Composing Social Interactions for an Interactive-Spatial Performance System

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ABSTRACT

This paper describes a recent composition, *No More Together*, in which performers' interactions directly influence the sound of the piece. The composition provides a structure for group interactions, and is performed with the *on-body* and *in-space* components of 'PESI', an interactive spatial performance system. Our composition attempts to compose social interactions, drawing upon notions of *participatory sense-making*, and the idea that these interactions are best construed as emergent systems, possessing their own internal dynamics. The composition is contextualised as part of the repertoire for the PESI system, exploring embodied, social and spatial interactions in sound and music computing.

1. INTRODUCTION

Implicit in any interactive system is a model for what constitutes interaction. Contemporary theories of social interaction offer new models for understanding social interactions, portraying interaction processes as autonomous, dynamic systems [1]. Group musical performances are unique social and collaborative environments, supporting a diverse range of interactions and group or individual goals. Novel technologies in sound and music computing, along with developments in human computer interaction, have brought about new possibilities for both designing and studying the social aspects of interactive performance systems [2]. The composition presented here explores these contemporary theories about the nature of these interactions.

This paper discusses the thinking behind a composition of a piece for an interactive, spatial and collaborative performance system developed as a part of the PESI research project. The system has unique affordances through the way it relates sonic, social and spatial interactions. Our composition represents an effort to develop a repertoire for this novel performance system which engages with these affordances. The composition consists of several components: the PESI system itself, the mappings (that relate performers movements to the manipulation of sounds), a set of nine audio samples and a short text score. Unlike what

might often be understood by a musical score, our score attempts to compose social interactions rather than specific arrangements of sounds.

PESI is an interactive-spatial performance system that consists of two main parts; *on-body* and *in-space* (figure 1). We have previously described and presented the technical architecture in [3, 4] . Our discussion there focused on the technical details of the system. The process of composing for its affordances discussed here. The system is designed for co-located collaboration, encouraging reflections about space and movements. The combined *on-body* and *in-space* components create an environment wherein musicians are not only free to move and interact with each other but in which their social interactions contribute to the sonic outcome.

This paper is structured as follows. Section 2 discusses the related work and section 3 defines models for social interaction and participatory sense-making which resonate with our experiences of group improvisation and music-making. Section 4 describes the PESI interactive spatial performance system itself. Section 5 presents our composition, *No More Together*, in detail and how it relates to the affordances for interaction in the PESI system. In section 6 we report upon a performance, and describe the way in which we engage with interaction theory through the composition. We indicate our future work and conclude the paper in section 7. A video of the performance is available at `http://vimeo.com/63524617`.

2. RELATED WORK

We have seen in the sound and music computing field a range of design strategies for enabling different types of interaction and collaboration in art and music making, along with a range of proposals for what form musical interactions can take, which is expanded to include those interactions that do not directly affect the sound- producing actions [5–7].

Some, such as Nick Bryan-Kinns Daisyphone, have specifically addressed the issue of collaboration. The Daisy-Phone allows players to modify loops without being in the same space, and Bryan-Kinns explores the social and musical aspects of their collaborations and interactions. Some of the notions explored in DaisyPhone, such as identity, *mutual awareness, mutual modifiability*, and localization of sounds, have informed the design of PESI. [8]. Like the DaisyPhone, Smules Ocarina is an iPhone instrument which facilitates remote collaboration and musical-social

interaction, allowing one to hear other Ocarina players throughout the world [9].

Similar to the PESI system, Le Groux and Verschure describe The SMUSE, an interactive performance system which applies ideas of emergence and situatedness, asking questions about cognition whilst still being a creative tool [10]. Their system differs from our own work in that the computer is biomimetic and imbued with more intelligence than our own.

Murray-Browne et al and Magnusson [11, 12] describe the process of composing for new systems, extending the idea of composition to include aspects of designing instruments and mappings; we take a similarly expanded view of composition. Relatedly, Schnell and Battier introduce the term composed instruments, for the very design of instruments and the constraints and affordances they offer might be seen as constituting the composition [13]. Young et al describe the process of composing for the Hyperbow controller, explaining how the development of a new repertoire can feed into the evolution of the instrument itself [14].

Hanne De Jaegher's work on social interaction presents a novel approach, framing interaction as an autonomous process and the idea of participatory sense making [1]. David Borgo has brought similar ideas to studies of improvised music, drawing upon ideas of emergence and swarm intelligence to interrogate the relationships and interactions between musicians and the group as a whole in improvised music performances [15].

We drew upon these previous works in interactive, collaborative music-making, and developed a composition which explored the models of social interaction that we found in de Jaegher's work.

3. DYNAMICS OF INTERACTION

Hanne de Jaegher and Ezequiel Di Paulo propose that the interaction process between individuals should be seen as emergent and autonomous. They reject the model of individuals in an encounter trying to figure each other out, instead noting how the encounter itself has its own internal dynamics which, in turn, influences the behaviour of those involved [1].

De Jaegher et al introduce the concept of *participatory sense making*. Sense-making is understood as the processes by which an organism creates and appreciates meaning through its interactions with the world. Meaning and signification emerge out of our encounters and interactions with the world: de Jaegher uses the example of the softness of a sponge, something which is only revealed to us through our interactions with the sponge (squeezing) [1].

We gravitate to their work because it offers a convincing model for the dynamics we witness emerging in collective, improvised music performances in general, and in performances on the PESI system specifically. It offers an open yet rigorous notion of social interaction that is suited to the inherent complexities of interactions we find in musical improvisation. Their model has strong similarities with literature which attempts to articulate the often ephemeral qualities of group interactions in improvised music. Musicologist David Borgo notes that a performing group, like

Figure 1. PESI interactive-spatial performance system.

a hive, has emergent properties that cannot be reduced to any one individual within the group, and the creativity of the group cannot be to individual psychological processes. We can see how these ideas relate to de Jaegher et als description of social interactions as being an emergent and autonomous. A complex feedback occurs between performers and sound, much as the interaction processes that de Jaegher et al describe feedback into the actions of the individual agents involved [15].

We also find that de Jaegher et als definition of interaction and coordination is wide enough to account for the subtleties and complexities we find in musical interactions. They describe how synchronization is not the only kind of co-ordinated behaviour, and other interactions such as mirroring or anticipation are also co-ordinated. Theorists defining modes of interaction and 'togetherness' in musical performances take a similar approach: Nick Bryan-Kinns uses the concept of mutual engagement to describe the interactions we might find in group musical performance. His concept goes beyond an oversimplification of what constitutes interacting or playing together, and accounts for some of the diverse forms that might take, such as mirroring or carefully editing other's work [16].

We wanted to create a composition that would explore these models of social interaction, enabling different types of co-ordination and allowing interactions to develop their own dynamics.

4. PESI SYSTEM

The social interactions in the PESI system that affect the sound are the spatial location and coordination of the performers. During performance, these interactions provide dynamic control features, and performers are able to affect the sounds through changing their distance from the other performers. The design of the *on-body* component is intended to allow participants to focus more on their interactions with other participants and with the environment, increasing mutual engagement and decreasing cognitive overload [16].

Sharing a space brings awareness of the others and their presence, which is reinforced by being able to control others' sounds through one's spatial relation to them. Space and social action are therefore deeply interconnected in the system [17]. In this way the PESI system is a novel collab-

orative system that aims to open up new ways of musical exploration in group music activity.

We also bring a novel approach to the spatialisation of sound, which occurs both through multiple speakers in the *in-space* component and through the speakers attached to the performers bodies in the *on-body* component.

5. COMPOSITION: *NO MORE TOGETHER*

5.1 Repertoire

No More Together builds up a repertoire for a novel music system, which responds creatively to the specific affordances of that system. Many advances in musical technologies exist purely as isolated developements in technology, without a thorough investigation of the specific musical and expressive possibilities that these new technologies beget.

Atau Tanaka has written about the development of repertoires and idiomatic writing for new electronic instruments [18]. Performance practices must often be created for new musical instruments. With traditional instruments, idiomatic writing engages with the affordances of the instrument, such as the pitch range and timbres it is designed to play. The affordances that PESI provides include its relation of the movements of performers and intersubjective relations with the sound produced, and thus writing idiomatically for the piece, and *No More Together* is intended to explore and engage with this.

We have been developing a repertoire to be performed with the PESI system (see table 1). The first piece, *In-Hands*, was an improvisation for three musicians. Each instrument possessed different sonic characteristics, varying from squarewave generators to granular synthesis of sampled sounds. Spatial distances between performers further manipulated the sounds by changing the grain sizes and the modulation values of the frequencies. The piece was performed in SOPI research group's studio in December 2012. The second piece, *Test Tone*, was a combination of three pure sine waves playing a single frequency, each modulated, with the harmonic values based on the musicians' distance between each other. The third piece, *Trad Ensemble*, was composed for a traditional ensemble, and the sonic characteristics of the instruments were designed to be digital models of traditional instruments; piano, bell and bowl instrument. The distance between musicians is mapped to create beating patterns. Both the second and the third piece were performed in Goldsmiths, University of London in January 2013. Following that what emerged was a composition *No More Together*. It differed from previous work with PESI through the addition of a score to further influence the social interactions of the players, which we describe in detail in this paper.

5.2 The Score

A significant part of the latest composition is the score (see Figure 2). Conventionally, a score is understood as the organisation of sounds through musical notation. The twentieth century saw the rise of increasingly diverse ways of doing this, such as the graphic scores of Xenakis (UPIC)

	InHands	**Test Tone**	**Trad Ensemble**	**No More Together**
Description	free improvisation	pure tones	traditional ensemble set-up	manipulate social interaction
Musical Materials	granular synth	sine wave	digital model bell, perc., bowl	granular harp samples
Performer Instructions	free improvisation	free improvisation	free improvisation	score
Spatial Mapping	grain size & freq. mod.	harmonic values	beating patterns	grain size & freq. mod
Tuned / Pitch	open	tuned	tuned	tuned

Table 1. Composed pieces listed according to their sound mapping strategies, musical materials used, performer instructions, spatial mapping effect and tuned-pitch constraints.

NO MORE TOGETHER

For three performers and PESI system

Choose one of the following three states, and remain in it until the music asks you to change. Performers need not aim to be in the same state as each other.

1. *Play a constant sound. Only move in the space when someone else is moving.*

2. *Investigate a point of change in the sound. Only move in the space when no–one else is moving.*

3. *Move and play freely.*

Figure 2. The Score.

or Stockhausen, and the text-based scores of the Fluxus movement [19]. Some of these scores departed from the relatively strict instructions about rhythm and pitch that we find in most modern European staff notation, and on occasion focusing on giving tasks or actions to performers. Our own effort with the score here is not to compose sounds, but to compose social encounters.

Through the score, the performers are given three states to choose from, with the instruction that they change state when the music tells them to, this being intended to make sure they remain listening to and responding to their collective sound. The intention is not that the performers are all in the same state at the same time, but that they drift in and out of synchrony. The third state, move and play freely, is intended to enable the performers to explore the sonic, interactive, social and expressive possibilities of the system with relative freedom. This, along with their ability to change state at will, contributes to ensuring the autonomy of the players.

The score is designed not solely to facilitate smooth social interaction, but to create moments of social interaction that might develop their own dynamics. In a sense, the score is intended to trick the performers and to pro-

duce moments of social interaction outside their immediate control, so that the piece is not simply the performers acting out their ideas of social interaction. The performers may believe that the score is intended to produce synchronicity: however, de Jaegher et al suggest that it is often through failed encounters that we witness the social as an autonomous object with its own dynamics that transcends the apparent intentions of the agents involved. In particular, de Jaegher uses the example of two people passing each other in a corridor, and accidentally getting into a situation where, rather than passing smoothly, they continually mirror each others actions. In such an instance, the interaction can often continue despite the individual's efforts to break from it (and pass each other), having its own dynamics, and being an emergent object.

It is in these moments of failed interaction where the internal dynamics and relative autonomy of social interactions might be revealed to the audience and the performers. For this reason, the three states specified in the score are all potentially contradictory to each other, designed to create narrow corridor moments. State one asks that performers only move when someone else is moving, and state two asks that performers only move when no-one else is moving.

We opted for a score that functioned in this problematising manner because it was important to us that the score encouraged interactions, but did not attempt to structure them too much, nor disrupt the emergent autonomy of the interactions. In early performances of the piece there was no score, and so the performers improvised with the piece and explored the instruments, space, mappings and sounds. Observing the evolution of the performers interactions with the PESI system, the space and each other was of great interest, and we were keen that the score should not provide too much structure or constraint and prevent such evolutions from occurring.

De Jaegher et al note that the individuals involved in an interaction must be autonomous. It was therefore importance that the composition maintained as much of the autonomy of the performers as possible, whilst providing a structure within which interactions could occur and be maintained. Hence, there is a great deal of freedom for the performers in terms of how they move and interact in the space, and what sounds they produce. Essentially, the performers can choose to follow certain rules (eg not moving unless someone else is moving), but discard these rules should they wish (and move to state 3, move and play freely)

We find a related approach to scoring in John Zorns Game Pieces. As Zorn desribes,

> "My pieces are written as a series of roles, structures, relationships among players, different roles that the players can take to get different events in the music to happen. And my concern as a composer is only dealing in the abstract with these roles like the roles of a sports game like football or basketball. You have the roles, then you pick the players to play the game and they do it " [15]

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Drawing upon this, our initial thoughts for the composition involved giving each of the performers a role, possibly based upon a contested model of psychological types (such as the Myerrs-Briggs Type Indicators). The piece could then potentially be a playful interrogation of a model of social interactions routed in individuals and types, as oppose to the dynamics of interactions themselves. However, we were concerned that this might make the performers too aware of social interactions or simply act out roles, potentially stiffling the sort of emergent dynamics of interaction that we are interested in.

5.3 Audio Engine

The soundworld of the piece is in large part determined by the samples and the granular synthesiser running in Pure Data [1] which plays them, along with the mappings. The granular synthesiser is based upon Noboyasu Sakonda's Max MSP granular synthesiser [20], modified by us and adapted to run in Libpd [2] on the iPhone and Pure Data on the computer.

The granular synthesiser is permanently in freeze mode, indefinitely stretching a single fragment of the sample, with x and y axis of the accelerometer changing the point in the buffer which is being frozen, and the degree of randomness which allows for fragments of the sample on either side of the buffer to be played. The mappings contribute to the sonic character of the piece. Because nothing is mapped to pitch, and all the samples are relatively in tune with each other, we have a degree of control over the tonal and melodic nature of the piece. The mappings afford the creation of shimmering soundscapes with the granular patch.

6. SONIFICATION OF INTERATIONS

As well as running on the mobile devices (the *on-body* component), the granular synthesisers run on a central computer and are spatialised through the *in-space* component. The mobile devices send accelerometer data via Open Sound Control (OSC) [3] network module to the host machine, which runs three versions of the granular synthesiser (one for each device), which are controlled by the movements of the device, effectively mirroring the *on-body* sounds.

The *in-space* sound is processed in two ways. Two Microsoft Kinects are used to track the locations of the three players in the space. The spatial location of each player moves the sound through multiple speakers in the space. In addition to this, we extract information about relations between performers, such as relative distances, velocity, acceleration and alignment, which we discuss further in [21]. These relations between the players cause the sounds to be further processed by an additional granular synthesiser. In this way, social interactions contribute to the overall sonic output, and the sonic output feeds back into social interactions. The *in-space* sounds are processed by a granular synthesiser, with grain length increasing when the distance

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[1] http://puredata.info/
[2] http://libpd.cc
[3] http://opensoundcontrol.org/

between the musicians gets smaller. Similarly, when the musicians move away from each other the *in-space* audio module produces shorter length grains of sound. At the same time if the musician gets closer to the the third musician the frequency response range exponentially increases. The movements of the three performers are therefore intertwined with the sound of the piece.

7. DISCUSSION: SOCIAL INTERACTIONS AND SENSE-MAKING

During the performance, the musicians were drawn into interactions through which they participated in the collective generation of meaning, as well as sound, within the environment. During the perfomance, we witness the participatory sense-making activity of the musicians as they sonically and socially engage with the each other and the environment itself. The composition becomes a way of exploring interaction-theory through practice, and this theory in turn becomes a way for the audience and the performers to access the practice.

It is through a process of participatory sense-making that gestures and actions acquire meaning within social interactions, the meaning anchored to the interaction. During performances of our composition, we see gestures and themes emerge over time and acquire meaning within the context of the performance; for instance, a performer may find a certain part of the space that they can play, moving slowly towards the centre and back to granulate the sound produced, repeating this gesture and feeding back into both the music (the gesture changes the sound) and the social dynamics (the movements of the other players are influenced by the stop-start, back-forward motion of the performer, as it potentially affects how they can behave depending upon their state).

Co-ordination in the performance of *No More Together* does not always manifest itself as a simple sychronization or entrainment. As we noted, our score is not aimed at producing synchronizations of performers' actions, and total synchronization may actually be construed as a draw back. Differences emerging during the interaction enable performers to continue the process in a different direction. If sychronization is total and there are no negotiations nor emerging differences, then any sense of true autonomous interaction quickly dissipates.

We informally discussed performer's experiences of the piece with them. Of performing the composition, performers said "I like the way that we really co-ordinated each other in the space". The score gave the performers a way to try and block others movements, or regulate their own. Performers attempted to follow the score more closely at the beginning, but in the end moved more freely and took more liberties. One performer saw the score as optional, following it only when they chose to (which is effectively permitted within the score). The score also encouraged performers to listen; as one noted, "the score makes you listen to the others to understand what's going on". The score, then, was successful, producing a blend of synchronized interactions and more problematic 'failed' interactions, with the interaction itself being foregrounded in the performance.

8. CONCLUSION AND FUTURE WORK

In this paper we presented the composition *No More Together* that we have developed as a part of the repertoire for the PESI system. We also described contemporary theories of social interaction, and demonstrated how our score provided a way to engage with these theories. Building up a repertoire provides a very strong justification for our system's use in allowing for interaction dynamics to be explored within composition. We further discussed compositional approaches for using the system as opposed to underlying design ideas that lead to system's development.

We intend to find more composers to work with the PESI system, developing a repertoire to further investigate the unique social-musical interactions it facilitates. We are also interested in working with more performers, and perform with different audience, to investigate how our score and the models of interaction resonate with them. Dan Stowell [22] has shown the Discourse Analysis techniques can be used to interrogate performers' experiences of new musical instruments. We intend to bring similar techniques to explore experiences of the PESI system.

Acknowledgments

9. REFERENCES

[1] H. D. Jaegher and E. D. Paolo, "Participatory sense-making an enactive approach to social cognition" in *Phenomenoogy and the Cognitive Sciences*, 2007.

[2] X. Serra, R. Bresin, and A. Camurri, "Sound and Music Computing: Challenges and Strategies", *Journal of New Music Research. 36*(3), 185-190, 2007.

[3] R. Pugliese, K. Tahiroğlu, C. Goddard, and J. Nesfield, "Qualitative evaluation of augmented human-human interaction in mobile group improvisation", in *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2012.

[4] N.N. Correia, K. Tahiroğlu and M. Espada, "PESI: Extending mobile music instruments with social interaction", in *Seventh International Conference on Tangible, Embedded and Embodied Interaction (TEI)*, Work in Progress, Barcelona, Spain, 2013.

[5] S. Benford. "Performing musical interaction: Lessons from the study of extended theatrical performances", *Comput. Music J., 34*(4):49-61, 2010.

[6] C. Dobrian and D. Koppelman. "The E in NIME: Musical Expression with New Computer Interfaces", in *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2006.

[7] M. Gurevich and J. Treviño, "Expression and Its Discontents : Toward an Ecology of Musical Creation", in *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2007.

[8] N. Bryan-Kinns and P. Healey, "Daisyphone: support for remote music collaboration", in *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2004.

[9] G. Wang, "Designing Smule's Ocarina : The iPhone's Magic Flute", in *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2009.

[10] S. Le Groux and P. Verschure, "The Smuse: An Embodied Cognition Approach to Interactive Music Composition", in *Proceedings of the International Computer Music Conference*, 2012.

[11] T. Magnusson, "Designing constraints: Composing and performing with digital musical systems", *Computer Music Journal, 34*(4):62-73, 2010.

[12] T. Murray-Browne, D. Mainstone, N. Bryan-Kinns, M. Plumbley, "The Medium is the Message: Composing Instruments and Performing Mappings", in *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2011.

[13] N. Schnell and M. Battier, "Introducing Composed Instruments, Technical and Musicological Implications", in *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2002.

[14] D. Young, P. Nunn and A. Vassliev, "Composing for Hyperbow: A Collaboration Between MIT and the Royal Academy of Music", in *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2006.

[15] D. Borgo, "Sync or Swarm: Musical improvisation and the complex dynamics of group creativity", *Algebra, Meaning, and Computation* (pp. 1-24). Springer Berlin Heidelberg.

[16] N. Bryan-Kinns, "Mutual Engagement in Social Music", *LNICST 78*, 260-266, 2012.

[17] A. Williams, E. Kabisch, and P. Dourish, "From Interaction to Participation: Configuring Space Through Embodied Interaction", in *Proceedings of UbiComp*, 2005.

[18] A. Tanaka, "Musical Performance Practice on Sensor based Instruments", In Wanderley, M., Battier, M. (Eds.) *Trends in Gestural Control of Music (CD-ROM)*. IRCAM, Paris. 2000.

[19] C. Cox, "Visual Sounds: On Graphic Scores", in C. Cox and d Warner(eds) *Audio Culture: Readings in Modern Music*, Contiuum, 2004.

[20] Sakonda's patch is available at `http://formantbros.jp/sako/download.html`

[21] K.Tahiroğlu, N. N. Correira and M. Espada, "PESI Extended System: In Space, On Body, with 3 Musicians", in*Proceedings of the International Conference on New Interfaces for Musical Expression*, 2013.

[22] D. Stowell, A. Robertson, N. Bryan-Kinns, and M. D. Plumbley. "Evaluation of live human-computer music-making: Quantitative and qualitative approaches", *International Journal of Human-Computer Studies, 67*(11):960-975, 2009.