Improvising with Machines – Designing Artistic Non-Human Actors

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Abstract
For musicians, improvising with other musicians is not uncommon. But what happens when musicians engage in musical improvisation with semi-autonomous machines? We investigated a seminar in which design students built machines for musicians to improvise with. We explored the experiences of musicians when improvising with non-human musicians, as well as the challenges of designing non-human musicians. Among other things, we found that while from an outside perspective, the machines appeared as independent actors that interact with the musicians, the musicians experienced them as additional instruments they controlled. The interaction design of non-human actors was challenging for designers.

Author Keywords
Animistic design; interaction design; autonomous system; human-technology relations.

CSS Concepts
• Human-centered computing~Interaction design~Empirical studies in interaction design

Introduction
From drum machines and synthesizers to fully integrated digital audio workstations, there is a long tradition to make use of computers to extend musical possibili-

Human-technology relations by Don Ihde

Embodiment relations
(human - technology) ⇨ world

Technologies form a "partial unity" with a human being. For instance, playing an instrument or speaking with other people through the phone.

Hermeneutic relations
(human ⇨ (technology - world)

Human beings read how technologies represent the world. For instance, a metal detector that represents the presence of metal by beeping.

Alterity relations
(human ⇨ technology (world)

Human beings interact with technologies. For instance, interacting with a social robot, getting money from an ATM, or make a copy on the copier.

Background relations
human (technology - world)

Technologies are the context for human experiences and actions. For instance, the warm indoor climate of a heating system or the sound of a fridge.

Figure 1: Brief description of human-technology relation by Don Ihde.

ties. This was never only about efficient music production, but about new ways of artistic expression. Increasingly complex algorithms ("AI") start to play an important role in music creation, especially in recent commercial applications. For example, *Izotope Ozone's* "Master Assistant" is a machine learning-based software, which listens to musical material and automatically optimizes its "tonal balance" – just what a master engineer would do [7]. While Ozone uses AI to support the optimization of mix and master, *Generative Music* is already fully composed and generated by algorithms (e.g., *Eternal Techno Flow* [14]). *Jukedeck* [10] allows a user to choose a genre, adjust the length, tempo, and climax of a song, which is then generated automatically. AI-assisted music composing systems, such as the *Flow Machines Project* [12], or *Bloom: 10 Worlds* by Brian Eno and Peter Chilvers [4] automatically create music, but at the same time invite musicians to influence this creation.

Other approaches investigate new ways of playing instruments and performing with the help of technology. New instruments, created by deploying sensors and actuation on found everyday objects, invite to explore new sounds and open up new ways of artistic expression [15]. Enabling instruments technologically can offer alternative ways of playing and writing music, questioning the typical relationship between a musician and an instrument [5]. Even in a performance as complex and variable as an improvisation, instruments do not always have to be played by humans. Pachet introduced a system that is able to perform and improvise with a musician based on a previously determined database (e.g. emulating the style of human musicians) [11]. McCormack et al. developed an AI drummer, putting special emphasis on non-verbal communication during performances with real musicians [9]. This raises new questions, both relevant to the field of music as well as Human-Computer Interaction (HCI). How does the traditional relationship between a musician and a machine change? How much artistic ownership do we grant a machine? How do we design these artificial musical collaborators?

The following study investigates a seminar, in which students designed semi-autonomous music machines for musicians to perform with in an improvisation. One goal of the study is to explore the experiences of musicians when improvising with non-human "musicians." In addition, we wanted to learn more about the challenges of designing inspiring "music machines."

Study

Context. The study took place in 2018 in the context of a regular design project seminar at the Folkwang University of the Arts in Germany. It was supervised by the fourth author. The objectives of the seminar were twofold: First, music students were asked to engage in musical improvisation with semi-autonomous machines. In musical improvisation, music is composed spontaneously when performing with other musicians. Improvisers interact with each other through the music they play, instrumental techniques, but also through visual cues (e.g., gestures or facial expressions) [13]. Uncertainty and instability, expressed through spontaneous responses of improvisers, make improvisation indeterminate and create creative space. Second, design students (communication and industrial design) were asked to experiment with sensors, actors, and prototyping tools, such as Arduino. Combining musical improvisation and physical prototyping, the aim was to build semi-autonomous music machines to improvise

Machine	**Participant**	**Age/ Sex**
A	Musician 1	26/m
	Designer 1	25/m
	Designer 2	28/f
B	Musician 2	25/m
	Designer 3	31/m
	Designer 4	36/f

Table 1: Participants in the study.

with. The seminar started with a general introduction to “animism” (e.g., [2]) and tinkering with prototyping tools. The design students then iteratively built machines in groups and were paired with musicians. The seminar concluded with a public musical improvisation, in which the participating musicians and the semi-autonomous music machines performed together.

Procedure. Our study consisted of three steps: (1) analyzing the interaction between musician and machine during the public session from an outside perspective; (2) interviewing the musicians to better understand their experience during the improvisation; (3) interviewing the design students to learn more about their experiences during the design process. Note, that the first three authors did not supervise the seminar but rather conducted the present explorative study, which began with the public musical improvisation, i.e., at the end of the seminar.

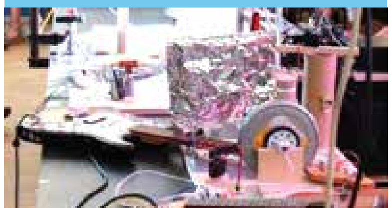
For step one, audio and video was recorded during the public performance. The improvisation took place in June 2018 during the art university’s annual exhibition. In four consecutive sessions, four musicians performed in front of an audience, each with a different machine (see video figure 1 and figure 4 and 5). Sessions lasted from 3 to 10 minutes. Each machine was designed by a team of two design students. Two musicians and the corresponding design teams agreed to further participate in our study (see table 1). After familiarizing with each session, the first two authors used thematic analysis [1] to organize emerging topics. Several topics emerged, which were discussed among the first two authors and then finally consolidated. For step two and three, semi-structured interviews were conducted by the first and second author. We conducted the interviews a few weeks after the improvisation, separately with each group. The interviews and their analyses were based on *Interpretative Phenomenological Analysis* (IPA) [16], since our focus was on the individual experiences of the musicians and design students during the improvisation and design process. Fitting with the small sample size, IPA values detailed individual experiences instead of generalization. Initially, the first and second authors analyzed the interviews individually. Then, in a second step, discussed and selected emerging phenomena together. Additionally, we made use of the concept of different human-technology relations suggested by Ihde [6]. It is a helpful model to better understand the potential qualitatively different relations between musician and machine (see figure 1 for a brief overview). The differences between *embodiment* and *alterity* relations are of particular interest for our analyses, as they describe existing concepts in music – from mastering an instrument (i.e., *Embodiment Relations*) to improvisation with other musicians (i.e., *Alterity Relations*).

Findings

In the following, we present each step starting with the findings and concluded by a brief reflection. For a detailed description of both machines see figure 2 and 3. Video figure 1 shows the performance of both machines and musicians.

Observed Interaction Between Musicians and Machine
In the following, we present and reflect on characteristics emerging during the public improvisation. The performance of machine A and the guitarist (figure 4), who plays a ukulele like a violin, lasted four minutes, that of machine B and a clarinetist (figure 5), lasted nine minutes. First, both the machines and the musici-

Machine A



The machine consists of an electric guitar whose strings are scrubbed by a piece of metal, which moves back and forth. Another element is a film can, filled with metal balls, that rotates using a DC motor. A third element is a piece of aluminum foil, that flutters back and forth, moved by a servo motor. All three elements move according to the volume the musician plays. High volume results in fast movement, while low volume lets the elements move slowly. The movement of the aluminum foil was delayed by an incrementing variable. A randomization of the sounds was not programmed, but the physical design led to uncon trollable outcomes. For instance, the metal piece every now and then not only scrubbed, but also plucked a guitar string and the sound of the foil and the metal balls had a naturally random nature. Both machines work with an Attiny85 (i.e. micro-controller) and use the audio signals as control voltage for movements (i.e., motors), smoothened via arrays.

Figure 2: Description of machine A.

ans are *adjoining subjects* without any physical connection. Both musicians focus on their own instruments, but *face* their machine. While playing, they continuously observe the machine's movements. During the performance of the clarinetist, he adapts his body movements to the movements of the cans. A further characteristic is that in both performances, the *initial sound* is played by the machine. Only then, the musicians follow. The clarinetist, for instance, waits for about 8 seconds before he starts playing a sound, slowly increasing in volume. Instead of constantly playing as in a solo concert, both musicians leave room for the machines to play. Finally, both machines and musicians affect each other with the speed and volume they play.

From an outside perspective, both performances convey the impression of two independent improvising actors that interact with each other in an *Alterity Relation*. An audience might have the impression that both provide individual input, which is processed and included in a reaction (i.e., output).

Experience of the Musicians

After being in the position of observers during the performance, we tried to understand the experience of the musicians through the interviews. At the beginning of the improvisation, the guitarist found it difficult to understand what the machine was responding to because it seemed unpredictable at first. The unpredictability was in part due to the fact that the machine lacked detailed means of expression, such as gestures and facial expressions. When improvising with other musicians, he notices quickly what his counterpart wants: *"If you play with other people, they have fine facial expressions and gestures"* (M1). The guitarist mentioned that his relation to the machine was just like playing another instrument that is controlled through the instrument in his hands: *"The machine is like a guitar amp. Although it is separate, it is part of the guitar"* (M1). Similar to the guitarist, the clarinetist perceived the machine like playing two instruments at the same time: *"[…] I could understand the interaction of the machine very well, so I played this 'noise box' as a second instrument"* (M2). He compared it to ringing the bells in a church tower – you pull a long rope, and you don't know exactly how hard to pull and have trouble controlling it, but there is a direct connection nonetheless, that maps onto one's actions.

While from the observer perspective, it appeared, as if the violinist was paying close attention to the machine, responding to what it does, as in a dance, his explanation in the interview showed a different perspective. All input had to come from himself, and he was looking closely to plan movements of the machine ahead while making sure to stay in control: *"I paid close attention in the sense that I played it as my instrument. I tried to plan, how the movements and the sound of the machine will be"* (M2). He felt that the amount of agency of the object was very limited and only played out through the instable physical design. Even though the machine was separate and physically facing him, the guitarist did not perceive it as a real counterpart either. Nevertheless, when asked about the authorship of the performance, the clarinetist and the guitarist would grant at least the designers of the machines a part. Note that they did not state that the machine itself could be an author.

In addition to his participation in the performance, the clarinetist had some previous knowledge about performing with interactive objects, since he conducts his

Machine B

The central visible element of machine B are two bright tin cans on a black column. The lower tin can is mounted very freely on a metallic pin and connected with a servo motor through two thin strings. At the upper edge of the lower can, a marble can freely roll around in a track. The lower tin can wiggles left and right, controlled by the volume the musician plays (fast and extensive at high volume; slow and reserved at low volume). The upper tin can is connected to the lower one by a flexible spring that making it bump against a piezo-element that generates a clicking sound every now and then. Just as in machine A, randomization of the movement (i.e., sound) was achieved by the high degree of freedom of the components.

Figure 3: Description of machine B.

own experiments and builds music machines. He pointed out some elements, he considers important in such a machine, to be able to perform with it: *"The mapping of my actions has to be recognizable, but also flexible. So maybe there would be four different types of mappings, and they change, and I can influence them"* (M2). While he did not believe that it is possible right now to build a truly intelligent machine that would be inspiring to improvise with, he pointed out that it is much easier to make it appear so to an audience during a performance: *"I believe for an audience it can be possible to see these things as independent beings sometimes. […] very naive single-cell organisms"* (M2).

Reflections. Both musicians clearly saw the machine as just another instrument in addition to the one they held in their hands. There is a big gap between how we perceived the performance as observers, and how the musicians saw the machines when interacting with them. From the outside, the performance gave the impression that the machines act as a being, an improviser, or as Ihde puts it "a quasi-other". This was not experienced by the musicians. The mental image of the guitar amp, for example, shows that the physical separation between machine and musician is not a good indication of their relationship. The interaction and experiences are much more important. However, especially the clarinetist provided some hints of what would make him experience the machine more in terms of an *Alterity Relation*.

Experience of the Design Students

At the start of the seminar, all design students struggled with the basic technical setup. For instance, the designers of machine A (D1, D2) did not have any experience with physical prototyping. However, even after overcoming technical problems, they found it challenging to design an interaction between their musician and their machine. Moreover, D1 and D2 had different ideas of the machine. D2 perceived the machine as an instrument, while D1 perceived it as another improviser. Thus, they did not even agree on the type of relationship to design. Ultimately, these fundamental differences were not reflected in the design process.

The designers of machine B (D3, D4) described that the interaction and the character of their machine were determined by the materials they picked, and they only shaped it minimally after that. Their only real guide was intuition: *"As soon as it was put together and connected to power, it did a lot of small movements […] we could not control. […] That predefined a lot […]. It was something purely intuitive […]"* (D3). Similarly, D1 and D2 mentioned that they rather coincidently created the "character" of their machine. D3 and D4 had the feeling that while their machine was not on the same level as a human performer in an improvisation, the performance was like a game the musician plays with the object, in which the exact rules have to be explored during the interaction. One particularly interesting approach they shared with us, but which did not make it into the final machine, was a function to make it fight back when demanded excessively: *"We had someone program an electronic piece to make it fight back. […] When someone gives […] too many impulses in a short time, that it doesn't act faster, how you'd expect, but that it does less"* (D3). This strongly points towards them seeing their machine as something more animate than a regular machine, like something you feel bad for when it is being abused.

Figure 4: Guitarist performing with machine A.

Figure 5: Clarinetist performing with machine B.

Reflections. Both design teams developed a functional machine with which a musician could improvise, but they had profound difficulties. Besides a lack of experience on tinkering and prototyping, the design of the interaction with non-human actors was challenging. Although animism provided first inspiring concepts (e.g., uncertainty or unpredictability), the difficulty designing the interaction (i.e., the experiences) with non-human actors could be explained by a lack of guiding theories (known to the design students). This becomes clear since the designers often use randomness in their design. Although randomness can, at times, bear good results in this context, it is only one design parameter. Instead of applying theory and knowledge to design their animistic machine and to then implement it technically (top-down), the designers had no choice but to create the machine while building it (bottom-up). On the one hand, this could be because the objective of the design project seminar was to get design students to explore physical computing. On the other hand, this could be because the design of non-human actors is currently not part of design education and current curricula. As in the future, interactions with more autonomous systems will become increasingly important, and more research is needed in this domain to support designers better.

Discussion

From an audience perspective, the performance of musicians with a semi-autonomous music machine conveyed the impression of two independent improvising actors – an Alterity Relation. On the contrary, the musicians' experience was that of playing a further instrument, i.e., to be placed in the complex continuum between an embodied or hermeneutic relation, as discussed by Magnusson [8]. Finally, beyond technical difficulties, the designers did not deliberately design their non-human musicians. They rather used the randomness they created due to a lack of control over their materials as the primary conceptual tool. This could be due to a lack of established methods and knowledge.

Conclusion

We believe that studies such as the present provided valuable insights for HCI. Sophisticated algorithms and AI represent new opportunities for interaction design. However, design still lacks experience and knowledge about how to design non-human actors [3], beyond simplistic notions of anthropomorphism. Although animism provides inspiring concepts for design and Ihde's human-technology relations help to better understand different types of relationships with machines, new design approaches and methods are needed. Especially the discrepancy between the interaction, which appears from the outside as if two independent actors collaborate, and the emerging inside view of the actors is interesting. With the possibilities of algorithms and AI, designers can conceptionally think of new ways of interactions. For example, a non-human musician could create sound by playing the piano with more than ten fingers – something a human would never be able to do. Of course, possibilities are abundant. What are the qualities that are unique to machines and which can lead to new, positive interactions with human musicians? Besides pushing the boundaries from a functional perspective (i.e., technical capabilities), future work should focus more on approaches, tools, and design methods to create meaningful experiences in collaboration with supposedly AI-driven technologies-as-opposites.

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