Back to the Experiences: Empirically Grounding the Development of Musical Co-creative Partners in Co-experiences

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Abstract

The development of musical improvisation partners is an important issue in the domain of computationally creative systems. While there have been several attempts to develop musically engaging systems, they are challenged by certain preconceived notions of what partnerships mean with machines. Here, I argue for the study of creative partnerships through the experiences that are engendered in such situations. The experience of creative partnerships is felt through the interaction with co-creators, and is termed co-experience. With a computational co-creator, the focus shifts towards the abilities of computational system to engender co-experiences through interaction. The position articulated in this paper is that musical co-experiences arise through the design of interaction behaviors that are responsive to human co-creators. Reports from music studies are drawn to support this position. The potential to further research in the domain of creative computational musical partnerships is highlighted through the position developed in this work.

Introduction

The development of computer systems that are creative partners is an important issue in the domain of computational creativity (Jordanous 2017). The notion of partnership can be broadly situated within the discussion on human-machine interactions such as human-machine symbiosis, (Licklider 1960), human-machine cooperation (Hoc 2000), and creative colleagues (Lubart 2005). The central question of interest in this paper is - How do we systematically address the issues of human-machine partnerships in artistic co-creative tasks?

It is important to acknowledge upfront that there are certain inherent challenges in facilitating creative computational partnerships. Firstly, evaluations of creative partnerships are often subjective. The notion of a creative partnership may mean very different things within the same group of people (e.g., experts) and across different groups (e.g., experts and novices). People are likely to have a bias towards or against the creative ability of machines which influences their evaluation. For example, subjective biases were found to influence the evaluation of the machines' co-creative agency with humans, as reported by earlier studies (Jordanous 2017). Secondly, eliciting design knowledge for creative and artistic support is challenging. The skills required to engender partner-like experiences are often embedded in experts know-how actions that are difficult to elicit as descriptive knowledge. Finally, translating expert knowledge into system design is an added challenge as experts are able to contextually take actions with an appropriate degree of creative variance. The above mentioned challenges are some impediments that need to be overcome for enabling creative musical partnerships with machines.

The rest of the paper is organized as follows: In the following section, works of computational creativity are covered to highlight an emerging trend in the evaluation of artistic co-creativity through subjective experiences. Then, work on musical co-improvisation is used to highlight the challenges that arise with certain preconceived ways of designing for creative partnerships. Finally, the paper formulates an alternate perspective through co-experiences, that allows us to circumvent the above mentioned challenges. Reports from music studies and musician interviews are drawn to support this position.

Evaluating computational co-creativity

In the domain of computational creative systems, there is a developing trend towards the study of artistic co-creativity through subjective experiences. A few approaches that are geared towards the subjective evaluation of computational creative systems in artistic co-creativity are mentioned here.

Work on computational co-creativity has studied the impact of listeners' perceptions of creative computational agents on their evaluation. In one such study, experts evaluated the musical duets played by the machine under various conditions (Jordanous 2017). During the evaluation, musicians rated the creative agency of the agent as an independent improviser, as a co-improviser, and the co-creativity of the human and computer group. While musicians gave similar ratings to the creative agency across the different conditions, they were less confident about the ratings that they gave for the group. This suggests that people may have certain biases about the ability of creative computational partners that need to be accounted in their evaluations.

In another approach to evaluation, Bown argues for an empirical grounding of computationally creative systems in anthropological descriptions (Bown 2014). This approach advocates the methodology of interaction design in which human co-creators generate fine-grained reports of their interaction with the system which counts as its evaluation. In latter works of computational co-creativity, the interaction design framework has been applied to study user experiences with co-creative systems (Kantosalo et al. 2015). Such a method is a turn towards the primacy of subjective experience of co-creators but uses evaluation metrics that extend in limited ways to a creative context. Let us look at an instance in which the interaction design framework was used to evaluate a co-creative poetry generation tool (Kantosalo et al. 2015). The system was used to draft a poem through word prompts from the user. Its evaluation was based on the metrics of usability, perceived usefulness, and enjoyment (which was correlated with usability) felt by the users. The evaluation identified issues of usability which are important but do not directly address the issues of creative partnership.

While the previously mentioned approaches are geared towards the evaluation of computational creative system, another approach addresses the concerns related to the development of co-creative partners.

More recently, some works have attempted to enable human-machine co-creativity by modeling a co-creative task through a mechanism of shared control. While sharing control, the responsibility of the task is divided among agents and each agent performs a part(s) of the task that are allotted to it. One such attempt to distribute responsibility was achieved through mixed-initiative task distribution (Yannakakis, Liapis, and Alexopoulos 2014). A mixed-initiative in the task distribution was found to improve the users' creative stimulation when the user and a co-creative algorithm contributed ideas to the sketch of a game level (Yannakakis, Liapis, and Alexopoulos 2014). Another attempt to blend human and computer initiatives was realized in a co-creative drawing assistant (Davis 2013). In a turn based task, the machine follows the role of artistic assistant that paints in the style of the human co-creator. The interaction was aided by an optional voting mechanism that human uses to communicate intentionality. In response to this communication, the system revises its contribution.

There are two main concerns with these approaches when they are combined with evaluation. Firstly, modeling a co-creative task using an artifice (e.g., mixed initiative) runs the risk of studying something atypical. For example, in an improvised musical duet, turn taking is an artifice and entails a very different co-creative engagement compared to the duet situation in which musicians are playing together (which is more typical of co-improvised playing). Secondly, the mechanisms that enable co-creativity are separated from the metrics used for co-creator evaluation. This raises questions of evaluation of certain mechanism with a respect to a co-creative outcome. Although there have been some efforts to correlate the efficacy of a mechanism regarding a co-creative outcome, it has not been possible with existing frameworks (Liapis et al. 2016).

Stepping back, the focus on subjective experiences is beginning to emerge in the evaluation of computational co-creativity, but there has been limited focus on the study of creative partnerships. While one set of issues relate to the evaluation of co-creative systems, another set of issues relate to their design. Next, let us look at how these issues are addressed in the design and evaluation of systems for creative musical partnerships.

Creative musical partnerships

While several systems have been designed for musical co-creation, systematic studies of partnership have been relatively limited. A select few systems that have been designed with a particular emphasis on engendering partnership along with a methodology for evaluation are presented in detail here.

There are several things that researchers have studied with musical co-improvisation systems (e.g., engagement, social interaction, and musical proficiency), but they do not directly address the experience of co-creative partnership. Work that has focused on improving engagement has focused on engendering flow state (Addessi, Pachet, and Caterina 2004), and improving the duration of engagement through non-verbal behaviors (McCallum and McOwan 2015). Work that has focused improving the machines' ability to socially interact with the musician has developed notational communication about the future (François, Chew, and Thurmond 2007), and synchronization with non-verbal cuing (Cicconet, Bretan, and Weinberg 2012). Finally, work that has focused on improving the musical proficiency of the system has developed algorithms to improve musical coherence (Nika and Chemillier 2012), and generate stylistically consistent responses (Pachet 2003; Assayag et al. 2006; Thom 2003). As interesting as those things are, they do not directly address the experience of creative partnership. In this section, a smaller subset of music co-improvisation systems that have focused on creative partnerships are analyzed.

The first approach identifies a subset of interaction behaviors that will be regarded as partner like, when demonstrated by a computer system. In line with this, Murray-Rust and Smaill (2011) developed a computational model of musical acts to analyze the communicative interaction among musicians in a performance. The model was used in an interactive musical system for guiding the systems' responses (e.g., disagree, propose) during live interaction. After preliminary tests with the musicians, the authors observed improvements to interactivity when the system related its responses (e.g., mirroring) to the musicians input. While this is a promising direction, the metrics of evaluation need to be sharpened to directly study experiences of partnership.

In a later work, Brown and colleagues (2016) explored the design of a system to facilitate creative partnerships through six musical behaviors that are commonly used in musical co-improvisation. The interaction behaviors - *repeat, imitate, shadow, initiate, silence, and turn taking* - were implemented in a music co-improvisation system that co-improvises duets with musicians. The improvisation system is best described as a collection of musical behaviors, implemented through rules, that transform the musical input into the system's response. Although musicians felt engaged

playing with the system, they felt a lack of creative initiative on the part of the computational co-creator.

Based on the above mentioned approaches, the design of musically responsive behaviors seems to be important for improving the interactivity and engagement with musical systems. However, the particular manner of restricting their interpretations raises two concerns. Firstly, the design of musical behaviors as specific interpretations restricts the responsiveness of the system in certain dimensions. For example, Brown reports that musicians playing with his system felt that it was engaging to play with, but they were not convinced by its ability to initiate musical directions. To extend this critique, in general, it seems problematic when designers choose the interpretation of the system's behaviors as musicians may not feel convinced by the efficacy of some design choices (e.g., initiate musical directions) during the interaction. Next, we turn to another kind of work in which the musicians choose the interpretation of the system's behavior during the interaction.

The second category of work studies creative partnerships with minimally autonomous systems. The systems are autonomous in that they automatically vary the degree of influence, that a musician has over the system, during the interaction. Such interactions are observed in work of George Lewis (2000), and work on live algorithms (Blackwell, Bentley, and others 2002). More recently, the work of Marcus Donnarumma contains an interesting proposition for the design of a minimal autonomous partner (Donnarumma 2017). The system under consideration is an extended prosthetic tool that gets input from the performers' body gestures and generates responses based on its dynamically evolving state. The claim is that, with sufficient training, musicians will begin to engage with the system in ways that feel responsive and partner-like. Donnarumma's account is a proof of concept that demonstrates that musicians subjectively feel the differences in experiences when they engage with a minimally autonomous system. That said, musicians' engagement with this system is subject to conditions (e.g., differing opinions, individual training) that are difficult to generalize. Firstly, comparing performer experiences is challenging as performers may have differing interpretations of the actions that are considered responsive by the system. Secondly, restricting the performers' movements to enable meaningful interpretations of the interaction limits the system's scope of use to narrowly constrained performance environments.

In summary, there have been several systems developed to address issues of musical co-creation, but only a smaller subset directly address the issues pertaining to experiences of creative partnerships. With the systems that focus on creative partnerships, musicians feel the differences in experiences when musical systems are responsive. However, the particular approaches that have been employed either restrict the responsiveness of the system in certain dimensions (e.g., initiating musical directions) or are reported to work in conditions (e.g., differing interpretations, individual training) that are difficult to generalize. Let us turn to an alternate position that enables us to address these issues.

Creative partnership as co-experience

To better understand partnership and co-creativity, an alternative position that focuses directly on the subjective experiences of the co-creators would be helpful. In this section, the notion of co-experience is introduced as the necessary condition for evaluating the subjective experience of partnership. An argument is developed for identifying the minimal conditions that are required for feeling co-experiences.

The particular position that is argued for in this paper is that experiences of creative partnerships are felt through acts of co-creation with agents, and thus, co-experienced. The term co-experience was first used as an elaboration of user experience to include experiences that are created together with other humans (Battarbee and Koskinen 2005). In this work, co-experience refers to the experience of musical co-creation that is co-improvised as opposed to improvised alone. By definition, co-experience implies that there is more than one agent that is involved in the process of co-creation. Thus, the study of co-experiences allows us to directly study the subjective experience of musical partnership felt by the co-creators. In this work, the concept of co-experience is applied to a human and machine interaction.

In a human-machine interaction context, the interpretation of co-experience needs to be appropriately adjusted for use by both the agents. For humans, co-experience is meant to be an experiential construct that measures aspects of feeling together during an interaction. For the computer system, it is meant to be a formalized construct that is used to guide the decisions of the system. The rest of the paper is an attempt to better clarify the notion of co-experience as it applies to the human during musical interaction with a machine.

If a sense of co-experiences is felt at all when playing with machines, it is felt in conditions that are different from the conditions for co-experiences with human co-creators. Humans feel co-experiences when they share events (through text or speech) and respond to their co-creators in different ways (e.g., agreeing, disagreeing) (Battarbee and Koskinen 2005). While reports of musician interactions in free improvised music are consistent with this account of co-experience (Wilson and MacDonald 2016), musicians also interact through extra-musical communication (Seddon 2005). However, the situation with machines is slightly different.

Compared to naturalistic human-human performance conditions, there are certain limitations to the richness in back-channel communication or shared experiences with computational partners or in computational environments. For example, the facility of extra-musical communication (e.g., physical movements, social interaction), although available, is limited with machine co-creators. Musical co-experiences with machines, if at all felt, are felt in performance conditions that are impoverished in comparison to the typical conditions for human engendered co-experiences. In order to better clarify the notion of co-experiences with machines, it is pertinent to identify the impoverished conditions in which musicians feel co-experiences.

But, what are the impoverished conditions in which musicians feel co-experiences? Said another way, how do we impose certain restrictions, through constraints and goals,

on natural interactions and still ensure that a group of musicians feels co-creative. The rest of the paper draws results from prior studies of musical improvisation and preliminary interviews with musical experts to identify these conditions, if there are any.

Minimal conditions for musical co-experience

A small group of musicians performing free improvisation is an ideal setting for exploring co-experience. It is focused, open to various kinds of interventions (musical goals and constraints), and musicians generally have a lot to say about their experiences. In this setting, moments of musical changes (e.g. changing sections, musical affect, lead/accompaniment roles, etc) are good points of focus as these are the moments where possibly different understandings must be negotiated (Wilson and MacDonald 2017). During these moments, musicians alternate between leading and following roles to coordinate the musical change. In the following sections, excerpts are drawn from interviews with free improvising musicians and results are used from prior studies to support this position.

Minimal structures

The "micro-scores" are one example of minimal musical structures that enable co-creative music making (Pelz-Sherman 1998). These scores are created for the genre of *Western Improvisation Contemporary Music (WICAM)* and contain textual instructions for musicians to negotiate musical changes (e.g., roles, ending a song). Using these minimal structures, musicians coordinate through musical devices called interaction events and engage in three static modes of interaction - shared, non-shared and lead-accompaniment (Pelz-Sherman 1998). However, the scores were executed in experimental configurations that make it impossible to separate the influence of non-verbal communication from the musical interactions. In order to study co-experiences through "micro-scores", we identified additional experimental configurations through interviews with musicians.

We conducted interviews with six experienced free-improvising musicians to probe some of their ideas about what makes for a creative co-experience. The primary purpose of the interviews was to identify the minimal conditions that free improvising musicians felt as essential for co-experiences. The interviews lasted for a maximum duration of 1.5 hours and were guided by a semi-structured protocol. Musicians were questioned about the strategies that they used to communicate and coordinate with each other during a free improvised performance. Based on their answers, the author formulated subsequent questions to probe for the differences in their co-experiences, if any, during impoverished conditions (e.g., no visual signaling). In the rest of this section, we use representative quotes by the musicians to illustrate the main themes about co-experiences. In this section, participants are referred through a participant number used in the following shorthand - "P#participantNumber". For example, P1 refers to the first participant.

Social interaction

At the beginning of the interview, we questioned musicians about the importance of social interaction in their experience of playing with others. Prior studies suggest that social interaction, through verbal and non-verbal communication, is an important aspect of music making in jazz (Seddon 2005). In contrast to this, free improvisation musicians relied more on listening to the sounds of other musicians and reported that they seldom socially interact with others. For example, P6, who is a free improvising musician, felt that he relied more on musical gestures to guide his playing. P4, who is a free improvising musician and a teacher, had a similar reaction. P4 said, "So I don't. You don't usually have to kind of visually respond to me when it's going to happen. It's going to be very free and natural".

Following this with probes, we asked the musicians if social interaction plays any role at all in free improvised music. Musicians felt that it helped to visually see the other performer, even though, they were not interacting in any manner that would be considered as a non-verbal form of communication. Musicians referred to this as the "physicality of playing" and considered this essential to co-experience. A quote from P6 is used to illustrated this, "Yeah it's funny because he even, even if I don't look at my band mates I want to feel their presence or presence next to me. I really want them to be when I open my eyes I want them there. I do like being close to my musicians". Though there is an extensive body of literature on the role of social interaction in musical co-improvisation, it does not appear to be essential to the co-experiences of the musicians.

Physicality

Subsequently, we questioned musicians about the impact of physicality of co-experiences. More than one musician considered that physicality was quintessential to their co-experiences. Only one musician, P5, felt that the lack of physicality may make him feel like playing with a computer. P4 felt that he would more engaged to be play with musicians that have a physicality to their performance. P4 said, "Oh yeah. Possibly to be very, if I'm really honest about it, I probably I find it more engaging be. To have to play physically. But then I have these great laptop musicians to play with. I find it sometimes complicated". P5, who was a trained improviser in electro-acoustic improvisation, felt that he would feel like playing with a computer when he is unable to see or feel that there are people standing and moving next to him in a performance. Physicality is essential for meaning-making at the level of human musicians, but it is not essential for co-experiences with computers.

Impediments

This was followed by additional probes to investigate the impact of impediments on the co-experiences of musicians. Musicians identified that co-experiences were altered when they performed with laptop musicians, computer-based performance environments, and with novice musicians. However, they did not rate their experiences as better or worse compared to their natural interactions.

Performing with laptop musicians Several improvisers felt that co-improvising together with laptop musicians was challenging due to the restrictions in their physical movements. Musicians felt that these situations required them to adapt their listening strategies, in order to co-improvise together. When asked about his co-experiences with laptop musicians, P4 felt that, working in conditions in which performers may not be looking at each other and do not have physical movement, is not better or worse compared to natural settings, but it requires him to adapt in certain ways.

On probing further about physicality, some musicians identified niche improvisation pieces in which physicality was an optional component of the performance. P1 described a piece for an improvisation workshop, in which musicians responded to each other by sitting back-to-back. In this piece, musicians are instructed to spontaneously respond to each sound of other musicians and slowly coordinate changes in note density. P6 described a musical piece (*Witness*) that was developed for improvisation through deep listening. The piece, created by Pauline Oliveros, instructs musicians to successively focus on different levels of listening. First, they listen to themselves, then to their co-performers, then to their environment, and finally, coordinate changes between these modes of playing. P6 felt that it would be appropriate to study co-experiences, without physicality, through the performance of the *Witness* piece.

Performing with restricted physical movements is challenging for musicians, but it does not appear to alter their co-experiences.

Computer-based performance environments Musicians also felt that other kinds of technical challenges arise through the introduction of a computer-based environment for music making. In such situations, musicians adapt to cope up with the restrictions of the performance environment. Musicians that are trained to perform in certain ambient performance conditions, such as, hearing to a certain quality of sounds. The introduction of an artificial environment, with occasional glitches and low quality sounds, may be considered as an interference to feeling co-experiences. P2, who regularly engages in performances comprised of musicians who are geographically dispersed, felt that musicians learn to accept interruptions in broadcasting and impoverished audio quality, as a part of the performance. Altered environments present challenges for musicians to co-improvise together, but musicians incorporate the restrictions as constraints that are a part of the performance.

Novice musicians Musicians felt that high levels of musical skill are not a prerequisite to the experience of co-creation, but the skill to coordinate musical changes sets apart experts from novices. Several of our interviewees were teachers, who taught improvisation, and regularly performed with their students. When asked about their co-experiences with novice musicians, the expert musicians reported that they were generally comfortable performing with their students. As a difference between performing novices and experts, musicians felt the need to be more instructional with novices. For example, in moments when they were required to negotiate musical changes, they often referred to shared structures or used explicit non-verbal signals when playing with their students. With experts, musicians felt that their co-performers intuitively knew to follow the music and negotiate such changes (e.g., leadership roles). Though, there is an extensive body of literature on endowing co-creative partners with a high level of musical skill, this does not appear to be critical to the subjective experience of co-creative engagement.

Musicians felt that the skill to negotiate difference in understandings as one of skills that was essential for co-experiences. Moments of musical changes (e.g. changing sections, musical affect, lead/accompaniment roles, etc) are good points of focus as these are the moments where possibly different understandings must be negotiated. Following this with probes, we asked the musicians about how they would coordinate musical changes during the performance.

Coordinating changes

Among the skills that sets apart experts from novices, musicians felt that the skill to coordinate musical changes is one of them. In free improvisation duets, musicians reported to leading and following changes in improvisation. P6 mentioned that he responds by selecting one of continuing, extending, providing a contrast, counterpoint, staying quiet, or opposing, to follow the changes initiated by other musicians. For leading changes, P2 said that he would introduce a change and listen for the musical devices that other musicians are using to respond to it. Through listening to the devices employed by other musicians, he decides his next action.

Though there is an extensive body of literature on artistic and musical co-creative systems that share responsibilities in co-creation, the ability to coordinate differences in shared understandings through leading and following appears to be important to feeling co-experiences.

Discussion

When it comes to co-experiences, free improvising musicians place more importance to listening and responding to their co-performers over social interaction, physical movements, and musical skill. When improvising in small groups, moments of musical changes (e.g. changing sections, musical affect, lead/accompaniment roles, etc) are good points of focus and are moments where possibly different understandings must be negotiated. In these situations, musicians perform dual roles of leading and following musical changes. These finding suggest the need to reframe research on co-creativity and creative partnerships in terms of subjective experience rather than specific musical, communicative, or physical attributes of the co-creative partner.

The findings about impeded social interaction and restricted musical expression inform future research on studying co-experiences in experimental configurations. While studying human music performances, factors such as social interaction, expressivity, and ambient performance conditions are most difficult to experimentally recreate. In free improvisation, musicians find it more important to listen and respond to the sounds of other musicians, rather than engage

in social interaction. Further, in artificial performance environments, musicians adapt to the quality of the sound and other technical challenges. The findings suggest that studies of co-experiences can be conducted in experimental configurations that involve restricted social interaction, and impoverished musical expression.

The study of co-experiences, without physicality, enables a level of meaning making that is common across humans and computational systems. This allows us to address the problem of creative bias with computational systems. During the interviews, musicians identified improvisation pieces in which physicality was an optional component of the performance. In conditions where physicality does not play a part, co-experiences are felt only through actions of listening and responding. This opens up a possibility of studying co-experiences in experimental configurations that enable the same level of meaning across human and computer co-creators. In such situations, it is possible to uncover biases with machine creativity through comparisons with human creativity. This allows us to address the problem of bias with machine co-creators.

Thirdly, although a high level of musical skill is not needed for co-experiences, the skills that seem to matter are related to the coordination of musical changes. These are moments where possibly different understandings must be negotiated. This allows us to address the challenge of finding a set of concepts that everyone agrees to as partner-like, through the study of behaviors that are essential for coordinating musical changes. It is an open question whether the automation of musical coordination will enable musicians to feel co-experiences with a computational system.

Finally, we found that in free improvisation settings, musicians coordinate changes through dual roles that involve both leading and following changes. The dual roles performed by musicians suggests that the role of the computational partner should be expanded for feeling creative partnerships. In particular, the expansion may involve a demonstration of co-creative agency (or autonomy) through the ability to negotiate differences in understanding (e.g., roles, musical changes). Enabling the ability of machines to lead and follow musical changes opens the avenues for future research on system design.

Conclusion

The position articulated in this paper, through analyzing relevant research on co-creative systems and supported with comments from musicians gathered through interviews, would help us to directly address the problem of engendering creative partnerships. A set of minimal conditions for the co-experiences were identified as good focal points that would allow us to study co-experiences in experimental configurations. This enables us to address certain important challenges that impeded the development of creative computational partnerships and opens avenues for further research in this domain.

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