The Design of Musical Instruments for Grey Parrots: An Artistic Contribution towards Animal-Human-Computer Interaction

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Dedicated to the memory of Coco 

ABSTRACT

This dissertation was carried out within the framework of an artistic research and art project called metamusic and documents the process of designing musical instruments for grey parrots in captivity. This cumulative work discusses the different steps towards an animal-centered design for auditory enrichment in the context of Animal-Computer Interaction (ACI) and related fields on the basis of four peer-reviewed publications.

It begins with a presentation of a wide range of artistic and scientific projects involving animals in musical settings. I analyzed and classified these projects focusing on the interplay between animals and music technology in order to arrive at a better understanding of these animal-based musical projects and the musical agency of the animals involved.

This is followed by a description of a series of sonic experiments with my research subjects: a group of African grey parrots living in a parrot shelter near Vienna. These investigations were intended to gain information about how this specific group of grey parrots perceive and respond to sound stimuli. I then used the results of these experiments to determine the interaction and sonic preferences of the parrots, which in turn informed the subsequent design process.

Building on this, the thesis describes the animal-centered design process for creating musical instruments and interfaces that provide auditory enrichment for grey parrots living in captivity and discusses how the implementation of such technological mediators could foster new auditory and interaction opportunities for improving the quality of life of grey parrots living in captivity.

This dissertation closes by exploring the implications of the research and artistic output of metamusic for both the animal and human participants in experiments, the design process as well as artistic installations and performances. The findings also suggest further research opportunities concerning the auditory enrichment of captive grey parrots.

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CONTENTS

1 Introduction

This thesis strongly supports the idea that wild animals should not be kept in manmade environments such as zoological gardens, laboratories, animal shelters or even private homes, but if they are forced to, for whatever reasons, we have the particular responsibility to promote adequate and dignified living conditions for each species. The challenges of maintaining wild animals in captivity are broad, and there are several forms of environmental enrichments that can be employed to increase their well-being. In the near future, the use of new technologies that promote species-specific behaviors could lead to significant improvements in many aspects of these artificial habitats.

The still relatively young research discipline of Animal-Computer Interaction (ACI) focuses on developing new technologies for animals from an animal-centered design perspective. One particular approach in the context of ACI is auditory enrichment for captive wild animals. Efforts are being made to improve the artificial habitats of these animals and to prevent them developing behavioral disorders by implementing different forms of auditory enrichment environments and devices. It therefore seems appropriate and promising to test and implement such auditory enrichment technologies for animal species with high auditory abilities and complex sound communication. African grey parrots, the research subjects of this PhD project, are, according to the current state of knowledge, considered to be one of the most talented musicians in the animal kingdom due to their auditory and vocal skills.

The artistic research approach adopted in this PhD project intends to make a substantial and experimental contribution towards issues of musicality in the animal kingdom, animal-centered design, the development of technology for environmental enrichment and art in collaboration with animals. To be precise, this cumulative dissertation documents the artistic research project to develop musical instruments and interfaces for the auditory enrichment of captive grey parrots.

Chapter 1 deals with the different starting points and approaches of this PhD project. At the beginning, I present metamusic, the artistic research project on which this PhD project is based. Furthermore, the various relevant research disciplines in these contexts are presented. The grey parrots as research subjects and the principal agents of this thesis are discussed from different viewpoints and brought to the center of attention. This chapter ends by formulating my research questions and presenting the research methods applied in the project.

Chapter 2 is devoted to the use of musical instruments and interfaces that involve animals in the interaction process in various contexts. The art and research projects that have been implemented in this unusual field are raising questions concerning ethical principles, animal-centered design processes and the possible benefits and risks for the animals involved. I examine several projects focusing on the interplay between animals and music technology in order to arrive at a better understanding of animal-based musical projects. Building on this, I discuss an animal-centered design approach that could be implemented for new musical instruments and interfaces for grey parrots in captivity.

Chapter 3 documents a series of sonic experiments conducted at ARGE Papageienschutz to develop acoustically enriched environments through the use of musical instruments. These investigations were intended to provide a better understanding of how grey parrots communicate through sound, perceive and respond to auditory stimuli and possibly generate sound and music through the usage of technological devices. The chapter also identifies the musical, sonic and interaction preferences of the parrots involved, which in turn informed the subsequent animal-centered design process.

Chapter 4 describes the design of musical instruments and interfaces for the auditory enrichment of a particular group of grey parrots. Based on the cognitive, physiological and auditory abilities of these grey parrots, and their intrinsic interest in sonic and physical interactions, I have developed and tested various interactive musical instrument prototypes from an animal-centered design perspective. As a result, I present the final musical instruments that were implemented and describe how they were adopted and played by the individual grey parrots.

Chapter 5 presents the interdisciplinary discourse that was stimulated by the “Animal Music Symposium” (ANIMUS) in Linz. The invited experts provided first-hand input from their respective disciplines that informed and shaped the evolution of this PhD project. Furthermore, I also document the “SoundJam” workshop, a format within the context of the ACI conference, to which I actively contributed as co-author and expert on auditory enrichment for grey parrots.

Chapter 6 presents the various artistic outcomes achieved by alien productions that were strongly supported by the research and developments of this PhD project. Under the direction of the artist group, a variety of art exhibitions, laboratory situations and interspecies sound performances for and with grey parrots were staged. By reflecting on these artistic practices, I propose further concepts and possible implications of the metamusic PEEK project.

Chapter 7 concludes with a summary of the research results that were investigated and achieved within different fields such as ACI, NIME and art. The section reflects on the research questions formulated in Chapter 1.4 and analyzes in detail the strengths and constraints of this PhD project. Finally, it proposes further steps for research on musicality, animal-centered design and auditory enrichment for and with captive grey parrots and other animal species.

The concept of music used in the context of this dissertation is understood in a very broad sense and allows animals to generate sounds that go beyond their basic sound communication. This includes sounds that have been created using musical instruments and interfaces designed for the cognitive and physiological abilities of grey parrots. Based on the idea that music has its biological roots in the animal kingdom, I follow this concept by studying how captive grey parrots interact with such musical devices and produce their own kind of "parrot music" in order to learn more about the aspects of their musicality. The musical patterns, rhythms and melody structures generated by the parrots using the musical instruments and interfaces are nevertheless not meant to sound aesthetically pleasing to human ears and goes beyond anthropomorphic musical appreciation.

"The parrots themselves communicate which each other by means of their own 'music' created by their music instruments. The goal is to research whether or not the parrots will create meaningful 'music' of their own accord and to understand how this 'music' will sound—in order to find meanings and use in sound, which we have not discovered yet; and which maybe will change our understanding of animal intelligence—and music itself."

[alien productions, Martin Breindl et al.]

This cumulative dissertation is based on the following four peer-reviewed papers, which were published during the project period from March 2016 to December 2019.

1. Gupfinger, R.; Kaltenbrunner, M.; "Sonic Experiments with Grey Parrots: A Report on Testing the Auditory Skills and Musical Preferences of Grey Parrots in Captivity." *In Proceedings of the 4th International Conference on Animal-Computer Interaction (ACI 2017)*, Milton Keynes, UK, 2017.

2. Gupfinger, R.; Kaltenbrunner, M.; "Animals Make Music: A Look at Non-Human Musical Expression." *Multimodal Technologies and Interaction*, vol. 2, 51, 2018.

3. Gupfinger, R.; Kaltenbrunner, M.; "Animal-Centered Sonic Interaction Design: Musical Instruments and Interfaces for Grey Parrots." *In Proceedings of the 6th International Conference on Animal-Computer Interaction (ACI 2019)*, Haifa, Israel, 2019.

4. French, Fiona & Gupfinger, Reinhard & Kendrick, Paul. "SoundJam: Acoustic Design for Auditory Enrichment." *In Proceedings of the 5th International Conference on Animal-Computer Interaction (ACI 2018)*, Atlanta, Georgia, USA, 2018.

In order to avoid possible redundancies, the sections that repeated themselves in the individual publications were summarized and discussed in more detail in Chapter 1. Thus, the grey parrots are presented as the central research subjects and are discussed in more depth from a variety of perspectives.

1.1 metamusic

1.1.1 Initial project: metamusic

metamusic is a project that was launched in 2012 by the Austrian artist group alien productions (Martin Breindl, Norbert Math and Andrea Sodomka).

The fundamental idea of alien productions is to develop interactive sound installations for animals in zoological gardens. Although there are numerous approaches, much remains to be done to offer new challenges, diversions and enrichment to zoo animals. metamusic is the idea of providing captive animals with musical environments that are interactive and can be voluntarily played by the animals themselves. This should be made possible through a wide range of new musical instruments and sound tools which are especially designed for the animals and allow them to explore and play with sounds and music [1]. Thus, the project's target is to improve the animals' quality of life by designing interactive musical instruments that take the specific needs and skills of the animals into consideration.

In their search for the most suitable animal species to work with, they were made aware of the grey parrots of ARGE Papageienschutz by Iris Baldinger, a zoologist who was working on her thesis on these parrots. Since then, the artists have been working in close collaboration with the zoologists, biologists and animal keepers of ARGE Papageienschutz. The zoological partners from ARGE Papageienschutz create the preconditions for alien productions' artistic work, the animal keepers take care of the parrots' welfare and they also help to interpret the animals' behaviors. Together they started working on sound installations for and with a group of African grey parrots. It soon became clear that these parrots were a very good study subject because of their complex cognitive and musical skills. Although they are regarded as wild animals with complex social flocking behavior, each of the birds has been bred or at least raised by humans so they are accustomed to interspecies interaction with humans [1].

In collaboration with the grey parrots, alien productions has been developing different mechanical and electronic musical instruments and sonic toys that can be explored by the grey parrots. Adopting an artistic approach, the collective has been investigating how grey parrots react to musical stimuli, exploring whether they can become an intrinsic part of interactive sound installations and assessing whether they are capable of producing "parrot music" by themselves. Nevertheless, the musical patterns and sonic structures generated by the parrots are not meant to sound aesthetically meaningful to human ears. The project also intends for the parrots to communicate with each other by means of the musical output created by their personalized instruments [1].

The metamusic project aims to generate artistic output for humans while improving the quality of life for grey parrots in captivity with musical instruments and interfaces. The early phase of the project has shown that there is great potential for these kinds of interactive sound environments for and with grey parrots and has also made clear that much more remains to be explored in this context.

"But, unlike the scientific approach, our artistic interest aims at a creative exchange with this intelligent species. We make music together with parrots. We call it music even though it sounds 'parrot-like'. We look at them as partners in a musical process and avoid conditioning and training."

[alien productions, Martin Breindl et al.]

In the context of their work with the grey parrots, the artist group alien productions makes it clear that they are not in favor of zoos or any other facilities designed to hold wild animals in captivity. They thoroughly disapprove of catching, trading or breeding wildlife creatures for amusement, entertainment or exposition purposes. They are aware of the problematic situation of keeping grey parrots and try to keep animal welfare at the heart of every project and try to raise public awareness for these problems in the framework of the metamusic project [1].

1.1.2 metamusic: Metamorphosis of a term

This part is a summary of Martin Breindls' text "metamusic: Metamorphosen eines Begriffes" and the paper "metamusic - a sound project for and with grey parrots", which was presented at the *8th International Conference on Artistic Research* in Helsinki in 2017. In my contribution to this paper, I emphasized adopting the methods and the animal-centered design approach from ACI research for the metamusic PEEK project.

This summary describes the theoretical concept of the term metamusic, the music-theoretical concepts underlying the project and the concept developed by the artist group alien productions. My PhD thesis does not pursue or build on these concepts, but the metamusic project, and in this regard the artistic standpoints of alien productions as a whole, should be mentioned here. Furthermore, consideration must be given to how such musical terms may generate expectations and create limitations to comprehensively describing the novel approach of making music together with grey parrots.

"The term 'metamusic', which we use as the title for our art project, evokes that which we hope to attain through our work and are in search of, be this a potential outcome or the method or path we pursue. When artists introduce a new term, it serves not simply to describe a thing but also to understand it, as well as to communicate how a prospective venture is seen. Initially, the term metamusic was empty; it served merely as a container for an attitude, an approach, for the first step into an epistemological adventure."

[alien productions, Martin Breindl et al.]

According to Martin Breindl, the concept of the term metamusic can be interpreted as an empty container which is gradually filled with meaning through artistic methods. The meaning arises from the project's progress, and the practice determines the meaning and development of the term "metamusic" [2].

“As Brian Eno said, we artists stand ‘before and after science’. The idea comes first and it’s only later, when implementing and scientifically analyzing the idea, that we are gradually able to refine our term (the container) by filling it with meaning.”

[alien productions, Martin Breindl et al.]

Due to the close relation between metamusic and music categories, the artist group thought it appropriate to transfer and link musical concepts to metamusic and wanted to further explore the extent to which such musical concepts can be found in the context of metamusic’s artistic practices. The musical terms that seemed suitable for describing the music within metamusic were found in Ulrich Dibeliuss’ concept of the “aleatoric”, Vilém Flussers’ “permeability” and Ornette Colemans’ “harmolodic”. According to alien productions, the musical terms aleatoric, permeability and harmolodic fit together as different stages of expectations in metamusic [2].

Aleatoric music

Aleatoric is a musical term used to describe a series of diverse procedures that incorporate the planned coincidence in compositions. Breindl has stated that “An aleatorically controlled sound installation can be generated by metamusic.” The grey parrots are the random source parameters and thus the planned coincidence in the sound installation. There is no feedback for the animals, and they do not need to be aware of what sounds they are generating. It is not obvious to the audience how the musical composition is created, and how the system works remains a black box [2].

Permeability

Permeability in the context of metamusic can emerge through sonic frequencies which penetrate the bodies of both humans and grey parrots. According to Breindl, the concept of permeability also attempts to explain how emotion is triggered by sound. Since the group of grey parrots not only trigger sounds, but also perceive them in the form of acoustic feedback from speakers, the question is how they experience these sounds physically. Animals can feel and they can communicate their current mental state in different ways. Whether animals can reflect on emotions is unclear [2].

“Animal musicality (as far as we can judge at the moment) is not reflective—it does not evoke. In the sense that ‘composition’ involves the separation of conception and interpretation of a musical event, a conscious process of planning, animals do not compose. This means that the conception is our responsibility. As composers, however, we must engage with the abilities of the interpreters—if we want to bring them in. It therefore remains exciting to find a way to express emotion through metamusic and to share emotional states with the grey parrots.”

[alien productions, Martin Breindl et al.]

Harmolodics

The immediacy and real-time dialogue within metamusic performances further refers to improvised music, where immediate compositions are created in a dialogical exchange between musicians. Improvisation does not mean that everything is allowed when making music; instead, it means the rules of playing music are set in freedom. The rules define the role of composition and setting. Harmolodics approaches free musical compositions from any tonal center, believe that all aspects of music should have the same value and results in a way that music can achieve immediate expression without any limitations [2].

“In our case, music and metamusic merge at the point where action and reflection merge. In this area, there are no more ratings. Just as all musical parameters become equivalent, so do all actors and participants. This does not mean overlooking the differences. Our animals are still not cultural products and they will continue to plan anything. On the positive side, they live and act in the here and now.”

[alien productions, Martin Breindl et al.]

1.1.3 Chronology of the initial project (2012 – 2015)

From 2012 to 2015, metamusic was created in several installations and performances in exhibitions and at music festivals. In these settings, alien productions examined how the grey parrots reacted to sound, identified some of their musical preferences and explored their interactions and sound generation with the musical instruments provided them.

The first public presentation and performance of the metamusic project took place at musikprotokoll as part of the Steirischer Herbst festival in in Graz, Austria in October 2013. Musikprotokoll is a festival platform for contemporary and experimental music and acts as a laboratory for new musical developments. For the festival, a custom-made indoor aviary was built by alien productions and became the temporary home for five grey parrots for a period of four days. Apart from the typical parrot furnishings, the aviary was equipped with early instrument prototypes for musical interaction. The grey parrots familiarized themselves very quickly with the instruments and accepted them as part of the aviary interior [1]. To avoid creating any stress for the grey parrots, the setting was divided into two rooms. One housed the aviary installation and access was very limited, and the other room was for the audience to attend the concert, which included a live video from the aviary room. The first performance featuring grey parrots and human players was given in this setting. Interestingly, whenever a limited number of visitors were allowed to enter the aviary room, the grey parrots obviously appreciated the presence of humans. Consequently, the two-room installation was not necessary, and maybe even overprotective or even counterproductive. Since the outcome of this first public presentation was generally promising, the artist group started to look for a way to implement an aviary installation over a longer period of time [1].

The following installation was a public laboratory space at the Kittenberger Adventure Gardens and took place in Schiltern, Austria over a span of five weeks in September and October 2014. During this time period, alien productions was able to work closely with six grey parrots. They focused on gaining a better understanding of the parrots' behavior, developing more musical instruments and also designing novel sounds for them [1].

Shortly after this, metamusic was presented at the CYNETART festival in Dresden, Germany in November 2014. Based on their previous experiences with the grey parrots and different settings, metamusic was presented this time to a wide festival audience. alien productions performed four concerts in collaboration with the grey parrots and, as further extensions, encouraged the audience to engage in interspecies interactions with the parrots. The installation and the performances received a lot of attention for their novel approaches and were finally honored with the CYNETART ARTE Creative Commission 2014.

In 2015, the project returned to Austria with a large-scale installation at Höhenrausch 2015: "The Secret of Birds" in Linz. Situated in the VOEST ALPINE OPEN SPACE on the rooftop of the OÖ Kulturquartier, the extensive aviary offered a temporary home for twenty-one parrots for five months. This long time span and the extraordinary location above the rooftops of the city, turned this implementation of metamusic into a very special place for the interspecies interaction and communication between grey parrots, artists and the audience [1]. The installation and its sonic outputs inscribed themselves into the urban soundscape and in return the sound of the city had effects on the grey parrots' calls and sounds.

The extensive installation project was when I joined the team working on the metamusic project. For the first time, I had the opportunity to get to know the grey parrots of ARGE Papageienschutz and learn about their nature, behavior and personalities. I was very impressed by their complex social interactions and communication by sound. I was motivated to work on improving the existing instruments and creating new designs for auditory enrichment devices for these grey parrots. As part of the Höhenrausch exhibition, I developed my first instrument prototype and improved some exiting instruments. In Chapter 6.1, I will describe in more detail the different aspects of this metamusic project phase. Many activities related to the metamusic project have been documented and prepared for Ö1 Zeit-Ton radio shows by Susanna Niedermayr.

1.1.4 metamusic PEEK project

The metamusic PEEK artistic research project was based on the initial work on metamusic by alien productions from 2012 to 2015. As described above, the artist group has been working since 2012 on interactive sound installations and performances for and with grey parrots in captivity. In collaboration with the parrots, the group has been developing mechanical and electronic instruments and sound toys which can be played by the grey parrots themselves. With the help of the grey parrot experts of ARGE Papageienschutz and further supporters, they created several exhibition installations and held concerts with the parrots. In the course of these exhibitions, the group has been examining how the grey parrots react to musical stimuli, have explored their interactions with musical instruments and sonic toys and have tried to establish the extent to which such activities point to musicality in these animals. Since the observations and informal findings of the first three years of work on metamusic seemed promising, alien productions wanted to expand and further develop the project [1]. Especially with regard to instrument design and implementation, they had reached a point where they could no longer move forward on their own and were looking for support in this specialized sphere. Professor Martin Kaltenbrunner, an expert in musical instrument design and the head of the Tangible Music Lab of the University of Art and Design Linz, was approached to collaborate on the project. Subsequently, I joined the team and accepted the challenge of doing my PhD project, focusing on the design of musical instruments and interfaces, within the framework of the metamusic PEEK artistic research project. In March 2016, the interdisciplinary project was finally started by the Tangible Music Lab in collaboration with the artist group alien productions, the zoologists and animal keepers of ARGE Papageienschutz and external advisors. My role as musical instrument builder was to design and develop musical instruments and interfaces for the grey parrots with the primary goal of improving their quality of life in captivity. On the following pages, I will briefly introduce the multidisciplinary research team including several institutions, the artist group and several experts from different fields.

Tangible Music Lab

The Tangible Music Lab is an artistic research group within the Institute of Media Studies at the University of Art and Design in Linz, Austria. It is directed by Prof. Dr. Martin Kaltenbrunner, who was also the head of the metamusic PEEK project. The research team experimentally explores the physical aspects of musical human-machine interaction and through this PhD project, expanded its research to include musical animal-human-machine interaction. Following a post-digital instrument design approach, we bring musical instruments back from the digital to the analog world and additionally work on physical forms and multisensory feedback systems to perceive sound and music in novel ways. The multidisciplinary team bridges the gap between art and technologies through the design of new musical instruments and sound artifacts in the context of artistic research that also includes artistic methods for gaining knowledge. The metamusic PEEK artistic research project mainly focused on the design and evaluation of musical instruments for grey parrots, as well as academic research and dissemination activities on this challenging topic.

alien productions

The well-known Austrian artist group alien productions was established in 1997 by Andrea Sodomka, Martin Breindl, Norbert Math and August Black. Their artistic works cover all sorts of media art productions from performances, installations, electronic music and digital art to more traditional art forms such as visual arts and photography. They are the founders of the metamusic project and within the metamusic PEEK project, the members of alien productions (Andrea Sodomka, Martin Breindl and Norbert Math) were the artistic directors. With their expertise, they gave input on the design concepts and were responsible for the artistic production and presentation of the project. These were implemented in the form of installations and performances with the grey parrots and were supplemented with additional exhibition formats and musical compositions.

ARGE Papageienschutz

ARGE Papgeienschutz is a non-governmental organization that has been registered in Austria since July 1996. The organization's mission is to improve the situation of parrots living in captivity and to provide educational work in this context. ARGE Papageienschutz is currently running a parrot shelter located in Vösendorf near Vienna, which is home to approximately 180 parrots of different subspecies. The NGO takes care of rescued or donated parrots and offers appropriate living conditions and health care to them. Nadja Ziegler, a biologist and the founder of ARGE Papageienschutz, and Julia Bellmann, the head of the parrot shelter, were our main contacts during our collaboration. Within the framework of the project, many other biologists and animal keepers saw to the well-being of the grey parrots involved, provided background information on the individual birds and their preferences and also helped to interpret their behaviors.

Irene Pepperberg

Irene M. Pepperberg is one of the main experts on grey parrots. Her research has provided fundamental insights into the cognitive abilities of grey parrots. She has passed on her knowledge as a professor and lecturer at numerous university institutions such as Harvard, Northwestern University, University of Arizona, and the MIT Media Lab. She is very well known for her studies with Alex (grey parrot) on cognitive, language and communication skills. In Chapter 1.3.2, I will describe her work in more detail. During the metamusic PEEK project, she participated as an external advisor and gave us valuable advice on carrying out our studies with grey parrots, setting up experiments as well as interpreting the individual parrots' behaviors.

Daniel Gilfillan

Daniel Gilfillan is an associate professor at Arizona State University. His research focuses on 20th-century literature in the German-speaking sphere, and on sound and media studies. As an external advisor and co-advisor of this PhD project, he directed my attention to what it means to make musical environments with animals and explored the role of such sound practices in the concept of the Anthropocene. He is a longtime companion of the metamusic project and with his philosophical expertise, he was able to position the project in a broader context and during the course of this PhD project, he motivated me to think beyond the borders of my discipline.

Norbert Schweizer

Norbert Schweizer considers himself to be a self-employed management consultant and project companion for art and culture. He has been supporting the metamusic project since the very beginning and during the PEEK project, his main tasks were the administration, organization, production and planning of the exhibition setting. Thus, his actual activities went far beyond the role of an external advisor and were essential for the well-functioning project implementation. His pleasant way of dealing with problems and challenges was a great role model for coping with this PhD project.

Team of grey parrots

Numerous grey parrots of ARGE Papageienschutz were involved in the metamusic PEEK project. Here some of the grey parrots that contributed voluntarily are briefly introduced. Many of them appear in more detail in the descriptions of the various project phases within this dissertation.

Bimboli is a very dominant male parrot. He is what is known as a persecutor who likes chasing others, whether parrots or humans, through the aviary. He likes to move on the ground, and you have to be quick if you do not want to get bitten. He liked to interact with instruments lying on the ground, such as the tube instrument (Chapter 4.3.5).

Coco was an approximately 40-year-old female grey parrot and the oldest parrot I worked with. She was very friendly, rather small and suffered from FDB syndrome (Chapter 1.3.3). She liked to be on the ground, and her favorite musical interface was the joystick device (Chapter 3.6). Unfortunately, she died in 2018, and this thesis is dedicated to her memory.

Cocomiso is a male parrot with a pronounced FDB syndrome. He was very interested in experiments with various instrument prototypes and showed a preference for the vox instrument (Chapter 4.3.6). He often responded to sonic feedback from the instruments by bobbing his head, a behavior that can be interpreted as positive engagement.

Moritz's most striking feature is a missing toe. He is one of the most talented parrots I have ever worked with, and he was obviously trained by his previous owner. He played a very active role in various experiments and "Jam Sessions" and expressed his joy by whistling catchy melodies.

Nepomuk is a dominant male parrot who has a crossed beak. He likes to chase others and displayed destructive behavior towards the musical instruments. He was also a very active performer during the live performances and showed no stage fright in front of large audiences, which he really seemed to enjoy.

Pauli is a joyous female explorer and participated especially in the “Jam Sessions” (Chapter 4.2.1) in the indoor aviary at the parrot shelter. She seemed to prefer the DJ instrument (Chapter 4.3.4) and actively performed in some metamusic live performances.

Rosi is a big and beautiful female parrot. She is rather cautious in interacting with the musical instruments, but she showed a clear interest in some of the clear and melodic sound structures generated, for example, by the chime instrument (Chapter 4.3.2).

Wittgenstein is a relatively young (under the age of 10 years old) female parrot. She has a rather bright head and is very interested in playing and interacting with instruments and humans. She prefers to be in the upper part of the aviary and is easy to recognize by her strange growling sounds. She was always one of the first to discover all sorts of new prototypes and was a very active performer and central figure during the whole project phase.

Other parrots that participated in the metamusic PEEK project were Billy, Jacko, Quentin, Joki, Lukas and Chica, just to mention a few.

1.1.5 Chronology of the PEEK project (2016 – 2019)

In the course of the metamusic PEEK project, there were numerous opportunities to present this artistic research project on different occasions such as academic conferences, art exhibitions and public science events. Below is a summary of the events in which I actively participated in the form of presentations, demonstrations and discussions on my PhD progress.

At a metamusic project presentation as part of the Höhenrausch exhibition in October 2015, I had the first opportunity to present my plans for my PhD research project to a broad audience during the panel discussion.

After one year of researching and prototyping, we invited experts from relevant fields to the ANIMUS Symposium, which took place at the University of Art and Design Linz on 1 June 2017. The speakers and topics of the symposium will be explained in detail in Chapter 5.1. In my talk, I presented a comprehensive classification and analysis of the literature and contemporary art projects that involve animals interacting with musical instruments or installations (Chapter 2). During this symposium, I also had the chance to discuss my PhD research with the invited experts from the different fields.

At the same time, we had the opportunity to work closely with six grey parrots from ARGE Papageienschutz at the Salzamt, an art production and exhibition venue in Linz. During the 14-day work-in-progress laboratory situation, I carried out further tests, implemented new instruments and took part in a performance with the grey parrots and the artist group alien productions. More details on this laboratory exhibition can be found in Chapter 6.2.

In November 2017, I attended the *Fourth International Conference on Animal-Computer Interaction* in Milton Keynes, UK, and I had the chance to present my PhD project and, in more detail, my tests on the auditory skills and musical preferences of grey parrots in captivity to the ACI community.

In the following year (2018), I was invited to contribute to the "SoundJam" workshop (Chapter 5.2) on auditory enrichment for captive animals, which took place at the *Fifth Conference on Animal-Computer Interaction* in Atlanta, USA.

At the *Sixth Conference on Animal-Computer Interaction* in Haifa, Israel in 2019, I presented some final results and outcomes of my research on the animal-centered design of musical instruments for grey parrots in captivity.

Furthermore, I gave public talks at the Lange Nacht der Forschung 2018 at the Art University Linz and at Arizona State University, where I was invited by our scientific advisor and co-advisor of this PhD project, Daniel Gilfillan, who holds a professorship there.

In the framework of the final public presentation of the metamusic PEEK artistic research project (Chapter 6.3) at the ARGE Papageienschutz parrot shelter in June 2019, I had the chance to present and discusses my results on designing musical instruments for grey parrots with a broader audience.

In addition, I collaborated with Martin Breindl on an article about designing enrichment devices for animals for the *Design Austria* magazine in 2019.

In the course of my PhD project, I also experienced numerous setbacks. Apart from the work on designs with and for the grey parrots, where failures occurred on a daily basis, I faced difficulties with publishing the required papers. It was not possible for me to get research papers accepted for NIME conferences, which is basically our research community and peer group for the design of new musical instruments. Two times papers were rejected and in one specific case, the reasons given referred to unreasonable ethical concerns (Chapter 1.2.3).

Particularly instructive and challenging during this PhD project were other peer review processes, in which I gained knowledge concerning many important aspects of this PhD project, such as scientific publishing, design methods for animals, ethical issues, animal behavior and artistic research.

1.2 Research fields

The research fields that might be interested in this interdisciplinary and artistic research PhD project will be discussed in this chapter. My PhD research is closely related to the relatively new field of Animal-Computer Interaction (ACI) in combination with the field of New Interfaces for Musical Expression (NIME), which is part of Human-Computer Interaction (HCI) research. At the beginning of my PhD project, I searched for scientific fields and arts-based-research adopting an interspecies design approach and found that ACI was the ideal research discipline that fit with many of my PhD project approaches and the broader context of the metamusic PEEK project.

1.2.1 Animal-Computer Interaction

ACI research studies the design and use of technology for and by animals and deals with the various aspects of animal-machine interaction, for example, in human healthcare for training support dogs and in the agricultural industry for monitoring the behavior and well-being of farm animals. Furthermore, technology has been developed for pet entertainment and for playful interactions between humans and pets. The market for such commercial products is growing rapidly and every new gadget has to be evaluated in terms of the costs and benefits for the animals involved. The increased use of technology for animals raises many technological, design and ethical issues that ACI seeks to explore from an animal-centered point of view [3].

In 2011, Clara Mancini in her “Animal–Computer Interaction (ACI): A Manifesto” proposed the keystones for ACI as a research field. ACI research aims to understand the interaction between animals and the computing technology [3] and is therefore a significant step toward an ethical implementation of such technologies. In her manifesto, Mancini discusses the ethical principles, guidelines and methodologies for the design, analysis and evaluation of ACI systems.

Mancini proposes three main design goals: enhancing the animals' quality of life and well-being; supporting animals in the functions assigned to them by humans; and supporting human-animal relationships. ACI aims at gaining a better understanding of how animals interact with technology, and thus some ACI employs technology as a mediator between different species, including humans [3]. The literature review “Seven Years after the Manifesto” [4] summarizes recent developments in ACI, gives an overview of the technologies, innovations and insights and presents a classification of different projects in the field of ACI.

One fundamental philosophy of ACI, which was particularly relevant for this PhD project, is the animal-centered design approach, which has been adapted from HCI research. This approach puts the animal in the center of the design process and is informed in the best possible way by the animals’ preferences, needs and personalities.

The specific challenge here is to design and evaluate interactive technologies for animals and thus learn to understand what it means to the animal to interact with such technologies built for their use. Such challenges could be addressed by studying animal-machine interactions in existing environments; developing interactive technologies that improve the well-being of animals and foster relationships between animals and humans; and systematically exploring and further developing methods in ACI research [5]. I think the specific ACI approach of involving the animals in the design process as active participants by playing together with them and the technology in order to understand their interactions and behaviors is especially well-suited to this PhD project. Also worth mentioning are the self-imposed high ethical standards used in ACI research.

ACI Ethics

To provide the highest ethical standards in ACI research, Clara Mancini developed an ACI Research Ethics protocol called "Towards an animal-centered ethics for Animal–Computer Interaction" [6]. In the context of this PhD project, I applied these ethical guidelines that can be found on the website of the Animal-Computer Interaction Lab.[1] Furthermore, I had to comply with the even more stringent ethical requirements of ARGE Papageienschutz (Chapter 4.2). The new animal-centered design approach in ACI also needed to define new ethical guidelines since existing regulations are not animal centered and still see animals mainly as research instruments. Two central points of ACI ethics are the welfare of the individual animals involved and the voluntary participation of the animals in the research [6]. Mancini proposed the following ethical principles for animal-centered research:

- "acknowledge and respect the characteristics of all species participating in the research without discriminating against any of them
- treat both human and nonhuman participants as individuals equally deserving of consideration, respect and care according to their needs
- choose to work with a species only if the intent is to advance knowledge or develop technology that is beneficial or otherwise relevant to that particular species
- protect both human and nonhuman participants from physiological or psychological harm at all times, by employing research methods that are non-invasive, non-oppressive and non-depriving
- afford both human and nonhuman participants the possibility to make choice, including to withdraw from the interaction at any time, either temporarily or permanently
- obtain both mediated (from carers and legal guardians) and contingent (from the participant themselves) consent to the involvement of (human and nonhuman) animal participants."[1]

[1] http://www.open.ac.uk/blogs/ACI/?page_id=15

One area of ACI research is dedicated to the behavioral enrichment for animals living in captivity. Through the introduction of new technological developments, researchers seek to identify ways of providing enrichment according to the animals' nature to increase their quality of life and to avoid boredom, health problems and stereotypical behavior in captivity.

ACI research is growing fast, and the potential opportunities for acoustic enrichment in the context of ACI technology are gaining interest. One focus of ACI enrichment is to study the effects that sound and music have on animals, and how these can be used to enrich the environment of captive animals.

Several ACI studies are devoted to the use of audio technologies to enrich the living environment of animals in captivity. Fiona French is, for example, currently investigating the potential of technological enrichment for captive elephants. The design of the interactive toys for elephants focuses on acoustic enrichment and physical experiences [7] [8]. A further relevant study in ACI was carried out with zoo orangutans by Patricia Pons, who developed a sound-based interactive system for auditory enrichment. Instead of providing orangutans with human music, the system allowed the primates to explore different types of sounds by manipulating tangible objects. The sound preferences of the orangutans were incorporated into the design process, thus focusing on an animal-centered approach [9].

Another step in that direction was the first workshop on acoustic design for auditory enrichment called "SoundJam", which was initiated by Fiona French and will be discussed in detail in Chapter 5.2. This workshop took place as part of the sixth ACI conference in Atlanta, USA in 2018.

1.2.2 Human-Computer Interaction

ACI research has adopted many design approaches and methods from Human-Computer Interaction (HCI). In relation to HCI, ACI focuses on the usability of technology and the user experience of animals to advance the design of new interactive technologies for animals. The term HCI was introduced in the late seventies and became widespread through Stuart Card's book "The Psychology of Human–Computer Interaction" published in 1983. HCI is a multidisciplinary field with relations to computer science, design, media studies and behavioral science. Much of HCI research focuses on improving the usability of interfaces and expanding multimodal interaction channels for human-computer interaction. In terms of methodology, HCI relies on design processes in which users play a central role in developing the interactive technology. Through the use of tests, these processes involve the users in many development steps to finally increase the usability of products. On the next page, I will go into more detail about some important HCI design approaches for this PhD project.

One particular challenge in HCI is the development of interfaces for users with cognitive, motor or sensory disabilities. There are many overlaps in these specific cases with the development of technology for animals. Both face similar issues in correctly understanding the feedback from users, disabled people or animals despite the limited possibilities of communication and implementing it into the design of the system. A set of HCI design methods called the user-centered design was adopted by ACI research and is now referred to as animal-centered design. In summary, HCI has done a lot of groundwork for ACI research, which was then able to adapt this groundwork for studies with various animal species. Thus, coming full circle, the findings of ACI research could suggest new approaches to HCI research, such as the design of interfaces for people with reduced communication abilities [3]. Some of my experimental design approaches in artistic research on musical instruments and interfaces for grey parrots might also be of interest to niches in HCI research.

Within HCI, user-centered design means to develop interactive technology by applying an iterative design process that puts the user center stage during the whole project. Thus, the direct engagement of end users is very important in this process. Several methods such as observations, interviews or surveys are used to find out the needs and requirements of users when engaging with interactive technologies. The iterative design process includes understanding the context in which such interactive system are used, defining and gathering the requirements of users, producing design solutions and finally evaluating, mostly through user tests, to see how well the designs are performing. These four steps can be repeated until the design is suitable and meets the requirements.

The participatory design approach, which is also pursued in HCI, is the method to actively involve the users as co-designers in the design process with the aim of developing interactive technologies that better meet the needs of users. Such a participatory design process can be very helpful when there is a lack of communication and understanding between the designer and users [10]. This kind of a communication gap occurs especially in designing technology for animals, and that's why the participatory design approach played a central role in this PhD project (Chapter 4.2.1).

User experience (UX) is a term that emerged from HCI and describes all qualities of impressions a person has when interacting with interactive technologies such as websites, applications or digital devices. Meanwhile, the term has spread and now refers to all sorts of human design interactions including person-to-person interaction, interaction with physical products or event experiences. The following three components play an essential role in the animal experience design within the metamusic PEEK project.

- The visual and physical design of the musical instruments and interfaces has a decisive influence on whether they are used at all by the grey parrots.
- The interaction design focuses on all interactions between the instruments and the parrots. The goal is to develop instruments that give the parrots a positive overall experience.
- Usability describes the extent to which the musical instrument helps the grey parrots to achieve satisfying and joyful activities within their captive environments.

1.2.3 NIME

A related topic within the field of HCI is the design and use of new technologies for musical expression and artistic performance, or NIME for short.[2] NIME started in 2001 as a workshop at the Conference on Human Factors in Computing Systems and combines interface design and music with a technological approach. At annual conferences, NIME researchers and artists present their new musical instruments and interfaces with the aim of understanding and influencing new forms of artistic expression, usability and playability. Over the course of the years, concepts for involving animals in the music generation process have also been presented and discussed at NIME conferences. The introduction and development of new technologies in this field opens up new possibilities for including animals in such systems. In Chapter 2.3, some projects in the context of NIME are presented that involve animals mainly via tracking systems that make the movements of animals, mostly fish, audible. However, in comparison to ACI, there are no clear guidelines for the implementation of projects including animals in NIME. Unfortunately, this led to the rejection of one of my paper submissions on the basis of the ad hoc establishment of new rules requiring ethical certificates. Although the metamusic PEEK project met the high ethical standards, it was rejected because of these ethical concerns although the peer-reviews for my paper contribution were quite good. The procedure of the NIME research board has led to much frustration for me, and I hope that in the near future NIME will establish clear rules on how to deal with animal-based contributions. One very important research approach in NIME is accessible music, which promotes the idea of music being played by non-musicians. It proposes opening the music generation process to include non-experts with little or no musical training through the development of new musical instruments, interfaces or software applications [11]. Becoming an expert player of a traditional musical instrument can be a very long and difficult process. Thus, designing musical instruments for non-musicians is especially challenging since they need to be easy to learn, intuitive to play and allow for expressivity. Accessible music has already been applied to inclusive music practice for disabled musicians and could be further developed for animal musicians.

[2] https://www.nime.org/

1.2.4 Zoological fields

Another fundamental field for this PhD research is ethology. Ethology examines the behavior of animals and has its scientific roots in the work of Charles Darwin, who was also very interested in the biological roots of musicality [12]. Trying to understand the behavior of the animals within the metamusic project is a fundamental challenge. The consideration and observation of the natural and individual behavior of the grey parrots allowed me to develop musical instruments for the individual parrots. It also allowed me to support the natural behaviors and well-being of captive African grey parrots.

A field of research which is also of great importance for this PhD project is biomusicology. Biomusicology is the study of musicality from a biological perspective. The multidisciplinary approach examines the generation, distribution and reception of musicality in animals as well as humans. A very recent publication on biomusicology from 2018 is “The Origin of Musicality”, edited by Henkjan Honing, which gives an up-to-date overview of and strategic research agenda for this growing field. The research program intends to provide information about the biological evolution of animals and humans and where the origins of musicality can be found in animal songs. Studies in this field have also been carried out on African grey parrots and their acoustic abilities in the wild as well as in captivity [13] [14].

The research field of zoomusicology is the study of the music-like aspects of sound communication in non-human animals . The term was introduced by the French composer Francois-Bernard Mache. In his book “Music, Myth and Nature”, he explores the concept of animals making music beyond biological necessity [15]. The interdisciplinary field uses different methods from scientific, musicological and philosophical approaches [16]. A central research topic in zoomusicology is the search for common features of animal song and human music. Further research in the field is focusing on auditory enrichment and the therapeutic effects of music on animals, which is a significant overlap with ACI research where exactly the same topic is being researched and developed.

Some of the questions that emerged in the course of the metamusic PEEK project and their detailed exploration would have gone beyond the scope of this PhD project but could be explored further by the abovementioned disciplines of ethology, biomusicology and zoomusicology.

1.2.5 Artistic research

The relatively young artistic research community sees itself as a discursive process that seeks to strengthen the similarities between art and research. The term is currently still very broad and much discussed, and further terms such as art-based research, practice-based research or artistic scientific research describe the same approach. There is also considerable discussion in the field about different interpretations of and approaches to art which is based on research, art that uses research methods or research on the arts. However, there is also consensus that diversity must be preserved in artistic research against efforts to narrow it down to a simple formula by just applying the strict rules of science. Furthermore, art and science should not be seen as separate domains, but rather two dimensions in the common cultural space [17].

The Arts.Research department of the University of Art and Design Linz, Austria, where this PhD project is based, is organizing PhD colloquiums each semester, where PhD students are invited to present and discuss their ongoing artistic research projects and get feedback from colleagues and professors. In addition, experts from the artistic research field are invited to present their approaches within this diverse field. Julian Klein, director of the Institut für künsterlische Forschung Berlin, has clarified what artistic research can do and where it can have a strong impact. He is particularly interested in using artistic methods to gain knowledge. As an example, he mentioned crime reconstruction as the use of the artistic method of reenacting crimes to gain explicit knowledge about the course of a crime and to help solve criminal cases.

At another PhD colloquium, Barbara Lüneburg, who is a professor of artistic research at the Anton Bruckner University Linz, presented a diametrically opposed approach. She used scientific methods from media sociology and cultural science to open up a participatory process for creating a multidisciplinary artwork called “TransCoding”.[3] The public was invited to actively inform, influence and contribute with videos and sounds to an art project via a web platform. The aim was to get the participants directly involved in an artistic process and for them to experience empowerment as art consumers.

[3] http://www.transcoding.info/index.html

Another artistic research approach is the theoretical examination of artwork and art practice. This research method focuses on the interpretation and reflection on art in the form of theoretical texts and theses. This approach has already been established in many disciplines such as art and cultural studies, media studies or musicology.

Like many other artistic research projects, metamusic is interdisciplinary, and the artistic activities have been used flexibly in different phases of the project. In the course of metamusic, artistic experience occurs at different times, for example, as a performance at the end of a project phase or in the ongoing process of developing and testing the instruments at “Jam Sessions” involving the grey parrots. These artistic methods enabled me to choose new, more experimental approaches in the challenging process of designing musical instruments for and with grey parrots. For example, I abandoned the idea of a strict animal-user test of the instrument prototypes with the parrots and instead introduced the “Jam Session” as an impromptu performance of the parrots playing music together where I made my observations. This artistic practice led to many questions that point in certain directions and provide important approaches for in-depth research and controlled experiments. Thus, it is obvious that such artistic methods also promote the generation of coincidence, and many scientific inventions and insights are based on serendipity. The artistic research approach allows researchers to examine various unexplored issues in unconventional ways. In my case, this approach motivated me to carry out this PhD research without ever having worked with and for animals before, and certainly not on designing musical instrument and interfaces for grey parrots and making music together with them.

In the framework of the metamusic PEEK project, additional artistic methods that informed this PhD project were used to gain a better understand of the complex task of designing for grey parrots. The art installation settings made it possible to observe the grey parrots interacting with the musical instruments in different environments. The performances raised issues of interspecies communication between the grey parrots, the artists, the animal keepers and the audience in musical environments.

1.3 Grey parrots

At the center of this PhD project was a changing group of grey parrots of the ARGE Papageienschutz parrot shelter near Vienna. Since 1996, the parrot conservation group has been looking after neglected, smuggled, poorly kept or too much humanized birds and has been fighting to improve the living conditions of parrots and to help protect this endangered group of animals.[4] The parrot shelter is currently taking care of about 180 parrots, from little parakeets to the big macaw parrots. Among the fosterlings are also many grey parrots.

In the metamusic PEEK project, unlike most research in this field, no new grey parrots were purchased or bred. The main focus was on the animals' welfare; consequently, the animals we worked with were also sometimes given away during the project phase to provide them with a new and better home, which meant that the group of grey parrots changed on a regular basis.

The grey parrot (Psittacus erithacus) is a Central and West African bird that is about 33 cm tall and weighs up to 450 g and has a life expectancy in captivity of about fifty years [18]. In the wild, it is a typical tree inhabitant of the tropical rainforest and prefers vegetarian food. They are not cultural followers and rather shy.

On account of their high intelligence and their fascinating ability to mimic sounds and voices, they have become a popular pet as well as an important research subject in cognitive research. The findings of researchers like Irene Pepperberg have attracted considerable media attention and created public interest in grey parrots, which has further increased their popularity as pets. In the meantime, grey parrots are a particularly endangered species and the 17th Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Conference in Johannesburg in October 2016 decided to tighten the rules protecting grey parrots (Psittacus erithacus sp.). They now fall under the highest level of protection of CITES.[5]

[4] http://www.papageienschutz.org/

[5] https://www.bmlfuw.gv.at/dam/jcr:a274efb2-5de0-4e51-8eb0 ca421f00a004/INFOBLATT%20Graupapagei.pdf

1.3.1 Grey parrots in history

The keeping of such “intelligent” and linguistically gifted animals has exerted a special charm on us humans for a long time. For the natives of their African home countries, the red tail feathers were particularly of interest. The red feathers were used as headdresses for chiefs and they were credited with a variety of attributes. The red feathers, for example, were said to provide the wearer with determination and a very good sense of orientation. In addition, the wearing of the red feathers was supposed to lead to an abundance of children.

Another superstition also claims that the red feathers of grey parrots cause burns on contact with human skin. However, there is no evidence that African tribes kept the grey parrots as pets to get their red tail feathers. It was Portuguese sailors that brought the first African grey parrots from the West African coast to the Iberian Peninsula to Europe around the middle of the 15th century [18]. At the beginning of aviculture, only noblemen were able to keep such exotic animals as house pets and status symbol.

A historically well-known grey parrot is that of Frances Teresa Stuart, Duchess of Richmond and Lennox, known as 'La Belle Stuart'. It is said that she lived for 40 years with her grey parrot who died a few days after her death in 1702. Beside her wax figure at Westminster Abbey Museum, her pet African grey parrot is displayed on a stand. Very few mounted bird specimens survive from this period and it is perhaps the oldest taxidermy of a bird in existence.[6]

[6] https://www.westminster-abbey.org/de/abbey-commemorations/commemorations/frances-teresa-stuart-duchess-of-richmond

Another historically known African grey parrot was the pet of the composer Joseph Haydn. Haydn had bought the exotic bird during a stay in London in 1791, and back in Vienna, he became his longtime housemate. The exotic bird aroused much attention in Viennese society due to his talent for speech and music. The grey parrot was able to whistle several tunes that Haydn composed.

It is said that when a toast to the Austrian Emperor was pronounced and the glass was raised, the parrot whistled the melody of "Gott erhalte Franz den Kaiser", which was composed by Haydn in 1797. When Joseph Haydn died in 1809, the grey parrot was part of his legacy. The composer's parrot was finally auctioned off and was bought by Prince Johann of Lichtenstein for a huge price at the time.[7] The taxidermy of the grey parrot is now on display as part of an exhibition in the Haydn Room at the House of Music in Vienna.

Figure 1.1 Joseph Haydn's grey parrot. Image downloaded from https://commons.wikimedia.org/wiki/File:Haydns_Papagei.jpg

[7] https://www.vienna.at/als-joseph-haydns-papagei-das-kaiserlied-krchzte/2962963

In the 18th and 19th century, there were single breeding successes of captive grey parrots; however, it was not until the middle of the 20th century, with the help of endoscopic sex determination, that regular breeding successes occurred [18]. This then led to the spread of the grey parrot as a pet. Today, there are strict and clear guidelines on how this animal species must be kept. Researchers also became interested in the birds due to the human desire to be able to communicate with animals. Grey parrots with their talent for vocal learning and mimicking were and are still an interesting research subject in this context. Konrad Lorenz, who won the Nobel Prize in 1973, established the study of how animals behave and defined it as animal psychology. Alongside all his achievements, it must be mentioned that, in the Second World War, Konrad Lorenz turned to National Socialism and joined the Nazi party. It is still unclear what role he played exactly in racial studies. Konrad Lorenz's book, "King Solomon's Ring", brought him worldwide recognition. It is a collection of observations and insights into the lives of all sorts of animals. In this book, he also describes how grey parrots that are kept in very small cages suffer similar symptoms as humans in prisons. Furthermore, he reports about different grey parrots with special cognitive and linguistic talents and about the FDB symptom discussed below. The title of the book "King Solomon's Ring" refers to the legend that King Solomon had a magic ring which enabled him to speak to the animals in their own language [19].

"I do not think it is very sporting to use magic rings in dealing with animals."

[Konrad Lorenz]

Based on other legends, it is said that King Solomon had owned a grey parrot [18]. At any rate, the talented grey parrots, like very few other animals, foster the idea of talking with animals. As a result, grey parrots have also become an interesting research object when it comes to animal cognition and the basics of language and communication with sound in animals. A famous researcher in the field of grey parrots is Irene Pepperberg, who was also inspired by the story of King Solomon. The following section is about her studies and her research subject, Alex, who was arguably the most famous parrot in the world.

1.3.2 Cognitive and communicative abilities of grey parrots

Irene Pepperberg, one of the most acknowledged researchers in this field, set out in 1977 to find out more about the cognitive and communicative abilities of grey parrots. Her most famous long-term study subject was the grey parrot Alex, with whom she carried out experiments for about thirty years. Over the course of this period, she published numerous papers in the field of animal learning, ethology, cognitive psychology, evolutionary biology and neurobiology. She was inspired by questions such as how much do grey parrots understand and how much could they learn to understand? Owing to his outstanding abilities, Alex has gained a great reputation even beyond the boundaries of research communities. He achieved remarkable results in identifying different objects, numerical understanding, distinguishing colors and shapes and the use of a vocabulary consisting of more than one hundred words [20]. Her studies with Alex changed the idea of the cognitive abilities of grey parrots and birds in general.

Alex died in 2007 and his death generated a great deal of sympathy. In terms of his cognitive abilities, the Guardian wrote in his obituary that "America is in mourning. Alex, the African grey parrot who was smarter than the average U.S. president, has died at the age of 31" [21].

Some researchers are still very skeptical about and critical of Pepperberg's methods and findings. They refer to conditioning and intensive training. Also, keeping Alex separate as a laboratory animal has been criticized by many parrot experts. It is regularly mentioned that Alex the grey parrot displayed a similar cognitive level compared to a 4- to 6-year-old child on some tasks [22]. Such tests have always been designed from the point of view of humans and hardly help to improve the understanding of an animal and can lead to anthropomorphism [18]. This means that human characteristics and behaviors are projected onto animals [23]. According to critics, Alex died too young for a captive grey parrot, at the age of 31, which suggests that he suffered from his living conditions in the laboratory and also suffered from the feather-damaging behavior (FDB) syndrome, which is very common among captive parrots.

1.3.3 Problems in captivity

Despite the long tradition of keeping grey parrots as pets, they are still among the most sensitive and demanding animals in captivity. Many of the grey parrots of the ARGE Papageienschutz parrot shelter that we worked with suffered from a variety of behavioral and mental disorders and had become humanized. These birds are often rescued or given away, but usually recover quite well after their admission to the parrot sanctuary. A very striking symptom in captive parrots is the feather-damaging behavior (FDB), which is believed to be rare or does not occur in wild parrots. FDB is generally very prevalent among captive parrots and describes the behavior of birds plucking their own feathers with their beak, which results in damage and the loss of their feathers. FDB is regarded as a multifactorial disorder combining factors such as neglect, isolation, boredom, a permanent stress situation, missing or wrong contacts, lack of care, wrong accommodation, too little movement and unfavorable climate or wrong diet [18]. More commonly, FDB occurs more frequently in grey parrots that were wild-caught rather than in captive-bred animals [24]. Improving their living environment can help grey parrots suffering from plucking. The term for this practice is enrichment, which means to enhance the psychological and physiological well-being of captive animals by providing environmental enrichment.

Figure 1.2 Cocomiso suffering from feather-damaging behavior (FDB)

1.3.4 Enrichment for parrots

There are three basic forms of enrichment for parrots that have already been tested in studies: providing foraging opportunities, increasing the physical complexity of the cage and allowing for social contact. Foraging enrichment, for example, requires the parrots to chew through barriers, sort out inedible materials or open and turn containers to access their food. Physical enrichments provide alternate perching sites, for example, with fresh branches; climbing and sitting opportunities such as ropes and rope swings; and toys for playing made out of different materials such as paper, cardboard, wood or plastic. There should always be more play facilities and feeding stations for a complex situation in the aviary. Social enrichment means keeping some parrots in same-sex, same-age and non-related pairs in one appropriate aviary. These three forms of enrichment have successfully prevented and reversed several common abnormal behaviors and improved the welfare of the parrots involved. The behaviors that have been studied are FDB, fearfulness, aggression toward humans, stereotypical behavior and screaming [25].

The ARGE Papageienschutz parrot shelter we were working with has been trying to apply these different forms of enrichment in the best possible way.

In the context of ACI, there have not been studies on enrichment approaches using new technologies for grey parrots and this dissertation is intended to provide basic work in this field by proposing auditory enrichment for captive grey parrots. To what extent this type of enrichment can be helpful for preventing the different forms of behavioral problems in grey parrots and how it can be used in specific situations remains to be studied further and would go beyond the scope of the metamusic PEEK artistic research project and this dissertation.

1.3.5 Grey parrots in art and culture

The long history of relations between humans and grey parrots has also produced symbolic meanings, cultural objects and art. This chapter highlights some of the ways grey parrots have influenced human culture. As mentioned above, native Africans made feather headdresses from the red tail feathers of the grey parrots, which were worn by the chiefs of the tribe. There are also many myths about the red feathers among the indigenous people of Central and West Africa, and the feathers are still collected and used as headdresses, for example, in pygmy tribes [18]. In addition, the red tail feathers of African grey parrots were also originally used for the elaborate headdresses of tribes such as the Bamileke people of the Grassfields region of Cameroon, who believe in the Juju religion.

These Juju hats were worn as traditional ceremonial headdresses at various celebrations. The entire headdress could be turned inside out to provide storage for the feathers. Special importance was given to the hats at funerals, when an elder died, they were passed down to the next generation who then inherited the wealth and standing of the person that had passed away.[8] The headdress was often worn in combination with the elephant mask (Figure 1.3), which denoted power and wealth. Today, the Juju hats are still used in Cameroon on ceremonial occasions, but have also become wall decorations.

[8] https://www.aphrochic.com/2018/11/15/the-history-of-the-juju-hat/

Figure 1.3 Juju hat with red feathers from the tail of grey parrots. Image downloaded from https://cameroonliterarygroup.com/post/15394455624/labrancaro- bamileke-headdress-mask-and-tunic

In Europe, grey parrots first appear as motifs in paintings in the early 16th century. Lucas Cranach the Elder, one of the most important German Renaissance painters, portrayed grey parrots in his painting *Adam and Eve* in 1520 [18]. However, the painted grey parrots, from my point of view, look more like pigeons with red tail feathers. The 1525 painting by the Italian painter Francesco Melzi, one of Leonardo da Vinci's pupils, clearly depicts a grey parrot sitting on the hand of a man who is scratching the parrot's head.

Figure 1.4 Unknown man and grey parrot, painting by Francesco Melzi (1525). Image downloaded from https://de.wikipedia.org/wiki/Graupapagei#/media/Datei:Melzi_portrait.jpg

The painting *Madonna with Parrots* (1533) by Hans Baldung Grien raises many questions and so far, scholars have provided no satisfactory interpretation of the picture. The painting depicts the Madonna giving her child her breast while a grey parrot nibbles on her neck. Parrots and parakeets were not uncommon in paintings of the Madonna at that time. Surprisingly, two parrots instead of the usual one are in Baldung's painting, which offers the viewer a series of ideas and pleasures: color, beauty, figurative familiarity and challenges to familiarity, theological truisms and provocative violations of these truisms, eroticism and a general warning to beware all women, including the Virgin, who Luther characterized as "like any other" [26].

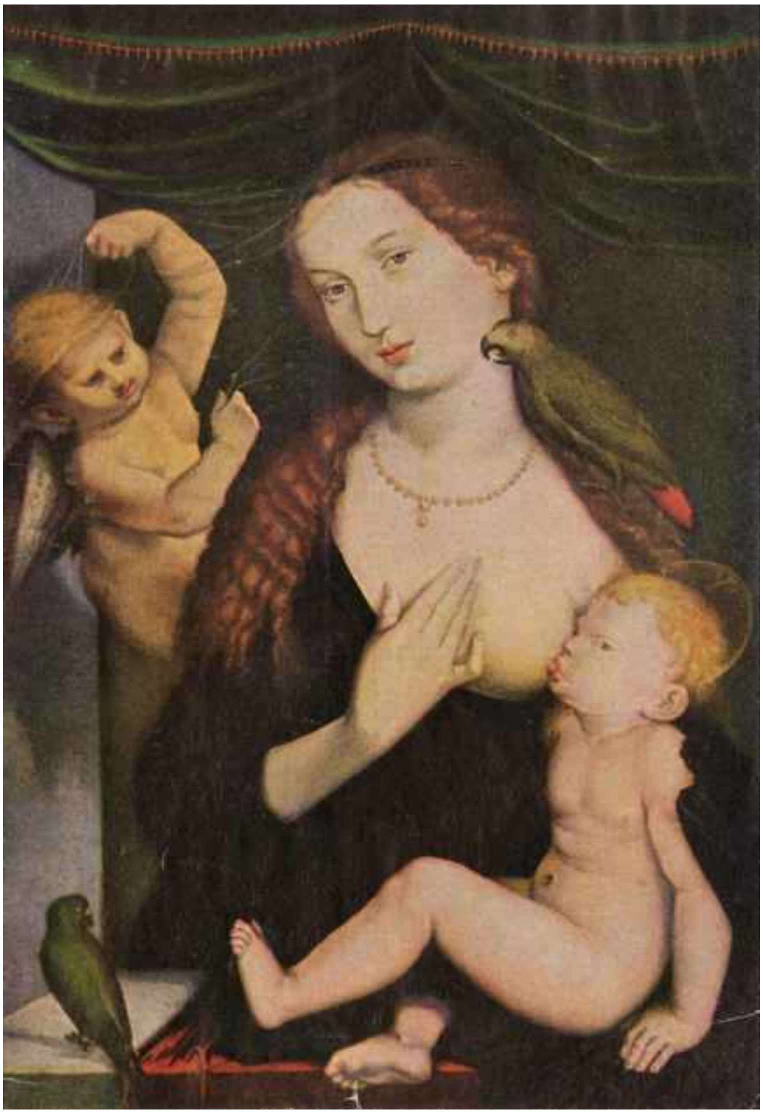

Figure 1.5 *Madonna with Parrots* (1533) by Hans Baldung Grien. Image downloaded from https://uploads3.wikiart.org/images/hans-baldung/madonna-with-the-parrots-1533.jpg

With the increasing spread of African grey parrots in Europe, the following decades and centuries saw increasingly better and much more naturalistic and detailed depictions of grey parrots in paintings and engravings. In this period, grey parrots could be seen and studied in more detail by the artists. But generally, the paintings of this period are dominated by other colorful parrot species from Asia and America.

The bird as a symbol is widely used in many cultures. In coats of arms, the eagle is very often depicted as the king of the skies. The use of grey parrots as a heraldic animal is rather uncommon. The coat of arms of the insular state of São Tomé and Príncipe shows a grey parrot together with the eagle. The two islands are located in the Gulf of Guinea, off the coast of West Africa. Both islands are well known for their variety of bird species, especially large stocks of wild grey parrots.

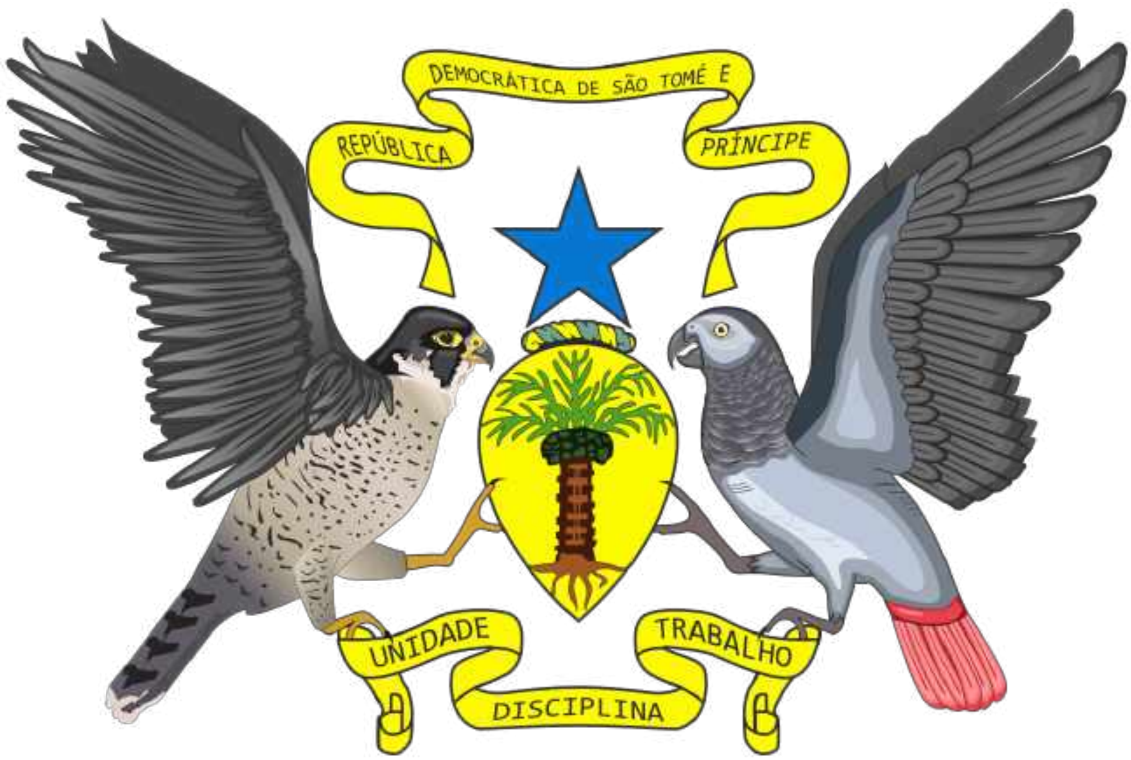

Figure 1.6 Coat of arms of the insular state of São Tomé and Príncipe. Image downloaded from https://upload.wikimedia.org/wikipedia/commons/9/96/Coat_of_arms_of_S%C3%A3o_Tom%C3%A9_and_Pr%C3%ADncipe.svg

Grey parrots have not only been a model and template for painters, but also an inspirational source and companion bird for other artists, especially for composers. As noted above, there are numerous anecdotes about the grey parrot of the composer Joseph Hayden. It is reported that the parrot could call out various words in several languages and whistle melodies that Haydn played on the piano.[9] The animal lover Richard Wagner is said to have owned three parrots [27] and Giuseppe Verdi at least one parrot, which can be still viewed in the exhibition at Verdi's country estate in Sant'Agata.[10] The eccentric French pianist and composer Charles-Valentin Alkan even composed a funeral march for a parrot.[11]

Humans have a long tradition of displaying the special abilities and attributes of animals as public spectacles. While the colorful relatives of the grey parrots are often used as circus acts and tourist attractions, grey parrots are usually exhibited differently. It is the grey parrot's special vocal and mimicking talent which places the animal in the limelight and since this talent is not immediately obvious to the eye, other channels are used to present and showcase its abilities. One grey parrot which is currently known for his presence on TV and the Internet is Einstein. He has achieved popularity through viral videos showing him speaking and imitating sounds and calls of other animals. Einstein has his own website and profiles on several social media platforms and even his own web shop. In 2006, the grey parrot Einstein performed a bizarre TED talk[12] with his trainer Stephanie White. The video on the TED platform has been viewed more than a million times.

[9] https://www.vienna.at/als-joseph-haydns-papagei-das-kaiserlied-krchzte/2962963

[10] http://www.klassik-heute.com/4daction/www_komponist_text?id=2993&text=746

[11] https://www.swr.de/swr2/musik-klassik/Der-Komponist-und-sein-Papagei,aexavarticle-swr-66198.html

[12] https://www.ted.com/talks/einstein_the_parrot_a_talking_squawking_parrot?language=de

Absurd events and incidences with grey parrots appear regularly on the news. In 2008, an escaped grey parrot could be returned to its owner in Japan. The owner had taught the parrot its name and home address. After being admitted to an animal shelter, the parrot repeated the name and address of his owner and was returned home after his 2-week excursion.[13]

In 2014 a grey parrot, who had disappeared for four years, was returned to its owner. When he disappeared, he spoke English with a British accent, but on his return, he spoke Spanish. It remains unclear how this could have happened.[14]

In 2015, a grey parrot, who witnessed the murder of his owner, was able to contribute to solving the crime. The victim's ex-wife assumed ownership of the grey parrot and reported in court that the grey parrot repeatably said, "Do not shoot!" Subsequently, the victim's wife was found guilty. However, the commentary of the parrot was not included as evidence in the trial.[15]

In 2018, a grey parrot in England triggered a firefighting operation by mimicking the alarm sounds of a smoke detector. The parrot mimicked the sounds so accurately that the neighbors believed it was a real fire alarm and called the fire department.

All of these incidents and anecdotes underscore the linguistic and auditory abilities of grey parrots, which make them especially interesting research subjects in connection with auditory enrichment for captive animals and the origins and roots of musicality in the animal kingdom.

[13] http://news.bbc.co.uk/2/hi/asia-pacific/7414846.stm

[14] https://www.bbc.com/news/world-us-canada-29612043

[15] https://www.thecut.com/2017/07/parrot-witness-murder-case-glenna-duram-guilty.html

1.3.6 Musicality and grey parrots

In the search for the origins of musicality, many researchers, starting with Charles Darwin in the “Descent of Man” (1871), where he devoted ten pages to music [12], point out that musicality can be found in the animal kingdom and has biological roots [28]. Such evolutionary concepts refer to biological functions such as sexual selection, which includes attracting females and defending territories, mother-infant communication or social bonding in groups.

Recent research in the field of cognitive biology has focused on the role of animals listening to music and further as a concept of enrichment for captive animals [29] [30] [31]. Since most of the music is selected by humans, this can lead to anthropomorphic biases. Therefore, the music should be attuned to the animals’ auditory skills. For example, creating compositions which are based on utterances of the animals has led to good results in studies with cats [32]. Another approach is to give the animals control over their auditory environment, where the animals can use devices to determine if they want to hear sound and which kinds of sounds they want to hear. Such animal-controlled sounds have the advantage of being available on demand and are a source of experience and learning through interaction [33].

Studies have shown that non-human species also have musicality [34] [35] [36] and display forms of entrainment to auditory stimuli [37] [38]. Animal species such as grey parrots, cockatoos, elephants, primates, pigeons and carps have been found to be able to discriminate between different types of music, prefer types of music to silence and can develop an individual taste in music [29] [34] [39] [40].

There are some indicators, such as vocal learning and entrainment, that speak to high auditory skills and musicality in various animal species [35]. Vocal learning is the ability to modify sounds, learn new sounds via imitation and produce vocalizations. Little is known about entrainment in animals as it is uncommon in animals and involves the complex brain ability to synchronize their movements to a musical beat [38] [39].

Aniruddh Patel, an expert on music and the brain in both humans and animals, has proposed the idea that the ability to synchronize movements to a steady beat is based on vocal learning. Thus, animals that are not vocal learners have no predictive and flexible entrainment abilities [12]. In 2009, researchers disproved the claim that entrainment to music is unique to humans. According to two studies, some parrot species such as grey parrots and cockatoos have the ability to align their movements to an externally perceived rhythm and thus have musical skills and a natural feeling for rhythm. Researchers have observed and documented the existence of spontaneous motor entrainment in parrots such as grey parrots and cockatoos [38] [39].

One of the few animal species that has demonstrated both vocal learning and spontaneous entrainment are grey parrots. Grey parrots are also well known for learning to repeat musical patterns and have the ability to reproduce and imitate sounds [36].

Therefore, there have been several investigations focusing on the musicality of grey parrots such as Luciana Bottoni's study on "Teaching a musical code to a parrot: Frequency discrimination and the concept of rhythm in a grey parrot" (2006). Bottoni taught an African grey parrot to use basic elements of music such as intonation and rhythm. The frequency analysis and comparison between the parrot's sequences and randomly generated strings confirmed the acquisition of the intonation concept and the amplitude peak of the notes showed the grey parrot's tendency to maintain rhythmic regularity [36].

Franck Péron investigated the existence of personal musical taste in grey parrots in 2012. He placed a touchscreen in an aviary which could be used at any time by two birds. He observed that the parrots were able to use the electronic device and discovered that they had varied musical tastes and showed different individual musical preferences. One grey parrot preferred classical music while the other one like rhythmical pop music. Classical music seemed to have a relaxing and calming effect on both of them [41].

In summary, based on the findings described above, it appears appropriate and promising to work with grey parrots in the context of musicality in animals and auditory enrichment for animals in captivity.

Motivated by research showing that grey parrots have high auditory skills and musical talents [36] [39], I carried out a series of sonic experiments with our group of grey parrots at the parrot shelter in order to better understand their auditory surrounding and how they perceive and respond to sound and music. The overall aim was to find out if music and sound in combination with musical instruments and interfaces adapted to the grey parrots' skills could be used for their auditory enrichment.

This PhD project should be considered as a general step towards the auditory enrichment of captive parrots. The principal goal was to design and develop musical instruments and interfaces for a group of grey parrots held in captivity at an animal shelter near Vienna. Based on the initial metamusic project and inspired by the findings of bioacoustics and behavioral studies with captive grey parrots, I developed the following research questions.

1.4 Research questions

- **What design aspects of musical instruments support the physiological and cognitive abilities of grey parrots?**

This question addresses the different ways in which grey parrots interact with their environment and enrichments toys in the aviary. Are there any specific materials they prefer or dislike? How do grey parrots communicate with sound and can one generally state what kinds of sounds they like to hear and produce?

- **Can grey parrots generate sounds and "music" with musical instruments?**

Based on the definition of music (Page 14), do the grey parrots generate sounds with the developed instruments that go beyond their normal sound communication? Are they motivated to make sound with these instruments, including considerations concerning the design of the instrument and the presence of the experimenter?

- **Can grey parrots develop musical skills and adopt an artistic role in a performance setting?**

Can grey parrots learn to play the instruments and develop musical skills that go beyond randomly making sounds? Do they show interest in playing the instruments in a performance setting in front of a human audience?

- **How can we design the musical interaction to support the parrots' individuality and can this be enriching for grey parrots in captivity?**

How can we adapt the design of the instruments to the individual preferences of the parrots in terms of material, interaction form and sound qualities in order to achieve the best possible enrichment for grey parrots in captivity?

1.5 Research methods

The metamusic project and the field of artistic research in which this PhD project is situated are highly diverse. This is also reflected by the combination of various research methods to accordingly cope with the different aspects of this PhD project.

- **Classification and analysis of contemporary animal music projects**

  The analysis of music projects that include animals plus the classification and overview of the projects found resulted in a comparative summary of the state of the art in different disciplines. The review shed light on the questions artists and scientists are dealing with in their projects and the different methods they use. I also looked at the state of research in musicality in animals and what is currently known in this regard in terms of grey parrots.

- **Biomusicology experiments**

  The sonic experiments with the group of grey parrots in the parrot shelter (Chapter 3) taught me how to deal with this given aviary environment. The informal experiments including volume and frequency measurements and discrimination tests provided me with first-hand knowledge of the auditory skills of the group of grey parrots. The observation of the parrots also gave me insights into their individual forms of interaction and sound preferences. The general conditions and ethical limitations for working with the grey parrots also became clear.

- **Animal-centered design**

  Rooted in the idea that the grey parrots must be at the center of the design process, I implemented an animal-centered design process for developing musical instruments and interfaces, based mainly on the findings of ACI research. My participatory design approach can also be seen as a form of enrichment for the captive grey parrots and was carried out in different forms of playing and making music together with the birds, a practice that I finally ended up calling the “Jam Session”.

- **Interdisciplinary discourse**

  Interdisciplinary discourse was stimulated to get first-hand input for this PhD project and the lager metamusic PEEK project. I co-organized the ANIMUS symposium in Linz in 2017 with invited experts from related fields such as animal behavior, ACI, biomusicology, art and cultural studies. I presented and introduced my artistic research approach and findings to the ACI community and contributed as expert to the “SoundJam” workshop (Chapter 5.2).

- **Artistic research**

  Several artistic research methods were applied during the research phase and conceptually framed the metamusic project. The “Jam Session” mentioned above is an artistic concept for playing music together in an informal setting. The art installations and the open laboratory situation for the public were further artist outcomes of the metamusic PEEK project. The artist research method culminated in performances of the artist group alien productions together with the grey parrots (Chapter 6). Observing and analyzing the reactions of the animals, human performers and the audience constantly informed the development of this PhD project.

It cannot be overstated that strict ethical guidelines have been applied for working with the grey parrots throughout the entire PhD project. These are comprised of the specifications of ACI research (Chapter 1.2.1), the strict rules of ARGE Papageienschutz and self-imposed measures (Chapter 4.2). Nonetheless, there is a bias against the development of musical instruments for grey parrots in captivity. I have tried to convince these critics that my concepts are a good approach, and this dissertation is intended to underpin the meaningfulness of auditory enrichment for captive grey parrots.

2 Animals make Music: A Look at Non-Human Musical Expression

This chapter is based on the review paper “Animals Make Music: A Look at Non-Human Musical Expression”, which was published in the special issue “Multimodal Technologies in Animal–Computer Interaction” of the journal *Multimodal Technologies and Interaction* in September 2018. The objective of the special issue was to collect research articles on the use and potential of multimodal interfaces for animal-centered applications and interactions. To the best of my knowledge, this journal paper publication represents the first review article about musical instruments and interfaces that involve animals and therefore constitutes a major contribution to the field.

The classification and analysis of historical and contemporary art projects that include animals in an interactive process with musical instruments and installations was important to position the musical role of the grey parrots within this PhD project. The review discusses the various project backgrounds, methods used and aims pursued by the artists and scientists in their projects. I also looked at the recent state of research in animal musicality and what is currently known in this regard about grey parrots. The goal of this classification was to define the various levels of musical agency which animals can take within an artistic project and to find best practice examples for an animal-centered design approach that would also fulfil the ethical rules of ARGE Papageienschutz.

Abstract

The use of musical devices that involve animals in the interaction process is an emerging, yet not widespread practice. The projects that have been implemented in this unusual field are raising questions concerning ethical principles, animal-centered design processes and the possible benefits and risks for the animals involved. ACI (Chapter 1.2.1) is a novel field of research that offers a framework for designing and implementing interactive technology for and with animals. From this viewpoint, this chapter examines several projects focusing on the interplay between animals and music technology in order to arrive at a better understanding of animal-based musical projects. Building on this, I will discuss how the implementation of new musical instruments and interfaces could provide new opportunities for improving the quality of life for grey parrots living in captivity.

2.1 Introduction

The number of physical products and software applications developed specifically for animals and the commercial interest in technological mediators for human–animal interactions is growing.[16,17,18] In addition to the physical and graphical interaction design aspects of such technology, sound and music can also play an important role in the design process. Despite the increasing amount of hardware and software for animals, there are not many studies devoted to the use of audio devices to enrich the living environment of animals in captivity [7] [9].

To the best of my knowledge, there is no comprehensive summary and analysis of projects that involve animals interacting with musical instruments and interfaces. I therefore have examined different approaches and technologies in diverse fields from a musical interface designer's perspective. This chapter gives an overview of current technologies and important developments in the context of musical instruments that include animals in the music and sound-generating process, with a focus on the creative and artistic outcomes for both animals and humans. I am interested in gaining a better understanding of the actual role of the animals interacting with such technologies. Finally, this chapter attempts to determine the factors that could lead to a suitable design approach and its ethical implementation for captive animals.

[16] https://www.fitbark.com/

[17] https://clever.pet/

[18] https://puppod.com/

2.2 Cultural context

Musical instruments and interfaces that involve animals as musical agents can be found in different fields such as New Interfaces for Musical Expression (NIME), contemporary art installations, animal cognition experiments and ACI. Some of the earliest examples of conjectural musical instruments that (ab)use animals as sound generators can be found between the 16^{th} and 19^{th} centuries under the names of the Cat Organ or the Pig Organ (Figure 2.1). Both are speculative, piano-like instruments in which cats or pigs are placed inside or attached to the instrument. When the keys are pressed, thus poking the pig or pinching the tail of the cat, the animal cries out in pain and generates the sound. Since both instruments are based on inflicting pain upon animals, I hope that such bizarre musical instruments have never been built out of ethical and animal welfare concerns. However, these ideas provide evidence of an early interest in humans making music involving animals, in this case, as a structural part of the musical instrument itself.

Figure 2.1 Pig Organ, cover illustration for the piece of sheet music "La Piganino". Image downloaded from https://commons.wikimedia.org/wiki/File:La_Piganino.jpg

In general, live animals are not usually a constitutive part of musical instruments, and there are not many examples in which such instruments have actually been put into practice.

The idea of animals becoming anthropomorphic musicians, playing traditional acoustic instruments, is common in the literature and in popular culture. Well-known fairy tales such as "The Town Musicians of Bremen", that tells the story of four old domestic animals—a donkey, a dog, a cat and a roster—becoming town musicians, have popularized this concept. Since the middle of the 20th century, this particular configuration has often been restaged in a circus environment, where, in general, various species including primates were capable of performing various musical tasks through conditioning.[19]

A related field within HCI (Chapter 1.2.2) is the design and use of new technologies for musical expression and artistic performance short NIME (Chapter 1.2.3). The introduction and development of new technologies in this field also opens up new possibilities to include animals in the music-generating process. The projects we could identify from the NIME community are mostly combinations of a computer vision system for tracking animals and a sound-generating system, which is controlled by the animals' movements. A very common approach in this field is fish-based interfaces [42] [43] [44] [45] [46]. The video tracking system observes the fish in the aquarium, and the sounds are generated or processed by the generally random movements of the fish. The output of such fish-based musical interfaces can be manifold and creative, but since the fish are separated from the audio feedback, they lack the auditory feedback of their movements. Thus, in some of the projects, all the plants, stones and other aquarium furniture have been removed to provide a better camera view, which leads to the discussions of potential negative impacts on the living environment of the fish themselves.

[19] https://www.youtube.com/watch?v=3zQ86n1OP_w

Another extensive field in which live animals are used in installations and projects is the contemporary art world. Various projects such as “Harness” by Robert Wechsler[20] or “from here to ear” by Céleste Boursier-Mougenot[21] focus on the relationship between animals and humans, and how animals can become the author or co-author of sound artworks and a creative process. Céleste Boursier-Mougenot also focuses and plays with the idea of musicality in animals by building installations that involve animals creating sonic environments. He works with finches, which are known for their musical talents [35], and often play an important role in such art installations and research.

In the field of animal cognition or biomusicology, test setups, for example with touchscreens, are sometimes used in controlled experiments to provide an insight into the animals’ musicality or musical preferences [41] [47]. However, these test devices are less attractive for musical interface design because they generally do not focus on a playful and creative design. However, the findings of such experiments and settings in this field (Chapter 1.2.4) have great significance for my study. These kinds of test devices have enabled scientists to gather evidence that animal species have auditory skills and musical talents and examine how these skills work [12].

[20] http://robertwechsler.com/harness

[21] http://www.xippas.com/artists/celeste-boursier-mougenot/

2.3 Musical animal–machine interaction

Based on the more active or passive role that animals can play in the interaction process with musical instruments and interfaces, I shall now discuss and analyze some projects focusing on the interaction between animals and music technology that I have identified as relevant to my PhD project. The analysis and classification of these projects provides a source of data that could potentially lead to further contributions in this field and theoretical improvements in an animal-centered design process. In the following, I define four categories, which are generally based on the degree of musical agency of the individual species involved: animal movement as control source; animals as unconscious performers; animals as trained performers; and animals as voluntary performers. Loosely related to the overall evolutionary stage, these categories are based on the musical understanding and the related physical and cognitive abilities of the individual species, which range from a complete lack of any auditory perception and expression to highly developed musical abilities and vocal expression. I intended to implement and extend the findings from the last category (animals as voluntary performers) in my PhD project to develop and design musical instruments and interfaces for captive grey parrots.

2.3.1 Animal movement as control source

The first category of musical interfaces generally involves lower life forms such as bacteria or other simple animal species such as worms. These animals either completely lack any auditory sensory capabilities or acoustic expression or are completely isolated from perceiving any musical stimuli. Thus, in such a configuration, these animals only play a passive role since they are unable to interact with input devices in the sound generation process and only serve as nearly aleatory control sources. A typical example of such a musical instrument, which in this case is controlled by live worms, is the “Din Datin Dudero” project developed by Peter Blasser. As the worms wriggle around metallic contact pins, their movements modify the circuits inside the synth and produce different sounds.[22] The experimental design of the instrument appears to be suited to the limited physical abilities of the worms and basically integrates their bodies into the musical circuitry itself. It remains unclear if the worms are perceiving the low-voltage signals though their bodies and are capable of sensing any musical result at all.

Many of the musical examples I have found use a video tracking system to observe various animals and create sounds based on the overall movements of these animals. The most common species used in these systems are fish in an aquarium. Since the mid-2000s, this idea has been explored in different fields with various fish species. For example, “The Accessible Aquarium” is a long-time project of the Georgia Institute of Technology in Atlanta that is based on the field of informal learning environments. It attempts to make aquaria, zoos and science centers more accessible for visitors through interaction and sonification and thus enhance the visitors’ learning experience [43]. “The Accessible Aquarium” environment allows visitors to mimic the animals’ movements by using tangible objects to tell when a new fish enters the viewing range, what kind of fish it is and in what direction it’s moving; or add sounds or melodies to a specific aquarium fish. Sonifications corresponding to the visitors’ movements can be paired with real-time animal-based sonifications produced by the existing system to generate a musical composition of the visitors and the fish [44].

[22] http://www.ciat-lonbarde.net/dindatindudero/

Other fish-based projects such as “FuXi” [42], “Submersed Songs”,[23] “Quintetto”[24] (Figure 2.2), “Musica sull’Acqua” [45], and “Sonification of Fish Movement” [46] take a more artistic approach. Here, fish are employed as musical instruments and interfaces for sound installations or musical performances. Even though all the projects mentioned above use a video tracking system, they differ from each other in the way in which sound is mapped to the fishes’ movement and what kind of sound was generated. Although it has been shown that some fish species such as carp can discriminate between different styles of music [48], and gurnard fish also have audio communication skills [49], these particular abilities have not been investigated within the fish-based projects found in this field.

Figure 2.2 Fish-based project “Quintetto” © Quiet Ensemble

[23] https://www.youtube.com/watch?v=uhTCf_3l1Eg

[24] http://www.quietensemble.com/quintetto.html

2.3.2 Animals as unconscious performers

This section deals with projects that involve animals directly touching or triggering the interfaces, instruments or sensors and also involves species that have a developed hearing capability. Nevertheless, these species lack a general cognitive understanding of the causality of their actions in relation to the musical results and are therefore unconscious musical performers. The “Intelligent MIDI Sequencing with Hamster Control” project by Levy Lorenzo was a musical instrument that generated sounds based on the movements of six hamsters. Each hamster was placed inside a narrow single track where they could only move in a lateral direction. Based on the effective range of a distance sensor and the typical length of a hamster, Lorenzo decided to build 36-inch tracks. This allowed the hamsters to walk, sit up and turn around while still remaining within sight of the distance sensor [50]. The sounds generated depended on the distance of the hamster from the sensor. The hamsters had no free choice to interact with the instrument, and they had only limited space to move within the instrument tracks. It is unclear how long the hamsters had to stay in the instrument.

Figure 2.3 “Intelligent MIDI Sequencing with Hamster Control” © Levy Lorenzo

Robert Wechsler adopted a different approach in his “Harness” project.[25] He combined a mouse cage, including a mouse wheel, with a music box situated outside of the cage. When the mouse exercised on the wheel, it powered the music box, and thus produced the sounds stored within it. Based on my work with grey parrots, I assume that it is a good approach for utilizing a well-established device for pet environments. However, positioning the music box outside of the cage and therefore shielding it from direct audio feedback in the cage seems disadvantageous since it also isolates the mouse from the musical result.

Figure 2.4 “Harness” by Robert Wechsler. Image downloaded from http://robertwechsler.com/harness

[25] http://robertwechsler.com/harness

A well-known art project is "from here to ear"[26] (Figure 2.5) by Céleste Boursier-Mougenot. Since 1999, he has been developing musical environments and installations for finches in public exhibitions. The installations combine a set of traditional musical instruments—mainly electric guitars and drums—that serve as a resting place for the finches and produce sounds upon contact. The public is invited to enter the installation space and mingle with the finches, whose movements generate a live music piece. Each installation can be considered as a unique piece that is living and ephemeral; it is determined by the given variables of the situation and linked to the circumstances of the given moment.[26] Influenced by the audience, the finches generate a random sound collage that allows for minimal compositional procedures and choreographies defined by spatial arrangements. This project is currently one of the most established installations in the field of animal–human co authorship in sound installation. Since it has been shown that finches have musical abilities [35] [37], it would be interesting to provide them with musical instruments that are adapted to the physical and musical skills of the finches.

Figure 2.5 "from here to ear" by Céleste Boursier-Mougenot. Image downloaded from http://www.xippas.com/artists/celeste-boursier-mougenot/

[26] http://www.xippas.com/artists/celeste-boursier-mougenot/

2.3.3 Animals as trained performers

In this section, I look at projects in which animals become active music performers. There are numerous entertaining videos circulating virally around the Internet showing animals playing musical instruments. On video-sharing websites, there are numerous videos of dogs[27] and cats[28] playing the piano, trained seals playing toy wind instruments[29] and hens playing toy instruments.[30]

Elephants are a species that have been given musical instruments to enrich their lives in captivity. An early attempt in this regard was made by the Thai Elephant Conversation Centre with its “Thai Elephant Orchestra” (Figure 2.6). With the intention of creating music for humans, they designed and built massive musical instruments adapted to the physical abilities of the elephants. In 1997, the orchestra made its first recording with five elephants and subsequently released an audio CD in 2001. From the very beginning, it was clear that elephants could, through endless repetition, be taught to play complex patterns. However, the creators decided that making music should also be fun for the elephants. Thus, the only commands given to the elephants were to start, stop and occasionally the number of times to strike an instrument.[31] The instruments that were used in the orchestra were mainly percussion instruments that the elephants could play with their trunks. The percussion instruments ranged from slit drums, marimba-like instruments and gongs to thunder sheets, bells and xylophones. Other instruments included single-string instruments, harmonicas and wind instruments.

[27] https://www.youtube.com/watch?v=OEcSKyVo950

[28] https://www.youtube.com/watch?v=ypJDXayM5FM&t=21s

[29] https://www.youtube.com/watch?v=ferKjZ5MQrA

[30] https://www.youtube.com/watch?v=UBdEo9kyqT0

[31] http://www.thailandelephant.org/

Figure 2.6 “Thai Elephant Orchestra”. Image downloaded from https://alchetron.com/Thai-Elephant-Orchestra

The designs of the instruments were adapted to the elephant’s anatomy and skills and to the Thai cultural environment in which the animals lived. The elephants often heard Thai music; therefore, the instruments were adapted to sound similar to Thai instruments.[32] It has also been observed that elephants can play a steady beat [51]. During the course of the project, it was shown that they could make music together with other elephants and humans [52]. The combination of good instrument design and the elephants’ musical skills makes this project a promising approach. That the project was founded to raise money for the Thai Elephant Conversation Center and thus became a tourist attraction may have had a negative impact on the animals. For instance, the project focused on training elephants to play human-like music for a human audience. It would have been interesting to see what would have happened without any training, by just providing the elephants with musical instruments and seeing what kind of musical output they created without the need to entertain a crowd of visitors.

[32] http://www.thailandelephant.org/

Figure 2.7 Pratidah playing a drum ©Millie Young. Image downloaded from https://www.wnycstudios.org/podcasts/soundcheck/segments/113516-thai-elephant-orchestra

2.3.4 Animals as voluntary performers

The musician David Rothenberg is investigating the sounds animals make, which he considers and defines as music. He is making music for and with wild animal species, such as birds, bugs and whales, in order to understand their sonic expressions and communicate with them. For example, he spent many years studying whale songs and performed a duet with a singing humpback whale off the coast of Maui. He played the clarinet, and a sound spectrum analysis determined if the whale changed its song in response to the clarinet performance. Rothenberg claims that creating interspecies music is a valuable tool for understanding the complex sounds made by humpback whales [53]. Through his work he contributed and further developed zoomusicology (Chapter 1.2.4) as a research field.

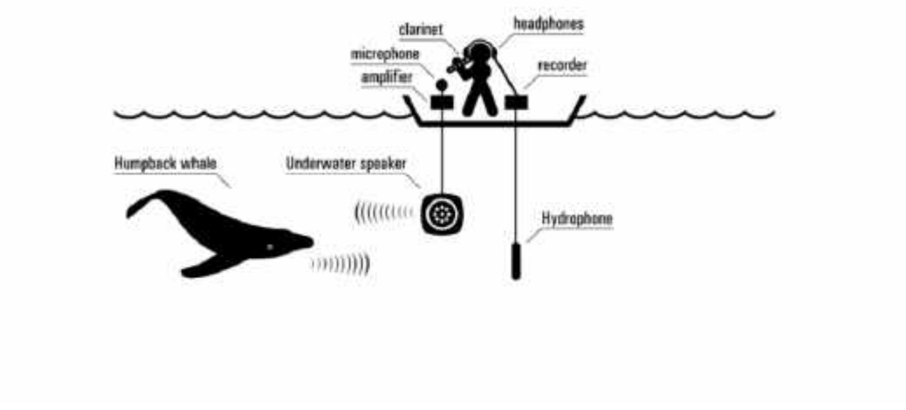

Figure 2.8 David Rothenberg, “Whale Song”. Screenshot from [53]

In 2014, the zookeepers of the Smithsonian's National Zoo in Washington D.C. provided their zoo animals with some musical instruments.[33] For example, they equipped their otters with a keyboard and the orangutans with xylophones. The zoo's intention was to enhance the well-being of the captive animals, keep them active and enrich their environment. They used traditional instruments designed for humans such as keyboards, xylophones and harmonicas, which obviously was a disadvantage to some animals with different physiologies.

Figure 2.9 Otters on keyboard at the Smithsonian's National Zoo in Washington D.C. Screenshot from http://www.smithsonianmag.com/videos/category/science/otters-play-a-piano-at-the-national-zoo/

[33] http://www.smithsonianmag.com/videos/category/science/otters-play-a-piano-at-the-national-zoo/

In the context of ACI research, several studies have been devoted to the use of audio technologies to enrich the living environment of animals in captivity. Fiona French [7] is currently investigating the potential of technological enrichment for captive elephants. The design of the interactive toys for elephants also focuses on acoustic enrichment experiences. For example, one design concept was based on a theremin-like instrument that the elephants could play with their trunks [8]. In collaboration with animal welfare experts and elephant keepers, French has developed prototypes for musical interfaces that utilized sensors and switches for triggering sounds. The sounds were adapted to the elephants' preferences, and 60–70 Hz low frequencies were used to arouse the interest of the participating elephant Valli [8].

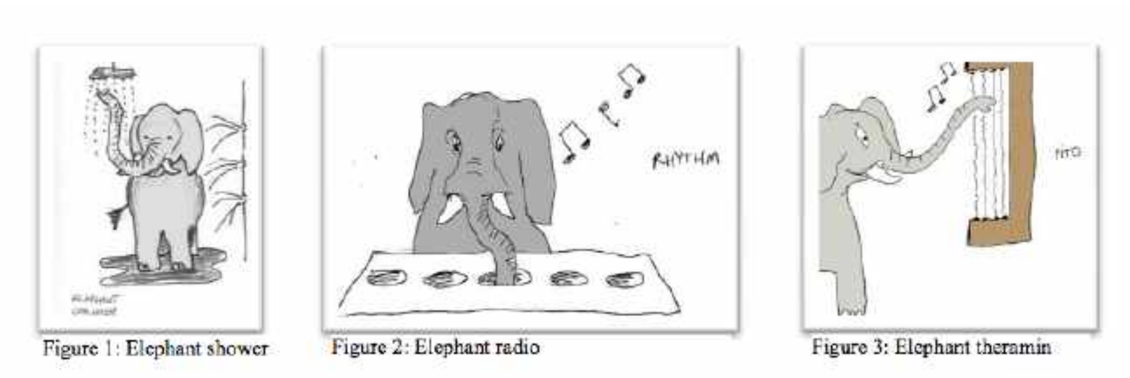

Figure 2.10 Design concepts for elephants ©Fiona French

Figure 2.11 Valli on "Elephant Radio" ©Fiona French

A further relevant study in ACI was carried out by Pons et al. with orangutans at Zoos Victoria in Melbourne [9]. A sound-based interactive system was developed for auditory enrichment. Instead of providing orangutans with human music, the system allowed the animals to explore different types of sounds by manipulating tangible objects. The sound preferences of the orangutans were incorporated into the design process, thus constituting an animal-centered approach. The system potentially allows to study which kind of auditory stimuli are engaging for the orangutans and which mappings would be best to mediate the interactions.[34]

Figure 2.12 "Sound to your objects". Image downloaded from https://patriciaponstomas.wordpress.com/projects/

In my opinion, the studies of French and Pons could be seen as best practices in the context of ACI, and both approaches could be adapted and used for the development of musical instruments and interfaces for other species such as grey parrots as well.

[34] https://patriciaponstomas.wordpress.com/projects/

I believe that the initial metamusic artistic project by alien productions also fits into this category because the grey parrots voluntarily participate in the musical interaction and design process.

The design of the instruments was adapted to the individual interaction forms of the birds. The music or sounds of the instruments were adapted to the individual preferences. The participation of the animals in the tests and musical actions was voluntary and was not rewarded with food. When working with the grey parrots, the ethical guidelines of ARGE Papageienschutz have been taken into account and complied with.

Figure 2.13 Kasi Casio early grey parrot instrument ©alien productions

2.4 Towards animal-centered musical interaction

In general, all the projects presented above have strengths and weaknesses in terms of their concepts and implementations. There are already promising approaches to improve the quality of life for animals in captivity with the use of music and sounds. In some of the projects, the selection of animal species seems arbitrary and not related to the animals' cognitive and physical skills. I have shown that some projects lack an animal-centered perspective, and many of the participating animals do not voluntarily intend to generate music by interacting with the provided interface or instrument. Additionally, many animals have been specifically trained or conditioned in order to perform predefined musical patterns.

Some of the projects also raise questions regarding the design of interfaces and musical instruments, which were not explicitly adapted to the abilities and needs of the participating animals. The use of traditional musical instruments designed for humans may not be appropriate and reveals a lack of an animal-centered design approach, as proposed in Mancini's ACI manifesto [3]. In many cases, the animals did not have the choice to not participate in the musical interactions or to choose between different musical instruments or interfaces. It is hard to imagine that such settings could be an enrichment for the animals or that voluntary musical performances could be performed there. Thus, ethical principles are another consideration altogether.

A further question that needs to be addressed is the meaning of sound and music to the animals. Although there are approaches to adapt the frequencies of the sounds [7] [8], or the music to the personal preferences of the animals [9] [47], there is still no evidence that any species appreciated the acoustic stimuli. A number of studies in the field of biomusicology, for example [32] [54] [55], have found that animals prefer sounds and musical arrangements that are biologically relevant for them. This important point was not considered in the examples provided above, and it is therefore questionable if any of the approaches provided beneficial enrichment to the animals.

This review was also focused on finding a framework that would fulfill the challenging tasks of implementing an animal-centered design process, generating an artistic output and, above all, helping to stimulate discussion about enriching the quality of life of grey parrots in captivity. In the next section, I will look at the key points involved in the implementation of musical interfaces for animals.

2.4.1 Musical capabilities

The selection of an appropriate animal species for participation in the interaction process with musical instruments and interfaces is of essential importance. Based on expertise gathered from biomusicology [28][35], I have identified several animal species that have a particularly high degree of musicality, such as vocal learning, vocal mimicking or spontaneous entrainment, in comparison to others. Hoeschele's list of species with vocal learning and entrainment abilities also shows those animal species that have been tested and shown to have musical skills.

As Figure 2.14 shows, vocal learning ability is generally a good indicator that the species has strong auditory skills. Entrainment in animals is unusual and involves the ability to align their movements to a musical beat. This ability has been found in grey parrots, cockatoos and elephants and has thus disproved the claim that entrainment to music is unique to humans (Chapter 1.3.6). These animals are able to move synchronously to music. Therefore, it is reasonable to assume that these animals can also maintain a rhythm with a steady tempo, as the active music performers of the Thai Elephant Orchestra have demonstrated. The animals on the list have the best prerequisites for playing an active role in projects that involve musical instruments. The questions of whether these talented animals appreciate music and whether they like making music or not require further study. Finally, whether the music created by animals pleases people is secondary to an animal-centered approach, and as such, animal music need not sound like music to human ears.

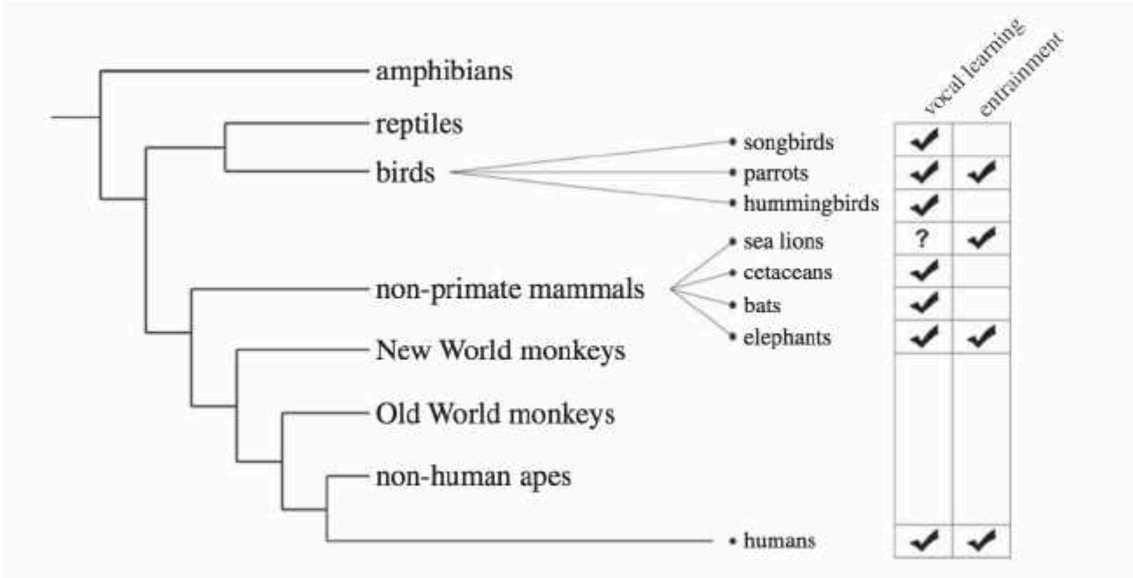

Figure 2.14 Vocal learning and entrainment in animals according to Hoeschele [35]

A further approach would be to select an animal species that is close to humans such as chimpanzees. It seems likely that they would share some human cognitive abilities [35], and thus would be interesting for further research. For example, orangutans, another related species, have shown interest in sound objects for individual auditory enrichment [9]. The Toronto Zoo conducted a study to determine the music preference of orangutans by using a participant-controlled, dichotomous-choice design. The orangutans were trained to indicate their music preference via touchscreen [47]. Furthermore, the orangutans of the Smithsonian's National Zoo in Washington D.C. were equipped with xylophones, and it was reported that they showed interest in playing them.

2.4.2 Physical and cognitive abilities

Another crucial question concerns the development of an appropriate animal-centered design approach, which concentrates on the specific physical and cognitive capabilities of each species, as well as its specific needs. The main problem here is to gather and understand the animal feedback. This requires different techniques [56], such as a review of the relevant literature on the animal species, the observation of the animals in their living environment and the development of testing prototypes [8]. The design process of such testing prototypes should also be based on the results of cognitive science and animal behavior, as well as an analysis of the physical capabilities of the animal participants. The sounds and music that are used need to take the individual differences of the animals into account. My work with grey parrots and French's work with elephants [8] show approaches that adjust the pitches of the audio frequencies to make them better perceptible for the animal species.

2.4.3 Engagement versus training

With regard to the various projects presented above, there are several different approaches to motivating the animal species that are involved in the installations. The scope ranges from imprinting behaviors, intense training and rewarding through food to setups in which the animals were free to interact with the instruments and were only rewarded and motivated though the sounds generated by their actions. I believe that a setup that relies on the animals' satisfaction to motivate them to make sounds with the musical instruments is suited for animal species such as elephants and grey parrots, which have been proven to have some form of musical skills. An engaging, playful sonic system may provide a self-training environment to improve the animals' musical skills. The animals' intrinsic motivation could be one of the keys to successfully implementing this kind of technology to improve the well-being of animals in captivity [57] [58]. For example, French uses such an approach in her work with elephants [7] [8]. The elephants are already integrated into the design process by voluntarily testing different sensors for their user interfaces. In contrast, there are elephants that are trained to play musical instruments [51] or draw pictures under the guidance of trainers. A study of four captive Asian elephants at the Melbourne Zoo, Australia, examined painting by elephants in zoos [59], which is believed to be a form of enrichment. However, the results indicated that the elephants gained little enrichment from the activity of painting.

2.5 Conclusions

This overview of recent musical instruments and interfaces that involve animals in the interaction and music-generation process is novel and highlights the costs and benefits of projects of this kind. It provides insights into current technologies in this field and the musical talents of animals. Some of the participating animal species such as elephants and grey parrots have shown musical abilities and skills in musical performances. I have proposed a classification based on the role that the animals play as a collaborator in the musical environments and performances. Only the few projects presented above in section 2.3.4. "Animals as voluntary musicians" seem to be promising technological and musical mediators between the animals themselves and between animals and humans. Thus, the proposed animal-centered design approaches and applied ethical guidelines could lead to musical devices to improve the quality of life of animals in captivity.

3 SONIC EXPERIMENTS WITH GREY PARROTS

This chapter is based on the paper “Sonic Experiments with Grey Parrots: A Report on Testing the Auditory Skills and Musical Preferences of Grey Parrots in Captivity”, which was published and presented at the *Fourth International Conference on Animal-Computer Interaction*, which took place in Milton Keynes, UK, in November 2017.

It was the first time that I presented this research project to the ACI community, and the artistic approach for dealing with the animals and musicality was well received. My contribution extended the species repertoire in ACI research by introducing grey parrots as research subjects.

At the ACI conference, I received a lot of fundamental information about designing for and with animals, which was very helpful in the further course of my PhD project. The feedback on the work presented on sonic experiments with grey parrots has been very important and has significantly raised aspects of and considerations about auditory enrichment for captive animals in shelters. Finally, I was able to establish a small network of researchers who are working on the same topic within the ACI field.

The sonic experiments with our group of grey parrots took place in the ARGE Papageienschutz parrot shelter. The informal experiments included volume and frequency measurements and several auditory discrimination tests.

I gained knowledge about the auditory skills of our group of grey parrots, and the experiments provided insights into their individual musical preferences and forms of interaction.

Another aim was to find and define basic design specifications for the planned series of experimental musical interfaces and instruments that should be adapted to correspond with the physical capabilities and sonic preferences of grey parrots that I identified in the experiments.

Abstract

This report documents a series of experiments towards the development of acoustically enriched environments through sonic interfaces and musical instruments for grey parrots living in captivity. These investigations intend to lead to a better understanding of how an individual group of grey parrots perceive, respond to and generate sound and music through the usage of technological mediators. It determines the interaction preferences of the involved grey parrots that informed the following animal-centered design process.

3.1 Introduction

Are the origins of human musicality to be found in the animal kingdom? In any case, there are certain similarities in terms of harmony, melody and rhythm between human music and animal songs and calls [60]. These phenomena have been noted by researchers in bioacoustics, biomusicology and related fields (Chapter 1.2.4). As described earlier, there are two indicators that speak for possible auditory skills and musicality in various animal species—vocal learning and entrainment [12] [35]. Vocal learning is the ability to learn new sounds via imitation and produce vocalizations, and entrainment means the ability to synchronize their movements to an externally perceived rhythm [38] [39]. Grey parrots share both vocal learning and spontaneous entrainment.

In the first practical phase of this PhD research, motivated by research showing that grey parrots have high auditory skills and musical talents [36] [39], I wanted to find out more about the general auditory skills and individual musical preferences of a group of African grey parrots held at the parrot shelter. I have carried out sonic measurements and sonic experiments in order to better understand how they perceive, respond and generate sound and music. My overall aim was to take a significant step towards the implementation of musical instruments for the auditory enrichment of a group of grey parrots.

3.2 Sonic experiments at the parrot shelter

To test the auditory and musical skills of grey parrots in captivity, I carried out measurements and experiments at the ARGE Papageienschutz parrot shelter in Vösendorf near Vienna. The shelter is home to approximately 180 parrots. Most of them are captive-born, hand-raised, exposed to human speech and some of them show behavioral disorders such as FDB (Chapter 1.3.3). The subjects of the experiments were 15 grey parrots between the ages of 4 and 40. They were housed in one group in a 5 x 4 x 3m indoor aviary, with an additional outdoor aviary of approximately the same size. All experiments took place in the indoor aviary. The aviaries were enriched with parrot tools, and the parrots had free access to food and water. For the experiments, the parrots were not separated. They were free to interact with the test devices and were only rewarded and intrinsically motivated though the sonic feedback generated by their actions. These tests were carried out in cooperation with zoologists and respected the ethical principles of ARGE Papageienschutz (Chapter 4.2). There was no rewarding by food, and when the grey parrots moved away, the test was stopped. In general, it is very noisy in the parrot shelter environment, and many of the animal keepers therefore wear ear protection.

Figure 3.1 Indoor aviary at ARGE Papageienschutz

3.3 Sonic pre-tests

Prior to the testing of the music preferences of the grey parrots described below, measurements were taken of the loudness, and a frequency analysis was conducted on the calls and songs of the grey parrots. It must be noted that the calls and sounds of the parrots from the neighboring aviaries were also clearly audible in the aviary in which the tests were carried out. I cannot exclude that they also influenced my measurements to some extent. To measure the sound pressure level, I used a Laserliner SoundTest-Master sound level meter and for the audio recordings, an R-09 EDIROL digital recorder. To protect the devices from the parrots, I positioned them in a small cage in the aviary.

Figure 3.2 Small cage for protecting the audio equipment

My measurements in the aviary found a maximum sound volume of 104 dB. That already lies in the harmful range for human hearing. The average communication volume of the grey parrots was between 60-90 dB. The analysis of the frequency range was run on a spectrogram. The frequency ranged from a minimum of 600 Hz to a maximum of 3,800 Hz. Most of the utterances of the grey parrots were in the range between 1,200-2,400 Hz. The frequency analysis showed that the basic frequency in the grey parrots' communication was substantially higher than in humans. This raises the question of whether we have to pitch up the sounds and music we are working with to make them better perceptible for the grey parrots.

Such frequency examinations on grey parrots in captivity have already been carried out in previous studies by Bottoni [36] and have showed similar results. Due to the particular set of living conditions in the animal shelter and the individual backgrounds of the parrots, I found it interesting to see if there were significant deviations from these previous studies.

Thus, to learn more about the basic hearing parameters of the grey parrots, I also tested their hearing abilities by exposing them to sound. The stimuli consisted of sine waves of different frequencies at an intensity of 70 dB at a distance of 1 meter. The frequencies ranged from below the hearing threshold to levels well above the hearing threshold and with frequencies covering the whole audible range of grey parrots.

For these tests, I used a speaker that was built into our rope swing test station described below. The small loudspeaker was 7.6 x 6.2 x 5.5 cm and had a frequency range from 150 Hz to 20,000 Hz. The animals were observed to see how they reacted to the different frequencies. A particularly interesting indicator was the head and body shaking of the grey parrots. This behavior was clearly observed at certain frequencies. According to the experts and animal keepers, this behavior can be interpreted as irritation. But that does not mean that this irritation is felt as negative. Another clear indicator were the utterances and calls of the grey parrots.

My observations and the evaluation of the animal keepers suggest that the lower limit of sound perception is around 150 Hz and the upper limit of sound perception is around 7,000 Hz. Particularly strong acoustic feedback was observed at 5,000 Hz. My results do not differ significantly from previous studies [36] [61].

3.4 Experiment with the rope swing test station

The rope swing test station is based on a typical tool for parrot enrichment—a rope swing with an outer diameter of 29 cm. Rope swings are used for physical enrichment by providing swinging and climbing opportunities and thus they often serve as a resting place for the parrots.

A rope swing had already been used as the swing instrument by alien productions as part of the initial metamusic project. An accelerometer sensor was attached to the rope swing to trigger sound with simple rhythms and melodies when parrots interacted with the ring. Since the swing instrument was well received by the parrots, I decided to further develop this instrument to test the auditory and music preferences of the participating grey parrots. First, I integrated the accelerometer sensor at the bottom of the rope swing where the parrots prefer to sit. Thus, I experimented with radio-frequency identification (RFID) antennas that were also integrated at the same place.

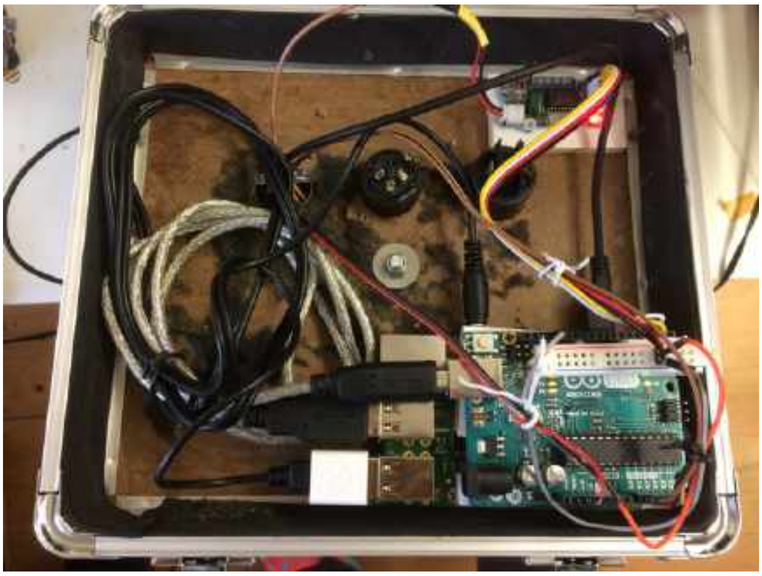

Figure 3.3 Inside the rope swing test station

The adapted rope swing was attached to a small case which housed a Raspberry Pi mini-computer and electronics for the sensors. This setup made it possible to trigger different sounds, record all the interactions and opened up the opportunity to identify the individual parrot interacting with the rope swing. For the purposes of my tests, I made a second copy of the rope swing.

Both rope swings were mounted side by side in the aviary. The distance between the rope swings was chosen in such a way that the parrots could easily change from one swing to the other. I had three long-time test phases over a period of three months. I carried out different sonic experiments within these test phases of three to four days. The rope swing test station was accessible 24 hours a day, and the interactions were digitally logged. Most of the time no persons were present during these test phases.

Figure 3.4 Rope swing test station mounted side by side at Salzamt

Basically, there were two setups:

1. One rope swing was active, which means that the swing responded with auditory feedback when a parrot interacted with it. The other rope swing did not give auditory feedback. In this way, I tried to find out which rope swing the grey parrots preferred—the rope swing with sound, or the rope swing without sound.

2. Both rope swings were active, which means that both swings responded with auditory feedback when a parrot interacted with them. The rope swings gave different auditory feedback. For example, one swing played a simple melody while the other swing played the same melody with a changed pitch, or one swing played a song with human vocals while the other swing played the same song without vocals. In this way, I tried to find out the music and auditory preferences of the individual grey parrots.

The following sounds were used for testing: single notes from different instruments, simple melodies at different pitches, songs with and without human voices or beats at different speeds. The volume intensity for testing was about 70 dB when a grey parrot sat on the swing and triggered the sound. 70 dB is the average volume of communication of our grey parrot participants.

In general, grey parrots are very territorial animals and thus the birds were not always free to move within the aviary. It was therefore important to find a suitable place to hang the test station in the aviary so as many birds as possible could interact with it. Furthermore, the accessibility of each rope swing played an important role. It made a difference in the frequency of use if the swing was reachable by using a branch or if the parrots had to fly to the swing. In addition, there were the individual preferences of the grey parrots themselves—some liked to use rope swings, others not.

Since digital logging also led to errors, this data is not very significant. For example, errors occurred when the birds passed and bumped the rope swings, or when they played around with the test station housing with their beaks.

However, some general knowledge can be derived from this data. Most interactions with the rope swing test station were digitally logged in the early morning hours between five and nine o'clock. Both swings—with sound and without sound—were regularly used and triggered. Based on what I observed, the animals actively triggered the sound of the active swing and used this swing over a longer period of time—from 5 to 30 minutes.

In the second test setup, when both rope swings were active, I observed that music with a continuous beat was favored to single notes. In response to music with a continuous beat, it often happened that the grey parrots spontaneously entrained by bobbing their heads and responded with utterances. I could not prove whether grey parrots tend to prefer music with human voices to music without human voices or which pitch they prefer.

Wittgenstein, a very active 4-year-old female grey parrot, was observed to repeatedly trigger the sounds at the rope swing test station. The distinctive jerky movements of Wittgenstein suggest that she was triggering the sound on purpose. The individuals from our group of grey parrots generally preferred a loudness and pitch matching their own communication habits.

Figure 3.5 Rope swing test station at Salzamt © Otto Saxinger

3.5 RFID leg rings for grey parrots

As mentioned above, I attached RFID systems to the rope swings. This was designed to help identify the individual grey parrot interacting with the device. The implementation required the use of bird ring tags for the tracking of the animals. These bird ring tags can be found on the market, mainly for collecting information on pigeons and chickens. Since the size and stability of these pigeon and chicken ring tags did not meet the demands of leg-ringing grey parrots, I tried to develop my own RFID tag rings. I disassembled a chicken RFID tag ring and kept the small RFID transponder. I bought 11 mm and 12 mm diameter aluminum split rings. This size is usually used and required for ringing grey parrots. Generally, these split aluminum rings last the parrot's entire lifetime. Finally, I attached the RFID transponder to a split aluminum ring and cast it in artificial resin.

Figure 3.6 DIY RFID leg rings for grey parrots

My first attempt to attach this open aluminum RFID tag ring to a bird was carried out on Moritz, a male grey parrot of our test group. Moritz has previously demonstrated approach and exploration of novel objects and musical instruments.

The animal keepers of ARGE Papageienschutz attached the RFID tag ring to Moritz by simply wrapping the split ring around the bird's tarsus and fitted it with a special applicator. After this, we observed Moritz’s behavior to see if he accepted the RFID ring. Moritz managed to remove the attached RFID transponder within two days. Because the period of functional reliability was so short and the range of the RFID reader was only 10 cm, I decided not to implement them in the experiments.

As mentioned in Chapter 1.3, the rules for protecting grey parrots were tightened at the 17th Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Conference in Johannesburg in October 2016. They have thus already reached the highest level of protection provided by CITES.[35] This also means that the grey parrots at ARGE Papageienschutz will most likely have to be chipped in the near future. This would open up new opportunities for the use of the proposed implementation of RFID technology.

[35] https://www.bmlfuw.gv.at/dam/jcr:a274efb2-5de0-4e51-8eb0 ca421f00a004/INFOBLATT%20Graupapagei.pdf

3.6 Experiments with the joystick test device

The predecessor of the joystick test device was the joystick instrument by alien productions. The joystick test device is battery-powered and consists of a 25 x 17 x 10 cm grey box, with two wooden joysticks, a perch for one bird and the electronics installed inside the box. The two wooden joysticks were originally popular tangible toys for grey parrot enrichment. These are mainly operated by the parrot's beak and leg. The wooden joysticks had different colors (yellow/green and orange/blue) and were mounted next to each other 10 cm apart. The interaction design for our experiment was as follows: One grey parrot sat on the perch which was mounted so the bird could interact with the two wooden joysticks. The parrot could choose freely between the two joysticks, which could be easily moved by the parrot's beak. By moving the joystick, the parrots could generate different sounds. If there was an auditory response, it came directly from the small speaker placed inside the grey box.

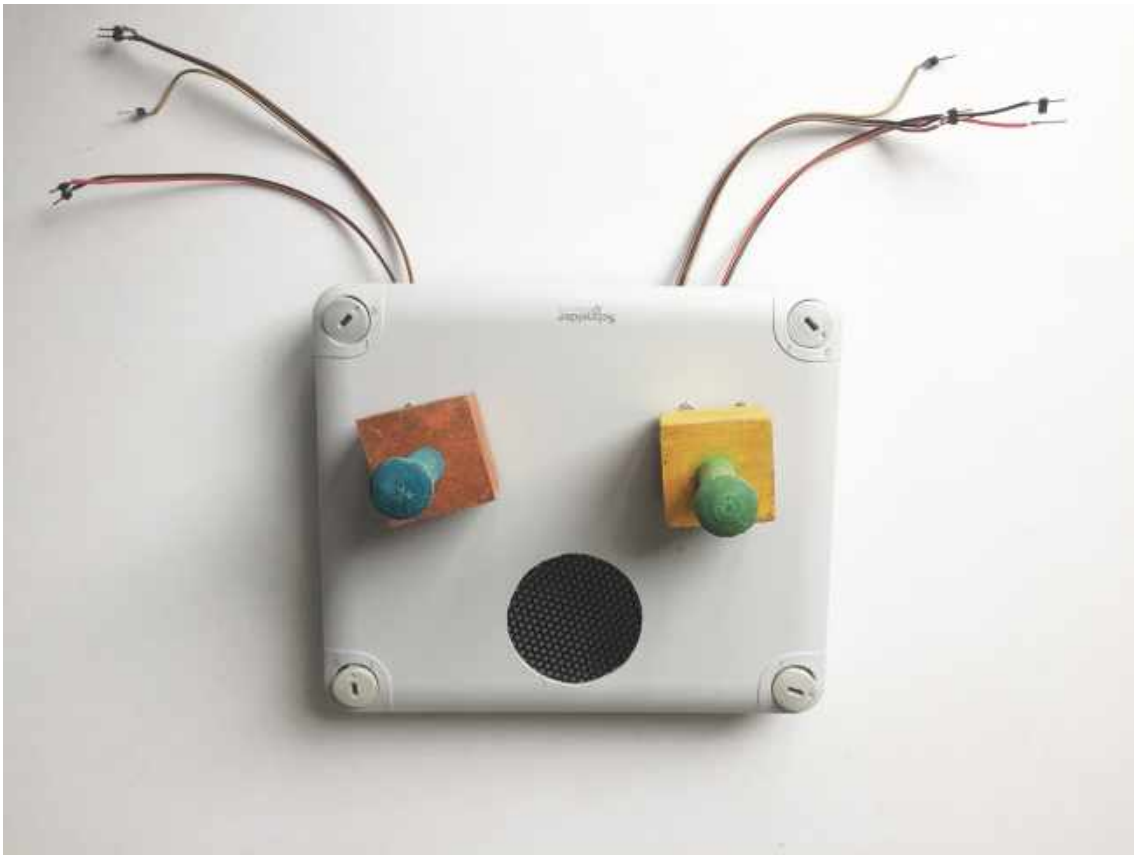

Figure 3.7 Physical design of joystick test device

The test setups for this experiment were similar to the ones for the rope swing test station:

1. One joystick was active, which means that the joystick triggered sounds when a parrot moved it. The other joystick did not give auditory feedback when moved. In this way, I tried to find out if the parrots prefer the joystick with silence or the joystick with sonic feedback.

2. Both joysticks were active, which means that both joysticks responded with auditory feedback when a parrot interacted with it. By using different sounds, I wanted to gain a better understanding of the music and auditory preferences of the individual grey parrots.

I used experiments to compare, for example, if the individual parrot prefers a musical beat to a single note or a slow musical beat (90 BPM (beats per minute)) to a faster one (120 BPM). The volume intensity for testing was between 60 and 80 dB for the grey parrots when they were sitting on the perch and triggered the sound. The joystick device test was carried out in the presence of a person that motivated the parrot to interact with the joystick device. A test phase lasted between 20 and 30 minutes depending on the motivation of the birds. Since the joystick device is battery-powered and wireless, it was possible to move around freely in the aviary and offer the device to different grey parrots.

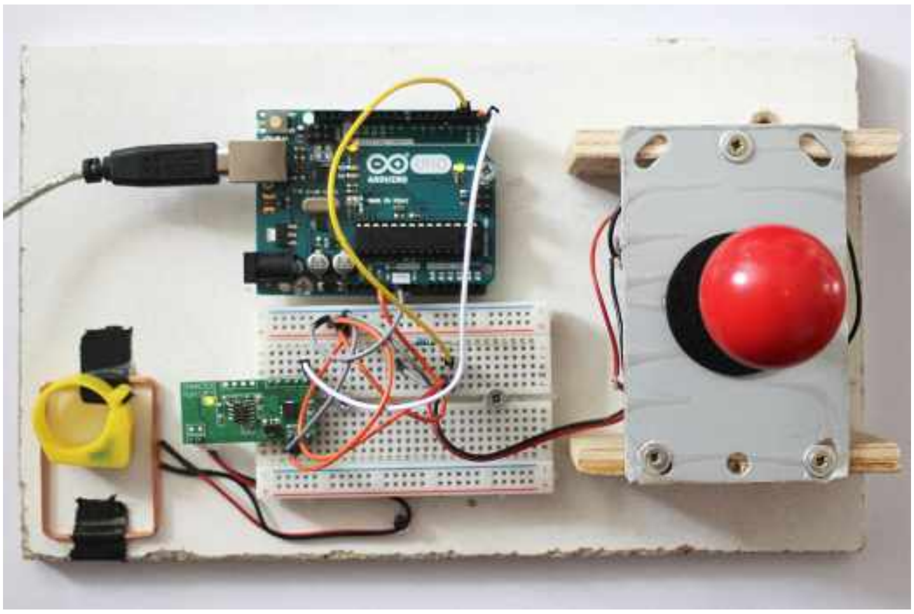

Figure 3.8 Joystick test device prototype with RFID

In general, the joystick test device was well received. Some of the grey parrots were willing to spontaneously interact with it. As with the rope swing test station, I observed that the parrots preferred music with a continuous beat to single notes. In the experiments with faster and slower musical beats (BPM), the grey parrots did not show any clear preferences. Another basic insight was that the musical taste of grey parrots is apparently very individual as in humans.

Figure 3.9 Joystick test device and grey parrot Wittgenstein ©Otto Saxinger

Coco, a 40-year-old female grey parrot, showed clear preferences for the joystick test device. If the device was positioned on the ground, it was occupied and used for a long period of time by her. She used the joysticks to trigger sounds and quickly found out which joystick triggered the sounds and which not. In response to the sonic feedback from the device, she started bobbing her head and making utterances.

3.7 Conclusion

The sonic experiments with grey parrots show informal results that suggest that the design and use of musical instruments and interfaces can possibly help to improve their quality of life in captivity. The grey parrots intrinsically participated in the experiments, interacted with the provided test devices and gave positive feedback by bobbing their heads or making utterances. Thus, my efforts are a significant step towards the acoustic enrichment of grey parrots in captivity. By logging the experiments digitally, recording videos and observing the grey parrots' behavior, I was attempting to determine what kind of sonic and interactive experiences the individual parrots prefer in their interaction with the proposed test environments. In the following project phase, I focused on the design of a series of experimental musical interfaces and instruments that are adapted to these physical capabilities and sonic preferences of grey parrots in captivity.

4 Animal-Centered Sonic Interaction Design: Musical Instruments and Interfaces for Grey Parrots

This chapter is based on the paper "Animal-Centered Sonic Interaction Design: Musical Instruments and Interfaces for Grey Parrots", which was published and presented at the *Sixth Animal–Computer Interaction Conference* in Haifa, Israel in 2019.

As part of the conference, I was able to give a final overview of the whole artistic research project, with a focus on the final phase of the project. The presentation was given in the session "Broadening Participation" and extended the field by introducing musical instrument design for grey parrots and the artistic research approach.

It was very interesting to see how things have developed in this community over the last two years. The pity was that at this year's ACI conference there were no further contributions, nor a deeper discussion about auditory enrichment for captive animals.

Nevertheless, there were many constructive suggestions and discussions that I have incorporated as far as possible in the last phase of my PhD project. At the conference, I again received a lot of fundamental information about designing for and with animals.

The animal-centered design approach carried out in this project is rooted in the idea that the grey parrots must be at the center of the design process. This chapter presents the implementation of an iterative design process for developing musical instruments and interfaces that is manly informed by ACI research. The participatory design can be seen as an enrichment approach for the captive grey parrots which was carried out in the form of playing and making music with the grey parrots.

The aim was to develop a set of musical instruments and interfaces that can be used for the auditory enrichment of grey parrots and musical performances in the context of the metamusic PEEK project.

Abstract

This chapter describes the process and the methodology used to design musical instruments and interfaces aimed at providing auditory enrichment for grey parrots living in captivity. Based on the cognitive, physiological and auditory abilities of grey parrots, and their intrinsic interest in acoustic and physical interactions, I have developed and tested various interactive instrument prototypes from an animal-centered design perspective. In the previous chapter, I analyzed the physical and musical skills of a group of grey parrots, and here I present the design results for auditory enrichment in the context of ACI and artistic research. My investigation should lead to a better understanding of how grey parrots interact with technological mediators, respond to sound devices and create “parrot music,” with potential benefits for their well-being while living in captivity.

4.1 INTRODUCTION

Designing technological mediators for and with animals is quite challenging. Working on the design and development of auditory enrichment devices for captive wild animals may increase the difficulty level, but the effort is worth it since we have a particular responsibility towards these animals. This PhD project on designing musical instruments for the auditory enrichment of captive grey parrots is closely related to the field of ACI (Chapter 1.2.1) and its animal-centered design approach.

One focus of ACI is devoted to the study of the relevance that sound and music have on animal welfare, and how these sounds can be used to enrich the environment of captive animals. The interest in technology for the auditory enrichment of captive wild animals is growing and a workshop was held by Fiona French on this topic at the ACI conference in Atlanta in 2018 [62]. Within this “SoundJam” workshop, which will be presented in Chapter 5.2, prototypes were developed and presented for different animal species. In addition to chimpanzees and elephants, new interaction design ideas were also developed for parrots. In this chapter, I document the animal-centered design approach carried out in this PhD project for the auditory enrichment of a group of grey parrots living in the ARGE Papageienschutz parrot shelter.

4.2 METHODOLOGY

The design of interactive technologies for grey parrots in the field of artistic research and musical interaction design is new and therefore requires careful consideration regarding an appropriate and responsive framework for the process of developing such environments. My process for designing musical instruments is mainly based on the findings of ACI and biomuicology, as well as our own observations and an analysis of the physical and acoustic capabilities of the various participating grey parrots. One of the main goals of this PhD project was to develop an approach that allows grey parrots to voluntarily participate as actively as possible in the design process without the application of any clicker training or food based reward training. The voluntary participation of the grey parrots in the different experiments is ensured by allowing the grey parrots to freely decide whether they wish to participate in the research activity and by creating experimental setups that assure the exercise of free will by allowing the grey parrots to move away from the experiments at any time. We take the fact that the grey parrots actively move towards the instrument, generate sounds with it and respond to the sounds as a sign of their voluntary participation.

When working with the grey parrots at the ARGE Papageienschutz aviary, I complied with their ethical requirements:

- No spatial separation (of individual grey parrots)
- No training (especially no typical parrot training with clicker or target stick)
- No rewarding with treats
- Voluntary participation

4.2.1 Participatory design

To actively inform the design process within the various stages of our prototypes, I have preferred to use the playful interaction between grey parrots and humans as a co-design method for the development of musical instruments for this animal species. The joint musical play, or as I call it, the "Jam Sessions", have yielded several insights into the individual preferences of each grey parrot and their general forms of interacting with natural, artificial or technical artifacts. I strongly believe that this participatory design approach leads to more creative outcomes, more usability of the musical instruments and fulfills all ethical research principles. The reactions and observed preferences of the grey parrots when interacting with the proposed devices has continuously informed the iterative design process.

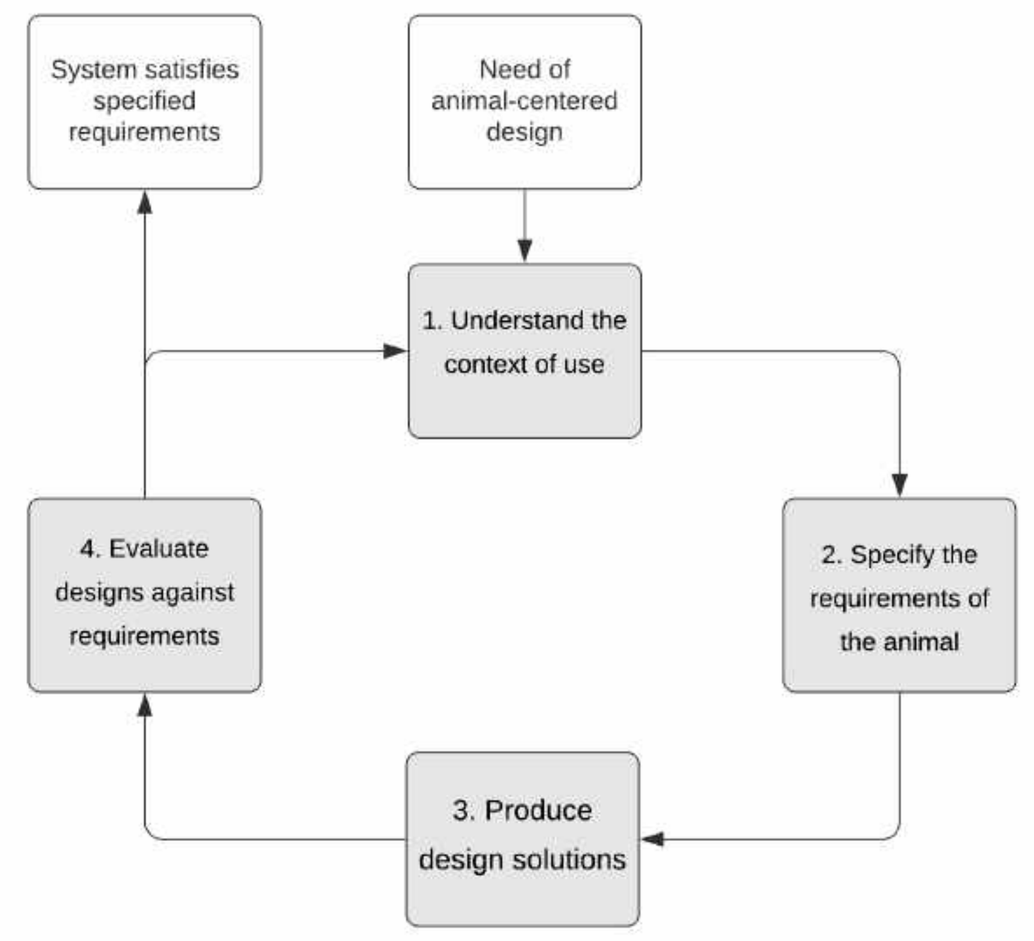

Figure 4.1 The applied animal-centered design process

The “Jam Sessions” have opened a wide range of possibilities to gain more knowledge about our group of grey parrots at the parrot shelter. These are the different aspects that have been implemented during the artistic research and participatory design practice for and with grey parrots:

- Artistic musical practice (jamming)
- Preference tests (forms of interaction, materials, sounds)
- Evaluation (grey parrot user tests, observations)
- Foster bonding (between animals and humans through musical instruments)

Whenever the grey parrots moved away or showed negative signs, the “Jam Session” was immediately interrupted. The very playful approach of the “Jam Sessions” was an appropriate method for overcoming the limits of grey parrot–human communication by making music and sound together.

Intrinsic motivation also plays an important role in this context. The motivation to engage with the musical instruments should arise from the grey parrots themselves. The cognitive challenge of interacting with musical instruments and the musical response should themselves be a reward and enrichment for the grey parrots. Making music is the spontaneous and voluntary activity undertaken for the parrots' personal enjoyment. The reward is the inherent playful activity and its sonic response, and not just an action to get treats. In short, playing with music replaces the peanut as a reward system and therefore should encourage the animal to continuously interact and play with the musical interface. Beyond the process of observation, measurement and analysis, a more reliable methodology that allows the grey parrots to participate in the design process itself has yet to be found. The design should avoid any conditioning of the animals but instead support their inherent acoustic capabilities and needs. Instead of providing grey parrots with what we believe is pleasant to their ears, the musical interface approach gives them control over the sonic stimuli. In this approach, the grey parrots can explore different types of interactions with the devices and sounds by playfully interacting with the musical interfaces.

4.2.2 Interaction design

Interaction design and its evaluation is the basis of Human-Computer Interaction (HCI) and thus also a fundamental part of NIME and ACI. Animal interaction not only always includes an animal and a certain technology, but often a human participant, researcher and/or animal keeper [4]. In our case, this means the interaction between animal and instrument often also includes keepers, artists and researchers. Interaction refers to the way in which parrots handle and respond to the musical instruments and interfaces and is obviously primarily determined by the physical and cognitive abilities of each species. What happens exactly within the animal while interacting is generally unknown, but I, in collaboration with the animal keepers, tried to interpret the behavior of the grey parrots. Therefore, the animal keepers participated in the process through their zoological knowledge and experience with the parrots. We observed the parrots' behavior when playing, exploring and interacting with the musical instruments and other artifacts within their environment. A good understanding of the parrots' body language and posture is essential for determining positive and negative responses to the design of the instruments. Grey parrots primarily interact with instruments by means of their beak, but sometimes a leg is also involved as a support, for example, to hold a device. In general, the parrots like to chew, pull and peck on most artifacts and interfaces, with a visible desire to disassemble or destroy them. In order to encourage this behavior, I have had good results from providing them with a wooden branch equipped with a piezo pickup. This setup has evolved and is presented below as the branch instrument. Branches are generally used as an enrichment toy for the aviaries, and the parrots like to nibble and chew on them and peel off the bark. I have encouraged this natural behavior of the grey parrots and added a sonic stimulus to it by amplifying the sound that occurred during these interactions. This has allowed me to find a good starting point through the use of familiar materials in combination with encouraging natural behaviors such as pecking or chewing.

4.2.3 Physical design, materiality and color

As mentioned above, a good strategy is to use materials which the grey parrots are familiar with. In the context of this PhD project, this generally refers to the existing equipment and enrichment of the aviary. Commonly used materials are, for example, wood for perches, metal grids, ropes, cardboard, plastic toys and fresh branches.

I observed a general curiosity toward artifacts that we added to the environment, leading to an overall exploration and a tendency toward trying to disassemble the whole artifact. During our initial experiments, I tried to protect the technical instruments from being damaged by the parrots by explicitly trying to build them very sturdy. But it quickly became clear that the instrument prototypes were far more interesting for the parrots if they at least partially appealed to their exploratory and destructive drive, as I observed with our piezo-equipped wooden branch.

In the case of the tube instrument described below, I initially used a cardboard tube, which was well-received by the parrots. As the cardboard tube quickly suffered damage, I tried replacing the cardboard tube with a natural and sturdier bamboo tube. Surprisingly, the parrots then completely ignored the instrument and were reluctant to play with it. According to the animal keepers, the grey parrots are not familiar with bamboo, and the material is therefore suspicious to them. Therefore, I had to take a step back and tested different materials for the tube instrument. I finally decided to use transparent acrylic glass as the material for the tube. This material has been well-accepted by the parrots. It is familiar to them, as many enrichment toys use this acrylic material.

In general, the neutral appearance and the strength of plastic tubes makes them a good material for the instrument cases and also adds a functional aesthetic that matches our needs. The neutral monochrome colors (white, grey, transparent) of the tubes make sense to us because we do not want the parrots to be distracted by the color of the instruments and thus not engage with the generated sounds.

For example, the grey parrot Wittgenstein is very interested in red objects and can be easily motivated to interact with instruments by using red attractors. I assume that such color-motivated interactions have little relevance for our research on auditory enrichment for grey parrots. I have therefore strived for a neutral color design. The use of colored wood cubes from parrot toys has helped somewhat in initially drawing the parrots' attention to the instrument and its usability. I have subsequently observed that the grey parrots react differently to the colors and materials of the instruments. Other attributes such as the smell and the taste of the material might play an important role here, but I have not been able to investigate this in further detail. Generally, I was making sure that no sharp edges or toxic materials were used.

4.3 INSTRUMENT IMPLEMENTATIONS

In order to develop the musical instruments, I regularly visited our group of grey parrots at the parrot shelter. As with the previous experiments, all activities took place in the indoor aviary. The grey parrots were free to interact with the musical instruments and were rewarded and intrinsically motivated though the sonic feedback generated by their actions and I also took into account the presence and influence of me as the experimenter.

The designs of the instruments have been informed by my research of the literature, my earlier sonic interaction experiments with grey parrots and the anecdotal experience and observations from the initial metamusic project by alien productions. An instrument from this initial project period that has worked particularly well is the gong instrument.

Table 1. Overview of the musical instruments presented below

Name	**Type**	**Interaction**	**Sound**
Gong instrument	Electro-acoustic percussive	Beak, leg; knocking, walking	Metallic, percussive
Chime instrument	Acoustic	Beak, leg; pulling, chewing	Metallic, percussive
Branch instrument	Electro-acoustic percussive	Beak, leg; nibbling, wiping	Woody, metallic; percussive
DJ instrument	Digital sampler	Beak; rotating, nibbling	Digital scratching
Tube instrument	Acoustic-digital effect	Beak, leg; pulling	Spring reverb
Vox instrument	Digital effect	Beak; utterance, nibbling	Reverb, delay, pitch shift
Reel instrument	Digital drum sampler	Beak, leg; rotating, nibbling	Digital percussive

4.3.1 Gong instrument

The gong instrument (Figure 4.2) had been developed by alien productions for a previous exhibition at the Höhenrausch in Linz during the summer of 2015 as part of the initial metamusic project. The instrument consists of a floating metal plate, which is mounted with metal springs on top of a case. The plate is equipped with a piezo pickup for sensing the impact interactions, and the case houses and protects the necessary electronic equipment. The gong is a percussive instrument in which the grey parrots generate sound by continuously pecking with their beak onto the metal plate. In the exhibition installation, these pecking sounds were amplified, manipulated with sound effects such as reverb effect and played back to the parrot aviary via a general PA system. Since pecking is a natural territorial behavior in parrots, the instrument was very well-received and used regularly. However, the smooth surface of the instrument made it difficult for the parrots to walk and rest on the instrument. For this reason, blue sandpaper was applied to the surface of the case of the instrument. It remains unclear how the sounds which were played back to the aviary affected the other grey parrots. During our observations, we were unable to detect any stress behavior such as other birds in the aviary fleeing, but I generally suggest that the sound should preferably come directly from a speaker inside the instrument to not affect other parrots in the aviary.

Figure 4.2 Billy playing the gong instrument ©alien productions

4.3.2 Chime instrument

This simple and purely acoustic percussive instrument is based on a wind chime with the audible musical notes G-A-B-D-A-G-B-D. The eight tones are produced by eight metal rods within a cylinder which are struck by a disk attached to a cord with a wind sail.

The sound of the wind chime was positively received by individual parrots such as Wittgenstein and Rosi during the "Jam Sessions" and was therefore adapted as an auditory enrichment instrument for the grey parrots. The cord to operate the instrument was renewed and instead of the wind sail, a colorful piece of wood from a parrot toy was attached to the cord. A cardboard tube was used as an additional protective resonator. This modification was also designed to motivate the parrots to interact with the instrument's case. Cardboard in various shapes is often used for enrichment in the parrot shelter, and I assumed that the use of this material would make the instrument more familiar to the parrots and motivate them to chew on and tear at the instrument. I observed various parrots interacting with the chime instrument.

Figure 4.3 Rosi playing the chime instrument. Screenshot from video by Elisa Unger

The parrots interacted with the chime instrument by pulling on the rope with their beak or a leg; nibbling and destroying the piece of wood attached to the rope; or, less frequently, nibbling on the cardboard resonator. Mostly, they interacted with the attached piece of wood, and it is therefore questionable to what extent the responsive sound of the instrument was the motivation for the interactions. The color of the attached piece of wood also had an impact on the frequency of the interactions. For example, with a red piece of wood, we observed more interactions than with other colors. Through these interactions, a sound carpet was created, which could subsequently be picked up by a microphone and amplified for the performance setting described in Chapter 6.3.

Figure 4.4 Chime instrument ©Elisa Unger

4.3.3 Branch instrument

The branch instrument is an electroacoustic instrument that makes the grey parrots' interactions with the branch and the additionally attached ludic elements audible. As described above, branches are always used for enrichment in the parrot shelter aviary. The parrots sit and move on the branches, peel off the bark and rub their beaks or knock on the wood.

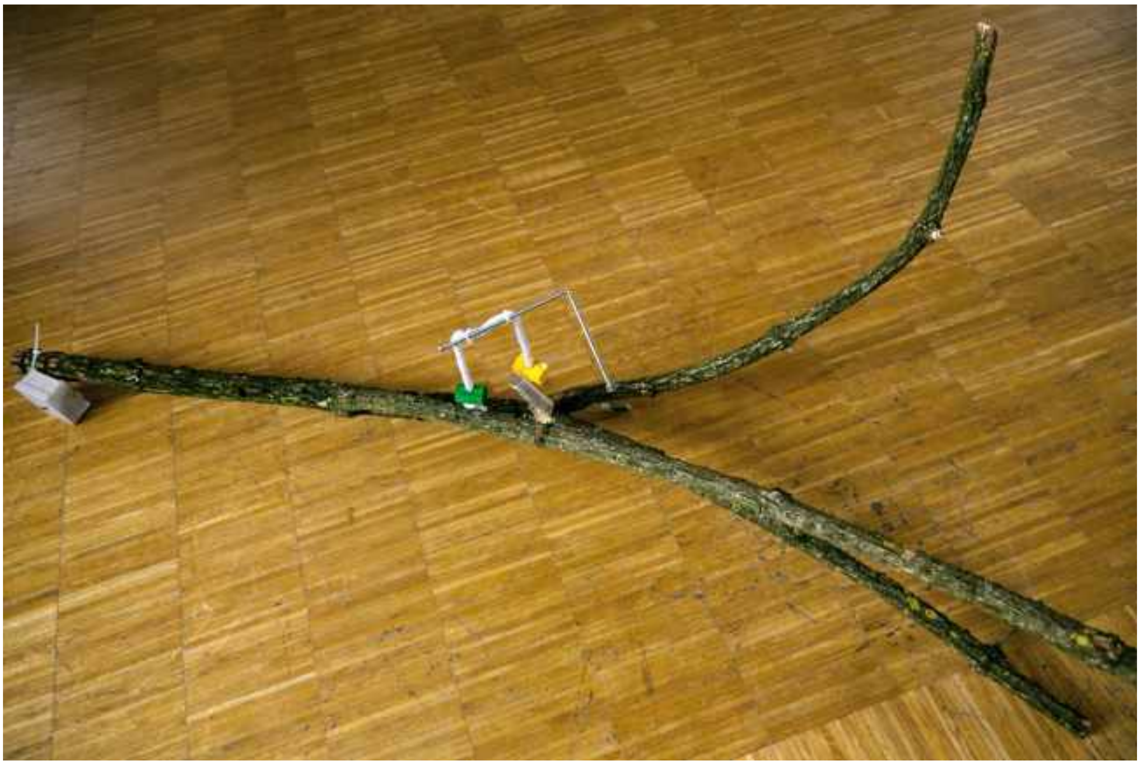

Figure 4.5 Branch instrument ©Elisa Unger

I chose a branch from a regional elderberry shrub because I thought its particularly soft wood and soft bark would stimulate the interest of the grey parrots in destroying the branch. By building piezo microphones into the branch, the instrument made the grey parrots' interactions with the branch audible. Additionally, to encourage playful interactions with the instrument, a metal spring was mounted, which could be used to make additional sounds with the two wooden cubes mounted on a cord next to the spring.

I observed that the grey parrots moved naturally on the branch while their movements were amplified. The additional spring toys aroused the interest of the parrots, and they played with them. I could not observe a change in the grey parrots' behavior due to the sounds generated by their actions.

Figure 4.6 Detail of the branch instrument. Screenshot from video by Elisa Unger

4.3.4 DJ instrument

The disc jockey (DJ) instrument (Figure 4.7) is based on a 15-cm diameter foraging wheel, which was originally designed for the playful enrichment of the feeding process. Foraging wheels are not only used for feeding but are also employed as physical and cognitive enrichment toys by providing challenges in which the parrots have to spin a wheel to collect their treats. When a grey parrot spins the wheel of the DJ instrument, the parrot will not be rewarded with food but with sound. The parrots usually use their beak to spin the wheel. The appearance of the instrument and the way in which the parrots interacted with the device strongly reminded me of a DJ scratching vinyl records on a turntable and therefore I adapted the sound design of the instrument to this analogy.

The feeding wheel is attached to a bent right-angled plastic pipe and equipped with a rotary sensor that triggers sounds when the parrots turn the wheel. In addition, visual feedback is provided by a LED attached to the wheel. In keeping with the turntable theme, I also designed a corresponding scratching sound as a sonic reward for the parrots. Since the scratching sound was well-received by the parrots, I have decided to further develop this instrument into a parrot turntable.

Figure 4.7 DJ instrument ©Elisa Unger

The adapted right-angled pipe houses a Raspberry Pi computer, an Arduino board and an amplified speaker for direct sonic feedback. This setup makes it possible to directly trigger scratching sounds when the wheel is turned. It is possible to upload different audio files to the instrument. When the parrots turn the wheel, it scratches through the loaded audio file. Depending on the speed and duration of the rotation, different scratching sounds, similar to DJs' vinyl scratching, are generated. The instrument is battery-powered and can be easily installed at different locations and therefore in the different territories of the individual grey parrots in the aviary. In general, grey parrots are very territorial animals, and therefore individual birds were not always free to move within the aviary. The mobility of the instrument compensates for this behavioral limitation.

Figure 4.8 Components of DJ instrument

Since the parrots were already familiar with this form of spinning interaction, they were able to quickly learn how to operate the instrument in order to receive their sonic treat. In further experiments with the DJ turntable instrument, I wanted to find out in more detail whether different sounds are perceived as a reward or a positive experience by the grey parrots.

Some parrots immediately engaged with the DJ instrument. The grey parrots Pauli, Nepomuk and Cocomiso showed clear interest in interacting with this instrument and used it for a period of several minutes. The parrots intuitively found out how to trigger the scratching sounds and in response, started bobbing their heads and responded with utterances. This kind of behavior can be interpreted as positive feedback and indicates excitement and interest.

Figure 4.9 DJ instrument played by grey parrot Pauli

4.3.5 Tube instrument

The tube instrument has been designed as a collaborative instrument in which a parrot can play “hand-in-hand” with another parrot or a human collaborator. Grey parrots mostly live in monogamous relationships and prefer to engage in activities with their partners. The tube instrument therefore intends to stimulate the birds’ interest in interacting and discovering things together or interacting with other humans who are part of their flock.

The instrument consists of a tube with a spring reverb installed inside that can be triggered from both sides by pulling on ropes that reach out from each end. The instrument is battery-powered and consequently also mobile and mostly generates reverberating sounds. The sonic response comes directly from a small amplified speaker placed inside the tube. The grey parrots interacted with the instrument exclusively by pulling on the rope with their beaks, thus creating a metaphorical tug-of-war. As already described above, I initially used a cardboard tube, which was later replaced by a bamboo tube.

Figure 4.10 Tube instrument showing a collaborative interaction

After switching from cardboard to bamboo, the parrots did not want to interact with the instrument, so I had to carry out material tests and opted for acrylic glass for the final version of the tube instrument (Figure 4.11). In the context of a musical performance, this instrument could also be used as an effect device by additionally modulating external sound sources by interacting with the instrument.

Regarding the collaborative design, the tug-of-war approach turned out to be appropriately chosen since two parrots could interact simultaneously with the instrument. They enjoyed the competitive and destructive experience and also responded to the sonic reverberations generated by their activity. I observed that the grey parrot Bimboli fluffed his feathers when interacting with the instrument, a behavior that animal experts interpret as a sign of positive excitement.

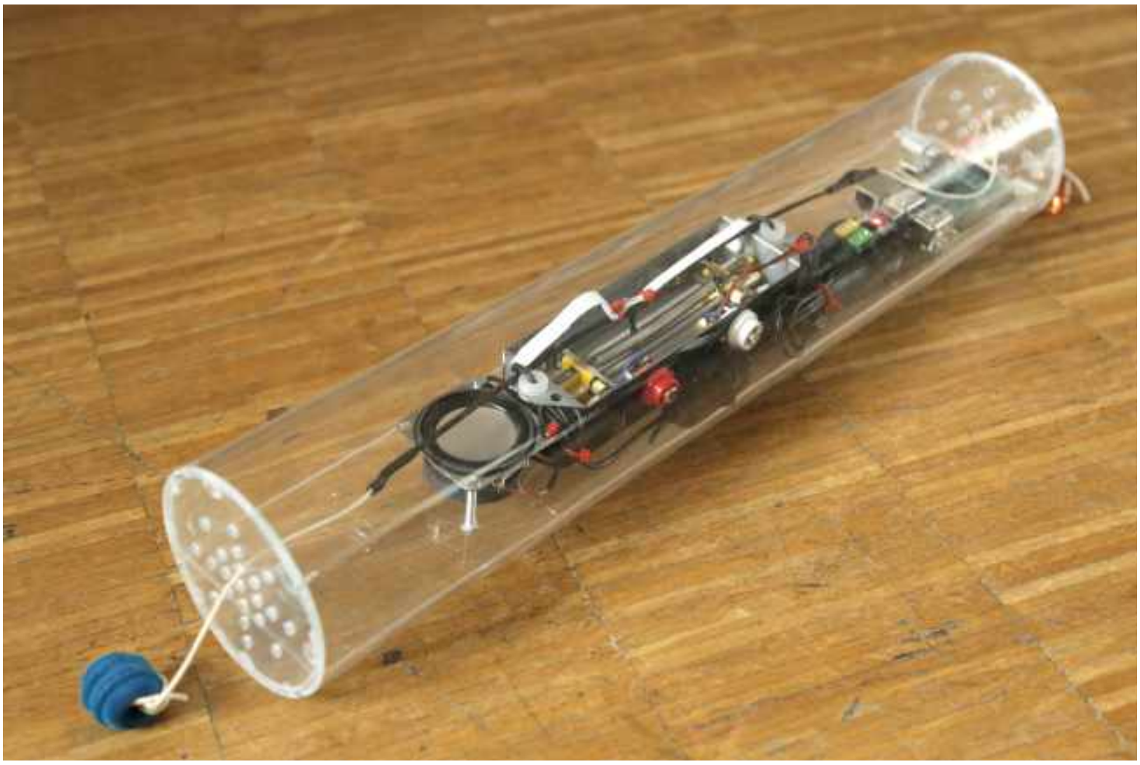

Figure 4.11 Final version of the tube instrument ©Elisa Unger

4.3.6 Vox instrument

Grey parrots show the exceptional ability to mimic human speech and environmental sounds [22] [36] [63] and therefore I also focused on designing an instrument that specifically encourages this behavior. I developed a vocal feedback instrument into which the parrots should shout, speak or sing. The idea was to record the sounds of the parrots and then play back an auto-tuned feedback with delay and reverb effects of their utterances. Such a practice could hypothetically even lead to the self-training of pitched notes for grey parrots.

The vox instrument consists of a plastic pipe system with three openings. A colorful children's microphone is mounted to the larger open end and receives the sounds of the parrots. At the other two smaller open ends, small speakers are installed for a direct sonic feedback. The necessary electronics such as a Raspberry Pi, soundcard and amplifier board were also built into the pipe system.

Figure 4.12 Final version of the vox instrument ©Elisa Unger

Once the microphone registers sound from the grey parrots, these sounds are slightly delayed and transformed by the instrument. The intended result is a call-and-response interaction between the grey parrot and the instrument that involves different sonic elements, such as reverb, echo and pitch shift.

The grey parrots interacted with the vox instrument by nibbling and chewing on the microphone and the pipe with their beaks and showed responses to the instrument's sonic feedback. A direct speaking or singing into the microphone or call-and-response interaction with vocalizations has not been observed so far.

Figure 4.13 Cocomiso interacting with the vox instrument. Screenshot from video by Elisa Unger

4.3.7 Reel instrument

Another design idea involving the construction of a drum sequencer instrument is based on the outstanding rhythmic entrainment capabilities of grey parrots. This instrument is intended to be used by the parrots to generate rhythmic patterns. I have observed that some parrots bob their heads to continuous beats of music. Thus, this drum machine instrument could encourage and promote this behavior. The first experimental approach towards such an instrument utilized bending rulers (Figure 4.14), which allowed the parrots to modify different beats and rhythmic patterns by bending the flexible ruler. Tests with this bending ruler prototype were not satisfactory. Although the parrots were interested in interacting with the rulers, they had difficulty bending the rulers with the integrated sensors to trigger the sound. Therefore, I had to rethink the interaction concept.

Figure 4.14 Prototype for a drum sequencer instrument with bending rulers

The following concept of the reel instrument (Figure 4.15) is like the DJ instrument in that it is based on an enrichment toy for creating a challenging and playful feeding process for the parrots. With this toy for physical and cognitive enrichment, the parrots must turn four wheels with their beaks to collect their treats. I equipped the four wheels with magnets that could individually activate reed switches to trigger different sounds. As previous experiments have shown, percussive sounds are well-received by the grey parrots and therefore I used drum sounds for this instrument. Each of the four wheels has been assigned a specific drum sound. By turning the wheels, the individual sounds are triggered, and turning different wheels allows the parrots to generate rhythmic drum sequences. The instrument includes a Raspberry Pi computer, an Arduino board, an amplifier and a speaker for direct sound feedback. Some grey parrots showed interest in interacting with the device and used it. The grey parrots triggered different drums sounds and responded with bobbing their heads and utterances.

Figure 4.15 Final version of the reel instrument ©Elisa Unger

Figure 4.16 Wittgenstein on reel instrument. Screenshot from video by Elisa Unger

In the animal-centered design process, I was always careful to consider whether the musical interfaces I had developed actually have potential benefits for the grey parrots. It has been shown that the parrots have individual preferences in terms of interaction styles and sonic feedback. Since I have always worked with a group of grey parrots, I do not know what the side effects of the musical output of a single parrot, for example, when pecking on the gong instrument, might be on the rest of the group. In captivity, the parrots need environmental enrichment and cognitive challenges. Toys and foraging exercises are intended to reduce the chance of behavioral problems. Confronting the grey parrots with cognitive challenges when interacting with musical instruments could provide additional enrichment for them and help reduce behavioral problems such as feather picking, fearfulness and aggression. Grey parrots are flock members and like to be where the action is. Thus, my approach towards developing collaborative instruments also appears adequate. In addition, the musical instruments and interfaces provide the animals with individual control over their shared sonic environment. The sonic interaction between animals, instruments and humans can help foster social relationships, compensate for a lack of social interaction and eventually improve the quality of life of grey parrots living in captivity through the musical activities.

4.4 Conclusion

This chapter described the process and the methodology used to design musical instruments and interfaces for grey parrots living in captivity. The instruments were intended to offer cognitive and auditory enrichment and to intrinsically motivate the parrots to interact with musical devices. I described the animal-centered design approach towards the implementation of such technology and the possible benefits for the grey parrots. I analyzed the different forms of interaction between our group of grey parrots and the musical devices and discussed the materials and parrot toys which were the source for the instrument. I established the “Jam Session” as an artistic research approach that allowed the grey parrots to voluntarily participate as actively as possible in the design process. The six final instruments were presented and discussed in detail. The staging of these musical instruments at several aviary installations and performances during the course of the metamusic PEEK project are described in Chapter 6.

5 INTERDISCIPLINARY DISCOURSE

An interdisciplinary discourse was stimulated to get first-hand expertise related to the metamusic PEEK project and this PhD project. Since studies with animals are still relatively rare in the context of artistic research, this interdisciplinary exchange and knowledge transfer was particularly important for me.

Valuable expertise was gained at the “Animal Music Symposium” (ANIMUS) in Linz in 2017, which I co-organized, and where internationally recognized experts were invited from related fields such as animal behavior, ACI, biomusicology, art and cultural studies.

I was able to pass on the expertise I had gained from this PhD research by presenting and discussing my artistic research approach with the interdisciplinary organization team and the participating ACI researchers at the “SoundJam” workshop at the ACI conference in 2018.

5.1 ANIMUS symposium

The “Animal Music Symposium” was a one-time event that took place on Thursday, June 1, 2017, at the Audimax of the University of Art and Design Linz, Austria. The symposium was intended to gain first-hand knowledge on the various aspects of musical animal-machine interaction from an interdisciplinary perspective. The invited experts from the fields of animal cognition, ACI, biomusicology, bioacoustics, contemporary arts and cultural studies presented their findings and kicked-off a broad discussion on the musical capabilities of animals. The ANIMUS symposium was part of a bigger event that also included an exhibition and performances at Salzamt, Linz (Chapter 6.2). Below I briefly present the various speakers and their respective positions and views on musicality in animals. All presentations were broadcasted and recorded and are still available on the Dorf TV video platform.[36]

[36] https://www.dorftv.at/video/27299

5.1.1 Speakers and issues addressed

Irene Pepperberg

Grey parrot expert Irene Pepperberg, who was also part of our research team as an external advisor, gave the keynote. Her presentation was about "Communicative and Cognitive Abilities of Grey Parrots: A Connection to Music?"

She gave insights into her studies on vocal learning in grey parrots and how she used this ability to examine their cognitive capacities. She linked their vocal learning abilities to spontaneous entrainment, which was also observed in grey parrots, and discussed how these two complex cognitive abilities could be fundamental in musicality in the animal kingdom. She talked about the strong personalities and the different musical preference of the grey parrots with which she was working. Finally, she argued that grey parrots are a particularly good model species for studies involving musical abilities. For me, this was further confirmation that grey parrots are one of the best possible animal species for our auditory enrichment approach, and that I was on the right track with my PhD project.

Clara Mancini

Clara Mancini, the author of the "Animal-Computer Interaction (ACI): a manifesto" and major scientist in ACI research, gave a talk about "Animal-Computer Interaction: Designing interactive technology for and with animals". She introduced ACI as a young research discipline and presented the different developments and tendencies. She focused on the work of her ACI lab at the Open University in Milton Keynes, UK, where she and her team are laying the groundwork for developing ACI as a discipline by exploring design challenges, methodological strategies and, most importantly, ethical issues. In keeping with the symposium title, she also called attention to the inclusion of musical technologies for and with animals.

Marisa Höschele

In her presentation “Searching for cross-cultural music universals in other species”, Marisa Höschele, a researcher in biomusicology, talked about how we can learn about human musicality from animals. In her studies at the Department of Cognitive Biology at the University of Vienna, she has been focusing on several avian species that are vocal learners and vocal mimics. She has been carrying out a variety of experiments to learn how animals categorize sounds, or how we can tell if an animal likes a specific sound. She described two experimental settings, operant conditioning and place preference, and tested humans in a similar way to compare human and non-human perception of music universals to ultimately find out more about the biological roots of musicality.

Helmut Kratochvil

Helmut Kratochvil is a researcher in the field of bioacoustics, specializing in phonetic systems in fish. The title of his talk was “Animal language, animal music: Are language and music exclusively human?” He argued that language communication and musical abilities are part of the animal kingdom. He described several examples of the evolution of sound generation and the use of sound communication in different species. Furthermore, he referred to rhythm as a very fundamental function with biological roots. He also presented audio recordings of grey parrots from Schönbrunn Zoo in Vienna and analyzed their vocalizations and their musical aspects.

Fahim Amir

Fahim Amir works at the intersections of nature, cultures and colonial historicities, transcultural agency and urbanism. His contribution “Promises of Pigeons and Dogs: What We Can Learn from Animal Aesthetics in the Black Public Sphere” introduced a cultural science point of view on human-animal relationships and interspecies interactions. He discussed these issues by analyzing Jim Jarmusch’s movie *Ghost Dog* (2000), in which a killer named Ghost Dog lives together with a group of messenger pigeons. Amir focused on the broader questions of the role different animals play in human culture and its political and cultural aspects.

Daniel Gilfillan

Daniel Gilfillan is one of our external experts and a long-time follower of and collaborator to the metamusic project. In his talk “Listening Before, Beyond, and Alongside the Human: On Parrots, Sound, and the Agency of the Non-Human”, he presented his philosophical and cultural perspectives on sound, listening and multispecies agency. Focusing on the role of sound in the Anthropocene, he presented how man-made ambient noise has strongly affected and changed the sonic behaviors of animals. Furthermore, he examined metamusic in the context of multispecies communication by using sound and music. He argued that projects such as metamusic ask us to rethink our understanding of interspecies agency and challenge us to create new ways of encountering sound in order to arrive at new ways of producing knowledge.

To complement the symposium and to present our artistic research approach, the artist group alien productions presented their initial project “metamusic – a sound project for and with grey parrots”.

In addition, I had the chance to present the outcomes of my first PhD research phase on recent musical instruments and interfaces that involve animals in the interaction and music generation process. It provided a classification of current technologies in this field and insights into musicality in animals.

As part of the “Animal Music Symposium”, I also had the opportunity to discuss my research and the current issues and problems with the invited experts Irene Pepperberg and Clara Mancini. They talked about their own work with animals and offered advice on how to improve my experiments, designs and how to document the findings and failures. Pepperberg questioned the size of the grey parrot group for the tests and, above all, the length of time between the test periods. She also pointed out that her own parrots had very individual tastes in music and also strong personalities and that the periodical pulses and rhythms in biology might be important for musicality in animals. Regarding this, Clara Mancini suggested adjusting the musical beats (BPM) to the heart rate of the grey parrots, which is between 340-600 BPM. Since this is very fast, it seems more advisable to just halve or quarter this speed. I have conducted some tests in this vein, but without the possibility of performing controlled experimentation, I have stop working on this but addressed this question in my outlook for further research.

The opportunity to talk with these eminent researchers gave me many suggestions and encouraged me to accurately document all my different approaches. Especially with regard to dealing with the setbacks that occurred when I was working with the grey parrots, which happened far too often from my point of view, they made it clear that is very important to also describe and document these failures to help other researchers avoid them in the future.

5.2 SoundJam workshop

This chapter is based on the workshop description of “SoundJam 2018: Acoustic Design for Auditory Enrichment”, which was published in the proceedings of the *Fifth Animals-Computer Interaction Conference* in Atlanta, USA, in 2018. The main author and the basic idea for the workshop is from Fiona French, who works in the context of ACI on technological enrichment for captive elephants.

My role as co-author and contributor to the workshop was to prepare a brief for the workshop participants, run a feedback session on the ideas developed and to write a reflection on the workshop results. As it was not possible for me to personally attend the workshop in Atlanta, I did my brief for the auditory enrichment of parrots and the feedback round via video chat.

“SoundJam” was the third workshop at the ACI conference organized by Fiona French in connection with technological enrichment for animals under the umbrella term “ZooJam”. This entire series was summarized in the paper “ZooJamming: Designing Beyond Human Experience”, which was published in the *Proceedings of the International Conference on Game Jams, Hackathons and Game Creation Events* in 2019.

For me, it was very interesting to see how auditory enrichment for animals could be mediated through different methods in a workshop format. The results and ideas generated in the workshop were partly convincing and could be further developed into working prototypes.

I can well imagine that such a “SoundJam” workshop format could be of great benefit if it were held directly in animal shelters and zoos so the employees could learn how to expand the enrichment opportunities through the use of sound and music.

Abstract

This workshop was designed to offer participants an opportunity to explore different kinds of auditory enrichment for a range of animals in different environments. Teams of participants worked together on a small set of briefs provided by domain experts, brainstorming ideas and developing concepts into well-designed blueprints for prototype devices. The day was organized along the lines of a traditional game jam by Fiona French.

5.2.1 Introduction

Animals have evolved forms of communication (signaling) that work in a species-specific environmental context—gestures that can be observed from a range of distances, olfactory cues that can be "posted" and remain until they dissipate, vocalizations and other acoustic signals that act immediately but in some cases with great range, enabling remote contact with conspecifics. Without humans contributing to the soundscape, their auditory perception and associated cognitive abilities would have evolved in relation to what was audible in the surrounding ecosystem.

As human populations expand over the globe, these "natural-sounding" places are slowly disappearing. People use sound insulation to protect their homes and working environments from sound pollution, and it can be argued that we also have a duty to pay attention to the acoustic well-being of the animals living with us in urban and confined spaces.

On the other hand, many non-human animals also make a considerable amount of noise, particularly those living in social groups. Since natural behavior includes demonstrating the ability to both make signals and interpret others' signals, it is important that an animal has both the opportunity and the motivation to perform this behavior. It follows that if a social species is housed independently or with a smaller number of conspecifics than would naturally occur in the wild, it is possible that their acoustic repertoire will be diminished, along with the cognitive processing required to discriminate between a range of sounds.

As a consequence of these issues, auditory enrichment for animals in captivity can take two distinct forms—negative, whereby noise levels are reduced, dampened or masked in order to protect animals from intrusive sounds (which could be of human origin or generated by a nearby predator species), and positive, when animals are offered acoustic experiences in order to give them sensory, cognitive or social stimulation.

The workshop will focus on the design of auditory enrichment for a small selection of different animals.

5.2.2 Motivation

Animals living in manmade environments may need protecting from anthropophonic noise. Current research in this area includes passive acoustic monitoring where soundscapes are captured and analyzed to infer environmental parameters [64], as well as animal behavioral studies [65].

Sensory enrichment uses devices which generate visual, olfactory, tactile and acoustic stimuli. Depending on the type of device, environmental enrichment can encompass different categories—thus, a puzzle feeder might simultaneously provide cognitive, food, olfactory and tactile enrichment; a suspended straw bale could offer food (foraging), exercise and social opportunities.

Many examples of auditory enrichment involve keepers (and researchers) selecting and playing sounds to the animals in their care. Captive gorillas have shown preferences for natural sounds over either silence or music (rock or classical) [66], while captive chimpanzees preferred silence to music [67], as did captive moloch gibbons [68]. On the other hand, Vivaldi (classical) had an observable calming effect on zebrafish [69], "classical music" seemed to reduce stereotypic behavior in zoo-housed elephants [70], while soft rock and reggae has been documented as reducing stress in kennel-housed dogs [71].

There are many studies in which the purpose of the enrichment is to calm an animal, in which case it makes sense. However, a device designed for auditory enrichment could have the potential to stimulate cognitive activity if the target species was offered a control mechanism that enabled interactivity. This could have the additional benefit of enabling designers to learn more about user preferences.

Several ACI researchers are making progress in this direction. For example, Gupfinger and Kaltenbrunner have developed interactive acoustic devices for captive grey parrots, which allow the birds to make choices about generating sounds and music, with the aim of gaining insight into how grey parrots perceive and respond to different auditory stimuli [72]. Pons et al. have focused on an exploration of orangutan behavior in relation to tangible objects with sound-controlling properties [9]. This is specifically in order to offer control and choice to the orangutans using moveable objects that they freely manipulate as part of their normal behavior.

Biological salience is mentioned by Mancini and Lehtonen [73] as a key factor in ACI design, and this feature is reinforced by Ritvo and Allison [47] who claim that ACI systems should be designed to mimic and augment the user species' natural behavioral tendencies. These examples also showcase the importance of volition and choice when designing sonic enrichment, factors emphasized by Mancini and Lehtonen. We believe that research in this area opens up the possibility for redefining aesthetics so that it is possible to take a more species-centric approach to ACI design.

5.2.3 Call for participation

This workshop aims to bring together expertise from different disciplines, enabling participants to network and move towards designing and developing exciting new auditory enrichment experiences for a range of animals.

The structure will follow the format of previous years' ZooJam [74] and FarmJam [75] workshops, which generated a broad range of innovative enrichment concepts in a relatively short time period. The game jam format shapes the design process by offering both accelerated and constrained design [76] with different rewards for different participants—some focused on outcomes, others on creativity, some on having learning opportunities, others on networking and finding potential research collaborators. To facilitate this, the workshop outputs will be shared publicly.

We invite participants from a wide range of communities, including but not limited to game design, computer science, engineering, education, HCI and ACI, acoustic engineering, animal behavior and environmental enrichment. This is an opportunity for those with an interest in animal welfare to share ideas and explore the potential of using acoustic technology to enhance enrichment.

5.2.4 Workshop aims

The workshop aims to:

▪ Raise awareness of the value of auditory enrichment amongst the ACI community and beyond.

▪ Provide opportunities for networking and creative teamwork.

▪ Investigate novels ways of using technology to support auditory enrichment.

▪ Examine briefs (challenges) relating to different species.

▪ Generate novel acoustic designs in response to briefs.

▪ Produce and present design documentation.

5.2.5 Activities

The workshop was facilitated in person by Fiona French and Valerie Hare, while Reinhard Gupfinger participated remotely as the expert on parrot enrichment.

Overview

The following activities were undertaken during the event:

▪ Short introductions for participants and members of organizing committee; participants received briefs.

▪ Structured workshop activities enabling people from different backgrounds to meet and discuss specific challenges in the field of auditory enrichment—starting with brainstorming sessions where participants worked together to imagine concepts in response to the briefs.

▪ Discussion of initial ideas with feedback from species experts—leading to the formation of small teams focusing on collaborative design briefs and creating early phase concepts.

▪ Team crafting session, when participants were tasked with creating a physical prototype of their concept using a variety of simple resources.

▪ Opportunity to present final designs and answer questions.

▪ The outcomes of the workshop are shared online in a repository of ideas to support future collaborations by keeping a record of participants' skills and interests. There is a website dedicated to the workshop.

5.2.6 Briefs

Challenges for participants were provided in the form of four briefs relating to auditory enrichment for four different species—parrots, chimpanzees, servals and elephants. In this paper, we use the brief for parrots as an example of the type of challenge and the associated outputs/feedback. Reinhard Gupfinger provided the brief for parrots and communicated with the teams during the event.

While parrots are known for their complex cognitive and communicative abilities, they need enrichment and attention in captivity, or they can become distressed. Behavioral disorders like feather plucking is a common symptom. Parrots are, along with others, the most intelligent birds and have become popular pets due to their specific auditory skills such as entrainment. Spontaneous entrainment in animals is unusual and involves the ability to align their movements to a musical beat. This ability has been found in grey parrots and cockatoos and has thus disproved the claim that entrainment to music is unique to humans. Building on this, providing appropriate auditory enrichment could provide new opportunities for improving the quality of life for parrots living in captivity.

Recent research in the field of cognitive biology has focused on the role of animals listening to human music as a concept of enrichment. Since most of the music is selected by humans, this can lead to anthropomorphic biases. Therefore, the music should be attuned to the animals' auditory skills. In addition, it has been found that animals prefer sounds and musical arrangements that are biologically relevant for them.

Challenge: design a playful musical instrument for parrots, which is based on traditional design metaphors such as string or percussion instruments. Consider the particular physical interaction patterns of grey parrots, which are mostly performed with the parrot's beak. Design a collaborative instrument to stimulate the birds' interest in discovering things together, since grey parrots usually live in long-term couple relationships. Determine the kind of sound the instrument should produce and discuss whether the sound could be biologically relevant to the parrots.

5.2.7 Brainstorming and feedback

After the first brainstorming round, Reinhard discussed the teams' early ideas; he was able to contribute feedback via Skype.

The brainstorming round generated a lot of promising ideas we could discuss. Many of the proposals of the three teams had overlaps and we tried to classify them as well as discussing the possibilities for development. We analyzed the different forms of interaction, possible auditory feedback, use of materials and considerations for positioning the instruments in the aviary. The feedback round was followed by a crafting session to develop prototypes for the auditory enrichment of parrots.

The team agreed to work on a system that could be installed in an aviary and that allowed the parrots to interact in different places and to generate sound and music individually or collaboratively. One idea proposed was to have a stand where sensors measured the pressure to find out where the parrots were located and then add some rods equipped with sensors so that the parrots could pull or push them to play notes of some sorts. The sonic feedback would come directly from a speaker placed behind the device. There was also the idea of adding some light for visual feedback to let the parrots clearly know whether the devices were active or not to support the idea of hearing and seeing what the parrots were doing.

A further concept was to enrich the aviary with multiple interactive swings equipped with sensors to detect if the parrots were on the swings. The swings would be equipped with different sounds—for example, one with beats and another with single notes that could be triggered by rocking the swings. The swings could allow several parrots to play music together at the same time.

5.2.8 Outcomes

After the team crafting session, the participants could present the prototypes they created. For the auditory enrichment of parrots, an interactive parrot sound perch concept was created. The model was a rough prototype demonstrating a system that could be built into an aviary where the parrots could move to different places on a perch to trigger different sounds. The perch should be placed in the middle of the aviary and was equipped with pressure sensors to detect where the parrots were sitting. While sitting on this perch, the parrot could trigger sounds with rods. Another presented prototype was a swing with sensors for sound creation, a concept that I had already implemented with the rope swing test station (Chapter 3.4). As proposed, a speaker for direct audio feedback should be placed nearby the instrument. The prototypes also included visual feedback in the form of lights to see what the parrots were triggering by their interactions with the system.

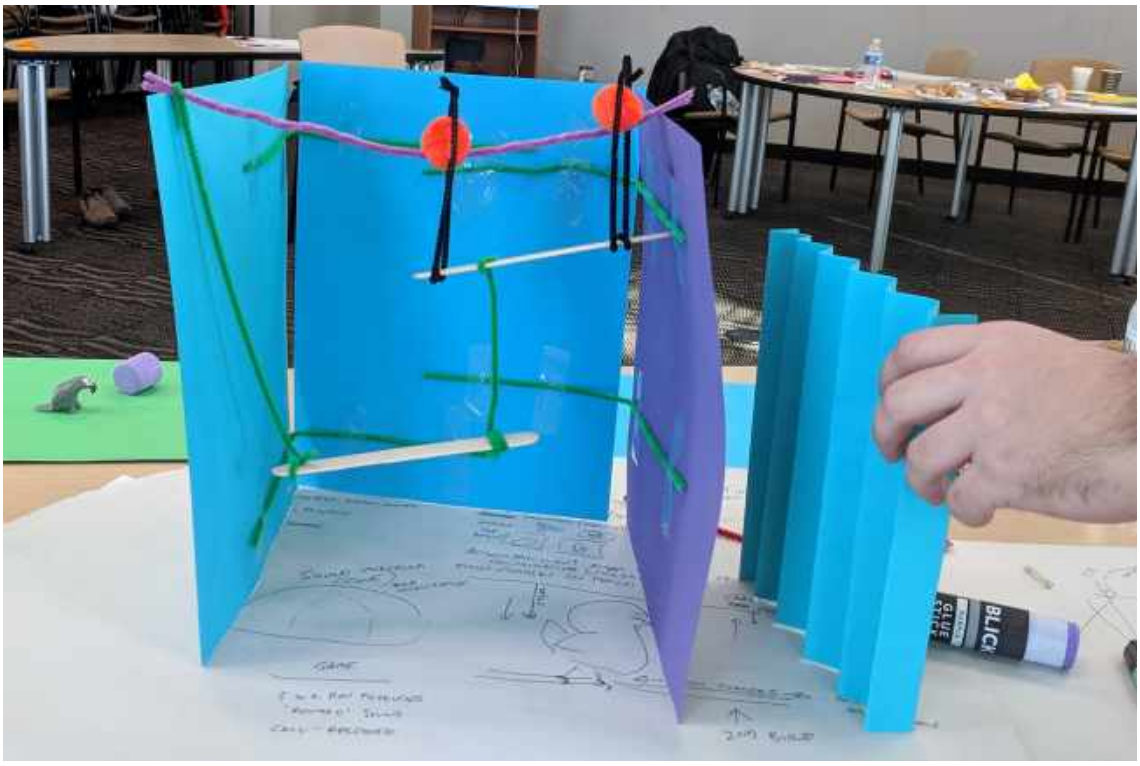

Figure 5.1 Workshop outcomes presented by Larry and Shogo. Image downloaded from http://zoojam.org/soundjam/parrots.html

5.2.9 Author reflections

Reinhard

Although I was unable to attend the workshop in person, I had the opportunity to participate as an expert via Skype video sessions. I discussed the brief and provided a handout with detailed information on the cognitive and physical skills and preferences of parrots. The aim was to explain some of the outstanding abilities of parrots, such as entrainment, so that the participants could include these abilities in their design concepts for auditory enrichment. In addition, the participants were confronted with more specific questions, as described in the brief for parrots.

The final prototypes were presented at the end of the workshop and were also made available on an online video platform. The multitude of promising ideas proposed by the participants was very positive, and the two final concepts for auditory enrichment environments are already partly in practical application such as the rope swing test station (Chapter 3.4) that was developed for testing the sonic abilities of grey parrots.

The experience of participating in the workshop via Skype was new to me. The drawbacks were (i) that it was difficult for me to obtain an overview of the ideas presented and (ii) that I was not able to clarify problems during the brainstorming and development process of the workshop. From my experience as a participant in the last ACI "FarmJam" workshop, this process and discussion was especially enriching for me. However, the remote participation in the "SoundJam" workshop was a very positive experience that I would not have wanted to miss.

Paul

The brainstorming session (for chimpanzees) produced a marble run system where sounds could be assigned to particular marbles which would then trigger audio at particular points in a marble run. Chimps could assign individual sounds to their marbles and interact with the sequence. This seems a simple yet intuitive idea.

It was interesting too that the control of the system was physical and avoided the use of touch screen technology, which perhaps may make the proposed ideas more appealing to the animals, and therefore more affective at enrichment. Perhaps the chimps could control the volume of the sounds by adjusting the gradient of the ramps and hence the speed and repetition rate of the sounds.

Fiona

“SoundJam” 2018 was successful in meeting its aims of promoting cross-disciplinary collaboration and generating novel concepts in the area of auditory enrichment. We were very fortunate that Valerie Hare, an expert in environmental enrichment, was able to support the workshop, facilitating activities and providing valuable feedback on ideas throughout the event.

For me, one of the clear revelations was how the crafting session helped participants to refine and share their ideas. We have always supplied craft materials during ZooJams, but this year we stipulated that teams would have to make a small physical prototype during the afternoon session. For some people, this proved to be an excellent way to communicate their ideas and aided the transition from thought to concrete example, as well as highlighting practical considerations that need to be considered when developing for animals in a captive setting.

6 Artistic Results

Several artistic research methods were applied during the research phase and conceptually framed the metamusic project. The above-mentioned “Jam Session” is also an artistic concept for playing music together with the grey parrots in an informal setting.

The aviary installations and open laboratory situation, which were accessible to the public, were also viewed as artist outcomes in the context of contemporary art installation. The artist research methods culminated in interspecies performances by the artist group alien productions together with grey parrots and other invited human musicians and performers. Observing and analyzing the behaviors and reactions of the grey parrots, human performers and the audience in these settings constantly informed the further development of this PhD project.

6.1 Höhenrausch

My first contact with the metamusic project and its experimental interspecies installations with grey parrots was at the Höhenrausch exhibition in Linz in 2015. During the course of this long-term project, I got to know and work with the grey parrots of ARGE Papageienschutz over a period of five months. My enthusiasm to work with, better understand and learn from them began to grow. In the framework of this exhibition setting, I developed my first instrument prototype and contributed by improving some of the existing instruments.

This large-scale installation was part of the “The Secret of the Birds” exhibition which attracted much publicity. It was situated in the VOEST ALPINE OPEN SPACE, an experimental open art space on the rooftop of the OÖ Kulturquartier. The space linked the exhibition building with the rooftop landscape of the city. In collaboration with the production team of the museum, alien productions developed an extensive aviary which offered a living space for more than twenty parrots. The aviary also included two indoor areas which offered the parrots a refuge and shelter from the weather conditions.

Figure 6.1 Aviary plan ©alien productions

The long duration of the exhibition and the large spatial environment created a space for interactions between the grey parrots, artists, the human audience and a series of specifically designed musical instruments [1].

alien productions received support in developing durable and weather-resistant musical instruments from musical instrument designer Florian Prix. I contributed by carrying out the technical implementation of the swing instrument, which was later duplicated and further developed as the rope swing test station (Chapter 3.4). I also modified two ready-made toy instruments by attaching wooden extensions to buttons and keys for better usability with the grey parrots' beaks. In addition, I developed and implemented the branch instrument (Chapter 4.3.3), which became part of the installation and was well received by the parrots as an edible instrument. In general, the instruments were exchanged regularly and mounted in different locations in the aviary to provide variety and enrichment for the parrots.

Figure 6.2 Improvement for Kasi Casio instrument

As part of this exhibition, several musicians were invited to play a concert for and with the parrots. The invited artists played their instruments in front of the aviary and tried to enter into a musical dialogue with the grey parrots. This led to a call-and-response performance where the animals responded to the sounds of the musicians and the musicians tried to emulate the birds' sounds. Roger Eno entered into such a musical dialogue with the parrots by playing the piano. At another concert, Irene Kepl played her electrified violin while the grey parrots tore at cardboard violins which were equipped with microphones and amplifiers. A very special atmosphere was created during the concert of accordion player Heideline Gratzl and birdcall imitator Helmut Wolferstetter. It was not possible to distinguish between the utterances of the grey parrots and the whistles of the birdcall imitator, which astonished the audience and the grey parrots as well. Basically, the grey parrots imitated the human whistles and the human imitated the parrots' sounds. Comprehensive documentation of all the participants, musical instruments, concerts and background stories is available on the metamusic @ Höhenrausch blog.[37] Over the course of the exhibition, the animal keepers of ARGE Papageienschutz saw to the welfare of the grey parrots. The installation had a significant impact on the urban soundscape and its surroundings.

Figure 6.3 metamusic installation view at Höhenrausch ©alien productions

[37] http://alien.mur.at/metamusic/hr15/

6.2 Salzamt lab exhibition

In May 2017, in preparation for the “Animal Music Symposium” in Linz, which was described in Chapter 5.1, I had the opportunity to work closely with six grey parrots at the Salzamt, an art production and exhibition venue in Linz. The participating parrots had already been part of the test group at ARGE Papageienschutz. Because of their interest in interacting with the test devices and with us at the animal shelter, their health and their partnering situation, they were chosen in collaboration with the animal keepers to take part in this laboratory experiment and exhibition. The aviary installed inside the exhibition space was 6 x 4 x 2.4 m. It was equipped with all the appropriate inventory, fresh branches, perches, several feeding places and enrichment toys. During their 14-day stay in the aviary of the Salzamt, the grey parrots were taken care of by the animal keepers of ARGE Papageienschutz as always. In this open laboratory environment, I was able to carry out further experiments with the rope swing and joystick device, I introduced some new prototypes and adapted some of the older instruments developed during the initial project phase.

Figure 6.4 Aviary setup at Salzamt

The smaller and therefore more manageable group of grey parrots made it easier to recognize their individual preferences. The parrots Coco and Wittgenstein expressed particular interest in the musical instruments offered and showed preferences for the joystick test device, which they played with for a long period of time by triggering sound and which they used as a resting place.

During the course of this exhibition, I was invited to take part in the musical performances staged by alien productions and the grey parrots. While two artists and one animal keeper were in the aviary, offering the parrots different instruments and artifacts to interact with, Norbert Math of alien productions and I took care of the incoming audio signals of the instruments played and on the basis of these signals, generated a real-time composition.[38]

Figure 6.5 Performance in the laboratory environment at Salzamt

[38] https://dorftv.at/video/27429

6.3 Final presentation at ARGE Papageienschutz

In June 2019, we had the final public presentation of the metamusic PEEK artistic research project at the ARGE Papageienschutz parrot shelter in Vösendorf near Vienna. It was the last staging of the project in cooperation with the artist group alien productions, ARGE Papageienschutz and the Tangible Music Lab. The event included an exhibition, various talks by experts, performances and an installation of an interactive aviary for seven African grey parrots. The public presentation format allowed us to focus on the various aspects of this project and led to a discussion between the audience, the participating artists and the experts. The central feature of the event was an aviary installation, which was specifically built for the final project presentation at the parrot home. For six days, this aviary was home to seven grey parrots of ARGE Papageienschutz. They were chosen by the animal keepers to take part in this installation setting due to their interest in interacting with the instrument prototypes at the animal shelter, their health and their partnering situation. The aviary consisted of an indoor and an outdoor area and was equipped with all the appropriate inventory and toys. While the indoor area served mainly as a resting place for the parrots, the outdoor aviary housed the final series of experimental musical interfaces and instruments that were adapted to the physical capabilities and sonic preferences of grey parrots.

Figure 6.6 shows the technical implementation and signal flows of the interactive aviary installation at ARGE Papageienschutz. The technical setup centered around a server computer for controlling the signal flow of the system and the sounds for the PA system. Basically, there were two possible signal connections from the musical instruments to the server computer: a cabling for the audio signals and a wireless network.

Most of the instruments, except for the tube instrument and the joystick device, had a direct audio connection cable to the audio mixer and to the server computer. This not only made it possible to provide sonic feedback from the speakers inside the instruments but also to play back the sounds generated via the PA system which was installed at the aviary. The second connection was a wireless network which was used by all the musical instruments that involved a Raspberry Pi computer. This made it possible to send the signals from the sensors of the instruments to the server computer, to remotely control the volume of each instrument from the server computer, and to upload new sounds to the various instruments.

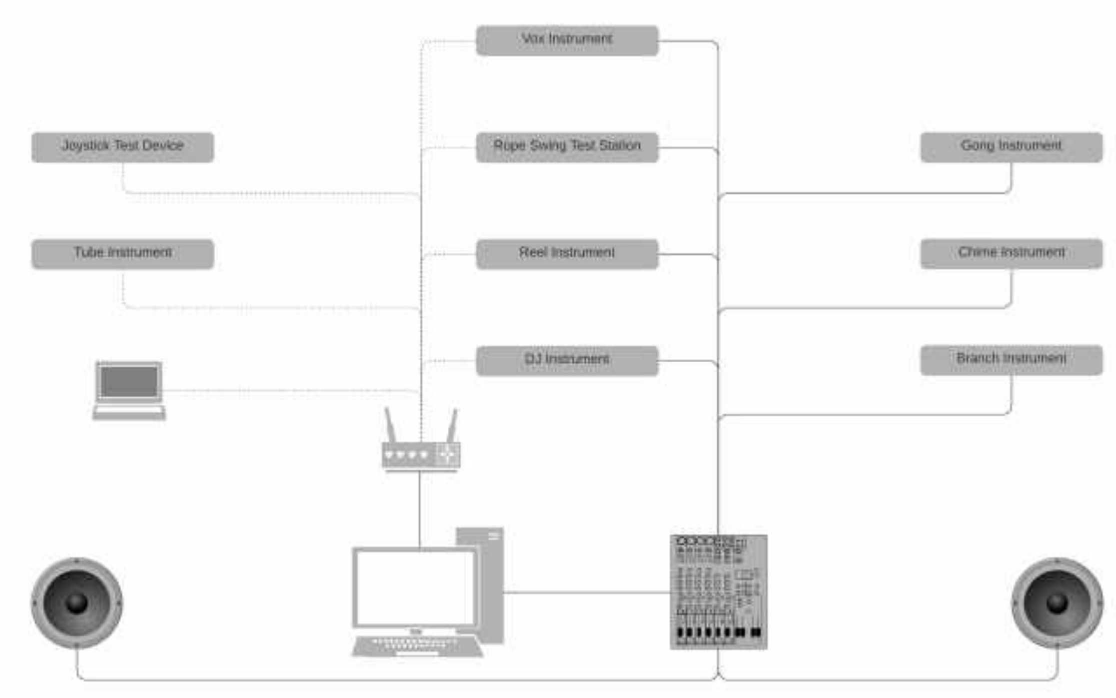

Figure 6.6 Technical setup of the aviary installations at ARGE Papageienschutz

The seven instruments described in Chapter 4.3 plus the two rope swing test station and joystick test device were made accessible for musical interactions. Since it was not possible in the short period of time to carry out experiments with the individual novel instruments, I mounted all of them at the same time in the outer aviary and observed this complex sound installation for grey parrots as a whole.

In general, it can be said that the parrots took some time to get used to their new living environment and factors such as the hierarchical and territorial behavior of the animals seemed to play a greater role in this new environment in comparison to the indoor aviary in the parrot shelter where I usually carried out the "Jam Sessions" experiments. Particularly important was the positioning and accessibility of the instruments; depending on this, some were used more frequently and others less often. The aviary was not always under observation and no data was collected on how often the individual instruments were used, but I did observe several interactions with the instruments installed in the aviary. Especially two dominant grey parrots Wittgenstein and Nepomuk were observed performing such activities.

Figure 6.7 Nepomuk on DJ instrument. Screenshot from video by Elisa Unger

Both parrots liked to stay in the outdoor aviary and claimed a lot of space there. Others, such as Cocomiso, who usually liked to interact with various instruments, showed little interest and mostly stayed in the indoor aviary. The gong instrument, which was familiar to the parrot Wittgenstein, was again received very well and after a few minutes, she was already knocking with her beak on the metal plate of the instrument.

Figure 6.8 Wittgenstein on gong instrument by alien productions. Screenshot from video by Elisa Unger

The DJ and vox instruments also worked well, for example. Both instruments were easily accessible to the grey parrots and aroused their interest. The reel instrument, which was exposed in the front area of the aviary and was more difficult to access, did not work as well. Since the two parrots, who liked to play with the tube instrument at the bottom of the aviary, did not participate in this aviary installation, this instrument was not played and used very often.

Part of the public presentations were performances by the artist group together with the grey parrots. In the presence of the audience, an artist and an animal keeper motivated the parrots to interact with the musical instruments and other sound-producing artifacts with the intention of performing a musical piece. As already noticed in previous performances, the presence of the audience had a big impact on the grey parrots, often drawing their attention away from the instruments and performers to the persons outside the aviary. In summary, as an auditory enrichment approach for grey parrots in captivity, the installation setting was more effective than the performances where the focus was shifted to interspecies curiosity between the grey parrots, the human performers and the audience.

Figure 6.9 Detail of installation view at ARGE Papageienschutz. Screenshot from video by Elisa Unger

Figure 6.10 Setup of the aviary at ARGE Papageienschutz ©Norbert Schweizer

Figure 6.11 metamusic performance at ARGE Papageienschutz ©Norbert Schweizer

6.4 Reflections on the staging

In order to get a better idea of the artistic staging of the installations and performances and thus the interactions generated between the grey parrots, the human performers and the audience, it is also important to hear from the other participants. First, there are the artistic directors of alien productions, without whom this PhD project would never have happened. Then there is Daniel Gilfillan, who has accompanied the metamusic project for several years. In his contribution, he reflects on metamusic from a broader cultural perspective and on interspecies communication and sound as larger phenomena in this context. Finally, I also invited two visitors to the exhibition and the performance to share their thoughts on and experiences of the public presentation of the metamusic PEEK project. Ultimately, it would be desirable at this point to present a statement from the grey parrots as well. Their experiences and feelings remain well-hidden, but in the scope of this thesis, some interpretations may reveal snapshots of their emotional states.

For me, there are always some negative connotations to presenting wild animals to a public audience. They are certainly not voluntarily in captivity and exposed to the audience and cannot decide on their own to be moved and placed in an aviary in a different city or country as it happened within the metamusic exhibition projects. Calling such moves a vacation for the participating grey parrots, which did happen, is rather anthropomorphic and inappropriate. On the other hand, subjectively speaking, the new aviaries gave the individual parrots more space and in some ways, a quieter environment and a more pleasant atmosphere than the aviary of the parrot shelter. In addition, many of the grey parrots seemed to really enjoy interacting with the audience and sought their attention. Thus, I am still ambivalent about the metamusic staging practice of alien productions, and for my part, would prefer that in the future the metamusic project consistently focus exclusively on the auditory enrichment of grey parrots without the desire to please or attract the attention of any audience, as is the case with art and artists as well.

Artist statement: alien productions

"As already mentioned, we build environments, or 'sounding installations', with the parrots and play 'concerts' with them, sometimes with musicians from different backgrounds. Many visitors were of course drawn first and foremost to the parrots. The parrots thus helped to quickly dissipate the moment of alienation that arises between the visitor/recipient and an art project, to such a point, in fact, that the 'art project' itself took a backseat at times. Moreover, the presence of the animals prompted visitors to seek conversation with us artists and with zoologists. Some visitors stayed a long time and others came more than once. As for the parrots, we were very surprised to see how quickly they adapted to each new situation, how much they enjoyed having an audience, and how intent they were on attracting visitors' attention and interacting with them.

Instances of social interaction between the animals and human beings were always very much center stage during the 'exhibitions' as well as at the specially organized 'concerts'. The latter had little in common with usual performance practice. The traditional separation of (loud) instrumentalists and (silent) listeners would have hampered any concert with the parrots, since these basically imitate the audience's behavior. If the people present are expectant/passive, then the parrots are too. They become active only when their public actively move around, sing, whistle or dance. The birds reflect the audience and the audience the birds."

[alien productions, Martin Breindl et al.]

Expert statement: Daniel Gilfillan

“I would argue [that] the ‘long duration’ of the performative practice of metamusic allows the experience of immediacy between parrots and humans to be slowed, engaging a temporality apart from a solely human-centered experience and opening up the encounter for moments of reflection. These are openings where parrots and humans alike can linger with the wonder, awe, and exhilaration that characterizes such moments of sonic immediacy, perhaps extending them as spatiotemporal networks of dwelling, interconnection, and coproduced forms of inter-species agency.”

“Within their performance work, alien productions have engaged an arts-based research practice that actively explores the idea and role of interfaces across a range of social issues and cultural experiments, including immigration and migration, intermedial forms of perception, and animal-human relationships. Through their sound-based work, these interfaces are revealed as states of transition where the human mind and body may encounter experience and knowledge frameworks that originate apart from the human. At its core, metamusic explores what it means when a group of African grey parrots are provided with a variety of electronic tools and sensors linked to typical parrot behaviors, to explore, produce, and play with sounds and sonic moods. Beyond reading this play as reflective only of human engagement with music, the project also examines what meanings and use in sound these animals themselves engage.”

[Daniel Gilfillan]

Visitor 1 statement:

“It was an incredibly hot afternoon, especially for the audience, at the parrot shelter in Vösendorf. The grey parrots took the opportunity that many entertainers such as artists, animal keepers and audience were on site. Certainly, the clever animals like to play with musical instruments from the metamusic PEEK project, but this afternoon they just needed to tilt theirs head to one side to get all the attention. If they were sometimes left on their own, they became obviously bored and intrinsically started playing with the installed music hardware.

I think providing musical instruments to the grey parrots is a wonderful idea. The birds come from very different animal husbandries and have found a species-appropriate home at the parrot shelter, but they still need cognitive inputs and challenges.

The manipulation of the generated sounds coming from the instruments was especially interesting for me. The further research goal of identifying if and how grey parrots communicate with each other via the sound coming from the ‘musical instruments’ and if the audience becomes outside spectators would be interesting for me.”

Visitor 2 statement:

"I really liked the installation of the metamusic PEEK project. It became clear that the project was about improving the grey parrots' quality of life and not about amusing an audience by exposing them as show animals. I've always had a great interest in parrots and that's why it was very interesting for me to learn more about the circumstances of their captivity at ARGE Papageienschutz. I have learned more about the problems of keeping parrots and have gained insights into the difficult conditions from which they were rescued.

At the metamusic aviary installation, I had hoped for more interaction between the grey parrots and me. I expected them to actively seek contact and come to me, but they were rather shy. I also had other ideas about the advertised grey parrots' concert; I expected that the animals would play much more actively with the provided musical instruments but that did not happen. They did not do much and the difference between the installation and the performance was not so great to me. It was not a concert experience for me, but I was not disappointed because it was not intended to amuse the visitors but to provide enrichment for the grey parrots. Overall, being there was a positive experience for me."

7 RESEARCH OUTPUT AND CONCLUSION

This chapter sums up the various research outputs that have been achieved during the course of this PhD in artistic research with extraordinary research partners (grey parrots). Generally speaking, it must be noted that working with the grey parrots was very challenging, and it was the first time that I had designed interfaces and musical instruments for animals. During the course of this PhD project, I was regularly confronted with critical questions from experts and non-experts concerning many aspects of the project. Thus, there are additional questions that were raised during the different stages of the experiments and at the exhibitions and performances with the grey parrots that I would like to discuss and summarize here. My previous research background in the field of musical instrument design and the summary and analysis of the existing musical projects with animals quickly provided clarity about where it would be best to position this PhD project for and with grey parrots. The ACI research field, which was unknown to me before the research on related fields, covered most of the different aspects of my work, except the artistic approaches, in the best possible way. The knowledge, methods and findings from the ACI field were of fundamental importance in mastering this extensive work.

7.1 Research results

The results and observations of this PhD project can be regarded as basic research and subsequently could be of use for researchers in areas such as ACI, HCI or NIME and might also be interesting as an experimental approach in biomusicology. The resulting answers to the research questions I posed at the beginning of this dissertation (Chapter 1.4) are discussed here.

- **What design aspects of musical instruments support the physiological and cognitive abilities of grey parrots?**

Interactions

The grey parrots primarily interact with the instruments via their beaks. This was not clear at the beginning of this artistic research project, and there were also some considerations to build instruments for leg interactions only. These design concepts were subsequently not pursued and implemented. In some cases, there is still leg interaction involved, for example, to hold a part of the device, or if the musical instrument allows the parrot to climb or rest on the instrument such as the gong instrument or the rope swing test station. In the special case of the rope swing test station, we can speak of full body interaction. In general, the parrots like to chew, pull and pick on the instruments and interfaces, with a strong impulse to dismantle or destroy them. To promote these behaviors, the instruments have been adapted for beak interaction and suitable materials have been selected.

Objects

It turned out that the use of objects the grey parrots were already familiar with led to faster adoption of the instrument. Consequently, for many of the instruments, the design concept included enrichment toys and materials that the grey parrots were used to as a source material. In contrast to the ready-made instruments of the initial metamusic project that the parrots were not familiar with, I used objects and toys they knew to develop novel instruments. Both durable as well as easily destructible instruments were built. The easily destructible instruments or destructible parts of the instruments were of particular interest to the grey parrots and stimulated interactions with them such as nibbling, peeling, pecking, knocking and ultimately eating.

Materials

Commonly used materials for the instruments were wood for perches, metal grids, ropes, cardboard, plastic toys and fresh branches. For the DJ instrument and reel instrument, I used different enrichment toys like feeding wheels that the parrots already knew how to use. What was more challenging and disadvantageous was the use of new materials that the grey parrots were not familiar with. In Chapter 4.3.5, I described, for example, the case of how the tube instrument was not used anymore because unknown materials were used in the construction of the new version. I first used a cardboard tube for the prototype of the tube instrument, which was especially well received by some of the grey parrots. Since the cardboard tube was quickly damaged by the interaction with the parrots' beaks, I replaced the cardboard tube with a natural and more durable bamboo tube. Surprisingly, the parrots then completely ignored the instrument and hesitated to play with it. It turned out that our group of grey parrots were not familiar with bamboo. Therefore, I had to take a step back and test different materials for the tube instrument.

Sounds

The sound design of the instruments was also of great significance. The tests on the auditory skills and musical preferences of our group of parrots showed that their lower limit of sound perception is around 150 Hz and the upper limit is around 7,000 Hz and most of the utterances of the grey parrots were in the range between 1,200 to 2,400 Hz. From this I inferred that it made no sense to work with very high or low audio frequencies which were not in this spectrum. Generally, the grey parrots have no trouble perceiving the human voice and music; moreover, it can sometimes get very loud in the aviary, so the sound has to be played at a certain volume in order to be heard properly.

A frequency analysis showed that the basic frequency of the grey parrots' communication was substantially higher than humans. This led to the sound design question of whether I should pitch up the sounds and music I was working with in order to make it easier for the grey parrots to perceive them.

I have conducted several experiments with different pitches of melodies but could not observe any differences in perception. The question of adjusting the pitch cannot be answered in the context of this work but would certainly be an interesting research question for future research projects dealing with the auditory abilities of grey parrots.

- **Can grey parrots generate sounds and “music” with musical instruments?**

Definitely yes. In the framework of the project and its various experimental settings in the aviary, sound installations and performances, I was often able to observe how the grey parrots actively interacted with the musical instruments and interfaces which were designed for them. I took video recordings of how the grey parrots actively triggered sounds and positively responded to the audio feedback generated by bobbing their heads or making vocal utterances.

Based on their observations, experts such as Irene Pepperberg have also confirmed that the grey parrots “know exactly what they are doing with the instruments” that produce sounds through their interactions. This was particularly evident when an instrument such as the gong instrument (Chapter 4.3.1) stimulated a natural behavior. Since pecking is a natural territorial behavior in parrots, the instrument was very well received and used regularly. Based on numerous observations, I have come to the conclusion that some members of our group of grey parrots, with alternating members, have deliberately generated sounds with the musical instruments and interfaces designed for them.

The grey parrots also actively participated in musical performances with the artist group alien productions by interacting with the musical instruments provided them and their own calls, whistles and mimicking sounds. The resulting concerts and musical performances correspond to the definition of music postulated in the Introduction. The parrots have therefore also generated music in the sense of the definition within the context of this PhD project.

- **Can grey parrots develop musical skills and adopt an artistic role in a performance setting?**

The question of whether the grey parrots were able to develop musical skills could not be conclusively answered within the scope of the PhD project.

I observed how the parrots learned to play the instruments, such as the joystick device, by using their beaks to actively trigger sounds, or the rope swing, where a grey parrot developed a certain technique to trigger the sounds while sitting on the swing. Some of the parrots learned special techniques to produce sounds, but not necessarily musical techniques to change sounds or to play rhythm or sound sequences.

Perhaps this is due to details in the interaction design of the musical instruments which made it relatively easy to create sounds but more difficult to control their further sound generation. At the moment, I would not call the technique that the grey parrots use to play with the instruments that I observed musical skills. Such skills would include rhythm, pitch, melody, intervals or chords, and more controlled experiments are needed to understand the parrots' motivation to interact with such musical instruments and the skills they can develop with them.

Since the grey parrots actively participated in musical performances in cooperation with the artist group alien productions, they were able to adopt an artistic role as voluntary musicians in a performance setting. Some of the grey parrots, such as Wittgenstein, Moritz, Coco and Nepomuk, became passionate performers and attracted the audience's attention.

- **How can we design the musical interaction to support the parrots' individuality and can this be enriching for grey parrots in captivity?**

By observing the grey parrots in the aviary, I was able to identify individual preferences in terms of interactions, territorial behaviors or favored objects and materials. Instruments were developed for individual grey parrots on the basis of the intended area of use in the aviary and the parrots' preferred forms of interaction. For example, the rope swing test station was designed for parrots that preferred the upper area and for individual parrots that liked to play with ropes and swings. A few parrots also liked to explore the floor of the aviary; for this behavior, instruments were designed which allowed to place and play the musical instruments on the floor. I could not find any major individual preferences in terms of materials. Cardboard, wood, plastic and metal were usually well received. In general, unknown materials were met with suspicion and caution by the grey parrots.

The individual preferences of the grey parrots regarding the forms of interaction with the prototypes and instruments developed have been demonstrated through different behavior such as swinging, knocking on something, pulling, tearing, destroying or nibbling. These characteristics were also taken into consideration and constantly informed the design process.

This was particularly challenging in terms of individual sound design. It was very difficult to find out more about the individual musical preferences of our group of African grey parrots. I have already described my approaches and procedures to this problem in Chapter 3. In several experiments, I could observe that music with a continuous beat was generally well received by some parrots. Certain parrots were observed to prefer the sound of the chime instrument. A precise classification of preferred musical styles such as classical music or rock music to individual parrots, as it is often postulated by informal reports of parrot owners, was not possible within the scope of this PhD project.

It is possible and appropriate to take the individual preferences of the grey parrots into account when designing musical instruments for their auditory enrichment. The parrots showed interest in interacting with the musical instruments and used them over a long period of time. The participation of the grey parrots in the different musical settings and experiments was voluntary. In my estimation and also according to the opinion of the experts and animal keepers of ARGE Papageienschutz, my efforts enriched and benefited the grey parrots.

7.2 Research constraints

As designing and working for and with animals to develop musical instruments and interfaces for them was novel to me, I faced many challenges. Some were too difficult to satisfactorily cope within this PhD in artistic research.

One of the major limitations during the course of the project turned out to be the spatial distance between my workplace at the Tangible Music Lab at the Art University Linz and the ARGE Papageienschutz parrot shelter in Vösendorf near Vienna, where the group of African grey parrots I worked with live in their captive environment. Even though I tried to work with the parrots as often as possible, the spatial distance of about 200 km was a big disadvantage. I often worked for weeks on designs or materials in the lab that turned out to be useless when I tested them with the grey parrots at the shelter. A more continuous and closer workflow with the grey parrots would have produced better results and led to faster progress in developing, testing and evaluating the instruments and interfaces. More regular contact with the grey parrots would have also created a stronger bond between the parrots and me. Thus, it would probably have been easier for me to interpret their behaviors without the help of the animal keepers.

These circumstances became particularly clear when the metamusic PEEK project brought some of the grey parrots to Linz for a period of two weeks. The project and setting in the Salzamt was described and discussed in Chapter 6.2. This framework allowed me to directly check and adapt the different design prototypes and implementations, a work situation that would have been desirable over the entire course of this PhD project. In a personal interview with Irene Pepperberg within the framework of the Salzamt project and the ANIMUS symposium, she confirmed that the spatial distance was a major disadvantage of the project and that it would have been an impossible task to carry out her research under such conditions.

Even though I fully support the ethical principles of ARGE Papageienschutz, they did create great limitations in working with the grey parrots.

In ACI research, for example, it is common practice to reward the animals for their participation in experiments with treats, a method we did not use due to the guidelines of the parrot shelter. Consequently, the motto of the metamusic PEEK artistic research project was that the sounds and music-making process were the inherent reward for the grey parrots in captivity.

Due to the ethical guidelines of ARGE Papageienschutz, we were also not allowed to separate the grey parrots for our experiments and “Jam Sessions”. This meant that parrots that were not interested in interacting with the musical instruments were also exposed to the resulting sound and music. Although we did not observe any signs of distress in these passive grey parrots, such as escape behavior, I cannot rule out that this practice had negative effects on these individual parrots.

Unfortunately, it was not possible to work with a set group of parrots over the entire duration of the project. If a new home outside ARGE Papageienschutz was offered for a pair of grey parrots—they are only allowed to be keep in pairs—the birds were given away and lost for my PhD research. As a result, some of my developments for individual parrots, such as instruments for Moritz or Bimboli, parrots that were given away, did not work well with other parrots. The tube instrument, for example, tested very successfully with Bimboli and his partner, but after another iteration of the design of the instrument, these two birds found a new home and many weeks of development and work were lost and could not be continued.

After the last iteration of the instrument designs and the final public presentation at ARGE Papageienschutz, which was the end of my practical PhD project in developing the instruments, it was no longer possible for me to verify how the latest modifications of the musical instruments affected the grey parrots' interactions. After the public presentation, the musical instruments and interfaces developed during the project were handed over to the artist group alien productions. The artist group will keep the musical instruments until the next planned exhibition or performance of metamusic.

After the end of my PhD project, I would have preferred to have left the instruments at the parrot shelter to be used as permanent auditory enrichment for the captive grey parrots. However, this cannot be guaranteed due to the difficult working conditions on site and the lack of staff. Most of the musical instruments developed in this project are technically demanding and would have needed constant maintenance.

The artistic research approach that allowed me to carry out this PhD project in unconventional and experimental ways by applying artistic methods also had its drawbacks in terms of accumulating knowledge and reliable data, data with which I could underpin my PhD research results.

7.3 Outlook

I still see a lot of potential in the development of auditory enrichment for grey parrots in captivity. In order to gather more knowledge and more accurate data about the auditory abilities and individual preferences of grey parrots, we need controlled experiments with them. One research field that could fulfill these requirements might be biomusicology. Some of the questions that have emerged during my work with and for the grey parrots which would be promising for further investigation in this field are as follows:

- Do the pitches of the music need to be adjusted to make them more perceptible to the grey parrots, and what frequencies would that be?

- To what extent do grey parrots have spontaneous entrainment? How flexible are they in aligning movements to different and variable rhythms? What effect does adjusting the musical beats (BPM) to the heart rate of the grey parrots have in this context?

- Can specially designed products support the individual musical preferences of grey parrots in captivity and offer benefits in keeping such animals in parrot homes and for parrot owners? Can such products foster the bonding between grey parrots and humans?

- Can we compose music based on the vocalizations of grey parrots that has positive effects on the birds and can be used as auditory enrichment in parrot shelters?

- How can we clearly determine whether the auditory enrichment approaches have a positive effect in general and on the individual grey parrots?

I hope that one or the other question will be taken up and worked on by researchers. Additionally, the research on the musicality of grey parrots could also be of importance for a better understanding of the biological roots of musicality in humans. In any case, gaining more knowledge about grey parrots could improve the well-being of captive grey parrots and foster bonding between this fascinating species and humans.

Ultimately, a comparative research approach could identify general cross-species design patterns for musical instruments, which might even be relevant to human-centered design aspects, too.

7.4 Conclusion

This dissertation presents my efforts in designing musical instruments and interfaces for grey parrots in captivity. The PhD project was divided into three main phases: a project review and classification, sonic experiments at the parrot shelter and the design of musical instruments in the context of auditory enrichment for grey parrots. During all three phases, I was able to publish peer-reviewed papers for conferences and journals and contribute to different research communities.

It was a fascinating journey of discovery to carry out my PhD project with and for grey parrots, and I am very grateful for this opportunity. Starting from scratch, I have gained some insights into the complex world of musicality in animals, designing for and with animals and enrichment for grey parrots—wild animals that should never have been taken into captivity. In trying to answer my research questions, a lot of new questions emerged, which, unfortunately, I could not answer, but was able to formulate for other researchers to continue working on in the future.

I hope that this dissertation offers useful details on how to deal with grey parrots in captivity and how to improve their quality of life through auditory enrichment devices. There is still a lot to be done to provide grey parrots in captivity with a dignified living environment, and I believe there is a chance to foster relationships between grey parrots and humans by opening new creative and even artistic communication processes based on sound and music.

In this dissertation, I have demonstrated an artistic research approach that combines both art as method and outcome and as a research practice for gaining knowledge and have shown how such an approach can have a practical and positive impact on captive animals. This PhD project has expanded the horizon of ACI and NIME research (whether NIME likes it or not) by developing musical instruments and interfaces for animals and has also provided further contributions to design approaches in these disciplines.

Ultimately, I hope that my efforts have improved the living situation of the African grey parrots at the ARGE Papageienschutz parrot shelter since they certainly deserve it.

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9 FIGURES