Co-Creative Spaces: The machine as a collaborator

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ABSTRACT

People have always used new technology to experiment with new forms of music creation. However, the latest developments in artificial intelligence (AI) suggest that machines are on the verge of becoming more than mere tools—they can also be co-creators. In this article, we follow four musicians in the project *Co-Creative Spaces* through a six-month-long collaborative process, where they created music by improvising with each other and with computer-based imitations of themselves. These *musical agents* were trained through machine learning to generate output in the style of the musicians. What happens to musical co-creation when AI is included in the creative cycle? The musicians are from Norway and Kenya—two countries with fundamentally different musical traditions. How is the collaboration affected by cultural biases inherent in the technology, and in the musicians themselves?

These questions were examined through focus groups as part of two five-day workshops. Analysis shows how the musicians moved between an understanding of *machine as tool* and *machine as co-creator*, and between the idea of *music as object* and *music as process*. These different *interpretative repertoires* were used interchangeably and paint a complex picture of what it is like being in the intersection between different musical and cultural paradigms.

Author Keywords

musical agents, co-creativity, artificial intelligence

CCS Concepts

•**Applied computing** → **Sound and music computing;** Performing arts; •**Social and professional topics** → **Cultural characteristics;**

1. INTRODUCTION

Recent developments leave no doubt that *artificial intelligence* (AI) will revolutionize how music is made. As ever more impressive AI technologies are introduced, most of the attention is dedicated to the generative capabilities of the models and how authentically they can replicate various genres of music. However, there is relatively little research on how the creative process itself may be affected by shifting the perspective and letting the machine act as a musical co-creative partner. What happens to musical co-creation when AI is included in the creative cycle? *Co-Creative Spaces* is a research project that has taken this question as a vantage point, and followed four musicians through a six-month musical collaboration that resulted in two concert performances. The musicians created new music through interaction with each other and with virtual collaborators based on AI. We refer to these virtual collaborators as *musical agents*, defined as algorithmic entities that fully or partially perform creative music tasks [29]. The musical agents in Co-Creative Spaces were created by using *machine learning* (ML) on previous recordings of the musicians improvising with each other, and could thus imitate the style of the musicians in the group.

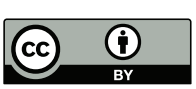
In addition to focusing on technology's role in the creative process, Co-Creative Spaces also had an intercultural dimension involving musicians from countries with different music traditions (Norway and Kenya). Therefore, we direct a critical lens at cultural biases manifest both in the technology and among the musicians themselves. This is a perspective that has become increasingly important in forums within music and technology—fields that are still dominated by men from Western countries [5]. The composition of participants in Co-Creative Spaces gave us the opportunity to adopt an intersectional perspective [13], where gender and cultural variations can be problematized.

The research presented in this article is part of a project initiated and funded by Arts Council Norway, and will be featured in a chapter of a forthcoming book with the working title *Creative practices in music*. Our contribution focuses on two five-day workshops, where the musicians co-created music with the musical agents. During the workshops, we conducted a focus group interview each day. The transcriptions of these constituted the empirical material of the project. Through an analysis of the musicians' *interpretive repertoires*, this article shows how the musicians oscillate between traditional and new understandings of music, creativity, and culture under the influence of technology's dual role as a tool and co-creator. The use of interpretive repertoires as a basis for analysis is grounded in the sociological method of *discourse analysis* and provides insight into how language constructs the reality of those who perform language acts [24].

2. BACKGROUND

2.1 Co-creative musical agents

Although machine-generated music has a long history that stretches back several centuries to experiments with mechanical musical automata [19], musical *co-creativity* is a more recent phenomenon. Here, we define co-creativity as a phenomenon that occurs in collaborative contexts where



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both humans and machines contribute to a process or product that is considered creative [18]. Early examples of co-creative interactive musical agents include CEMS [11] and The League of Automatic Composers starting up in the 1970s [7]. Since then, the number of musical agents has proliferated. Many of these are identified and categorized by Tatar and Pasquier [29], including several pioneering systems [25, 21, 23, 2]. Of particular relevance for Co-Creative Spaces is trombonist George Lewis' improvisation system *Voyager*, which he developed towards the end of the 1980s [21]. Voyager was imagined as Lewis' autonomous co-performer and is still in use more than 30 years later.

Central to Lewis' music philosophy is the concept of *multidominance*, which he sets up as an opposition to the Western aesthetic that often involves letting a dramatic foreground dominate over background elements. In much African music, however, there are many discursive layers in the music: multi-rhythms and parallel melodies that do not harmonize according to the principles of Western art music. Lewis believes that Eurocentric music education does not equip its students with the ability to perceive multidominant rhythmic and melodic elements as anything other than noise or chaos. Multidominance requires an inclusive attitude towards the voices that contribute to the collective, where the music emerges from the interaction. We believe that it is Lewis' focus on the musical interaction between human and machine and its social and cultural ramifications, rather than the technology itself, that explains the Voyager project's enduring relevance. Such a focus is also what we wanted to cultivate in Co-Creative Spaces.

2.2 Creativity as a social phenomenon

Creativity is often thought of as an individual characteristic. A view of the "giftedness" of creativity emerged around the time of the Enlightenment [1], with being born as a "creative genius" as the pinnacle of creative endowment. In recent decades, however, the focus on creativity as an individual capacity has been challenged by theorists who argue that creativity is a phenomenon that arises in the interaction between multiple agents as well as in relation to the broader sociocultural environment in which the agents operate [14, 33]. The difference between the individual and sociocultural conceptions of creativity is illustrated in Figure 1.

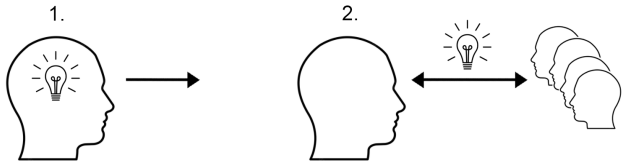

Figure 1: Creativity as individual (1) and sociocultural (2).

The type of creativity that arises in groups of people cannot be understood by studying the psychology of individual members of the group—it arises as a result of group dynamics. Sawyer [26] refers to this as an *emergent novelty*. Bown [6] emphasizes that such collective dynamics are inherent in artistic behavior. Ideas can arise, "not because individuals think of them, but through a jumble of social interaction. Such a view of creativity involves the possibility of being creative with nonhuman actors, such as computers. In a similar vein, Co-Creative Spaces is also based on the idea that creativity is a phenomenon that arises in relationships—not isolated within people, but between people and their surroundings. "Creative spaces" emerge where ideas appear as a result of interaction—between musician and instrument; between hand, pencil, and paper; between collaborating people—and machines. To create is to discover the potentials that these spaces afford and to refine them.

3. THE PEOPLE AND THE SOFTWARE

Co-Creative Spaces has consisted of the musicians Morten Qvenild (piano and electronics), Gyrid Kaldestad (vocals and electronics), Bernt Isak Wærstad (electric guitar and electronics), Labdi Ommes (vocals and orutu[1]), and project leader Notto Thelle. Thelle, Qvenild, and Wærstad have experience from previous projects that experimented with various forms of musical co-creation between humans and machines [31, 17, 34]. The experiences, knowledge, and tools from these projects were consolidated into a piece of new software specifically developed for Co-Creative Spaces, carrying the name *CCCP* (Co-Creative Communication Platform)[2].

A comprehensive technical description of how this software works is beyond the scope of this paper, but here we provide a brief description. The musical agents were trained on a number of recordings of the project's four musicians engaging in collective improvisation sessions. Before training, the audio was segmented into slices based on an onset detection algorithm. Using a feature extraction technique, these slices were subsequently labeled according to loudness, rhythmic, spectral, melodic, and harmonic content. The feature vectors were then categorized using a *self-organizing map* (SOM)—a type of artificial neural network that utilizes unsupervised learning to map high-dimensional feature vectors onto a two-dimensional topological grid [20]. Thus, similar-sounding audio slices could be grouped together at the same coordinates in the SOM. Finally, the original audio files were encoded as sequences of indices serving as pointers to potential audio slices in the SOM.

In run-time, these SOM sequences may be recombined in countless ways using various sequence modeling techniques, resulting in output sometimes appearing to mimic the style of the material in the corpus and other times serving up near-matches to the audio in the input stream. The music agents "listen" to the human musicians and respond with the recombined material according to principles that vary between pure imitation, contrasting phrases, and an independent and initiative-taking behavior that is more independent of what the agent hears. These principles are based on a number of studies of how musicians in different genres improvise together by alternating between following and leading in the interaction [31].

A more in-depth description of the algorithms that constitute the main part of these musical agents can be read in other publications [28, 32, 31]. CCCP should be considered a further development of the softwares described in these publications, including both refinement of existing modules and the addition of new functionality. A screenshot of CCCP in its current iteration can be seen in Figure 2.

It is important to note that neither the technology nor the humans involved are neutral, and that the answer to our research question largely depends on how the technology is designed and who uses it. Attitudes and ideas are encoded into the products and may manifest themselves anew when used [8]. On the other hand, it is not a goal for the music to be neutral. On the contrary—for many people, music

[1]Orutu is a traditional Kenyan string instrument with only one string.

[2]https://github.com/co-creative-spaces/cccp/tree/NIME2023

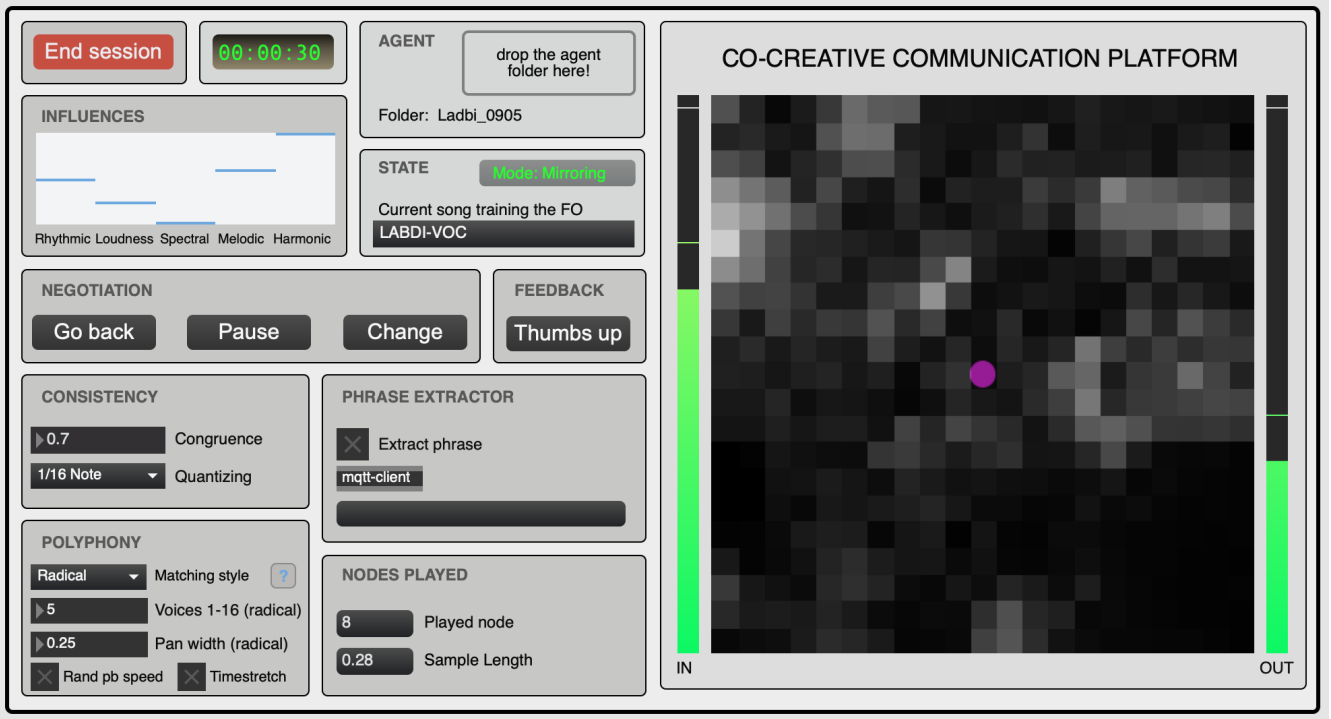

Figure 2: Screenshot of CCCP in mid-session.

is deeply personal. Some of the biases encoded into the software may be desirable, because personal expressions are precisely where aesthetics are emergent. We have tried to balance these two perspectives through dialogue and awareness.

4. METHOD

The research study has had a relatively narrow focus, and the data used in the analysis for this article was collected from ten focus group discussions between the musicians and the main author, who moderated the discussions. The focus group discussions lasted between 20 and 40 minutes and were conducted daily during the two five-day workshops. The first workshop, in December 2021, featured three musicians (Qvenild, Ommes and Wærstad)—Kaldestad joined the project later. The second workshop was held in May 2022, with all four musicians present.

In the analysis of the transcriptions from the focus group discussions, we focused on how the musicians adapted their language when discussing the creative process upon the introduction and gradual incorporation of the musical agents. The discourse analysis approach that uses *interpretive repertoires* as analytical components looks at the constructive function of language in individuals [16, 24]. Whereas social psychology traditionally assumes that individuals have *one* personality and *one* coherent worldview, interpretive repertoires can be used to examine how people adapt their language—consciously or not—depending on social context, how they want to present themselves, and what they intend to represent in different contexts. People create and recreate themselves every time they express themselves in different contexts.

In the analysis, Thelle has reviewed the transcriptions and coded the data according to a number of potential interpretive repertoires. Based on the research question concerning what influence AI may have on the creative process, the intersection of different ways of understanding technology's agency, creative agency, and musical interaction was particularly important in the analysis work. The interpretive repertoires we were left with were those that Thelle considered to be most profoundly anchored in the participants' own formulations. The analysis has been *abductive* [30], insofar as Thelle initially sought interpretive repertoires based on theoretical understandings, but also remained open to allowing for surprising angles that could lead to new or supplementary theory.

5. RESULTS

We have identified some interpretive repertoires in the transcribed data material that demonstrate how musicians balance between different and partly conflicting ways of interpreting music-creating practice. We present the repertoires as dichotomies where the musicians are apparently pulled between different interpretations of music, technology and creativity. One dichotomy that we have broached several times is the understanding of the *machine as tool* versus the *machine as co-creator*. Additionally, we propose that regarding *music as object* stands in a sort of opposition to viewing *music as process*.

5.1 Machine as tool or machine as co-creator

Co-Creative Spaces obviously began with a clear agenda, suggesting already in its title that the machine can be seen as a co-creator. However, it is far from certain that an intention of this being the case means that this is actually the view that the musicians have at all times. The focus groups revealed a complex relationship between the two different interpretive repertoires that represent the musical agent as either a tool or a co-creator. For example, after interacting with Ommes on the first workshop day (December 2021), Qvenild pointed out that the bar for interrupting her felt a lot higher than if it were the machine—a sentiment that testifies to a fundamental difference in attitude towards the musical agent as opposed to people as co-creators. As the musical agents were trained and included in the interactions over the first few days, it was commented that they lacked

a "dramaturgical sense". There were discussions about how to get the music agents to "shut up" and not be so persistent all the time. Concurrently, the musicians revealed that they tried to understand how the musical agents responded by "trying many different things" and provoking responses as if they were lab rats. This is clearly not a vocabulary musicians would use to talk about other human co-musicians. Arguably, this is language taken from the tool repertoire. The dual premise of wanting the machine as a co-creator while being able to make decisions about how a co-creator should behave has a paradoxical crux that we will return to in the discussion.

A significant change of attitude took place during the first week of the workshop. Already on the second day, Qvenild commented that "maybe we also have to shut up more and give space to [the musical agent]". After an interaction between Wærstad, Ommes and a musical agent based on Ommes' vocals on the third day, Wærstad pointed out that he felt he had moved away from an analytical attitude towards the musical agent. He was now more preoccupied with finding a flow without trying to understand what the machine was doing. He experienced this change of attitude as a movement towards a more intuition-based type of interaction, which is an attitude he recognizes from interacting with people. He illustrated this by saying that he doesn't "try to understand how Morten's brain works" when they play together. Ommes had a similar experience of a gradual acceptance of the musical agent's contribution, but said it was like "talking to a child", because she felt that much of the burden of carrying the conversation fell on her.

There was a breakthrough of sorts on the fourth day when Qvenild played an improvisation with a musical agent trained on Wærstad's material from the previous days[3]. Everyone agreed that it sounded like an interaction where the musical influence was mutual. Qvenild commented that it felt like a turning point for him, because he experienced a balance between his own playing and what the musical agent contributed. His tactic had been to play much less himself, and to let the musical agent appear more in the foreground. Wærstad described this as stepping back and "giving small seeds to the machine". Based on this successful interaction, a consensus formed around the principles of "not giving the machine too much" and "giving space to the machine". These principles shaped both the further software development and how the improvisation sessions were set up in the second workshop half a year later.

During the five-month period between the two workshops, Thelle and Wærstad worked on implementing changes in the software based on comments from the first workshop week. The algorithms were fine-tuned to ensure smoother transitions and the possibility of longer sequences that could be experienced as more lingering. The updated software presented the musicians with an unexpected problem. The improvements made it more difficult to hear the differences between the musicians and the musical agents, especially in sessions where everyone was playing at the same time. In order to make the contrast clear, it was decided that the collaboration could take place in different "constellations". A musical agent could play with one, two, or three musicians at a time, but when a musician's "virtual double" was introduced into the collaboration, this musician would hold back or temporarily stop playing. Sequences of such constellations were agreed upon in advance of each session, making it more obvious "who" the machine was.

Qvenild wondered if the musical agents had become "too polite", and missed some aggression in the newer responses. Based on this and similar comments, a new function was added to make the musical agent capable of making drastic and random changes from time to time. The musicians experienced this additional feature as providing excitement, which they appreciated. It is noteworthy that, in the project's final phase, there was talk of making the machine more aggressive and unpredictable, whereas this was less desired in the initial phase. The desire to be provoked and thrown off by the machine contrasts with how the musicians described trying to provoke responses from the musical agents at earlier stages. They went from wanting to influence to wanting to be influenced. This change may indicate that the musicians drew more from the machine as co-creator repertoire than the machine as tool repertoire as the project progressed.

[3] `https://www.youtube.com/watch?v=KjersaPuI6w`

5.2 Music as object or music as process

The second pair of interpretive repertoires that we have chosen to focus on is the relationship between conceptualizing music as object and music as process. The idea of music as object has become so common that it is easy to overlook that this is not a commonplace idea in a historical context. Our language is permeated by the music-as-object repertoire. We refer to music pieces, musical form, and musical works as if they are concrete physical structures. Carpenter [10] pointed out that this is an extraordinary view of music that has emerged in Western culture in the last two centuries. From a larger historical and cultural perspective, however, music is experienced as something one does as part of activities, such as dance, rituals, child-rearing, and self-expression. This is also something that Small [27] advocates for when he claims that music should be referred to as something one does—*musicking*—instead of something that is.

The four musicians in Co-Creative Spaces all explore the boundaries of their respective genres and are drawn between different cultural ideals in different ways. The three Norwegian musicians (Qvenild, Wærstad, and Kaldestad) are all involved in free improvisation, which in many ways epitomizes a music-as-process ideal and opposes the idea of music as object. At the same time, they are also rooted in the music-as-object paradigm—they are registered as composers and receive royalties for works that are published as music products. For her part, Ommes' practice is grounded in traditional Luo music from Kenya, which she freely uses and incorporates into her pop-oriented songwriting. This is a device also recognizable in Norway with the popularization of folk music—a commodification of traditional functional music that creates a distance between the music and the activities that created it. The transcriptions of the focus groups are rich in examples of the tension between the object and process repertoires. We especially look at how the inclusion of musical agents affected this tension.

From the outset, there was an underlying artistic ambition in the Co-Creative Spaces project that it would result in a musical work—an album release. As a result, the focus group discussions were continually drawn between the idea of creating music as improvised through interaction with the musical agents (musical processes) and the idea that interaction with the musical agents would contribute to creating musical form (musical objects). The concept of form was used by the three Norwegian musicians considerably more than Ommes. Qvenild apparently became aware of this, and early on wondered if he was "stuck in my old self" as he asked Ommes if she was accustomed to thinking about form or dramaturgical elements such as crescendos in the music of her culture. To this, she replied that Luo music often has an activity purpose. There are musical styles associ-

ated with different rituals that must be performed in certain ways, such as slow-paced wailing in funerals (*sigweya*), high tempo and long-form narratives for dancing (*ohangla*), or loud and rhythmical for self-praise (*pakruok*). The common denominator for these music styles is that the music is often circular and repetitive. Wærstad compared this to other kinds of folk and indigenous music that also often relates to rituals and daily tasks: "A lot of the times the beginning and end aren't so important. We're very concerned about how the song starts and how it ends". Ommes claimed that some of what has been exciting about the collaboration with Wærstad is that she has been initiated in structural thinking: "It's a very awesome thing to now think about a bridge and chorus and pre-chorus and all these things. Our songs before were really just like one way the whole length."

Although it cost her a lot of energy to get used to both the musical agents and improvisation in general, Ommes claimed that a maturing took place. In the second workshop, during the final phase of the project, she was much more comfortable with both. At the same time, the other musicians noticed that her ability to adapt to them may have come at the expense of the intercultural aspect of the project—she took on the aesthetics of the others in the group to a much greater extent than vice versa. Her distinctive Kenyan vocal style was less present than the other musicians had expected. Qvenild pointed out that Ommes had been outnumbered both culturally and in terms of genre, and wondered if this had created an asymmetry where her own musical background had not come through enough. Although she assured that she had not felt that way, the musicians came to an agreement that both technological and methodological steps could be taken to better accommodate the Kenyan influence in the group. For example, the musical agents had a tendency to disfavor repetition and rhythmical groove, which are already mentioned as basic pillars in traditional Luo music and other dance-oriented genres that are Ommes' "home turf". Therefore, the decision-making parameters in the musical agents were adjusted so that they could have more repetitive responses. Although this only led to minor changes in the response, the collective awareness of this cultural bias in the technology helped the group develop methods to bypass these limitations, such as allowing Ommes to take the lead more with themes in her own style.

Towards the end of the project, the musicians moved away from discussing how the musical agents should create musical form. This development corresponded with the previously mentioned emerging desire to give more space to the machine. The focus shifted to curating "constellations for interaction" between the musicians and musical agents. For the concerts, the "score" was a detailed overview of different human-machine duets, trios and tutti interactions[4]. In other words, the plan was not exactly what should be played, but what kind of interaction should happen and in what order. Once the idea of constellations came in as a guiding principle, the project was no longer about creating "a piece" of music. Rather, it became focused on dividing the improvisation sessions into different types of activities, as shown in the setlist in Figure 3. The choice of musical agents (named after the musicians they were based on) and the constellations of co-creating actors became what determined the course of events. When the musicians started talking about constellations instead of form, the discourse edged towards the music-as-process interpretive repertoire.

[4]Video recording of the final Co-Creative Spaces concert: `https://www.youtube.com/watch?v=KbIC6WGlop8`

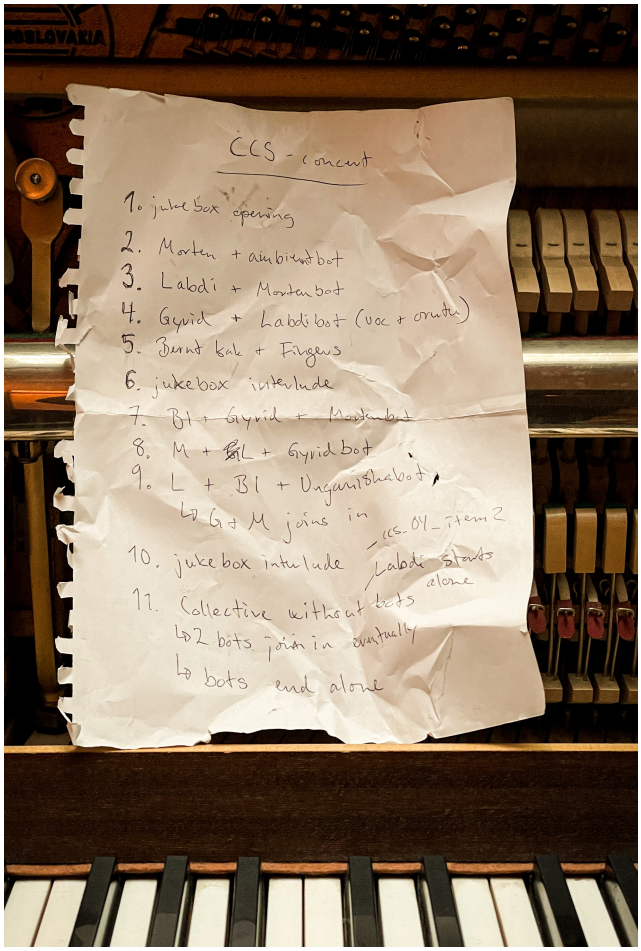

Figure 3: The plan for the order of different human-machine interactions.

6. DISCUSSION

The analysis of the interpretive repertoires used by the musicians in the focus groups demonstrates that the inclusion of AI in the co-creative process led to new insights. Accepting the machine as a co-creator turned out to be a lengthy process, even though this was a premise for the project itself. The musical agents were initially referred to in terms that revealed a machine-as-tool repertoire, but through repeated interactions, attitudes changed. As a result of the change in attitudes, the interaction and the entire co-creative process also changed. The attention to possible cultural biases in the technology and among the musicians raised awareness in the group that also had an influence on the creative process.

As previously mentioned, there is something paradoxical about the desire to design a co-creator. The ability to influence how a co-creator behaves and makes decisions makes it very easy to disapprove of the contributions it makes. As humans, we have the power to implement technological "solutions" in the machine pertaining to what we immediately perceive as "un-musical" contributions. Between people, it is different. To the extent that one tries to "fix" one's co-players, it happens at a much more abstract level where social codes and communication are essential in order not to step on anyone's toes. Eventually, the musicians' contributions must be accepted for what they are, or else the group dynamics will break down. When both designing and playing with musical agents, however, the process of finding technological solutions to musical problems can continue to

the extent that genuine interaction never is established. If one always has the attitude that one can change the machine, it will forever stay a tool and never become a co-creator.

A main finding in the project is therefore that the musicians underwent a shift in focus, and became conscious of changing themselves more than the machine. As the project progressed, there was considerably less talk about making the machine "good enough" and having it conform and more talk about "how it can change me". The musicians' gradual acceptance of the aesthetics of the musical agents as genuine artistic contributions made it possible to give more space for the musical agents' creative agency. This contributed to an improvement in both the individual performative experiences and the combined result of the interaction. This attitude change shows that it is not given that the machine can be experienced as a co-creator. It is only when human musicians are open to attributing creative agency to the musical agents that a dialogue can develop, and interesting new trajectories can be discovered.

There was also an apparent change of attitude among the musicians also with regard to the other pair of interpretive repertoires—music as object versus music as process. In particular, the Norwegian project participants used structural concepts such as "form" and "work" when talking about the creative process, demonstrating a tendency towards a view of music as object despite actively trying to acquire a more process-oriented view in their improvisation practice. Qvenild's point that Ommes was in a cultural minority led to a realization that a balance had to be imposed. This insight coincided with the realization that the musical agents did not necessarily have to "create musical form". The musical agents were adjusted to be more repetitive, and the musicians introduced rules in order for Ommes to establish her "cultural signature" by taking the lead more often. The fact that the musical agents were initially more or less agnostic to rhythm and groove is a good example of how algorithms can reproduce cultural asymmetry, such as has been documented in many technology fields [8, 22, 4, 12, 15, 3]. It is worth noting that the software developers Thelle and Waerstad (who are also the authors of this paper) were not particularly diverse, so the issue of cultural biases in technology turned out to be timely.

The analysis of the interpretive repertoires music as object and music as process indicates that the cultural biases manifest in the musical agents reflect the biases inherent in Thelle and Wærstad's aesthetic preferences. In a broader sense, it can be said that this represents the predominantly Western view of music as a structural concept, with the consequence that the musical agents were developed with the idea of creating something rather than doing something. Through the focus groups, the musicians gradually turned from formal thinking to thinking in terms of types of activity. In this regard, they drew more tactics from the music-as-process interpretive repertoire towards the end of the project. The music performed at the concerts was thus not "objects", but rather what Cage [9] describes as "occasions for experience".

7. CONCLUSION

The main finding of this study has been that machines can be musical co-creators, but this requires that people are prepared to adapt to the aesthetics of technology, and not just try to create the technology in their own image. By providing the insight that playing less and giving the musical agents more space, the musicians in Co-Creative Spaces demonstrated that striking a balance between viewing the machine as a tool and co-creator can take musical creation in directions that are different from interactions between people. When taking the agency of the machine seriously, co-creative spaces between humans and machines open up, and this can provide valuable new perspectives for musical co-creation in general. We posit that creativity arises in the absence of full control. It emerges when one's own will is attuned to what the environment affords and leads to surprises. Musical agents are not replications of people. They are something different, which the musicians learned to take seriously. They also manifest the attitudes of those who develop them, and co-creation with agents proved to be a constructive way to challenge oneself to accept alternative perspectives.

Co-Creative Spaces is a clear example of how artificial intelligent technologies and machine learning can lead to new forms of creative practices in music. It also clearly demonstrates that technology development is a part of the creative process. Instead of fearing that machines will take over music, it may be better to invite them to a co-creative dance.

8. ACKNOWLEDGMENTS

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9. ETHICAL STANDARDS

The musicians have given consent to be identified by their full names in this publication. Norwegian research projects that collect personal information must be submitted to the Data Protection Official for Research at the Norwegian Social Centre for Research Data (NSD) for approval. NSD has approved the project, and we have abided by NSD's guidelines for safe storage of personal information.

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