Engendering co-creative experiences through agent parametric control

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Abstract

One of the important challenges in developing computational musical partners is to impart experiences that are different from musical support. In this work, we use an existing rhythm improvisation system to explore how we can engender different co-creation experiences by varying the system's co-creative behavior. In an exploratory study, the system's co-creative behavior was varied by manipulating a single experimental control and used to engender co-creative experiences in rhythm duets. In one experimental condition, the system induced a sense of producing divergent material, influencing creative outcomes, and negotiating musical outcomes, three aspects that were consistent with group music creativity. These findings provide supportive evidence that the system's parameter can be varied to systematically engender co-creative experiences distinct from creative support.

Introduction

The development of semi-autonomous systems for creative partnership is an important topic in the domain of computational co-creativity. Creative partner systems align well with co-creative systems in their autonomous or semi-autonomous decision-making abilities, and engendering engaging user experiences. These characteristics suitably place them within the spectrum of fully autonomous systems that produce creative artefacts on their own, and creativity support tools that support the user's creative thought (Davis 2013). In this work, we focus on engendering experiences of creative musical partnerships with co-creative music systems.

Prior work on the topic has focused on studying computational music partnerships in particular musical setups and improvisational genres. This includes work on systems that use autonomy and impart a perception of agency (Bown 2018), have a musical personality and sometimes engender a sense of partnership (Albert 2013), behave unpredictably and engender a sense of equal co-improvisation (Lewis 2000), and provide support with engaging interaction behaviors (Brown, Gifford, and Voltz 2016). In spite of this progress, one of the challenges for computational musical partnerships is to engender experiences of creative collaboration different from the experience of being creatively supported by an agent. A comparative analysis of such differences among systems is difficult as they often play different musical genres and have specific performance settings that are difficult to experimentally control and recreate. As a first step towards addressing these challenges in the study of creative musical partnerships, we present a study setup focused on engendering and studying different experiences of collaboration with the same music co-creation system.

The central question about partnerships addressed in this work is: *How can systematic variation of an agent's rhythmic interaction behavior engender different experiences of co-creation?* The co-creative system, MASSE (Ravikumar and Wyse 2019) is used in an experimentally designed musical environment to study co-creative experiences. MASSE provides a facility to control the system's co-creative behavior through a single parameter which could directly impact a musician's experiences of collaborating in rhythmic duets. The central hypothesis is that the differences, if any, in human experiences with the agent configurations could be analyzed to identify factors that distinguish a musician's sense of creative collaboration different from a sense of co-creative support.

In the rest of the paper, we review prior work on collaboration with rhythm improvisation systems and methods for studying co-creative experiences in artistic co-creation systems. Then, we present an experimental study design to study human experiences of collaboration with MASSE (Ravikumar and Wyse 2019). We report the observations of collaboration experiences of 4 expert musicians when they co-improvised rhythmic duets with different configurations of the system. The musicians' responses to probes regarding various aspects of their experience from the study are qualitatively analyzed and the emerging themes are discussed through Sawyer's framework of group creativity (Sawyer 2006). The study and the analysis highlight themes that productively contribute to a musician's experiences of collaboration different from creative support.

Related Work

Related work briefly reviews other rhythm improvisation for partnership studies. Through an evaluation of these systems, we realized that there has been limited empirical validation with participants to understand how this engendering could possibly happen. Thus we widen our review of existing work

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to cover and techniques for the comparative study of co-creation experiences with systems in other artistic and linguistic domains.

Rhythm improvisation systems

For the purposes of the paper, we restrict our analysis to three music co-creation systems that provide the facility to vary their co-creative behavior in rhythmic improvisation. We focus on rhythmic improvisation as it allows for restrictions relating to musical tempo, a fixed metrical structure, a few timbres, and events quantized to beats that constrain musicality but do not substantially reduce the complexity of the interactions. Three rhythm improvisation systems that co-improvise with humans in such environments are described along with musicians experiences of playing with them.

One such system is the Clap-along system developed to interactively negotiates musical outcomes in a rhythmic duet (Young and Bown 2010). The system receives an input rhythm, and produces variations of the rhythmic onsets that simultaneously increase similarity with a target rhythm, and the musician's input. Musicians who engaged in negotiating with the system felt a sense of negotiating towards a target rhythm when they predictably repeated their rhythms. However, they found it difficult to introduce rhythmic changes as the system produced rhythmic variations that were too divergent and difficult for them to follow.

In contrast to Clap-along, the *Ambidrum* system uses deterministic mappings to produce rhythms that maintain a balance between coherence and novelty (Gifford and Brown 2006). The system produces responses by transforming the rhythmic input based on a correlation function. In its transformation, the system modifies three aspects of the input rhythm, namely, intensity, pitch, and duration. Depending on the target correlation value, the system produces rhythms that vary on a range of behaviors from imitating to complementing the inputs. In real-time performance, the system provides a slider that can be used to directly control the complementary of its responses. An avenue for improving the system's unpredictability was to change target coherence values to introduce fluctuations in its behaviors. However, there did not seem to be a follow-up of this work that demonstrated this. A possible challenge with using deterministic mappings is that the musicians may begin to anticipate the system's behavior ahead of time, which may not be perceived as co-creative.

The musical system MASSE (music action selection with state evaluation) (Ravikumar and Wyse 2019) uses a combination of techniques from the two prior systems. Similar to Ambidrum, the system uses a target correlation value that it maintains during the interaction. In order to produce rhythmic responses, the system generates rhythmic variations and selects one based on evaluation functions. However, the system is different from both the previous systems in that makes adaptive decisions to guide its behavior based on an author-specified goal.

MASSE is specified with a system goal to maintain a perceptual level of rhythmic stability and togetherness. In real-time performance, the system assesses the combined musical outputs in terms of deviations from the goal. In response to this assessment, the system produces rhythmic output that brings the stability and togetherness levels back to the expected state. Through a goal state that drives system behavior, MASSE provides a facility to manipulate co-creative behaviors using a single parameter. As a proof of concept, MASSE was used to demonstrate differences in co-creative behaviors with a synthetically constructed lead-input. The system is yet to be tested with human subjects.

Although different rhythmic improvisations have been developed with parameters that can be varied to change system behavior, there seems to be a limited evaluation of a system's ability to impact co-creative experiences in experimental control. We widen the scope of our analysis of systems beyond music to identify methods and experimental setups to evaluate co-creative systems in other artistic domains.

Comparing co-creative experiences in artistic systems

Experimental work from computational co-creative is reviewed that has engendered different collaborations through experiments with human and non-human actors, and between mixed-initiative conditions.

The experimental study with the Drawing apprentice system is perhaps closest to the notion of engendering and studying different collaboration experiences that is the focus of this paper (Davis et al. 2016). Davis and his colleagues created an art-based co-creation system that collaboratively creates free-form drawings with a human, and studied humans sense of their engagement with the system in two conditions - Wizard-of-Oz, and the agent condition. The reports from different conditions were compared to observe differences in human's collaboration experiences. From this study, three themes related to participatory sense-making emerged in the human-human collaboration and were used to analyze the collaboration in the human-agent condition. The themes pertained to making sense of contributions, the dynamics of the interaction, and emergent meaning in the interaction. The method used to evaluate the Drawing apprentice is directly relevant to the work here. However, differences in collaborations were engendered through interactions between a human co-creator and co-creative agent, an aspect that is peripheral to the focus of this work.

Another approach that has been used in artistic systems involves engendering differences in collaborations in systems conditions of mixed-initiative. In Sentient Sketchbook, users collaboratively design the elements of a game level with an agent that provides suggestions for this task (Yannakakis, Liapis, and Alexopoulos 2014). The experiments with Sentient Sketchbook investigated the degree to which users take suggestions of the computational co-creator in the follower condition. The authors evaluated how did the computational suggestions affect the perceived quality of the solutions. Results indicate that the computer-generated suggestions are not used often when the human has initiative, but they can result in major changes in the maps' appearance. As an example, the computer-generated output breaks the visual patterns and introduces more imbalance. The paper by Oh et al. 2018 identifies themes pertaining to the per-

ception of art-based co-creation systems with human users. In a mixed-initiative structured co-creation task, the human and the agent co-create artistic drawings (Oh et al. 2018). In conditions when the system leads, the human co-creator felt that they were being forced to move in a certain direction by the AI.

In summary, authors of some artistic co-creative systems have varied task-initiatives to observe different collaboration experiences. However, prior work does not focus on directly studying the differences between musical support and musical collaborations - an aspect that is of interest in our work. For the purposes of addressing the central research question, we present a system and study configuration.

Agent improvisation system

The central question about co-creative experiences that is of interest in this work is: *How can the systematic variation of an agent's rhythmic interaction behavior engender different experiences of co-creation?* Among the rhythm improvisation systems reviewed in the related work, MASSE (Ravikumar and Wyse 2019) was selected for. Compared to other rhythmic systems, MASSE was selected for exploring creative collaboration experiences due to its technical and design considerations. From a design standpoint, the system was developed based on guidelines that were designed for imparting a sense of co-creation in minimal improvisation settings (Ravikumar and Wyse 2019). From a technical and provided a facility to vary system parameters to affect co-creative behaviors.

Agent configuration	State-score range
Low state-score	[0.0 - 0.2]
Medium state-score	[0.2 - 0.4]
High state-score	[0.6 - 1]

Table 1: Agent configurations and state-scores

At the onset of the interaction, the authors specify the goal that drives the system's co-creative behavior. The system's goal specifies the expected target value of rhythmic stability (of the agent's rhythms) and togetherness (with the musician) that system maintains in response to the musician's input (Ravikumar and Wyse 2019). Based on pilot tests, the authors found three configurations that produced noticeable differences in the system's behavior varying from creative support and opposition. Table 1 refers to the internal numeric representation of goals in MASSE.

Characterizing experiences of musical co-creativity

In order to analyze musicians experiences of interaction with the system, Sawyer's model of group creativity is selected (Sawyer 2006). Sawyer's model describes several interaction-level characteristics important to group creativity practices and was selected as an appropriate level of analysis for studying co-creation experiences. Notably, Sawyer's work on small group interactions has studied the characteristics that contribute to a sense of group musical creativity (Sawyer 2006). Improvising groups often talk about unpredictability in determining future outcomes, symbolic interaction through musical and extra-musical communication, and *meta-pragmatics* as negotiating subjective understandings of the musical emergent through interaction as an integral part of engaging in group creative interactions. In this work, the performances between the agent and the musician are analyzed through creative process in group interactions in music improvisation.

Among the factors that are identified in Sawyer's work, we focus on three aspects of musical interaction that are important to musicians experiences of free-improvisation. Prior work that has studied the musicians attitudes and beliefs about improvisation identifies a sense of interaction through sound, sense of alternating musical roles, and negotiating musical characteristics as more important to a sense of co-creation over other aspects such as social interaction or musical skill (Ravikumar, McGee, and Wyse 2018). In the rest of the work, we focus on these aspects of musical interaction for analyzing and discussing musicians co-creative experiences.

Experimental design for studying co-creative experiences

Experimental Setup

Several constraints were added to ensure that the performances generated in the experimental setup were comparable in their musical aspects. These constraints were enforced in order to minimize the differences in the user's experiences between the system conditions, and enable meaningful comparisons across conditions. The performances were constrained in terms of the structure of the musical piece, style and organization of the musical content, and the range of musical elements available for improvisation. In addition to these, musicians were also informed about about the limitations of the co-creation system as the expectations of the partner may influence the experience. The different constraints are described below.

Length and structure of musical pieces The musical pieces were limited to a period of 1.5 to 2 minutes. In each musical piece, musicians start a rhythm pattern, initiate two transitions to other rhythms (excluding the starting and the ending), and conclude the piece. The performances were focused around transitions as these are focal points of decision making during collective free improvisation (Canonne and Garnier 2012). During these moments, musicians are highly likely to expect co-creative interaction such as negotiating musical material, and influencing the behavior of other performers.

Maintain musical style While constructing each piece, musicians were instructed to play at a medium level of density (neither too high nor too low), maintaining a similar feel in the musical groove, and performing similar kinds of rhythm patterns that are similar in their musical feel. This was enforced to minimize the differences in musicians actions between performance trials and to improve consistency in actions across different musicians.

Restricted timbres and dynamics The setup also involved restrictions on the range of musical elements available. Musicians performed rhythmic sequences that were constructed from eighth notes, quarter notes, and half-notes. The musician and the agent were each assigned one timbre with which they constructed the rhythms. A high timbre was assigned to the musician to subtly indicate that they were leading the performance, and the base timbre was assigned to the agent. Musicians were informed that there were no changes in the volume of the hits. This constraint was added to reduce the impact of the creative selection of the sounds and musical phrasing that may impact the experiences of the musician.

System restrictions In addition the musical restrictions, musicians were informed about the restrictions of the rhythm improvisation system with which they co-improvised duets. Prior to their interaction, musicians were informed that the agent listens to 2 bars of their playing, and responds with 2-bar rhythm patterns synchronized with the tempo. In all the settings, musicians were instructed that they would initiate the rhythmic material, and decide when to shift rhythms to which the agent responds. This was enforced to keep musicians focused on how the agent responds to their rhythms, and focus less on the agent's ability to create musical material on its own. Finally, musicians were asked to evaluate interaction in the middle portion of the piece leaving the beginning and the ending. The system did not make decisions about the starting, or ending of the musical piece. Subsequently, musicians were not asked to evaluate the system's behavior during these portions of the piece. With the above-mentioned restrictions, musicians performed rhythmic duets with the co-creative agent and reported their experiences.

Study setup

The study involved four musicians who played rhythmic duets with two configurations of the agent (high state-score, and low state-score). These two conditions were selected as we expected the agent's behavior to be most divergent in terms of their co-creative actions, and likely to produce differences in co-creative experiences. The details of the study conducted are presented.

Participants Four musicians took part in the study. Each musician had more than 10 years of experience of playing the percussion or other melodic instruments (e.g., saxophone, piano) and more than 4 years of experience improvising with other musicians.

Materials The materials used in the study included a Korg controller for playing rhythm patterns, instructions for generating rhythmic duets (refer to Experimental Setup), and two versions of the co-creation system.

Musicians used a Korg controller to generate musical patterns and play with the system. The musician pressed the designated buttons on the Korg controller to trigger musical sounds. These sounds were played back along with the system's response through a speaker. In this experiment, the musician was assigned the high timbre and the system was assigned the base timbre.

Two configurations of the system were used as conditions for the study. The system was configured to the *low* state-score and *high* state-score respectively as specified in Table1. Musicians were exposed to the different conditions in a counter-balanced order.

Protocol At the beginning of the session, musicians went through the training procedure in which they used the interface to play a two-minute music performance with the metronome. Each session lasted for 45 minutes to 60 minutes.

In the musical task, musicians played short rhythmic duets for 1.5 to 2 minutes. Musicians were instructed about the constraints of working with the system before the performance. Musicians began their performance by listening to the metronome bell and initiated rhythm patterns to move the improvisation forward. The system used a selected strategy to respond to the cues initiated by the musician. They were encouraged to initiate at least 2 transitions in the rhythm patterns during the performance.

Musicians played duets with both versions of the system that are presented in counterbalanced order. After each duet with the system, they answered questions about their interaction with the system through a semi-structured interview.

Data gathering A semi-structured interview technique was used to gather musicians experiences of performing with the agent. In the interview, musicians described their overall sense of interaction with the system and answered several probe questions about negotiating the structure of the piece, musical characteristics of the performance, their sense of leading the interaction and developing rhythms together with the system. The interview guide used for these interviews is available in the Appendix.

Findings

The responses gathered from the musicians were qualitatively analyzed through thematic analysis (Attride-Stirling 2001). For the purposes of contrasting the differences in experiences, the themes that emerged in the different study conditions are organized along three main categories - sense of interaction, negotiating musical roles, and negotiating changes in the music (Ravikumar, McGee, and Wyse 2018). The main themes that emerged from the analysis of the different system conditions are explained and pictorially represented in Figure 1.

Producing divergent responses versus direct responses Musicians reported that system produced a variety of responses in the *high* state-score condition compared to the *low* state-score condition.

In the *high* state-score condition, three musicians reported that the system produced divergent behavior as it responded to them. This was observed through their comments about the range of behaviors exhibited by the system. P2's reports indicate that they engaged in several interaction behaviors other than mimicry. An illustrative quote from P2 was, "I did not feel like the system was trying to respond to me as

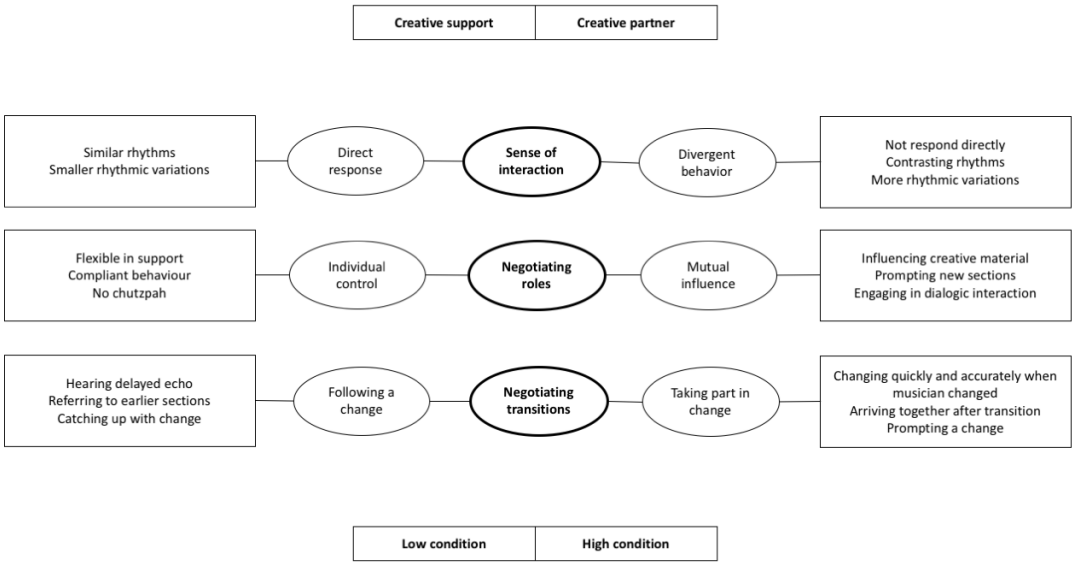

Figure 1: Thematic Map for low and high conditions

directly. Not that it would not respond to me as directly. It felt like, ratios. You know my four ideas of response. The ratios were different. The system was a lot more willing to ignore or contrast. Before this, it felt like it was trying to complement. The first one had a lot more contrast than this one. Even sometimes ignore". P4 felt that the system produced divergent behavior through musical responses that were variations of their input. P4 said, "The system started making more interesting patterns. The system was feeding me the information I played before but musically more interesting". These reports suggest that the system produced responses that related to musicians' input but also diverged from it.

In contrast, musicians felt that the system was mostly mirroring them in the *low* state-score condition. This is illustrated through quotes about quality of systems responses to input, and its diversity of responses. P1 described that the system was adapting to the musical motifs that they played. P1 said, "I did not feel like it was playing many offbeat notes. Maybe it was because of what I was playing. I think it captured whatever my input was and supported that very well". P2 reported the system's behavior was less divergent in its response. P2 said, "This version of performance it seemed to hang on to ideas much stronger. It developed more closely with respect to the smaller language." The second comment suggests that the system was not as divergent in its response, which made them feel that it was playing rhythms closer to what musicians were playing.

Mutual influence versus individual control Musicians reported differences in their sense of being influenced by the system's playing in different conditions. Musicians felt a sense of being creatively influenced by the system's actions in the *high* state-score condition, whereas they expected the system to adapt and follow their actions in the *low* state-score condition.

In the *high* state-score condition, three of the four musicians identified moments in the performance when they allowed the system to influence their musical decisions during the performance. During the moments when they were changing rhythms, P3 felt inspired to use the bass drum as material for the next section. P3 commented that "the system was not just bouncing off what they play but also influencing my decisions as a performer". P4 also recognized a sense of mutual influence when they felt like starting a new section based on the systems' response. P4 said, "The system played more interesting patterns that I listened to and wanted to start a new section in the piece, but did not do that as it would go beyond the constraints of the piece". The above quotes illustrate the instances in the performance when musicians were listening to the system and being creatively influenced by its material.

In the *low* state-score condition, two musicians felt that the system creatively supported what they wanted to do in the piece. An illustrative comment from P3 on the system's supportive behavior was, "It has been good as it is flexible in its support. It is like eh. Everything that I was after playing. Everything it did made sense. It supported what I was playing but also did not get in the way which I think is perfect for a duet." Other themes that emerged in this condition indicate that system was a compliant follower in the interaction. A specific quote from P2 that illustrates this is, "It was like, I stepped on it and did not kind of play its way out. Instead, it responded and improviser does not need to do it. You can end up in a situation where you respond to plough through. If you step in it, it said, oh that happened, I'm going to do this. Which is very responsive but it does not have a lot of chutzpah".

Changing together versus following transitions The third theme that emerged from the analysis highlights the differences in musicians' sense of performing transitions to-

gether with the agent in different conditions. In the *high* state-score condition, musician expressed that the system's actions induced a sense of taking part in the change whereas in the *low* state-score condition, they felt that the system followed their lead during a change. Illustrative quotes from musicians are used to support this observation.

While making changes, three out of the four musicians felt that the system arrived together in the transition in the *high* state-score condition. P1 felt that the system took part in the change and induced a sense of negotiating the transition. The specific quote was, "System prompted a change, I'd change along with it. Yes, whenever I had more eight notes, the system would also play eighth notes, when the system started to decrease, I would decrease, and then it would decrease, but also, there was a disruptive element that prompted the change". Other comments from P2 and P3 suggest that there was more than one moment when the system completed the transition together with them. A quote from P2 is used to illustrate this, "I really felt like we arrived together, which was really interesting and it did kind of the same thing again". These are some quotes from the musicians that describe their experiences of coordinating transitions with the system.

In contrast, musicians felt a perceivable latency in the system's response during the transitions in the *low* state-score condition. Two quotes from P2 and P3 are used to highlight this. When asked about the systems' response during changes, P2 reported that they sensed a perceivable latency in the system's response. They said, "I was thinking of the lag bar. I do not know how quickly. I give it some musical input in the performance. It processes it in some way. It plays, supports what I'm playing. Its basically the lag between what I give it and what it responds that one or two bars, even what you play is getting resonated. It still works to support but I can hear the echo". Another comment by P3 suggests that the system induced a sense that it was catching up to the musical changes initiated by them. P3's specific quote was, "Maybe there is still that slight lag. Obviously, when trying to change the rhythm too quickly it might, its always trying to catch up, support. Like you said, it might be bar or two behind. That is only obvious when you are trying to change your rhythm a bit quickly". These are some comments from musicians that support the observation that the system produced responses that were slightly behind the changes played by them.

In summary, the analysis of the two system conditions indicates three main differences that contributed to musicians' sense of co-creation in the different conditions. Musicians reported a sense of co-creation when the system produced musically related yet divergent material, influenced their material during the performance, and induced sense of taking coordinating transitions together.

Discussion

The observations from the collaboration condition are discussed in the wider context of group creativity and consistent comparisons are drawn. Three aspects of Sawyer's framework are used for this discussion, namely, emergent symbolic interaction, unpredictability in musical direction, and negotiation inter-subjective understanding (Sawyer 2006).

Emergent symbolic meaning

The first aspect that Sawyer notes is that of *symbolic aspects of communication in the interaction*. The system for rhythmic improvisation generated rhythmic responses by transforming parts of the input played by the musician. Musicians who performed with the system reported that the system engaged in complementary, contrast behaviors or even sometimes ignored the musician. One of the interesting observations of the interaction was that even though the system's strategy for response remained the same, musicians ascribed different behaviors to system based on their own actions. This is interesting as it raises the possibility that the meaning of musical interaction behaviors is situated in the context of the interaction rather than encoded in the system or described in the musician's actions. The meaning of symbols, that musicians described, were emergent from the dynamics of the interaction.

Unpredictability in the musical material

The second aspect of group creativity that is highlighted by Sawyer is the notion of unpredictability. In group creative performances, musicians have several choices to make in terms of the musical trajectory of the performance, and often do not know beforehand which trajectory will be chosen. In the *high* state-score condition, musicians reported that listening to the system influenced them to change musical trajectories that they could not have predicted before.

A possible reason for the emergence of this unpredictability is the system's contrasting behavior in the *high* condition. In this condition, the system generates a rhythmic response that contrast the stability and togetherness of rhythms. In order to construct a response rhythm, the agent generates a set of musical choices that vary in the onset positions of the input rhythms. Rhythms that are selected to contrast stability and togetherness are more likely to have onsets that are in syncopated positions, unstable with respect to the meter, and do not overlap with the input. This difference may have introduced a sense of unpredictability in rhythmic development, at least in our experimental setup.

Negotiating inter-subjective understanding

The final aspect that Sawyer notes is that of *meta-pragmatics* that involves negotiation of inter-subjective understandings. In order to do this, musicians' evaluate their successive contributions with respect to the emergent, and together make decisions about whether to include the contributions of others in the emergent. The agent set to the *high* state-score condition sometimes induced a sense of negotiation of the rhythmic change by taking part in deciding musical material (e.g., eighth notes, moments of silences).

During the moments of rhythmic change, the agent observes deviations in state-scores of the combined sequences from the expected target state-score. These deviations may be a result of changes in either or both stability and togetherness. In response, the agent generates and selects from a

new set of musical rhythms with contrasting levels of stability and togetherness. This may have induced a sense that the agent wanted to change the musical characteristics that were introduced for change. Through decisions that alter the stability and togetherness of moment-to-moment contributions, the system induces a sense of rhythmic negotiation during moments of change, at least in this experimental setup.

Conclusion

This research started with the question: *How can a music system engender different experiences of co-creation in a musical performance*. In order to study this, an existing music co-creation was configured in two conditions that were expected to be most divergent in terms of their co-creative actions. Musicians performed rhythmic duets with the system and reported their experiences. The analysis of the reports produced themes that differed in factors that were important to a sense of musical co-creation. A wider analysis of the work with regards to group creativity raises three key observations regarding the study of collaboration experiences and the design of musical systems that engender them.

The findings from the studies inform the partner characteristics that are critical to musicians sense of co-creation different from creative accompaniment support (in the *low* state-score condition). In the *high* state-score condition, musicians sensed that the system produced divergent responses, creatively influenced their musical outcomes, and coordinated transitions together. These characteristics were different from the *low* state-score condition in which the system behaved predictably, and let the musician lead the interaction.

Furthermore, the co-creative aspects of performances in *high* state-score were consistent with the characteristics of group creativity. In the *high* state-score condition, the system generated co-creative behaviors that induced a sense of emergent meaning, unpredictability in rhythmic trajectories, and sense of negotiation during rhythmic changes. These observations are an initial validation that the combination of *high* state-score and rhythm generation procedure and is effective in engendering performances that exhibit aspects of group creativity, at least in our experimental context.

Finally, the conditions in which the system engendered different co-creation experiences correspond to two extremes of a parameter that was varied in the system design. The different versions of the system that engendered different co-creative experiences were generated by varying a single parameter, i.e., the target state-score range of the system. The findings from the study provide support to the claim that state-score computed from evaluation metrics may be varied to engender differences in co-creative experiences.

A potential direction for improving agent design could involve the development of agent initiative for generating musical material and studying its impact on musicians sense of creative partnership. Other avenues for improving the system evaluation involve using a greater number of participants for improving generalizability and exploring the middle ranges state-score to observe whether the different experiences of co-creation lie on a spectrum.

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Semi-structured interview guide for co-creation questionnaire

1. What were the moments that worked for you in the performance?
   - What was happening in those moments that worked?
   - Were there other moments that worked?
2. Were there moments that did not work for your performance?
   - What were you expecting in those moments that did not work?
   - What has happening in those moments that did not work?
   - What could have made it work?
   - Were there other moments that did not work?
3. Probes:
   - Can you describe the different sections of the piece?
     - Did the different sections come together?
     - Were there things that did not work about them?
   - Can you describe the transitions between the sections?
     - Did the transitions work?
     - Were there things that did not work about transitions?
   - What worked about leading the system through the piece?
     - Were there things that did not work? item What were you expecting in those moments that did not work?
   - What worked about playing rhythms together with the system?
     - Were there things that did not work?
     - What were you expecting in those moments that did not work?
4. Based on your sense of the moments that worked, and did not work, how would rate the overall sense of co-creation with them? 1(rarely felt), sometimes, about half the time, more than half, 5 (always felt)
5. How important are each of the things you identified in the performance important to your sense of co-creation? (1 - not important at all, 2 - of little importance, 3 - of average importance, 4 - very important, 5 - absolutely essential)
6. Are there any other thoughts that you would like to express about the performance, your interaction with the system?

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