php

Background. As It's well known, Emile Jaques-Dalcroze (1865-1950) has thought and realized a very important method for music education; Nowadays his thought influences many methods and it's the focus of many studies in the field of music education. It's less known that Emile Jaques Dalcroze was a very active musician, he studied composition with musicians like G. Fauré, Fuchs and Bruckner. Jaques-Dalcroze had a very big success with his pedagogical intuition, and also with his musical production.

Aims. Reading his biography and listening to his music, that now is very difficult to find, many questions were born:1) Is the Jaques-Dalcroze music strictly linked to his pedagogical method, so, to the body movements dimension of that? 2) Are the composition processes of Jaques-Dalcroze influenced by this body movements dimension?

Main contribution

Method. To answer to these questions, two kinds of Jaques-Dalcroze compositions are analyzed: some didactic composition, like *Dix Miniatures pour Jeunes Pianistes* and *Esquisse*, and some composition written for the performance like *Impressions fugitives* for piano. A specific grid, based on the foundations of the Jaques-Dalcroze method, in particular on the plastique animeé technique, is used to compare the two types of compositions.

Results.The composition activity of Jaques-Dalcroze appears strongly influenced by his conception of movement. The music composed for performance presents many features of the pedagogical method, a very complex system, that deals with music parameters deeply, and the more evident elements are the improvisation style, and the recognition of a particular type of movement (codified in the method) in the music. Also harmonic and melodic features are found.

***Conclusions*.** Without intention of exhaustiveness, this study is a part of an articulated research in progress that aims to investigate in deep the Jaques-Dalcroze thought.

Implications. This study proposes an original way to consider the Jaques-Dalcroze method, not only in a pedagogical way, but also in a scientific and musicological way. There are not studies focused on this topic, and the big number of Jaques-Dalcroze compositions are for the most unknowns or used for pedagogical activity, without a scientific systematization. Also the bibliography about Jaques-Dalcroze is focused, for the most, on the biography and on the proposal of activities. Only in the last years, various studies treat the possibilities of applications of the method in a scientific way.

Biography. Elisabetta Piras: pianist, musicologist, teacher. Elisabetta Piras studied Musicology at the University of Bologna, specializing in contemporary music and in the field of the music education. She works as musicologist, pianist and teacher, collaborating with Unibersities and Conservatoires, and publishing both popular and scientific works. She is currently member of national board of SIEM, Italian Society for Music Education.

The idea behind the present study comes out from my personal approach to the Dalcroze methodology. Reading the fascinating Jaques-Dalcroze biography and in my first experience in practicing eurhythmics activities, I noticed a substantial lack of knowledge of the musical production composed by Jaques-Dalcroze for performance, but also the general lack of interest and consideration about this aspect. The revolutionary pedagogical ideas of Jaques-Dalcroze maybe let forget the big and rich activity of Jaques-Dalcroze as a composer, but it has not always been so. It's easy to remark, that in Italy, from where I come, where I live and work in the field of music education research and performance, this defect of knowledge is total, while the comprehension and the diffusion of the methodology is entering slowly in the institutional conception of the music education.

The composer Jaques-Dalcroze

To frame Jaques-Dalcroze as a composer , it's necessary to review briefly his training and the basic steps in his activity as a composer. As it is well known, the musical training of Emile Jaques-Dalcroze starts in the infancy, in Vien, under the guidance of a not very beloved teacher, but with many musical stimuli. The first academic experience is in Geneve; since 1877 he attends the Conservatoire under the guidance of Schulze, Ruegger and de Senger. In 1881, he starts the Gymnase, and the collaboration with his friend Philippe Monnier takes place, doing some opera type compositions. In 1883 Dalcroze is still uncertain in choosing between a serious engagement in music or in theatre; he accepts the occasion of a tournée as an actor, and in 1884 he goes to Paris to live strongly the artistic context of the city, and to deepen his skills in both the disciplines. In Paris, Dalcroze makes important meetings, and socializes with his colleagues; he frequents other young musicians like Charpentier, De Bréville, Chausson. He attends the courses of Marmontel and Fauré, and frequents Leo Delibes; he works in organizing concerts, and in 1886 we know about a fundamental experience in his musical path: he goes to Algeria for a tournée as a second orchestra conductor, and there, after knowing the algerian rhythmic structures, he deeply reflects about his concept of rhythm. In 1887 he starts to attend regular courses in Vien, studying composition with Graedener, Prosnitz, Fuchs and Bruckner. His music begins to be performed and to achieve success, and he continues the collaboration with his friend Monnier. Then, since 1892 he starts to teach at the Conservatoire in Gèneve; those years are very intensive; Dalcroze deepens his conception of rhythm with Lussy: he works hard and in a prolific way. Many of his compositions are performed across Europe. The name of Dalcroze as a composer becomes really famous when he writes *Chanson Romandes* and *Rondes Infantines* and his swiss vein emerges in all her force in compositions like *Poéme alpestre*, performed at the Exposition nationale suisse in 1896. Meanwhile his skills in the piano improvisation are highly recognized and admired, and the collaboration with Eugène Ysaye is emerging, and Dalcroze starts to systematize his idea about the rhythmic. Since the beginning of the '900 the brilliant pedagogical career joins his music career. Music written for method demonstrations, and for popular representations and festivals, join the composition of music specific for the concert contexts.

As we can see from this brief overview of the most significant events, considering the composer Jaques-Dalcroze, the activity as a composer has been soon intertwined with the thought about music education and eurhythmics, consequentially, the repertoire of Jaques-Dalcroze music mostly consists of works involving educational aspects or at least the dalcroze-methodology.

Jaques-Dalcroze Compositions

Opera, Operetta, Music Drama	33
Orchestral works	56
Chamber Music	70
Voice and Piano	256
Voice and Orchestra	72
Choir a cappella	165
Choir and Piano	80
Piano	98

Figure 1. Number of Jaques-Dalcroze compositions

The catalogue of Jaques-Dalcroze compositions is huge, and still raises doubts. In the numbers indicated in Figure 1, the anthologies and the works composed by different little pieces are considered each as one single composition, so the total amount of the compositions is very high. Among the works for music drama, there are big works, like *Festival Vaudois*, *La Fête de la Jeunesse et de la Joie*, *Poème Alpestre*, that include several sections published and performed independently and arranged for other instruments. Many of the orchestral works are composed for celebratory and patriotic demonstrations. In this field, Jaques-Dalcroze shows a predilection for string instruments, if we leave out some compositions for fanfara and military band. In the indicated number, the ballets and the extracts of the operas are not considered. The chamber music is devoted to the movement and the music education for about its half. The most used instruments are the violin and the piano, or the cello and the piano. The music for voice and piano is almost entirely composed for didactic activity often with gestures and choreographies. Among the pieces for choir and piano, only 14 are specifically composed; the others are arrangements or extracts of sections from operas and similar compositions.

Aims

For the above considerations, some questions arise:

Is the compositional style of Jaques-Dalcroze linked to his ideas about music education? If yes, how can we recognize these aspects in his music features? Besides this, which are the distinctive features of the Jaques-Dalcroze style?

Method

To answer to these questions, different kinds of piano composition of Jaques-Dalcroze are considered. The piano works are more than 98, and we have to remember that many works consist in different pieces. The piano is the instrument of Dalcroze; this instrument marks his life both in music and pedagogical activities; as all we know, it is the instrument of the method. It's ever present in the main steps of his career; his improvisations are with the piano, his composition activity starts with piano pieces, and it's estimated that the piano is used by Dalcroze in 1200 works for piano and voice, in addition to the works for piano solo.

Considering a general division of the piano works we can note that the pieces composed supposedly for performance appear more than the other categories, but we have to remember that in the other categories there are works including many pieces; actually the main part of works is for didactic activities. The pieces of the works *Esquisse Rythmiques II, III, Douze petites images pour enfants, Dix Miniatures, 40 Impressions fugitives,* are analyzed according to some parameters identified as dalcrozian subjects, starting from the assumptions of Jaques-Dalcroze about the correspondence between music and plastique animée.

MUSIC	PLASTIQUE ANIMÉE
pitch	Position and direction of gestures in space
Tone-color	Muscolar dynamics
Timbre	Diversity in body shapes (sexes)
Sound duration	Durata of the geste
Tempo	Tempo
Rhythmic	Rhythmic
Pause	Pause
Melody	Continuous succession of isolated movements
Counterpoint	Opposition of movements
Chords	Fixed positions of gestures (or gestures in group)
Harmonic successions	Sequences of associated movements (or gestures in group)
Phrasing	phrasing
Construction (form)	Distribution of movements in space and time
Orchestration (see timbre)	Opposition and combination of different body shapes (sexes)

Figure 2. Le rythme la musique et l'education, Paris, Librairie Fischbacher, 1920

The parameters considered are: Form and construction, harmony, counterpoint and meter. *Dix Miniatures* and *Douze Petites images pour enfants* are works for children, and arecomposed previous than *Esquisse Rythmiques*, that is a work for rythmic activities. *Impressions Fugitives* is one of the last works, and it's a work for performance. All the pieces are composed in the maturity of Dalcroze.

Results

First suggestions emerge from the analysis. About form and construction, doesn't appear that there are substantial stylistic differences among the compositions. The works are short pieces, in salon music style, in ABA' or AB form with little coda that resumes the section A. In some case there is a rhythmic or melodic pattern that is dominant in the hole piece. There is not an idea of development of the main theme, instead, we can note an idea of variation or processing of single elements, for example rhythmic or harmonic patterns, without a result of transformation. There are many sections structured in melody and accompanying, but it is not the main way. There is a large use of ostinatos, omorhythmic writing, and elements divided in different registers. In all pieces is used a large part of the registers, without touching the extremes in high or low. In *Impressions Fugitives* the section B is often more different from the section A than in the other pieces, where is often repeated the main theme in other way.

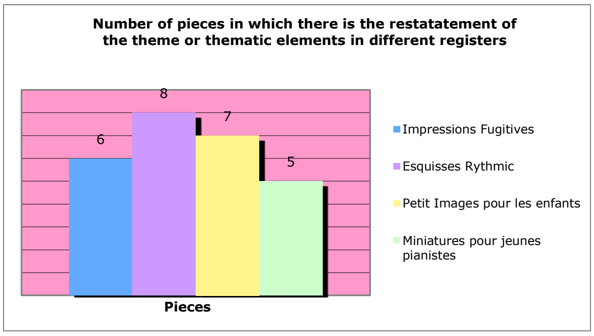

Figure 3. Restatement of theme

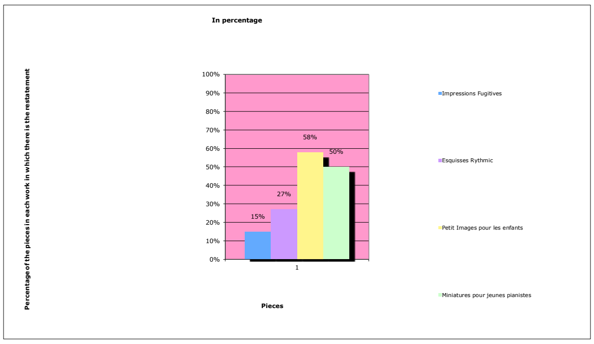

Figure 4. Restatement of theme in percentage

About harmony, there is a traditional use of the harmonic successions. Chromatism and dissonances are often used, but never in an audacity way. The use of the tonality is also traditional, with quick modulations in the related keys. The section B of the pieces is ever in a related key, and there are often secondary dominants, but the coda or the end of the pieces is ever affirmative in the main key.

About conterpoint there is not a significant use of counterpoint, but there is often an evident and effective polyphonic effect caused by the combination of ostinatos with melodies or accompanying elements.

There are many changes of meter, and this is the more evident and original feature to quantify in the analysis.

In every piece of the works in which there are different meters, the changes are often more than two. In *Impressions Fugitives* and in Esquisses there are also unusual meters, like 15/16 or 7/8. These results suggest us the will of Jaques-Dalcroze in preserving the importance of the downbeat in a continuous fluctuating in different meters. Many composers in the time of Dalcroze experimented different kind of metric structures, Stravinsky, Satie etc., often without bar-lines or in the specific way of considering every value of the notes, thus far from a traditional idea of meter. In the Dalcroze process, instead, the result is a very natural and clear combination with phrasing, melody and harmony parameters.

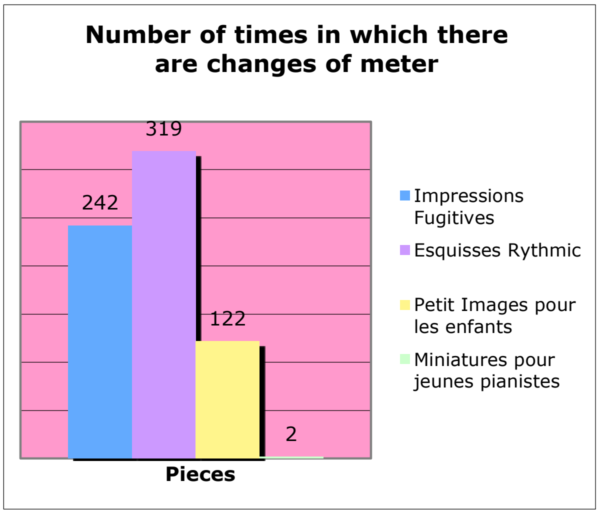

Figure 5. Changes of meter

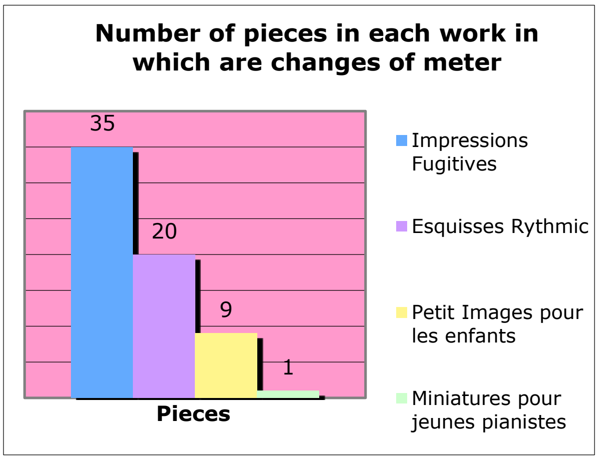

Figure 6. Changes of meter

Conclusions

In relation to the initial aims of the present study, considering the results of the analysis we can see that it's possible to link the compositive processes in Jaques-Dalcroze works for performance to his music education ideas. The music features used in pieces clearly composed for rhythmic and didactic activities are the same of those in the pieces composed for performance. There is the possibility to consider both *Impressions Fugitives* and *Esquisse Rythmic* equally works for concerts and works for activities. These two works are written more or less with the same technical and interpretative level of difficulty, while *Dix miniatures* and *Douze petites images* are easier in formal, technical and interpretative way, but although we can find the same characteristics, and it's clear that those pieces are written for children. These works show a bigger tendency in repeating the same theme or pattern in different ways, while the other two works show a bigger tendency in changing meter, often in unusual way and fast frequency. We can read these findings in the way of increasing difficulties; the repetitions of the theme could meet the objective to memorize musical patterns for deepening different ways to interpret those. The evident changes of meters are present in all his works, but in *Images Fugitives* and *Esquisses* they are more complex.

These findings encourage us to go on in analyzing in a systematic way the Jaques-Dalcroze repertoire. The next step will be to consider the big works of chamber music like the concert for violin and orchestra and the orchestral music.

References

Jaques-Dalcroze, É. (1920). *Le rythme, la musique et l'éducation*. Paris: Fischbacher.

Brunet-Lecomte, H. (1950). *Jaques-Dalcroze. Sa vie, son oeuvre*. Genève/Paris: Jeheber.

Martin, F. et al. (1965). É*mile Jaques-Dalcroze, l'homme-le compositeur-le créateur de la rytmique.* Neuchâtel: Ed de la Báconnière.

Bachmann, M.L. (1984). La rythmique Jaques-Dalcroze, une éducation par la musique et pour la musique. Neuchâtel: Ed de la Báconnière.

Jaques-Dalcroze, É. (1920). *Le rythme, la musique et l'éducation*. Paris: Fischbacher.

Evaluation of individual contributions in a group estimate of the position of a moving point of common interest

Davide Punta, Giulio Puri, Fabio Tollini, Giorgio Gnecco, Marcello Sanguineti, Antonio Camurri
Department of Informatics, Bioengineering, Robotics and Systems Engineering (DIBRIS), University of Genoa, Italy
firstname.lastname_at_unige.it

In: Glowinski, D., Lepri, G., & Pedrina, A. (Eds.)
Proceedings of the Sixth International Conference of Students of Systematic Musicology (SysMus13)
Genoa, Italy, 12-14 September 2013, http://www.infomus.org/Events/SysMus13/index.php

Abstract. This paper presents a feasibility study on the application of cooperative game theory tools such as the Shapley value to measure quantitatively non-verbal interaction inside a group of people. More precisely, a method is tested to evaluate individual contributions in the estimate of the position of a mobile point of interest. Various social aspects are evaluated, like synchronization between people and group's topology, together with computational aspects for the evaluation of the Shapley value, like efficiency and accuracy. The results show that among the main factors that influence the contribution of each individual on the team's utility there are the displacement of the players and the type of movement performed by the point of interest. Possible applications in a musical context are also described.

I. Introduction

Non-verbal signals are part of human nature and represent a very important communication medium. Psychological studies have shown that the use of different facial expressions, tones of voice, postures and gestures is an intrinsic feature of human brain, which can be used to convey information about people's mood and thought (Knapp et al., 1972; Richmond et al., 1995). Because of the importance of this communication medium, for decades researches have been conducted in order to obtain theories and models to understand how it works. Thanks to the development of modern technologies, able to extract more and more precise data, and with the growing interest in human-computer interaction, recently this matter has been expanded considerably. Several studies have been performed to understand not yet explained natural behaviors, such as the emergence of a person within a group, or some factors involved in social interactions among people (e.g., leadership, dominance, role recognition, mechanisms of synchronization (Varni et al., 2010; Vinciarelli et al, 2009).

This paper faces a case study about this social aspect. In particular, a method is investigated for the evaluation of individual contributions in the estimate of the position of a mobile point of interest (termed "*PoI*" in the following) by a group of people. Various factors that may influence such an individual contribution are also investigated, like predictability of the *PoI*'s movement, players' displacement, and the presence of "noisy" players.

In order to be able to analyze it quantitatively, the social interaction is modeled by the theory of cooperative games: in particular, a model expressed by a Transferable Utility Game (TU-Game) - which admits the Shapley value as a solution concept - is investigated.

Game theory appears to be particularly appropriate to be used in the present context, since it is a theory that concerns with decisions and interactions among subjects; more formally, it is "the study of mathematical models of conflict and cooperation between intelligent rational decision-makers" (Myerson, 1991). Born in 1928 with the publication of Von Neumann's seminal paper (Neumann,1928), it immediately achieved success for the useful theoretical models it provides, which have been applied successfully to different environments ranging from economics to psychology. More precisely, a "game" is defined as a situation in which some individuals, called players, interact and take decisions to gain possibly different objectives. In the case in which players are allowed to form binding commitments, the game is called cooperative, otherwise it is termed non-cooperative (Roth, 1988). A particular subclass of cooperative games is constituted by TU-Games. In such games, the players form a team (termed coalition), and one is interested in finding fair individual allocations of the utility of the coalition (hence the name "Transferable Utility" games). There exist different solution concepts for finding such a fair allocation: in this work, it is proposed to use the Shapley value, which has been already applied successfully to different typologies of problems (Aadithya et al., 2010; Bachrach et al., 2008; Moretti et al., 2010; Narayanam et al., 2010; Zhang et al., 2011).

The paper is structured as follows. In Section I, the main approach followed in the work is presented. It includes the definition of the problem, the methodologies for data collection that have been used and the recordings that have been acquired, and the proposed solution of the problem through the Shapley value. Section III is focused on some alternative solutions to the problem: in particular, the use of the Banzhaf power index and of suitable angular coefficients to weigh the contributions of the single players to the utility of the coalition and of its subsets. In Section IV, the computational problem of evaluating the Shapley value for the class of TU-games under investigation is analyzed: various algorithms are implemented and tested, with the aim to compute either exactly or approximately the Shapley value as quickly as possible. In Section V, the data collected are analyzed to obtain empirical rules on the individual contributions in the estimate of the position of the *PoI*: for instance, possible dependencies from the topology of the group of players and from their coordination level. Finally, Section VI presents some conclusions and possible developments.

II. Problem definition and its solution through Shapley values

The starting point of this work is the feasibility study performed in (Boccardo et al., 2012), which reports an accurate analysis of some visual features involved in the process of estimating the position of a mobile point of common interest (*PoI*) by a group of people of size *n*. Such a study recommends the use of the orientation of each person's head as a good approximation of the gaze direction – at least in some controlled situations - and the use of the least-squares method for the estimation of the position of the *PoI*, starting from the knowledge of the heads' positions and directions. In (Boccardo et al., 2012), and also in this work, these features are computed through the analysis of data sets recorded by the Qualisys Motion Capture system (www.qualisys.com), installed in Casa Paganini (Genoa, Italy - www.infomus.org). More precisely, the recorded data (which have been collected in two different moments of time) provide, for each frame of each recording, the three-dimensional positions of various passive markers which have been placed on several parts of each individual's body. In particular, in the following analysis we consider only the three markers placed on the heads of the subjects (two frontal markers, and one placed on the back of the neck), discarding the vertical components of their positions. Figure 1 shows their displacement.

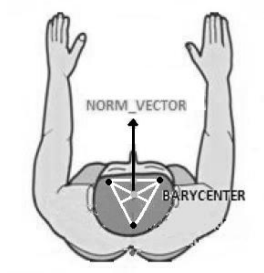

Figure 1. Displacement of the three markers on each head.

For each subject, the gaze direction is approximated by the head direction, defined as the unit-norm vector joining the barycenter of the triangle formed by the three markers and the mid-point of the segment connecting the two frontal markers. Such a vector is also normal to the head, and is termed "*NORM_VECTOR*" in Figure 1. Likewise in (Boccardo et al., 2012), the estimation of the position of the *PoI* is then performed by the least-squares method, using as inputs the coordinates of the barycenters of the players' heads and the above-determined approximations of the directions of their gaze directions. More precisely, denoting by

$$\boldsymbol{P}^i = \left(P_x^i, P_y^i\right)$$

the position of the barycenter of the head of the *i*-th subject and by

$$\boldsymbol{V}^i = (V_x^i, V_y^i)$$

the associated head direction, the line passing through such a barycenter and having such a direction is made by all the points (x,y) satisfying the equation

$$V_x^i(y - P_y^i) = V_y^i(x - P_x^i).$$

This can be also written as

$$V_y^i x - V_x^i y = V_y^i P_x^i - V_x^i P_y^i.$$

Then, considering all n subjects, one obtains the following linear system:

$$\begin{cases} V_y^1 x - V_x^1 y = V_y^1 P_x^1 - V_x^1 P_y^1 \\ \quad \cdots \\ V_y^n x - V_x^n y = V_y^n P_x^n - V_x^n P_y^n \end{cases}$$

which can be also expressed, in matrix form, as

$$\begin{bmatrix} V_y^1 & -V_x^1 \\ \vdots & \vdots \\ V_y^n & -V_x^n \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} V_y^1 P_x^1 - V_x^1 P_y^1 \\ \vdots \qquad \vdots \\ V_y^n P_x^n - V_x^n P_y^n \end{bmatrix}.$$

Then, defining the matrix

$$A := \begin{bmatrix} V_y^1 & -V_x^1 \\ \vdots & \vdots \\ V_y^n & -V_x^n \end{bmatrix},$$

and the vectors

$$\boldsymbol{x} := \begin{bmatrix} x \\ y \end{bmatrix}; \boldsymbol{b} := \begin{bmatrix} V_y^1 P_x^1 - V_x^1 P_y^1 \\ \vdots \qquad \vdots \\ V_y^n P_x^n - V_x^n P_y^n \end{bmatrix},$$

the linear system above can be written as

$$A\boldsymbol{x} = \boldsymbol{b}.$$

As this linear system in general may not have an exact solution, in the following we consider its least-squares solution, whose expression is

$$\boldsymbol{x} = (A^T A)^{-1} A^T \boldsymbol{b}.$$

Since – for a meaningful estimate - the estimated point must be also in front of each subject, the following additional constraint is introduced:

$$\forall i, \boldsymbol{V}^i \cdot (\boldsymbol{x} - \boldsymbol{P}^i) \geq 0,$$

where $\cdot$ denotes the Euclidean dot product. If such constraint is not met, the estimate is not considered as valid.

The recordings have been performed using two different displacements of the players: a linear displacement, with the *PoI* in front of them (see Figure 2), and a circular displacement, with the *PoI* inside the circle (see Figure 3). The comparison of such two configurations allows an accurate analysis of some important differences in the behaviors of the subjects, which will be described in the next sections.

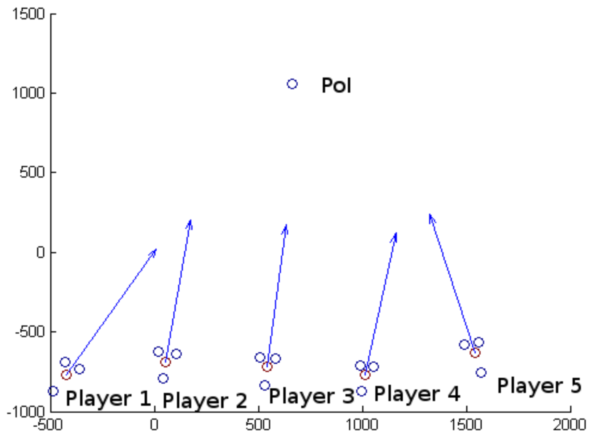

Figure 2. Linear displacement of the players.

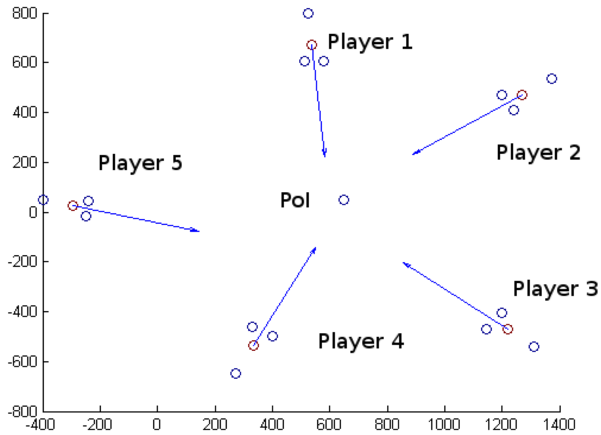

Figure 3. Circular displacement of the players.

Following the approach suggested in (Camurri et al., 2013), we have decided to apply the theory of cooperative games to evaluate the individual contribution of each player to the estimate of the position of the mobile *PoI*. So, we have modeled the problem as a TU-Game (Roth et al., 1988), formalized as follows:

TU-Game:

$$\langle N, v \rangle,$$

where:

$$N = set\ of\ players\ looking\ at\ the\ PoI,$$
$$v = characteristic\ (or\ utility) function.$$

Here, v is a function that associates a real-valued utility to each subset (sub-coalition) of *N*, that is:

$$v: P(N) \to \mathbb{R},$$
$$P(N) = set\ of\ all\ subsets\ of\ N.$$

Given a TU-Game, the individual contribution of each player to the group's utility - measured by the Shapley value - is defined by the formula:

$$Shapley\ value\ of\ the\ i\text{-}th\ player:$$
$$\Phi_i(v) = \sum_{S \subseteq N | i \in S} \frac{(|S|-1)!\,(|N|-|S|)!}{(|N|)!}(v(S) - v(S \setminus \{i\})),$$
$$i = 1, .., |N|,$$

where we have used the notation $|\cdot|$ for the cardinality of a set.

In order to compute the Shapley value, it is necessary to choose a suitable expression for the characteristic function. Such a choice should be based on the peculiar features of the particular class of problems under study. In the present context, $v(S)$represents the utility of the estimate of the position of the *PoI*, derived from a sub-coalition *S* of players. Now, if $|S|<2$, the utility of the sub-coalition is 0, since in these conditions the number of intersections (0) is insufficient to obtain a meaningful estimate of the position of the *PoI*. So, we have the following constraint on the functional form of the characteristic function:

$$v(S) \begin{cases} \geq 0, & for\ |S| \geq 2, \\ = 0, & otherwise. \end{cases}$$

Concerning the expression of $v(S)$ for $|S| \geq 2$, various choices are possible. The first choice considered in this study has been

$$v(S) = \frac{1}{d(S)},$$

where $d(S)$ represents the distance between the position of the *PoI* and its estimate obtained by the sub-coalition *S* by the least squares method described in Section II, restricted to the equations corresponding with the players belonging to *S*. For the case in which the estimate above is not valid, the value 0 is assigned to $v(S)$. However, one can observe, in general, that the expression of $v(S)$ considered above assumes too high values in the presence of an accurate estimate. Therefore, for $|S| \geq 2$, we have then considered the choice

$$v(S) = \frac{k}{1+d(S)},$$

where *k* is a positive constant, which restricts the range of possible values for the utility $v(S)$ (see Figure 5 for the Shapley values obtained in such a way, for one of the recordings). Moreover, in addition to the frame-by-frame Shapley value computation, we have also evaluated the average Shapley value (where the average is performed with respect to all the frames of each recording), and the normalized Shapley value, obtained by dividing the Shapley value by the utility $v(N)$ of the whole coalition *N* when $v(N) > 0$, otherwise replacing it by *1/n*. The definition of the normalized Shapley value is motivated by the fact that the sum of the Shapley values of the players is equal to the utility of the whole coalition *N* (Myerson, 1991; Roth, 1988). However, the last two alternative methods revealed to be not particularly useful for the present work: the first one is too a rough approximation, while the second one discards the information related to the quality of the estimate of the whole coalition *N*.

III. Some variations on the basic setting

In the following, different alternative solutions are proposed to extract additional information from the recorded data.

A. Inclusion of angular information

In order to validate the proposed approach, during the analysis phase, also artificial data have been used, together with the ones acquired by the Qualisys Motion Capture. More precisely, to generate the artificial data, the measurements of the positions of the markers associated with the head of one player have been artificially modified, in order to make the head be directed exactly toward the *PoI* throughout the whole recording. The expectation was that, in this way, one should get an artificial player who provides the best contribution to the estimate, and should subsequently achieve the maximum among all players' Shapley values. Experiments have shown, however, that this expectation is not always respected: in some particular situations, players whose head directions are not perfectly aligned with the *PoI* may, in fact, provide a greater contribution than the artificial player (see Figure 4).

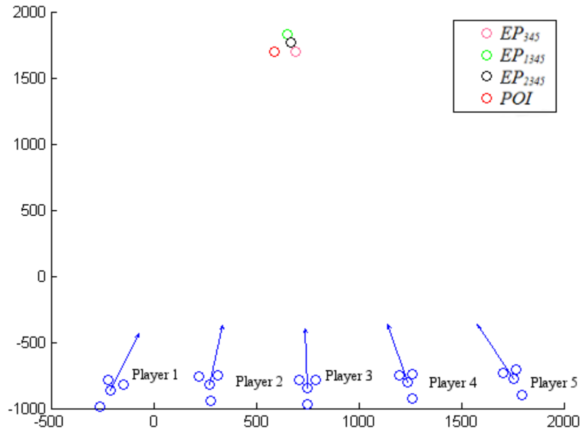

Figure 4. This figure represents a possible situation (artificially created), in which the players are numbered from left to right. Player 1 looks exactly at the *PoI*, player 2 looks at a point positioned 5 cm on the right of the *PoI* and players 3, 4 and 5 look at a point positioned 10 cm on the right of the *PoI*. EP_{345} represents the estimated point (Estimated Point, *EP*) of the sub-coalition {3,4,5}, EP_{1345} the one estimated from {1,3,4,5} and EP_{2345} the one estimated from {2,3,4,5}. As it can be seen from the obtained results, the sub-coalition {2,3,4,5} provides a better estimate than the sub-coalition {1,3,4,5} and has therefore a larger utility. This shows that a player who looks perfectly at the *PoI* is not guaranteed to be the one that gives the greatest contribution to the estimate. Indeed, his Shapley value happens to be the lowest among all the players.

To address this issue, two different solution methods have been designed and implemented. The first one consists in inserting an additional weight inside the definition of $v(S)$, in order to be able to take into account the head direction of each player.

This is obtained as follows. Consider a sub-coalition *S* with $|S| \geq 2$. Let a_i be the angle between the direction of the head of the *i-th* player belonging to *S* and the vector joining the barycenter of the head of such player to the *PoI*. We define θ_S as the arithmetic mean of the angles a_i:

$$\theta_S = \frac{1}{|S|} \sum_{i \in S} a_i.$$

Then, for $|S| \geq 2$,the modified expression for the characteristic function is

$$v(S) = \frac{k}{1 + d(S) * \theta_S}.$$

The obtained results (not reported here) show that this approach assigns actually, in most cases, the highest value to the player who looks exactly toward the *PoI*. This is in accordance with similar results already reported in (Camurri et al., 2013).

The second adopted solution, instead, makes use of the mean gaze direction of the sub-coalition *S*. The characteristic function thus assumes, for $|S| \geq 2$, the following form:

$$v(S) = \frac{k}{1 + d(S) * a(S)},$$

where *a(S)* denotes the (non-negative) angle between the mean direction of the heads of the sub-coalition *S* and the vector that connects the mean of the barycenters of the heads of the players to the *PoI*. This solution, however, does not appear to be reasonable for certain configurations (such as the circular one), and has not led to significant results in any case.

B. Banzhaf power index

In this study we have also tested another

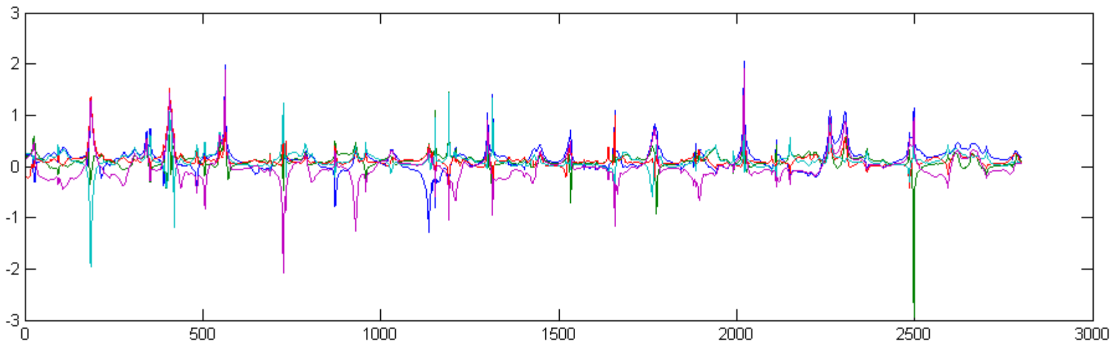

Figure 5. Plot of players' Shapley values, computed frame-by-frame in Matlab. The horizontal axis represents the frame number, while the vertical one provides the Shapley value for each subject.

solution concept for TU-games which is different from the Shapley value, i.e., the Banzhaf power index (Bachrach et al., 2008), which provides an index of criticality for each player. This applies to the so-called "simple" TU-games, i.e., ones in which the characteristic function can take only the two values 0 and 1.

To make the original TU-game "simple", its characteristic function has been made binary by a threshold: for $|S| \geq 2$, if the point estimated by the sub-coalition *S* is valid and its distance from the *PoI* is smaller than a certain (tunable) value, then the sub-coalition "wins", otherwise it "loses". More formally, one sets

$$v(S) = \begin{cases} 1, & if\ S\ wins, \\ & otherwise. \end{cases}$$

Moreover, a player *i* is called critical for a sub-coalition *S* containing it when the utility of *S* is equal to 1, while its utility after the removal of *i* is equal to 0, i.e., when:

$$v(S) = 1 \wedge v(S \setminus \{i\}) = 0.$$

Finally, the Banzhaf power index is defined as

$$\beta_i(v) = \frac{1}{2^{n-1}} \sum_{S \subseteq N | i \in S} [v(S) - v(S \setminus \{i\})],$$

where, without loss of generality, the summation above can be restricted to critical sub-coalitions only. A comparison of the results (not reported here due to space limitations) obtained using the Banzhaf power index with the ones obtained using the Shapley value, shows that the rankings of the players are basically the same under the two cases, as long as the value of the threshold for the Banzhaf power index is small enough.

IV. Performance analysis and improvements

The computational time of the Shapley value is, by its nature, exponential with respect to the number of players. Indeed, to determine the Shapley value of each player, the utilities of all the sub-coalitions need to be calculated. With *n* players, one has

$$|P(N)| = \sum_{k=0}^{n} \binom{n}{k} = 2^n$$

sub-coalitions to be examined. For instance, with *n=5* players one obtains 32 sub-coalitions. Since the sub-coalitions containing less than 2 players can be automatically discarded (because they do not produce a meaningful estimate of the position of the *PoI*), one can restrict the attention to the remaining 26 sub-coalitions. Then, in this case, to compute the 5 Shapley values, the characteristic function needs to be considered 26 * 5 = 130 times for each frame. Now, the Motion Capture (MoCap) system used here has a resolution of 96 fps (frames per second). Then, for a recording of 10 seconds, each of the 5 Shapley values has to be computed 960 times, which requires - in the most-direct implementation - 124800 calls to the function that calculates $v(S)$. As a consequence, in order to be able to compute the Shapley value in real-time, several alternative approaches have been designed and implemented.

A. Pre-calculation of the utility values

The first proposal simply involves, for each frame, the pre-calculation of the utility values of each possible sub-coalition. In this way, the number of calls to the function which computes $v(S)$is drastically reduced (e.g., for the case of 5 players and 960 frames described above, it reduces from 124800 to 24960). In Matlab, unfortunately, search in an array has a linear cost and it has been observed experimentally that this cost is more burdensome than the calculation of $v(S)$ itself.

It was then developed a second solution, which provides inside its implementation the use of a sort of hash table (not present in Matlab) to compensate for the burden of the linear search in the array. This latter implementation has led to calculation times similar to those required by the original implementation for the case of 5 players discussed above. However, the modified implementation is more efficient for the case of a larger number of players.

B. Monte-Carlo method

As suggested in (Bachrach et al., 2008; Fatima et al. 2007), a possible solution to reduce the computational burden in the evaluation of the Shapley values consists in sampling the sub-coalitions using the Monte Carlo technique. In this way, one can choose beforehand the number of sub-coalitions to be taken into account and the computational time can be reduced (e.g., becoming linear in the number of players $|N|$ if also the number of random sub-coalitions is linear in $|N|$ .However, this reduction in the computational complexity may correspond to a substantially large approximation error.

In particular, by calculating the Shapley values approximately using half the number of all the sub-coalitions, it was found experimentally that the obtained values followed the same trend of the exact ones, and that the ranking of the players was maintained for the majority of frames.

C. Averages on the whole recording

Two additional solution methods were designed. Both provide, for the whole recording, only one calculation of the Shapley value for each player, and have in common the feature of replacing the instantaneous position of the *PoI* by its average position with respect to all the frames of each recording.

In the first approach, an additional frame is constructed in which, for each player, the barycenter of the head and its direction are replaced by their averages on all the frames, respectively. In the second one, instead, in the additional frame, the estimated point from each sub-coalition is replaced by its average on all the frames.

Despite the small variations of the positions of the heads of the players in each recording, in both cases, the results obtained experimentally were inaccurate when compared to the average of the Shapley values on the full recording.

D. Shapley values calculated on time windows

The ideas presented in Section III.D was then generalized by calculating the Shapley values on time windows rather than performing averages over the entire recordings. The time windows were juxtaposed, and their size set by the user.

When the size of the time windows is equal to 1 frame, the values obtained from both implementations are equal to the values obtained by the original calculation of the Shapley values presented in Section II, while, when their size is equal to the total number of frames, the values are the same as those obtained in the case described in Section IV.C. For intermediate sizes, both techniques behave as low-pass filters smoothing the peaks that occur in the original versions of the time-series of Shapley values.

Analysis of the data acquired shows that, using time windows made up of 24 frames (which can be interpreted as a reduction of the frame-rate to 4 frames per second), the average trend of the original time-series of Shapley values obtained frame-by-frame as described in Section II is preserved, whereas the execution time is reduced dramatically, making feasible the online calculation of the Shapley values.

In general, for the calculation of the Shapley values on time windows of size d_w frames, the calculation time t_w is

$$t_w \approx \frac{1}{d_w} t_S,$$

where t_s is the calculation time of Shapley values frame-by-frame. The results obtained demonstrate that this method, among those examined, is the most effective way to obtain reliable values in acceptable times. However, the order of the computational time remains unchanged.

V. Data analysis

Starting from the features described in the previous paragraphs, we have analyzed data acquired in different settings. In particular, in the following we present results about possible dependencies of the Shapley values from the players' displacements, specific movements of the *PoI*, the Motion Index (MI) of players' heads, and the presence of one or more players looking deliberately at a fixed point far away from the *PoI*.

A. Motion index

Human gaze is characterized by two principal movements which are continuously alternated: saccades and fixations. The first ones are very fast, and their duration is about 20~50ms; in the second ones, whose duration is about 60~700ms, the gaze remains fixed. In order to identify possible relevant factors in the determination of the Shapley values, one could take into account only the frames in which the players' Motion Index (MI) - an index of the quantity of motion of a subject (Mancas et al. 2009) - is smaller than a certain threshold. In the following, the MI is calculated relatively to the angular velocity of players' head directions; a small value could correspond therefore to a fixation moment, which in turn could correspond to a more accurate estimation of the position of the *PoI*. For a run-time calculation of the Shapley values, therefore, one might think of using only those frames in which the MI is close to zero. However, this solution might lead to the elimination of too many frames; for this reason, it would be better to insert an additional counter to impose the use of a minimum number of frames per second.

B. Study of the group's topology

Players' displacement may have a relevant role in determining the contribution of each of them to the team utility; for this reason, two different configurations have been used for the experiments (see Figures 2 and 3). As one would expect, apart from possible dependence on the individuals, in the circular arrangement no player has a Shapley value significantly different from the other players' ones. In the linear arrangement, instead, as shown in the following, the obtained results are different.

To analyze the influence of the position, one "noisy" player was asked to look at a fixed point away from the *PoI*. We made three recordings: in the first one, the left-most player looked at a point located on the left of the *PoI*, in the second one, he looks at a point located on the right of the *PoI* and, in the last one, the central player looks deliberately far away from the *PoI* (for the central player, it does not matter if he looks at a fixed point on the left or on the right of the *PoI*). The results obtained show that, on average, the smallest Shapley value is attributed to the left-most player in the first experiment. This is motivated by the fact that, in most cases, the intersections of his head direction with those of other players fall behind the players getting invalid estimates, and therefore the utility of a sub-coalition containing the noisy player is set to 0. Even in the third experiment, the average Shapley value associated with the central player is small since, as in the case above, there are many invalid intersections.

Different results have been obtained, instead, in the second experiment. In this case, the left-most player obtains very high Shapley values on average. As there are few invalid intersections, the marginal contribution of the player to the utilility of a subcoalition is positive in most cases. So, in the linear configuration, not only the position of a player is important, but also the direction of the introduced perturbation.

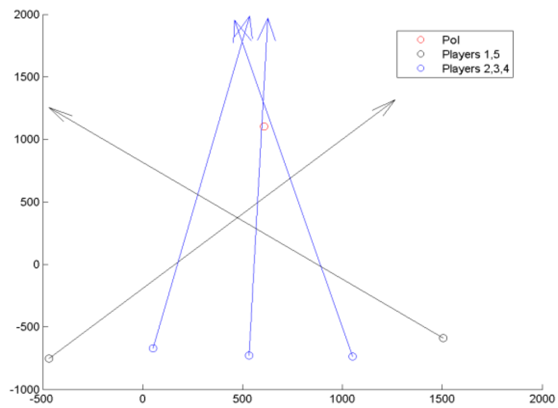

Figure 6. The two lateral players look purposely not at the *PoI*, but at two points located on opposite sides of the *PoI*, respectively.

A fourth experiment has been accomplished to study the case in which the two external players look purposely at two points located on opposite sides of the *PoI* (Figure 6). In this case, it was noticed that the Shapley values for the central player increase on average with respect to the Shapley values that would be obtained in the absence of the disturbance players. Moreover, the temporal variations of such values are much smaller with respect to the case in which all the players look at the *PoI*.

C. Dependence on the *PoI* position

An experiment was performed to see whether the proximity of the *PoI* to one player may influence the associated Shapley value. Then, using the circular layout, the *PoI* was moved with a random trajectory near one of the players.

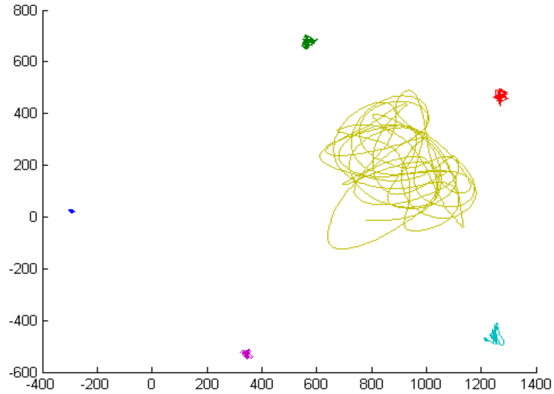

Figure 7. *PoI* and players' barycenters trajectories (view from above).

In most of the frames, the Shapley value of the player closest to the *PoI* (red player in Figure 7) turns out to be the highest one, while the one of the farthest player (blue player in Figure 7) is the lowest of the group. This indicates that the contribution given by the player closest to the *PoI* is higher, on average, than that given by a farther player.

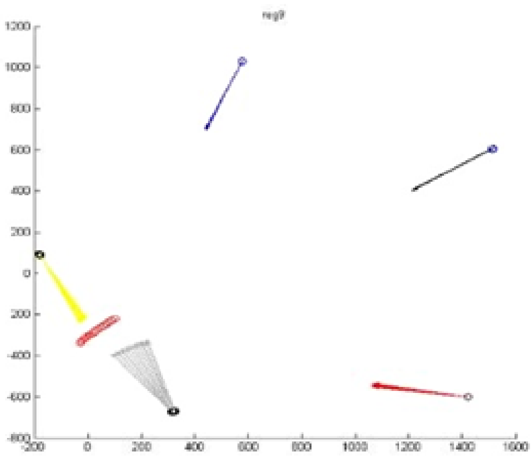

Figure 8. Movement of the *PoI* between two players.

A further experiment was conducted to analyze the case in which the *PoI* is located between two players. From an initial analysis it seemed that this configuration would lead to similar contributions for the involved players. However, subsequent experiments have shown that there is not a clear relationship between the utilities of the two affected players.

D. Study of the predictability of the *PoI* movement

An interesting consideration is to determine whether a repetitive movement of the *PoI* may have a positive influence on players' Shapley value. The hypothesis is that, after a certain number of repetitions, the movement of the *PoI* may start to be anticipated by the players, so that they can follow it better. To test this hypothesis, the *PoI* was moved with an oscillatory trajectory (see Figure 9).

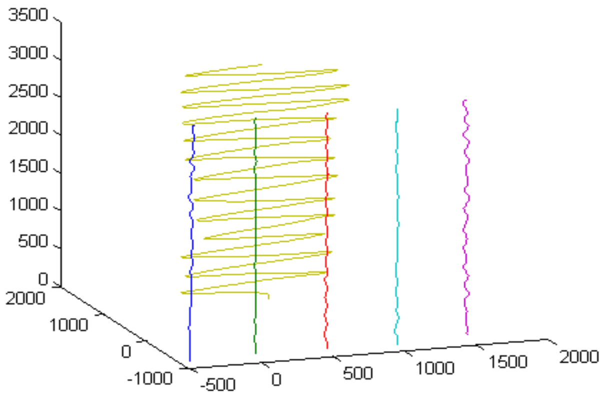

Figure 9. Players' barycenters and *PoI* trajectories (the vertical axis represents the frame number, while the other two dimensions are the spatial coordinates).

As shown in Figure 9, however, there is no significant increase of Shapley values with respect to time that could be associated with an improvement of the quality of the estimate. Peaks, due to the reversal of direction of the *PoI*, are nevertheless clearly visible.

VI. Discussion

In this study, it was shown that the coordination of the whole group is important to obtain high Shapley values; indeed, modeling the problem with cooperative game theory, the individual contribution of each player to the quality of the final estimate depends not only on his actions, but also on those of the other players. Other factors that had a significant impact on the obtained values are the displacement of the players and the *PoI* position. In the linear configuration, a wrong head direction of one player leads to an increase of the error in the estimation of the *PoI* position; this error was large if the player is in the central position, while it was smaller when his position is external. This fact confirms that the proximity of the *PoI* with respect to a player, in most cases, may influence his Shapley value. The introduction in the linear arrangement of two external players not looking at the *PoI*, as shown in Figure 6, led to a reduction of the oscillations in the time-series of Shapley values for the other players. Repetitive movements of the *PoI* did not lead to an increase of the Shapley values associated with the players; from the results it seems that, for the characteristic functions used in this paper, the Shapley value is not influenced by the predictability of the movement of the PoI. For what concerns the discussed approximation techniques, it emerges that a run-time computation of the Shapley values is feasible, by using either time a window or the Monte-Carlo technique. A possible future development concerns the application of machine learning techniques to confirm the generality of the results that we have empirically obtained.

Concerning practical applications, the proposed methods may be applied, e.g., to a symphony orchestra, or to a string quartet: in this framework, the musicians represent the group of people who interact through non-verbal signals, while the *PoI* is represented – at least in some particular moments of a performance - by the conductor or the current leader of the quartet.

Acknowledgments

We thank F. Fimmanò, F. Muratorio, I. Di Lorenzo, D. Pollarolo for the collaboration in the recording phase. We also thank Prof. F. Patrone for the support in the theoretical section about game theory.

References

Aadithya, K. V., Ravindran, B., Michalak T. P., & Jennings, N. R. (2010). "Efficient Computation of the Shapley Value for Centrality in Networks". *Internet and Network Economics, Lecture Notes in Computer Science*, Volume 6484, pp. 1-13.

Bachrach, Y., Markakis, E., Procaccia, A. D., Rosenschein, J. S., & Saberi, A. (2008). "Approximating Power Indices*". Proc. of the 7-th Int. Conf. on Autonomous Agents and MultiAgent Systems (AAMAS)*, pp. 943-950.

Boccardo, N., Claudio, G., Corradi, D., Moltedo, M., & Camurri, A. (2012). "Computational and Analysis Models of *Non-Verbal Signals"*. *DIBRIS Technical Report*, Univ. of Genoa.

Camurri, A., Dardard, F., Ghisio, S., Glowinski, D., Gnecco, G., & Sanguineti, M. (2013). "Exploiting the Shapley Value in the Estimation of the Position of a Point of Interest for a Group of Individuals". *DIBRIS Technical Report*, Univ. of Genoa.

Fatima, S. S., Wooldridge, M., & Jennings, N. R. (2007). "A Randomized Method for the Shapley Value for the Voting Game". *Proc. of the 6-th Int. Conf. on Autonomous Agents and MultiAgent Systems (AAMAS)*, pp. 955-962.

Knapp, M., & Hall, J. (1972). "*Nonverbal Communication in Human Interaction"*. Harcourt Brace College Publishers.

Mancas, M., Glowinski, D., Volpe, G., Camurri A., Bretéché, P., Demeyer, J., Ravet, T., & Coletta, P. (2009). "Real-time Motion Attention and Expressive Gesture Interfaces". *J. of Multimodal User Interfaces*, vol. 2, pp. 187–198.

Moretti, S., Fragnelli, V., Patrone, F., & Bonassi, S. (2010). "Using Coalitional Games on Biological Networks to Measure Centrality and Power of Genes". *Bioinformatics*, vol. 26, pp. 2721-2730.

Myerson, R. B. (1991). "*Game Theory: Analysis of Conflict",* Harvard University Press.

Narayanam, R., & Narahari, Y. (2010). "A Shapley Value-Based Approach to Discover Influential Nodes in Social Networks". *IEEE Transactions on Automation Science and Engineering*, vol. 8, pp. 1-18.

Neumann, J. v. (1928). "Zur Theorie der Gesellschaftsspiele". *Mathematische Annalen,* vol. 100, pp. 295-320.

Richmond, V., & McCroskey, J. (1995). *Nonverbal Behaviors in Interpersonal Relations*. Allyn and Bacon.

Roth, A. E. (1988). *The Shapley Value: Essays in Honor of Lloyd S. Shapley*. Cambridge Univ. Press.

Varni, G., Volpe, G., & Camurri, A. (2010). "A System for Real-Time Multimodal Analysis of Nonverbal Affective Social Interaction in User-Centric Media". *IEEE Transactions On Multimedia*, vol. 12, pp. 576-590.

Vinciarelli, A., Salamin, H., & Pantic, M. (2009). "Social Signal Processing: Understanding Social Interactions through Nonverbal Behavior Analysis*". Computer Vision and Pattern Recognition Workshops*, pp. 42–49.

Zhang, S., & Li, Q. (2011). "Application of Cooperative Game Theory to Benefit Allocation of Interruptible Load Management". *Proc. of the Power and Energy Engineering Conference (APPEEC).*

Perception of Pitch Organisation in Equitone Music: Implications for Psychology and Ethnomusicology

Barry Ross
Centre for Music and Science, University of Cambridge, United Kingdom
br314 _at_ cam.ac.uk

Sarah Knight
Centre for Music and Science, University of Cambridge, United Kingdom
MRC Institute of Hearing Research, University of Nottingham, United Kingdom
Sarah.Knight _at_ ihr.mrc.ac.uk

In: Glowinski, D., Lepri ,G., & Pedrina, A. (Eds.)
Proceedings of the Sixth International Conference of Students of Systematic Musicology (SysMus13)
Genoa, Italy, 12-14 September 2013, http://www.infomus.org/Events/SysMus13/index.php

Background. Intervallic rivalry theory suggests that tonal knowledge is constituted by knowledge of the intervals possible within the tonal set. These intervals exist in virtue of the structure of the set, as conceptualised in musical set theory. A key feature of tonal sets is that scale arrays consist of more than one step size between successive pitch classes. This gives rise to the psychologically relevant property of uniqueness, where each pitch class can be uniquely defined in terms of potential interval relationships with other set members. Scales with only one step size (e.g. whole tone scales) are tonally ambiguous due to a lack of intervallic uniqueness. Unequal step-sized scales have been proposed to be both cognitively significant and potentially universal to human musical behaviour.

Aims. This paper aims to bring the existence of a substantial number of musical traditions with equal-stepped tuning to wider attention, and to suggest several alternative pitch organisational principles in such equitone cultures. A further aim is to encourage interdisciplinary consideration of present data, as equitonicism in sub-Saharan Africa has hitherto gone unnoticed in music psychology.

Main contribution. The nature of the cognitive problem surrounding equitone music is detailed. Several possible cognitive explanations for the perception of basic pitch organisation in equitone traditions are then proposed. Also included is a list of equitonic traditions in sub-Saharan Africa, compiled from the ethnomusicological literature by the authors.

Implications. A full assessment of the validity of claims regarding equitonicism, as well as a determination of the cognitive relevance of equitone scales, depends on interdisciplinary collaboration between psychologists and ethnomusicologists. Furthermore, the existence of equitonic systems challenges current views that unequal step-sized scales are universal and fundamental to pitch organisation.

Intervallic rivalry theory (IRT; Butler, 1989) suggests that knowledge pertinent to tonal organisation can be characterised as knowledge of the rarity of certain intervals in the tonal set. These intervals are rendered possible due to the structure of the set as understood from a music set-theoretic perspective (Balzano, 1980; 1982). The tonal set is simply the set of pitch classes forming the scale or tonal hierarchy. For example, the Western diatonic major set starting on C consists of [C, D, E, F, G, A, B]. To illustrate why this conception of tonal knowledge is of interest to music psychology, consider the property of uniqueness in diatonic sets, taken to be important in tonal perception and key-finding (Cross, 1997; Balzano, 1982):

(1) In a given diatonic set, a pitch class can be differentiated from, or defined in terms of, the set of intervals it forms with every other pitch class in the set. That is, a pitch class has a defined set of possible interval relationships it can have with other members of the set.

The related properties of simplicity and coherence are features of *diatonic* sets that arise partly from (1), and are not directly relevant to the problem described in this paper. The critical feature of (1) is that it applies to any set where there is more than one interval size possible between successive scale degrees (such as pentatonic scales in Western tuning). To illustrate (1), consider the diatonic key of C major, and the C major pentatonic scale. We can define each scale degree in terms of the intervals it forms with successive scale degrees. Every pitch class has a different set of relationships to the notes above it:

C major diatonic:

D: [M2, m3, P4, P5, M6, m7]

E: [m2, m3, P4, P5, m6, m7]

F: [M2, M3, a4, P5, M6, M7]

G: [M2, M3, P4, P5, M6, m7]

A: [M2, m3, P4, P5, m6, m7]

B: [m2, m3, P4, d5, m6, m7]

C major pentatonic:

C: [M2, M3, P5, M6]

D: [M2, P4, P5, m7]

E: [m3, P4, m6, m7]

G: [M2, P4, P5, M6]

A: [m3, P4, P5, m7]

These sets of intervals can be thought of as the within-key intervals that are possible from a specific note. (1) states that each defining interval set within a scale is unique. From this, it is apparent that some intervals, such as P5 in diatonic sets, are structurally common (the interval P5 is a possible within-key continuation from many notes). Others, such as the aug4/dim5 are exceedingly rare. Rare intervals are therefore taken to be more informative: should a listener versed in diatonic music hear a dim5, he would know that the only two notes that could possibly be involved are the fourth and seventh scale degrees. Thus, in terms of key-finding, possible candidates for the tonal centre are drastically reduced. (The tonic will be one semitone above one of the two notes.) Conversely, a major second or a perfect fifth can imply many more possible tonal centres, because there are many possible notes that bear a M2 relationship with others in the diatonic set. Experimental evidence exists (Butler & Brown, 1984; Brown, Butler & Jones, 1994) that listeners are able to infer key easily and speedily when the implicative intervals involved are made up of rare intervals in a diatonic pitch set, as opposed to common intervals.

It is important to note that the idea of interval diversity between successive scale degrees within a set is fundamental to IRT. Should

C: [M2, M3, P4, P5, M6, M7]

there be only one class of interval within a set (e.g. a scale made up of just whole tones), key-defining interval information will be absent. In a whole-tone scale, every note has an identical set of possible intervals to every other note—namely, [M2, M3, a4, a5, m7]. IRT posits this as the reason why whole-tone and chromatic scales are tonally ambiguous. Thus, the existence of scales with unequal steps is taken as an important and psychologically relevant feature of human music (Sloboda, 1985; Trehub, 2000), and has been put forward as a candidate for a musical universal (Brown & Jordania, 2011). However, these studies fail to recognise that there are a significant number of musical traditions that are reported *not* to feature unequal-spaced scales. These 'equitone' systems have identical tonal properties to whole-tone and chromatic scales, despite the presence of syntactical pitch organisation (that is, the presence of principles governing the non-random selection and ordering of pitch class). This calls into question the cognitive mechanisms underlying the perception of non-equal spaced systems, as well as the universality of unequal-stepped scales. This paper aims to bring this evidence, and its implications, to a broader psychological audience.

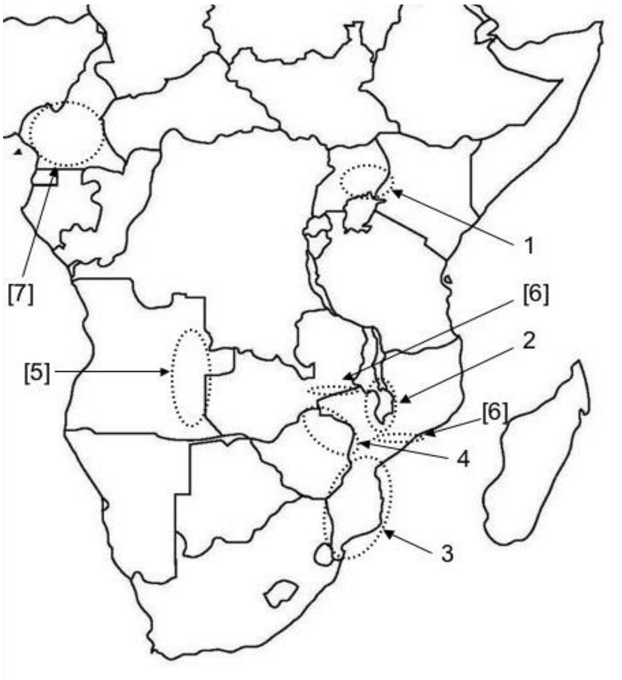

Figure 1. Geographical dispersion of equitone music in sub-Saharan Africa. Numbers refer to the text; bracketed numbers indicate cases where information is less detailed.

Equitone music and IRT

A significant variety of equitone music exists in sub-Saharan Africa, which has hitherto gone unnoticed in the music psychological literature. At present, no large-scale ethnomusicological study exists that focuses primarily on tuning, although case studies of tuning for several specific cultures do exist. The geographical spread of such claims is summarised in Figure 1.

Reports include the Baganda and Basoga (Uganda [1]; Wachsmann, 1950; 1957; 1967; Cooke, 1992), the Asena (Malawi [2]; van Zanten, 1980), the Chopi (southern Mozambique [3]; H. Tracey, 1948), and Sena, Tonga, and Budya (Shona/Korekore) (north-eastern Zimbabwe [4]; A. Tracey, 1970; although see Berliner, 1993 for an alternative account). Other reports, less detailed, include several cultures in eastern Angola ([5]; Kubik, 1985), inhabitants of undefined Zambezi Valley areas ([6]; Kubik, 1985), and the Beti (Cameroon [7]; Kubik, 1985).

Broadly speaking, IRT has three fundamental claims, all of which are rendered impotent by the lack of uniqueness in equitonic systems:

(2) Listeners assume that the first pitch class heard is the tonal centre, until a better candidate is presented (in terms of intervallic information).

(3) In establishing key, listeners rely more on rare, as opposed to common, interval combinations.

(4) Listener judgments of key [pitch organization] are more accurate when rare interval combinations appear in a temporal order that implies or reinforces harmonic movement.

(2) is dependent on the concept of 'tonal centre', and therefore our conception of tonality in the cultures in question. Some level of pitch organisation is present in all the music that has been investigated by the current authors. In some cases, there appears to be some form of hierarchical organisation (e.g. the existence of 'hombe', or 'home' notes, in Chopi *timbila* music). Other cases are less clear, but random ordering of notes is not in evidence (Cooke, pers. comm.). (2) can be rephrased to apply to pitch organisation in general, regardless of whether there is a single tonal centre or some other organisational principle, provided we accept (for the time being) that syntactical relationships are somehow expounded by pitch class relationships. That is, the problem of syntactical orientation remains as long as pitch classes aren't differentiable by means of interval information. The nullification of (3) and (4) follows, although it is clear that (3) is the most important claim regarding structure of tonal systems. (A modified form of (3) might read, 'In terms of orientation with respect to pitch organisation, listeners rely more on rare interval combinations than common interval combinations'.) Without rare interval information, (3) cannot apply to equitone systems.

Pitch cognition in equitone musical traditions: Proposals

Expanding current data

The present analysis is based on what are sometimes fragmentary accounts of the phenomenon of equitone music. Some accounts are also dated, having used possibly inaccurate or inexact techniques in determining tuning of instruments (e.g. sets of tuning forks, differing by 4Hz increments). Also, within each musical tradition, more individual cases need to be used, along with adequate statistical techniques (i.e. not simply descriptive statistics, such as averaging frequency across a number of instruments). All of this is required in determining whether the music is truly equitone, taking heed of complications such as just noticeable difference (JND; Burns, 1999) and tolerance of tuning deviation.

Fortunately, despite encroaching cultural globalisation, in at least two cases—the Chopi in southern Mozambique and the Baganda and Busoga in Uganda—the musical traditions, along with the equitone tuning regimen, still survive today. Thus, adequate data on tuning practices can be assessed more thoroughly.

Frequency/distribution accounts

It is the case that in many (but not all) equitone musical traditions, a fast delivery of notes is common (Wachsmann, 1950; Cooke, pers. comm.). Thus, pitch organisational cues might be handled by sheer distributional frequency, with frequent pitch classes being assigned some syntactical significance (Krumhansl, 1990). With adequate knowledge of the theoretical (e.g., metrical) principles of a musical culture, the creation of simple distributional models would allow some insight into the relationship between pitch organisation and pitch-class distribution.

Patterns and learnt features as cues to pitch organisation

Certain common patterns might function as learnt cues to pitch organisation. For example, when a listener hears a familiar pattern, he may be aware that the first note always has a particular position in a tonal hierarchy (or some similar organisational principle). Assessment of this claim would require an intimate ethnomusicological knowledge of the music in question, providing an opportunity for interdisciplinary investigation.

Secondary musical parameters

Primary (syntactical) musical parameters are those that if altered, would change the fundamental nature or identity of a piece of music (after Meyer, 1989). For example, changing the order of pitches in a melody would change the identity of the melody. Secondary parameters, on the other hand, are features of the music that do not affect identity (e.g., varying loudness does not change a melody into a new one). It may be the case that in equitone music, pitch organisation is signalled primarily by means of secondary parameters (e.g., accents).

Rare intervals are statistical-distributional, not structural

We have considered rarity of intervals in terms of the properties of pitch class sets. However, certain intervals may be rare due to cultural or stylistic norms. For example, it may just be the case that sequences of seconds are uncommon through choice rather than structural constraints. However, when seconds occur, they may have profound syntactical implication.

Tonal set membership is of minimal importance

This point has been left to last, because it is the most fundamental issue that has been brought to the authors' attention. Pitch organisation is an important feature of Western music, as well as the art music of India and the Middle and Far East. However, it may be the case that pitch organisation is simply not a very important syntactical or functional feature in equitone traditions. However, it is apparent that pitch ordering is not random in the equitone music we have encountered, so some form of pitch organisation must be at play—and because of equitonicism, structural-interval information is not a possible cognitive strategy for dealing with pitch organisation.

Psychology and ethnomusicology: interdisciplinary perspectives

The most pressing concerns for an investigation into equitone music are preliminary: more data needs to be collected, basic issues surrounding tolerance of tuning deviation need to be resolved, and the nature of pitch organisation within equitone cultures needs to be firmly established. The cross-cultural nature of the data obviously opens up an opportunity for interdisciplinary collaboration. Cross-cultural work in music psychology has been limited by a number of practical concerns, such as expense and lack of expertise. The resultant paucity of cross-cultural data has arguably led to the tacitly held view that conclusions drawn from Western contexts, subjects, and stimuli are universally applicable in most psychologically important respects. For instance, the idea that unequal-spaced scales are universal (e.g. Brown & Jordania, 2013), and therefore cognitively significant (Trehub, 2000), has been put forward. Such positions are symptomatic of a lack of interdisciplinary dialogue between ethnomusicology and psychology. As has been pointed out in this paper, the assumption of universality is incorrect and the cognitive significance of non-equitone scale structure has to some degree been called into question.

The question of whether analogues of tonal hierarchies are present in all musical traditions is an obvious candidate for fruitful cross-cultural work. Modelling syntactic structure in a psychologically relevant manner would require close interdisciplinary collaboration. Even simple descriptive data, such as some index of pitch-class distribution, would be instructive for researchers hoping to begin to understand structural tendencies within such music.

Pitch organisation is not the only aspect of music that is of interest cross-culturally. For example, there exist reports of the widespread occurrence of absolute pitch, both in equitone traditions and beyond (Wachsmann, 1967; Tracey, 1948). Because many sub-Sarahan African languages are tonal, an opportunity presents itself for further cross-cultural investigations into speech-language relations (after Deutsch *et al*, 2004). Within the scope of investigations into equitonicism, work on tolerated tuning deviance and pitch-interval categorisation will benefit from cross-cultural investigation. In addition, JND has not (to our knowledge) been tested with non-Western subjects. Remaining within the West, psychologists might further investigate equitone cognition with infants (as has already been done by Trehub, 2000), as well as by using implicitly learnt artificial grammars with whole-tone scales to investigate the cognition of equitone systems in adult listeners.

More broadly, investigations into non-Western musical systems prompt questions about the fundamental nature of music-syntactic organisation, in terms of both functionality and purpose. If key features of Western music—deemed to be cognitively important—are absent from other musical traditions, questions arise as to whether fundamental assumptions in our current conceptions of pitch cognition are also culturally bound.

The case of equitone tuning systems therefore provides an opportunity for cross-cultural collaboration. This paper has aimed at bringing the existence of such music to broader psychological attention, as well as highlighting several possible avenues for further research. However, even should the puzzle of equitonicism prove to be trivially solved, we hope that closer interdisciplinary collaboration will become a feature of music psychology in years to come.

Acknowledgements. The authors would like to thank Peter Cooke, Andrew Tracey, Ian Cross, Kofi Agawu, and the Centre for Music and Science Seminar Group for helpful and informative discussions regarding this work.

References

Balzano, G. J. (1982). The pitch set as a level of description for studying musical pitch perception. In Clynes, M. (ed.), 322-351, *Music, Mind and Brain: The Neuropsychology of Music*. New York: Plenum Press.

Balzano, G. J. (1980). The Group-theoretic Description of 12-Fold and Microtonal Pitch Systems. *Computer Music Journal 4*(4): 66-84.

Berliner, P. F. (1993). *The Soul of Mbira: Music and Traditions of the Shona People of Zimbabwe.* Chicago: University of Chicago Press.

Brown, H., Butler, D., & Jones, M. R. (1994). Musical and Temporal Influences on Key Discovery. *Music Perception 11*(4): 371-407.

Brown, S. & Jordania, J. (2011). Universals in the World's Musics. *Psychology of Music 41*(2): 229-248.

Burns, E. M. (1999). Intervals, Scales, and Tuning. In Deutsch, D. (ed.), 215-264, *The Psychology of Music*, 2nd edition. San Diego: Academic Press.

Butler, D. (1989). Describing the Perception of Tonality in Music: A Critique of Tonal Hierarchy Theory and a Proposal for a Theory of Intervallic Rivalry. *Music Perception 6*(3): 219-242.

Butler, D., & Brown, H. (1984). Tonal Structure versus Function: Studies of the Recognition of Harmonic Motion. *Music Perception 2*(1): 6-24.

Cooke, P. (1992). Report on Pitch Perception Experiments Carried out in Buganda and Busoga (Uganda). *African Music 7*(2): 119-125.

Cross, I. (1997). 'Pitch schemata'. In I. Deliege & J. Sloboda (eds.), *Perception and Cognition of Music*. Hove: Psychology Press.

Deutsch, D., Henthorn, T., & Dolson, M. (2004). Absolute pitch, speech, and tone language: Some experiments and a proposed framework. *Music Perception: An Interdisciplinary Journal*, *21*(3), 339-356

Krumhansl, C. L. (1990). *Cognitive foundations of musical pitch*. Oxford University Press, USA.

Kubik, G. (1985). African Tone-Systems: A Reassessment. *Yearbook for Traditional Music 17*: 31-63.

Meyer, L. B. (1989). *Style and Music: Theory, History, and Ideology*. Philadelphia: University of Pennsylvania Press.

Sloboda, J. A. (1985). *The Musical Mind: The Cognitive Psychology of Music.* Oxford: Clarendon Press.

Tracey, A. (1970). The Matepe Mbira Music of Rhodesia. *African Music 4*(4): 37-61.

Tracey, H. (1948). *Chopi Musicians: Their Music, Poetry, and Instruments*. London: Oxford University Press.

Trehub, S. (2000). Human Processing Predispositions and Musical Universals. In Wallin, L., Merker, B., & Brown, S. (eds.), 427-448, *The Origins of Music*. Cambridge, Mass.: MIT Press.

Van Zanten, W. (1980). The Equidistant Heptatonic Scale of the Asena in Malawi. *African Music 6*(1): 107-125.

Wachsmann, K. P. (1967). Pen-equidistance and Accurate Pitch: a Problem from the Source of the Nile. In Finscher, L. & Mahling, C.-H., 583-592, *Festschrift Walter Wiora*. Basel: Bärenreiter-Verlag Kassel.

Wachsmann, K. P. (1957). A study of norms in the tribal music of Uganda. *Ethnomusicology 1*(11): 9-16.

Wachsmann, K. P. (1950). An Equal-Stepped Tuning in a Ganda Harp. *Nature 165*: 40-41.

Pictorial structure of M.K. Čiurlionis's aphoristic piano compositions

Paweł Siechowicz
College of Inter-Faculty Individual Studies in the Humanities, University of Warsaw, Poland
pawelsiechowicz_at_wp.pl

In: Glowinski, D., Lepri ,G., & Pedrina, A. (Eds.)
Proceedings of the Sixth International Conference of Students of Systematic Musicology (SysMus13)
Genoa, Italy, 12-14 September 2013, http://www.infomus.org/Events/SysMus13/index.php

Background. Although Mikalojus Konstantinas Čiurlionis is widely recognized as a painter influenced by music, which has primarily resulted from the large amount of scholarly research regarding his artistic output (see: Goštautas (1994), Kazokas (2009), and Vergo (2010)), his musical output had not received any scholarly attention until the publication of a monograph by Landsbergis (1986) followed by works of Kučinskas (2003) and Holm-Hudson (2004). Outside of his native Lithuania, Čiurlionis's music has attracted little analytical attention, with the notable exception of Eero Tarasti, who dedicated an article to the interrelations of the arts in Čiurlionis's creative output (Tarasti, 1993) as well as two chapters in his latest book (Tarasti, 2012), where the oeuvre of Čiurlionis is placed in the broader context of Tarasti's semiotic theory.

Aims. I will examine the role of contour line in Čiurlionis's paintings and his attitude towards musical line in piano pieces that were composed in parallel with his paintings to reveal their contour-based formal structure.

Main Contribution. For Tarasti (2012) and others, the core of the problem evoked by Čiurlionis's output is "how a painting can be music and music painting" (p. 368). However, I claim that painting cannot be music and music cannot be painting simply for ontological reasons, although surely they can inspire each other. Moreover, as listeners perceive music as music, it must be appreciated as such through musical, not pictorial, means. Nevertheless, I acknowledge the interrelations of painting and music in Čiurlionis's works. My claim is that although the formal structure of particular piano pieces by Čiurlionis are clearly of pictorial origin, they can be appreciated independently from his paintings in a musically viable way. Arguing in favour of this thesis, I will identify the strategies chosen by Čiurlionis to emancipate musical line from the rigors of harmony and rhythm so that it can serve as a subject and basic formal unit of a composition.

Implications. Tarasti (2012) suggested that "close examination of Čiurlionis's work may perhaps one day reveal something central to the problematics of the interrelationships of arts" (p. 368). Indeed, my work reveals some analogies between music and painting that have remained unnoticed elsewhere. However, the main intention is to bring theoretical reflection on Čiurlionis's music back to the realm of sound, where its meaning is constituted in the act of listening. Thus, the interdisciplinary matter of my considerations can be of interest to musicologists, musicians, art critics and historians.

Educated firstly as a composer, Lithuanian – Mikalojus Konstantinas Čiurlionis (1875-1911) achieved posthumous fame as a painter. He owes that success to his extraordinary ability of transferring music into painting. Indeed, he developed his unique style of painting according to the rules of musical composition: polyphony, that is simultaneity of musical lines and repetition and variation of clearly stated themes.

Many have reflected upon the influence of music on Čiurlionis's paintings[1]. Some have pointed out and characterized the relationship between particular paintings and musical pieces (and a literary work in one case)[2]. I would like, however, to follow the example of Kučinskas and Holm-Hudson (2004), who attempted to identify the influence of painting on Čiurlionis's music. Assuming that symmetry is the main rule of visual arts, they looked through Čiurlionis's compositions that were written after the beginning of his artistic studies tracing symmetrical structures that can be called analogous to plane isometries[3]. My attempt has a different starting point, although it reaches a similar conclusion: Čiurlionis's experience of painting changed his understanding of music.

There are two purely formal devices used by Čiurlionis that give his paintings the fantastic atmosphere which reveals his individual style: contour line and repetition of painted objects in augmentation or diminution. Both of them are of musical origin. The importance that Čiurlionis attributed to line stems from the privileged place of melody in the romantic paradigm of music (one can find influences of Chopin and Strauss in Čiurlionis's early musical compositions)[4]. Repetition in turn is constitutive of all the most important musical genres exercised by Čiurlionis: sonata, fugue and variations. Formal as they are, both of these devices can be transferred back to music. The transfer, I will argue, occurred in late aphoristic piano pieces composed between 1908 and 1909.

The examples that I am going to present prove that the relation between music and painting in Čiurlionis's oeuvre was reciprocal (contrary to the interpretation of Landsbergis (1992) who denies the causal connection between Čiurlionis's art studies and the change in his musical style). Čiurlionis's artistic imagination was formed in the world of romantic music, then discovered in the world of painting, later explored in a struggle to give it musical-like structure and finally returned to the world of music. After that artistic journey Čiurlionis "evidently came to see musical lines *as* lines in an abstract, spatial sense" (Holm-Hudson, Kučinskas 2004, 8) but also developed a painting-like idea of musical structure. After giving some attention to the former I will focus more carefully on the latter.

Contour line

Landsbergis (1994) notices a single specific contour that can be found in both Čiurlionis's paintings and musical pieces (p. 469). His observation shows that Čiurlionis's artistic imagination remained constant regardless of artistic medium. It is undisputable that Čiurlionis attached great importance to contour lines in his paintings (see: Forest, The Sun or My Road (I) all painted in 1907, in which he juxtaposed planes of color to emphasize the border line between them)[5]. The importance of contour increased even more when he began his musical paintings entitled "Sonatas" and "Fugues".

The first painted sonata, which after its author's death gained the title "Sonata of the Sun" (1907), is a cycle of four paintings entitled after the usual tempos of four-part sonata cycle: Allegro, Andante, Scherzo and Finale[6]. Allegro itself is divided into three parts corresponding to the parts of sonata form: exposition, development and reprise. All of them are a variation of the same contour, the one in the middle being the biggest and differing from others although at the same time remaining recognizably similar. Importantly, only the shape of contour can give us an impression of the similarity between painted objects. Čiurlionis made use of that principle extensively in numerous paintings in which he shaped trees' crowns, clouds and mountains to resemble human silhouettes.

The importance of contour stems from its emancipation. Čiurlionis's lines stand out from flat surfaces covered with pastel colors and do not follow the rules of linear perspective. They are flat and often float from left to right border of the painting continuous in their wavy motion. In effect, a contour line, which is a formal device of pictorial art, becomes the painting's subject. Hence, Čiurlionis's paintings are self-oriented, in which way they are similar to music. This is how Čiurlionis leads traditionally representational art towards abstraction. Although he always makes his contours resemble some aspects of reality – landscapes shaped either by nature or by people – the resemblances are only another vehicle of giving significance to the contours.

Musical lines

Although Čiurlionis devoted much of his time to painting, he never stopped composing. During the summer of 1908 he was thinking about composing an opera based on Baltic myths, the libretto of which was to be written by his fiancée – young Lithuanian poet Sofia Kymantaitė. He sketched his musical ideas quickly while improvising on the piano. What was left from that ambitious agenda is a set of aphoristic piano pieces usually called preludes and some sketches of scene decorations. The preludes can be divided into two groups: some of them are based on an ostinato in bass voice, others – and these are especially worth our attention – show an interesting attitude of the composer towards musical line[7].

Instead of a simple division on melody and accompaniment, there is an ambiguity as to the role of each voice. The bass voice leads a wavy melody which often expands from a very low to a very high register. Higher voices move in a less continuous way. They do not avoid repetitions and parallelisms. Their lines are shorter and change direction more frequently.

The bass voice does not play a harmonic role – it do not follow triads (see Figure 1.) or changes them to quickly to anchor tonality (see Figure 2.). Higher voices take over the harmonic function forming chords both in basic and arpeggiated form (see Figure 1.). Hence, the musical line led by the lowest voice gains importance. It is displaced from the highest voice – a usual space for melody, but begins in the lowest so that it can develop freely through all of the possible registers. It is continuous and always forms a variant of a wave – a combination of ascending and descending motion.

Figure 1. Prelude VL 319, m. 1-2. The wavy line of the bass voice slowly ascends and quickly falls. Higher voices play harmonic function forming chords in basic and arpeggiated form.

Rhythm is either based on sequences of equal note lengths or on altered groups of eighth notes' duplets and triplets as well as sixteenth notes' quadruplets. In both cases it does not remind of any dance originated rhythmic pattern. Rather, it gives the impression that rhythm is strictly dependent on the motion of musical line.

Figure 2. Bass voice of Prelude VL 318 (m. 1-2) restlessly changes triads without stopping for any repetition.

All of the aforementioned features contribute to the fact that the musical line is freed from the rigors of harmony and rhythm and takes central place in the composition.

Painting-like musical structure

The emancipated line serves as a basic element of musical structure analogous to the painted version of sonata form developed by Čiurlionis within his pictorial cycles. *Allegro* from "Sonata of the Sun" is its perfect example. Contour line of a fantastic city landscape presented at the top of the painting serves here as a subject. It is developed – augmented, repeated, reversed – and then stated in an even clearer form at the bottom. Sun serves here as its counterpoint – a contrasting complement. The developmental dynamics of sonata form, which in its typical musical instance are conditioned by the contrast of its subjects and harmonic tensions, in its painted counterpart are dependent only on the transformations of contour line.

The idea of basing the development of musical form solely on musical line – melody – is therefore clearly of pictorial origin. Čiurlionis, took this idea back to the world of music when later composing some of his aphoristic piano compositions.

In prelude VL 318 the bass voice restlessly flouts through succeeding arpeggiated triads never stopping to repeat any of them. It goes through three principal changes. Its prime form is asymmetrical: it ascends more quickly than it descends (Figure 3.).

Figure 3. The bass voice of Prelude VL 318, m. 2-4. Initial, asymmetrical contour.

Then the melodic contour of the bass is augmented (Figure 4.).

Figure 4. The bass voice of Prelude VL 318, m. 10-14. Augmented contour.

Finally, when it seems that the contour comes back in its prime form, its second half changes, descending more quickly than previously, so that now the melodic contour is nearly symmetrical (Figure 5.).

Figure 5. Bass voice of Prelude VL 318, m. 21-22. Nearly symmetrical, closing contour.

Initial asymmetry of contour triggers its further development. Symmetry of the closing contour, gives conclusion to developmental logic of the form.

A similar formal idea is developed in prelude VL 319. It makes use of two distinctive melodic contours in bass voice. The dynamics are here caused both by the asymmetry of initial contour (slow ascension and rapid descent of the voice) and by the contrast between the two contours. The conclusion is reached by combining both of the contours in a new, symmetrical one (Figure 6.).

Figure 6. Evolution of bass voice of Prelude VL 319: m. 1-2, 2-5 – first contour and its augmentation; 9, 10-12 – second contour and its development; 17-19; 19-21 – combinations of two contours.

A static variant of the idea can be found in Prelude VL 324 (Figure 7.). Here a musical line which forms a symmetrical wave ranging from very low to very high register undergoes only slight changes during the musical process. Certain dynamism is evoked by the other voices intertwined with the wave either enforcing or contradicting its movement.

Figure 7. Prelude VL 324: m. 1-2. A symmetrical wave begins under the lower staff, reaches its peak over the higher and comes back to its starting point.

The three aforementioned preludes stand out considerably from others composed at that time. The others were based on the ostinato figures of the bass voice and hence do not employ a line-based form. In some of them however, noticeably VL 250, VL 327, VL 329 and VL 331, bass figures are longer and form a variant of a wavy line. All of the pieces express Čiurlionis preoccupation with linearism, an interest in imitational polyphony and an abundance of characteristic descending lines of melody which can be traced back to his earlier compositions.

Conclusion

Three aphoristic piano pieces that make structural use of musical line were composed after the experience of the first painted sonatas – in the period when Čiurlionis was preoccupied with thoughts about composing an opera. That new project must have triggered his eagerness towards experimentation with musical material. Encouraged by his successful artistic transfer of musical structure to painting, he attempted to give the structure of his paintings to a musical piece.

The effect of his endeavors is now performed by pianists who need to answer the tricky question of how to treat the wavy line of a bass voice[8]. Landsbergis (2004) notices in the endnotes that Čiurlionis usually wrote down only notes, without any hints for the performer. Therefore, in his edition Landsbergis suggests articulation, phrasing and tempos that are appropriate for each piece. My considerations show that pianists attempting to perform Čiurlionis compositions need to discover a whole new world of musical imagination which remains in a close relationship with the world of painting. Remembering that most of the pieces are of improvisational origin and knowing that what they are about is actually a musical line, encourages experimentation with tempo rubato and changes in traditional voice hierarchy.

As the music manifests itself only in the realm of sound, the pianistic interpretation of Preludes is needed to appreciate them. The uniqueness of Čiurlionis's compositional ideas and the lack of any indications for performer left by the composer, however, make the interpretation very difficult. Editor's hints blur the image even further[9]. Čiurlionis's piano compositions are therefore a field where musicologists and musicians should inspire each other in a struggle to make the intricacies of Čiurlionis's music understandable to the listener.

References

Čiurlionis, M.K. (2004). *Kūriniai Fortepijonui. Visuma/ Compositions For Piano. Completed.* Ed. V. Landsbergis. Kaunas: Edition J. Petronis.

Čiurlionis, M.K. (2011). *Piano works (URTEXT).* Ed. D. Kučinskas. Tokio: Ars nova.

Eberlein, D. (1985), *Čiurlionis, Skrjabin und osteuropäische Symbolismus*. In Karin von Maur (ed.) *Vom Klang der Bilder*, München: Prestel-Verlag, pp. 340-345.

Fedotov, V. (1995). "Polyphony in the Paintings of M. K. Čiurlionis." Leonardo 28/1: 53-56.

Goštautas, S. (1994). *Čiurlionis: Painter and Composer. Collected Essays* and Notes 1906-1989. Chicago: The Institute of Lithuanian Studies.

Holm-Hudson K., & Kučinskas D. (2004). Plane isometries in the music of M.K. Čiurlionis. In R. Parncutt, A. Kessler & F. Zimmer (Eds.), *Proceedings of the Conference on Interdisciplinary Musicology (CIM04).* Graz: Karl-Franzens-Universität Graz.

Kazokas, G. (2009). *Musical Paintings. Life and Work of M.K. Čiurlionis (1875-1911)*, Vilnius: Logotipas.

Kučinskas D. (2001), *Muzyka Čiurlionisa [The music of Čiurlionis]*, In *Mikalojus Konstantinas Čiurlionis: twórczość, osobowość, środowisko [Čiurlionis: work, personality, background],* Kaunas: Nacionalinis M. K. Čiurlionio dailės muziejus, pp. 35-42.

Kučinskas, D. (2003). *Three etudes on music of M.K. Čiurlionis*. Kaunas: Kauno technologijos universitetas.

Kučinskas, D. (2004). Symmetry in creative work of Mikalojus Konstantinas Čiurlionis, http://www.mi.sanu.ac.rs/vismath/visbook/kucinskas/index.htm.

Landsbergis, V. (1986). Čiurlionio muzika. Vilnius: Vaga.

Landsbergis, V. (1992). *M.K. Čiurlionis: Time and Content*. Vilnius: Lituanus.

Landsbergis, V. (1994). *Symbolism of Sounds.* In Goštautas, S. (ed.). *Čiurlionis: Painter and Composer. Collected Essays* and Notes 1906-1989. Chicago: The Institute of Lithuanian Studies.

Szerszenowicz, J. (2008), *Inspiracje plastyczne w muzyce [Music Inspired by Visual Arts]*, Łódź: Akademia Muzyczna im. K. i G. Bacewiczów.

Tarasti, E. (1993). Mikalojus Constantinas Čiurlionis and the interrelationships of arts. *Semionordica*. *Vols. 1-2.* Odense/Imatra: Nordic Associations of Semiotics Studies.

Tarasti, E. (2012). *Semiotics of Classical Music. How Mozart, Brahms and Wagner talk to us.* Berlin/Boston: De Gruyter Mouton.

Vergo, P. (2010). *The Music of Painting. Music, Modernism and the Visual Arts from the Romantics to John Cage.* London: Phaidon Press.

---

[1] An exhausting anthology of scholar reflection regarding Čiurlionis's oeuvre was collected and edited by Goštautas (1994). Among others, the collection presents texts of Viecheslav Ivanov, Valerian Chudovsky, Nicolai Vorobjov, Aleksis Rannit, Vytautas Landsbergis and Genovaitė Kazokas. As the influence of music on painting is the most striking feature of Čiurlionis's oeuvre, almost all of authors comment on that subject. Landsbergis's "The Spring Sonata" and Kazokas's "The First Painted Fugue" dedicated to the "Fugue" from 1908 are perhaps the most thorough attempts of explaining that influence. Tarasti (2012) proposes another, more convincing, explanation of the way in which musical form of fugue was transferred to that particular painting.
Another interesting proposition is made by Fedotov (1995) who uses musical term of polyphony metaphorically to describe the fact that Čiurlionis's paintings simultaneously evoke contrasting impressions: of the real and the unreal, of the small and the large, of night and day etc. Čiurlionis also appears in the broader context of the relation of music and pictorial modernism in works by Szerszenowicz (2008) and Vergo (2010).

[2] Eberlein (1985) points out the analogy between a three-part piano cycle "The Sea" and a painted triptych "Sonata of the Sea". Kučinskas (2001, 2004) argues that musical "Variations on the theme EASACAS", painted cycle "The Sparks" and literary poem "Psalm" all created in 1906 share the same formal structure based on mirror symmetry.

[3] Holm-Hudson and Kučinskas (2004) found numerous examples of translation, mirror reflection and rotational symmetry in Čiurlionis's piano pieces. Among their

discoveries is the amusing rotational symmetry of the wavy line which forms a spine of Prelude VL 324.

[4] More about stylistic features of Čiurlionis's music can be found in the article of Danutė Staškievičius in Goštautas (1994).

[5] Paintings can be seen under the following addresses.
Forest: http://ciurlionis.eu/paveikslas/miskas-2/
The Sun: http://ciurlionis.eu/paveikslas/saule/
My Road: http://ciurlionis.eu/paveikslas/mano-kelias-i/
(Information accurate as of 28.07.2013).

[6] See: http://ciurlionis.eu/en/painting/info/?ciklas=1. (Information accurate as of 28.07.2013).

[7] I take under consideration compositions that were composed after the cycle "The Sea" in the second half of 1908 and first months of 1909. The fourteen preludes were gathered under the name "Sea preludes" in the edition of Landsbergis (2004).

[8] The most representative selection of Čiurlionis piano music currently available was published by Celestial Harmonies (19923-2) in a 5 CD box set "The complete piano music of Mikalojus Konstantinas Čiurlionis" featuring pianists: Nikolaus Lahusen and Rokas Zubovas.

[9] Therefore, urtext edition of Čiurlionis's piano pieces edited by Kučinskas (2011) is especially worth recommendation.

Perceiving rhythm complexity under different body movements: Can people tell the difference between each rhythm?

Li-Ching Wang
Centre for Music and Science, Faculty of Music, University of Cambridge, UK
Lcw36_at_cam.ac.uk - http://www.mus.cam.ac.uk/CMS/home/people/lcw36/

In: Glowinski, D., Lepri, G., & Pedrina, A. (Eds.)
Proceedings of the Sixth International Conference of Students of Systematic Musicology (SysMus13)
Genoa, Italy, 12-14 September 2013, http://www.infomus.org/Events/SysMus13/index.php

Abstract. Although the relationship between metrical structure and body movement has been investigated in various ways, whether or not people perceive rhythms differently under various body movements has received less attention. To explore how rhythms activate different types of movements and rhythm perception accompanied by these movements, the present experiment asked participants to judge the complexity of 12 rhythms by giving score ranging from 1 (simple) to 5 (complex) under 5 conditions: sitting still without movements; moving whatever they want; nodding head on beat; tapping right hand on beat; and tapping right foot on beat. The consistency of rhythm perception and perceived rhythm complexity were analysed through the scores given by participants and the body movements in the condition "moving whatever they want" were analysed to examine the natural tendency of movements. The results showed that the consistency of simple rhythms judgment is higher than that of complex rhythm judgment. The perception of complexity is not only affected by body movement, but also by individual preference of movement patterns and enjoyment. Body movements on beat may help some participants to perceive the rhythms easier, but may make the task more difficult for some participants because they had to spend more energy to deal with the movement.

Keywords. Rhythm complexity, body movement, perception, enjoyment

Why many people tend to move with music has long been a question that has interested musicologists, scientists, and other professionals. A possible hypothesis is that the feedbacks caused by body movements affect the perception of music (Chen et al. 2006; Phillips-Silver and Trainor 2005).

Background

It is commonly observed that people move to music voluntarily. Chen et al. (2006) suggested that among musical elements, metrical structure and the sense of beat play especially important roles in the activation of body movement with rhythm through auditory-motor interactions. Most research on the relationship between body movements and music address metrical structures and rhythm. Phillips-Silver and Trainor (2007) found that simply tapping the foot in different ways results in varying perceptions of rhythm; even being moved rhythmically by adults affects the rhythm perception of infants (Phillips-Silver and Trainor 2005).

To see how music activates body movements of listeners, Toiviainen et al. (2010) define the embodiment of music by exploring the hierarchical expressions of body movements toward the metrical structures of music.

The relationship between music and body movements has been investigated through various ways. It is suggested that different movement patterns may result in difference perception of metrical structures, but how people perceive other elements; such as rhythm complexity, under various body movements has not been thoroughly discussed.

Aims

This experiment aims to explore whether or not people perceive the complexity of different rhythms and whether or not patterns of movement influence ratings of rhythmic complexity.

Method

Participants

Twenty-four right-handed participants with normal hearing and motor abilities were recruited.

Stimuli

To analyse rhythm complexity, Shmulevich & Povel (2000) compared three informatic models proposed by Tanguiane (1993), Lempel & Ziv (1976), and Povel & Essens (1985) to caculate the complexity of a rhythm set followed by his own psychological method of analysis (Shmulevich & Povel 2000).

12 of the 35 rhythms from Shmulevich & Povel (2000) were used to generate new stimuli (See Table 1), in two sets of six, representing high and low complexity. Each original stimulus contains only 8 beats in Shmulevich & Povel's experiment. In present experiment, each of the original stimuli was repeated 3 times so participants can move with it more easily. The final set of stimuli were played three times to each participant in random order.

<table>
<tr><th>No.</th><th>Pattern</th><th>Comp.</th><th>No.</th><th>Pattern</th><th>Comp.</th></tr>
<tr><td>1</td><td>|||||..||.|.|...</td><td>1.56</td><td>19</td><td>||..||.||||.|...</td><td>2.64</td></tr>
<tr><td>2</td><td>|||.|.|||..||...</td><td>2.12</td><td>20</td><td>||..||.|||.||...</td><td>3.24</td></tr>
<tr><td>3</td><td>|.|||.|||..||...</td><td>2.08</td><td>21</td><td>|||||.||.|..|...</td><td>3.08</td></tr>
<tr><td>4</td><td>|.|.|||||..||...</td><td>1.88</td><td>22</td><td>||||.|..|||.|...</td><td>3.04</td></tr>
<tr><td>5</td><td>|..||.|.|||||...</td><td>1.80</td><td>23</td><td>|||..||.|||.|...</td><td>3.04</td></tr>
<tr><td>6</td><td>|||.|||.||..|...</td><td>2.44</td><td>24</td><td>|.|||..|.||||...</td><td>2.56</td></tr>
<tr><td>7</td><td>|.||||.||..||...</td><td>2.20</td><td>25</td><td>|.|..||||.|||...</td><td>2.56</td></tr>
<tr><td>8</td><td>||..|||||.|.|...</td><td>2.56</td><td>26</td><td>||||.|.|..|||...</td><td>2.84</td></tr>
<tr><td>9</td><td>||..|.|||.|||...</td><td>3.00</td><td>27</td><td>||.|||.|..|||...</td><td>3.60</td></tr>
<tr><td>10</td><td>|.|||.||||..|...</td><td>2.04</td><td>28</td><td>||.|..|||.|||...</td><td>2.68</td></tr>
<tr><td>11</td><td>|||.||..||.||...</td><td>2.76</td><td>29</td><td>|.||||.|..|||...</td><td>3.28</td></tr>
<tr><td>12</td><td>||.||||.|..||...</td><td>2.72</td><td>30</td><td>|..|||||.||.|...</td><td>3.08</td></tr>
<tr><td>13</td><td>||.||.||||..|...</td><td>3.00</td><td>31</td><td>||||.|||..|.|...</td><td>3.52</td></tr>
<tr><td>14</td><td>||..||.||.|||...</td><td>3.16</td><td>32</td><td>||||..||.||.|...</td><td>3.60</td></tr>
<tr><td>15</td><td>|..|||.|||.||...</td><td>2.04</td><td>33</td><td>||.||||..||.|...</td><td>3.04</td></tr>
<tr><td>16</td><td>||.||||.||..|...</td><td>2.88</td><td>34</td><td>||.|..|||||.|...</td><td>2.88</td></tr>
<tr><td>17</td><td>||.|||.|||..|...</td><td>2.60</td><td>35</td><td>|.|..|||.||||...</td><td>3.08</td></tr>
<tr><td>18</td><td>||.|||..||.||...</td><td>2.60</td><td></td><td></td><td></td></tr>
</table>

Table 1. The 35 rhythm patterns used in Shmulevich & Povel's (2000) study with their mean judged complexity. Each vertical line represent a tone and each dot represents a rest. The rhythms used in present experiment are the six rhythms with the lowest complexity (1, 5, 4, 10, 15, 3) and the six rhythms with the highest complexity (27, 32, 31, 29, 20, 14).

The stimuli were generated using mac Garage Band software with a tempo of 126 BPM. Previous studies have suggested that there seems to be a natural preference for a tempo of 120 BPM (Van Noorden & Moelants 1999; Repp 2005), and experiments in terms of tapping have showed the hierarchy of body movements accompanying music of tempo around 120 (Toiviainen et al. 2010). In present experiment, stimuli are with tempo of 126 BPM which was the same in Toiviainen et al's (2010) study.

Apparatus

The stimuli were played through a computer which participants were then asked to key their answers into.

Three audio-video cameras were used to film the body movements of each participant. Two of them were set at 90º in elevated positions with the subject in the centre and one camera under a desk on which a tapping response pad was situated focusing on the foot.

Procedure

Participants were instructed to take their shoes off before the experiments started in order that the foot movements could be observed clearly.

This experiment manipulates three variables: rhythmic complexity of the stimuli, body movements of the participants and the orders of the movements assigned to participants. Stimuli are defined in 2 levels of rhythmic complexity and the participants need to perform 5 levels of body movements (including a "no-movement" condition). Participants thus undertook the experiment either starting with the no-movement condition or with a movement condition (yielding 2 different orders as a between-subjects variable) (See Table 1.). Details are described below.

All 12 stimuli used in this experiment were selected from the set in Shmulevich & Povel's (2000) study. Six of them represent high complexity and another six, low complexity.

Participants were asked to judge the complexity of each rhythm in the following 5 conditions: *no-move* (sit still), *move-head*, *move-hand*, *move-foot* and *move—whatever* when listening to the rhythms. In whichever condition, participants were required to sit on a chair in front of the computer through which they complete the tasks. Tasks are described as follow:

1. No-move (sit still): Participants were asked to sit still without any body movements when listening to stimuli.
2. Move-head: Participants were

instructed to nod their heads per beat with the stimuli. The range of the movement was limited in the coronal plane(flexion and extension) within 30 degrees.

3. Move-hand: Participants were instructed to tap per beat with right index finger with their wrists resting on a wrist-rest to limit degrees of freedom of movement of the arm with the stimuli. Movements were limited in coronal plane (flexion and extension) within 90 degrees.
4. Move-foot: Participants were instructed to tap with their right foot per beat with the stimuli. Movements were limited in coronal plane with their heels attaching the ground (ankle dorsiflexion and plantar flexion). Thus, only ankles and toes can move.
5. Move-whatever: Participants were instructed to move with the stimuli freely, using whatever body parts in whatever way they prefer.

In *move-whatever* sub-condition, participants were instructed to move with the stimuli freely, using whatever body parts in whatever way they preferred. In other sub-conditions, participants were only allowed to move one of their body parts with the stimuli as instructed. They also had to limit their movement frequency to one move per beat.

All subjects were randomly assigned to start with either *move* or *no-move* conditions. Participants assigned to start with move condition always started with *move-whatever* , followed by the other three *move* sub-conditions in random order. After accomplishing all *move* sub-conditions, they completed the *no-move* condition. Participants assigned to *no-move* condition did *no-move* condition first followed by *move* condition starting with *move-whatever*, then the other three sub-conditions in random order. Table 2 shows two of the possible orders for a subject assigned to *move* condition first and another subject assigned to *no-move* condition first.

Data Analysis

The experiment was designed to inspect the effect of body movements on rhythm perception. Both consistency of rhythm perception and perceived rhythm complexity were analysed. To analyse consistency of rhythm perception, the difference between the complexity scores that each participant gave to the two occurrences of the same stimulus in each task was calculated. The data were then analysed by means of a Two-way ANOVA using SPSS software. Independent variables include two within-subject variables, "stimulus structure" (simple vs complex rhythm) and "movement" (no move, move-whatever, move-head, move-hand, move-foot).

Scores given to each stimulus were used as perceived rhythm complexity. To examine how rhythms activate movements, participant's body movements in the task *move-whatever* were analysed. A chart was created with details of the ways, and the timing with which, each participant moved with each stimulus; for example, the range of each body part moving with stimuli and the beats on which those movements happened. These details were the basic resources to categorise movements of participants in 2 types of pulse – on beat or not on beat (See table 2). 'On beat' includes moving on either up beat or down beat, every beat and every two beat. The rest of the ways participants move, including sitting still without movements, are defined as 'not on beat'.

According to participants' self-report and my observation about how they enjoyed moving with rhythms in *move-whatever* task, I gave each of them an 'enjoyment' score ranging from 1 to 3. Group 1, 2 and 3 each represents participants who felt more comfortable sitting still than moving, those who felt the same in two situation and those who felt more comfortable moving than sitting still (Table 3).

	Movement Pulse	Number of Participants
1	On beat	4
2	Not on beat	20

Table 2. Description of pulse of movements and the numbers of participants in each group.

	Enjoyment	Number of Participants
1	Feeling more comfortable sitting still than moving with stimuli	6
2	Feeling similar in sitting still and moving with stimuli	8
3	Feeling more comfortable moving with stimuli than sitting still	10

Table 3. Description of enjoyment of participants and the numbers of participants in each group.

Further analysis of movements in *move-whatever* task and participants' enjoyment showed that participants demonstrated different preference in terms of how they move. The way they feel comfortable to move with stimuli may affect their perception of rhythms. Thus, I included two more between-subject factors in analysis of perceived rhythm complexity. They are 'pulse' (on beat vs none) and enjoyment (enjoy move, neutral, not enjoy move)

Complexity scores given by participants were then analysed using a repeated measures mixed ANOVA with two within-subject variables, "stimulus structure" (simple vs complex rhythm) and "movement" (no move, move-whatever, move-head, move-hand, move-foot), and three between-subject variables "task order" (sit still/move vs move/sit still), "pulse" (on beat vs none) and "enjoyment" (enjoy move, neutral, not enjoy move) to see if these affected their judgments of stimuli complexity when completing each task.

Bivariate (Pearson) Correlation was used to explore the relationship between scores given by participants and those reported in Schmulevish and Povel's (2000) article.

Results

Consistency of the complexity scores given by participants

A Two-way ANOVA conducted to compare the effect of rhythm structure and movement type on consistency of participants' judgments shows a highly significant effect of structure which means there is difference between the consistency of judging simple and complex structures, $F_{(159.158,\ 6.920)} = 3.14$, $p=0.005$ (Greenhouse-Geisser corrected). The mean difference between the scores (i.e., the consistency of the scores) given to simple rhythms (0.53) is lower than that given to complex rhythms (0.74) which means the consistency of judging simple rhythms is higher than that of judging complex rhythms. The remaining factor, "movement", did not affect consistency.

Complexity scores given by participants

A repeated measures mixed ANOVA conducted to compare the effect of rhythm structure and movement type on rhythm complexity perception revealed a main effect of rhythmic structure, $F(1, 14)=19.672$, $p=0.001$ (<0.05) indicating participants could tell the difference between simple and complex rhythms. There is an interaction effect of movement and pulse, $F(4, 11)=5.888$, $p=0.011$ (<0.05). Test of between subjects effects revealed that enjoyment has a marginal effect, $F(2, 14)=10.895$, $p=0.043$ (<0.05). There is no significant difference between complexity scores given by participants under different movement tasks ($p=0.108 > 0.05$), but the order in which participants accomplished the tasks did have an effect.

Participants who were asked to do *move* tasks first and those who were asked to do *no-move* task first showed different results in judging complexity of rhythms in five tasks (Figure1).

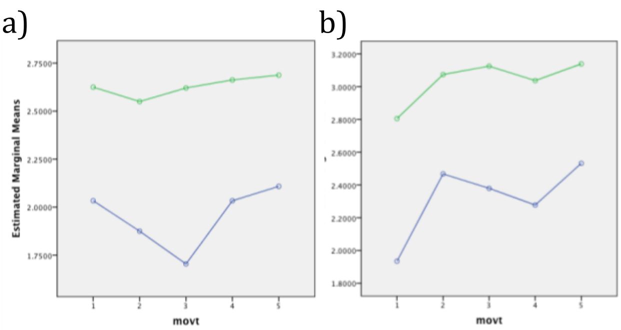

Figure 1. Average complexity scores given to simple (green lines) and complex rhythms (blue lines) in five tasks (1: no-move, 2: move-whatever, 3: move-head, 4: move-hand and 5: move-foot) by a) participants who started the task from 'no-move' task and b) participants who started the task from 'move' tasks.

Through analysing the movements participants performed in *move-whatever* task, two kinds of pules types were observed – 'on beat' and 'none'. Participants who tended to move with rhythms on beat also showed different results from participants who did not move on beat (Figure 2).

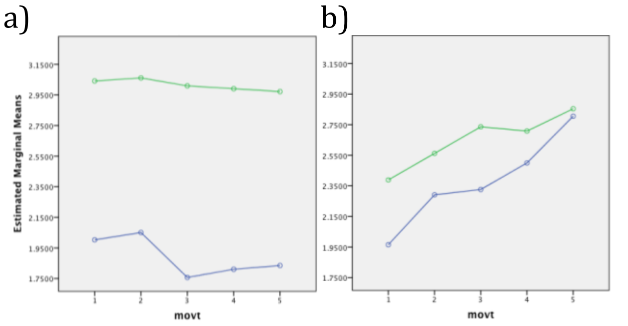

Figure 2. Average complexity scores given to simple (green lines) and complex rhythms (blue lines) in five tasks (1: no-move, 2: move-whatever, 3: move-head, 4: move-hand and 5: move-foot) by a) participants who tended to move on beat with stimuli in 'move-whatever you like' task and b) participants who tended not to move on beat.

It is observed that those who felt more comfortable not to move have shown a different pattern than the other two groups. They gave lower scores in both simple and complex rhythms when doing all of the tasks than participants who preferred to move did (See Fig 3).

Bivariate (Pearson) Correlation shows the correlation coefficient between complexity scores given by participants and those calculated in Schmulevich & Povel's (2000) paper in every task is significant at the 0.01 level (2 tailed). *Move-head* task has the highest correlation coefficient (r=0.457) followed by *move-hand* (r=0.441), *move-foot* (r=0.436) and *no-movement* (r=0.433). *move-whatever* task has the lowest correlation coefficient (r=0.415).

Discussions

It seems like the average consistency of the complexity scores given to the stimuli was lowest when participants performed the *move-whatever* task although statistically this difference is not significant. Even the participants reporting more enjoyment were not necessarily more consistent in scoring this task than other participants.

In all five tasks, the complexity scores given by participants correlate to the scores reported in Schmulevich and Povel's (2000) article. *Move-head* scores the highest while *move-whatever* the least.

In terms of complexity scores given by participants when performing five tasks, it seems like *move-whatever* does not necessary make participants feel each stimulus becomes easier. Repeated Measures ANOVA showed the difference among each task is not significant. When looking into average scores, *move-whatever* task may even have made participants experience the stimuli as slightly more complex than in the *no-move* task. The difference between the average score given to simple and complex stimuli shows that participants may perceive the smallest difference between two groups of stimuli when moving whatever they like, and may perceive the largest difference when nodding their head.

The results revealed that participants can tell simple rhythms from complex rhythms regardless of the order of movement tasks they were instructed to do and the type of movements they preferred. It is observed that participants who started the tasks with *no-move* and *move* did show different patterns in complexity perception. There is an order effect, but not that they felt tasks became increasingly easier as they progressed. Both groups gave lower scores to simple rhythms in the second than first, and in the third than the second task they did, but higher scores in the fourth than the third task. Participants who did *no-move* task first gave simple rhythms in the last task they did – *move-foot* highest scores while participants who did *move* tasks first gave simple rhythms in the latest task – *no-move* lower scores. Simple rhythms perceived by participants who started with *no-move* task when moving head received significantly lowest scores. In terms of complex rhythms, the scores given showed a different pattern. Scores given by participants who did *no-move* task first seem to be more similar by those given by participants who did *move* tasks first.

According to most participants' feedback, moving with stimuli made them experience the complexity of each stimulus differently and moving with the stimuli made them appear less complex. Some even pointed out that sitting still was the most difficult task. On the other hand, some participants felt uncomfortable when moving with stimuli. They also displayed a degree of uncertainty as to how to move at the beginning of the experiment. After being encouraged to move, their facial expressions suggested that they were actually reluctant to do so. Although statistically the complexity scores given in five tasks do not differ significantly, different participants may experience the stimuli differently.

Participants come from different backgrounds. Some of their movements are relevant to their music experience. For example, conducting-like movements, drumming-like, piano playing-like movements and (disco) dancing like movements. Twenty out of 24 participants nodded their heads with stimuli when they were asked to move whatever they liked and their head movements all happened on beat – whether down-beat, up-beat or every beat. Nodding head seem to be the most natural response to stimuli. Besides, although there is no statistically significant difference among tasks in terms of consistency and complexity scores given, the average consistency in *move-head* is the highest, and this task also received the scores that showed the highest perceptual variance between simple and complex stimuli. Furthermore, the correlation between Schmulevich & Povel's (2000) scores and the scores given in *move-head* task is the highest among the five tasks. This may imply participants could tell the difference between each stimulus most clearly in this mode. Vestibular stimuli resulting from nodding head may contribute to this difference.

The reason why participants seemed not to be able to tell the difference between each stimulus better when they were asked to move whatever they like than in other tasks may be due to the possibility that they were distracted by their own movements. Some of the participants' movements were on time with beats or rhythms, but some others were vague. Hierarchy of movements was observed in some of the participants; for example, tapping fingers on every beat, and at the same time nodding head on the down-beat. Some used head or foot as a reference tapping on the beat, and at the same time tapping fingers with the rhythms. Some participants added ornamentation when tapping with rhythms, and emphasized the beats in the end of each stimulus or the syncopation parts.

Another phenomenon observed is that some participants' movements were very 'rigid'. This may be due to the nature of the stimuli as isolated beats.

Therefore, I not only categorised all the participants into two types of pulse – moving on beat or not, but also grouped them into three kinds – enjoying moving more than sitting still, enjoying sitting still more than moving, and enjoying both the same.

Participants who tended to move on beat gave more homogeneous complexity scores to both simple and complex rhythms in five tasks than participants who did not move on beat. It seems to be obvious that participants who preferred to move 'on beat' perceived simple rhythms easiest in *move-head* task, and they also perceived a much bigger difference between simple and complex rhythms than participants who tended not to move on beat did. Participants who did not move on beat perceived rhythms to be most simple when they did need to move. Perhaps it is because they were allowed not to move on beat in *move-whatever* task, they perceived rhythms to be most easy in this task of all the *move* tasks. Besides, they perceived simple and complex rhythms to be with very similar complexity when they were doing *move-foot* task. These may be due to the fact that moving with rhythms on beat may be challenging for them they thus had to be more focused on their movements. For them, moving on beat may be unnatural, especially tapping their foot on beat.

In terms of enjoyment, participants who did not enjoy moving with stimuli gave significantly lower scores to both simple and complex rhythms in all tasks than others. The results in *move-whatever* and *move-head* tasks even showed that participants who did not enjoy moving judged complex rhythms as slightly simpler than simple rhythms judged by other participants and they gave simple rhythms in *move-head* task particularly low scores. It is also observed that participants who enjoyed moving gave significant higher scores to both complex and simple rhythms in *move-whatever* task than to those in *no-move* task while those who did not enjoy moving gave similar scores in both tasks. Possibly, it is because they were allowed to sit still when doing *move-whatever* task so those who felt uncomfortable to move did not necessarily need to move, but those who preferred moving were not allowed to move when accomplishing *no-move* tasks. Moving head may be more natural for most participants, even for those who felt reluctant to move; while moving hand or foot may irritate them. Thus, rhythms were judged as more complex in *move-hand* and *move-foot* task by participants who did not preferred moving.

The reason why people move with music naturally may be because body movements accompanying rhythms enable them to perceive music differently. It is not necessary that body movements render the rhythms more easily perceivable. For some, listening to rhythms accompanying body movements may be a challenge resulting in the rhythm being perceived as more complex. Nevertheless, body movements provide an opportunity for listeners to utilise music in different ways.

Acknowledgment

Special thanks to the Centre for Music and Science, University of Cambridge and Wolfson College, Cambridge, for their generous support.

Reference

Chen, J. L., Zatorre, R. J., & Penhune, V. B. (2006). Interactions between auditory and dorsal premotor cortex during synchronization to musical rhythm. *NeuroImage, 32*(4) 1771-1781.

Phillips-Silver, J., & Trainor, L.J. (2007), Hearing what the body feels: auditory encoding of rhythmic movement. *Cognition*, *105,* 533-546.

Phillips-Silver, J., & Trainor, L.J. (2005), Feeling the beat: movement influences infants' rhythm perception. *Science, 308,* 1430.

Toiviainen, P., Luck, G., and Thompson, M. R. (2010). Embodies meter: hierarchical eigenmodes in m.usic-induced movement. *Music Perception, 28* (1) 59-70.

Van Noorden, L., Moelants, D. (1999). Resonance in the perception of musical pulse. *Journal of New Music research*, 28(2), 43-66.

Repp, B. (2005). Sensorimotor synchronization: a review of the tapping literature. *Psychonomic Bulletin & Review, 12,*(6) 969-992.

Shmulevich, I., & Povel, D. (2000). Measures of temporal pattern complexity. *Journal of New Music Research, 29,* 61-60.

Tanguiane, A.S. (1993). *Artificial Perception and Music Recognition.* Berlin: Springer-Verlag.

Lempel, A. and Ziv, J. (1976). On the complexity of finite sequences. *IEEE Transactions on Information Theory*, 22 (1) 75-81

Povel, D.J. & Essens, P.J. (1985). Perception of temporal patterns. *Music Perception, 2*, 411-441.