Sonic Experiments with Grey Parrots:

A Report on Testing the Auditory Skills and Musical Preferences of Grey Parrots in Captivity

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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 grey parrots perceive, respond to, and generate sound and music through the usage of technological mediators, with the aim to improve their quality of life.

Author Keywords
musical interaction design; animal computer interaction; auditory experiments, grey parrots; sonic enrichment.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

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 [1]. These phenomena have been noted by researchers in bioacoustics, biomusicology and related fields. There are two indicators that speak for high auditory skills and musicality in various animal species – vocal learning and entrainment [2]. Vocal learning is the ability to modify sounds, learn new sounds via imitation, and produce vocalizations. Entrainment in animals is unusual and involves the ability to synchronize their movements to a musical beat [3, 4].

One of the few animal species that share both vocal learning and spontaneous entrainment are grey parrots. Grey parrots are highly intelligent and have become popular pets due to their ability to mimic human speech. Irene Pepperberg, one of the most acknowledged researchers in this field, has conducted numerous studies on the cognitive abilities of grey parrots, in which they have displayed a similar cognitive level compared to a 4- to 6-year-old child on some tasks [5]. In 2009, Pepperberg and her colleagues disproved the claim that entrainment to music is unique to humans. In a case study, they demonstrated the existence of spontaneous motor entrainment in two nonhuman animals – grey parrots and cockatoos [4].

There have also been other investigations focusing on the musicality of grey parrots such as Luciana Bottoni's "Teaching a musical code to a parrot: Frequency discrimination and the concept of rhythm in a grey parrot" (2006). They 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 [6].

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 the birds. He observed that the birds were able to use the electronic device and discovered that parrots also have varied musical tastes and showed different individual musical preferences [7].

While grey parrots are highly intelligent and 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 are a common symptom [8].

Based on research showing that grey parrots have high audible skills and musical talents [4, 6], we wanted to carry out further sonic experiments with grey parrots in captivity in order to better understand how they perceive, respond, and generate sound and music. Our overall aim is to find out if music and sound in combination with musical instruments and interfaces adapted to the grey parrots' skills can be used to activate and challenge them. Our study should be considered as a step towards the audible enrichment of grey parrots in captivity.

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BACKGROUND

In 2016, a research project was started by the authors of this report in collaboration with the Austrian artist group *alien productions* and zoologists and animal keepers of ARGE Papageienschutz. Since 2012, under the project name “metamusic”, the artist group has been working on interactive sound installations for grey parrots in captivity. In collaboration with the birds, the group has been developing mechanical and electronic instruments which can be played by the grey parrots themselves and has been producing several public installations and concerts with them. In the course of these exhibitions, the group has been examining how the birds react to musical stimuli and exploring whether they are able to produce meaningful music by themselves. Since the results of this art-based research seemed promising, the group wanted to expand the project. The group asked us, the musical interface designers of the Institute of Media Studies of the University of Art and Design Linz, to collaborate on the project. Our principal goal in this context is to develop musical instruments and interfaces for the grey parrots to improve their quality of life in captivity.

Our research questions within the scope of this project are:

- Is it possible to improve the situation of grey parrots in captivity through the development and use of musical interfaces?
- What qualities do such instruments have to fulfil in order to meet the physiological and psychological needs of grey parrots?
- Can grey parrots generate musical and artistic output with such instruments and what are the benefits?

In the first year of our research, we wanted to find out more about the individual auditory skills and musical preferences of a group of African grey parrots held at the animal shelter of ARGE Papageienschutz. To help design musical instruments and interfaces for grey parrots in captivity that could be useful for their auditory enrichment, we started by examining how grey parrots respond to sound and music.

SONIC EXPERIMENTS AT THE PARROT SHELTER

To test the auditory and musical skills of grey parrots in captivity, we carried out measurements and experiments at the ARGE Papageienschutz parrot shelter in Vösendorf near Vienna. The shelter is home to approximately 190 parrots. Most of them are captive-born, hand-raised, exposed to human speech and some of them show behavioral disorders such as feather destructive behavior (FDB). 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. There was no rewarding by food and when they showed distress, the test was stopped.

Sonic Pre-Tests

Prior to the experiments 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. We cannot exclude that they also influenced our measurements to some extent. To measure the sound pressure level, we 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, we positioned them in a small cage in the aviary.

Our 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 [6] and have showed similar results. Due to the particular set of living conditions in the animal shelter and the individual backgrounds of the parrots, we found it interesting to see if there are significant deviations from these previous studies.

Thus, to learn more about the basic hearing parameters of the grey parrots, we 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, we 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 150Hz to 20,000Hz. 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 was the utterances of the parrots.

Our 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. Our results do not differ significantly from previous studies [6, 9].

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 the alien productions artist's group as part of the "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, we decided to further develop this instrument to test the auditory and musical preferences of the participating subjects. First, we integrated the accelerometer sensor at the bottom of the rope swing where the parrots prefer to sit. Thus, we experimented with radio-frequency identification (RFID) antennas that were also integrated at the same place.

The adapted rope swing was attached to a small case which housed a 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 our tests, we made a second copy of the rope swing.

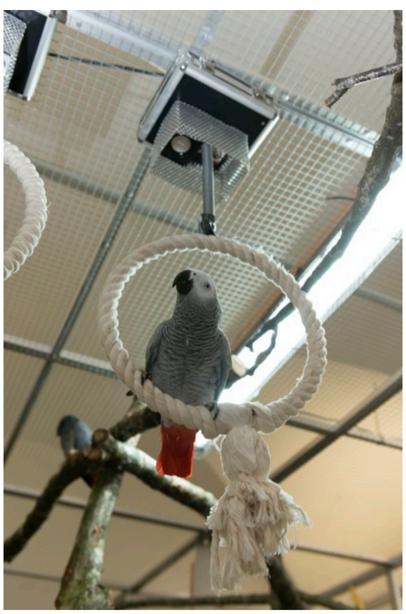

Figure 1. Rope Swing Test Station

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. We had three long-time test phases over a period of three months. We 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. 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, we 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, we tried to find out the musical 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 therefore 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 we 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, we 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. We could not prove whether grey parrots tend to prefer music with human voices to music without human voices or which pitch they prefer.

RFID Leg Rings for Grey Parrots

As mentioned above, we 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, we tried to develop our own RFID tag rings. We disassembled a chicken RFID tag ring and kept the small RFID transponder. We bought 11 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, we attached the RFID transponder to a split aluminum ring and cast it in artificial resin.

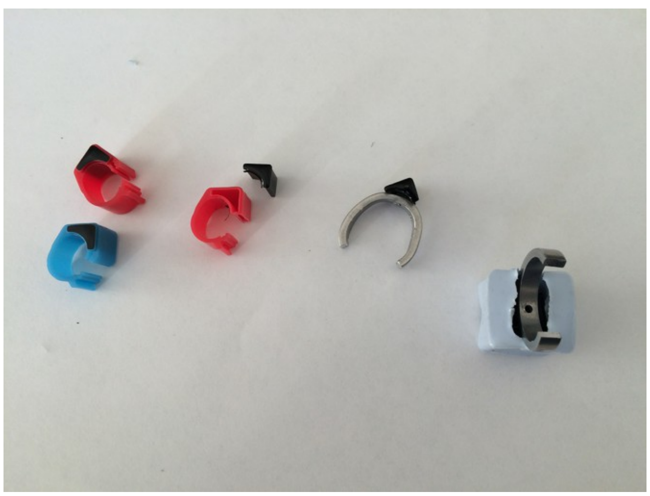

Figure 2. Leg Rings for Grey Parrots

Our 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 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, we decided not to implement them in our experiments. But we are continuing to work on the further development of this idea.

At the 17th Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Conference in Johannesburg in October 2016, it was decided to tighten the rules protecting grey parrots (*Psittacus erithacus sp.*). They now fall under the highest level of protection of CITES [10]. This also means that the grey parrots at ARGE Papageienschutz will most likely have to be chipped in the near future. This would bring new opportunities for the use of our proposed implementation of RFID technology.

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.

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, we 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, we wanted to gain a better understanding of the musical and auditory preferences of the individual grey parrots.

We 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. Joystick Test Device

In general, the joystick test device was well received. The grey parrots were willing to spontaneously interact with it. As with the rope swing test station, we 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.

SALZAMT LAB EXHIBITION

In May 2016, in preparation for the Animal Music Symposium in Linz, Austria, we had the opportunity to work closely with 6 grey parrots at the Salzamt, an art production and exhibition venue in Linz. The participating parrots had already been part of our 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.

The aviary installed inside the exhibition space was 6 x 4 x 2.4 m. It was equipped with all the appropriate inventory and toys. During their 14-day stay in the aviary of the Salzamt, the parrots were taken care of by the animal keepers of ARGE Papageienschutz. In the open laboratory environment, we were able to carry out further tests with the methods described above.

The smaller and therefore more manageable group of grey parrots made it easier to recognize their individual preferences. For example, 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.

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.

As part of the Animal Music Symposium, we also had the chance to discuss our research with internationally renowned experts in this field such as Irene Pepperberg and Clara Mancini. They were reporting on their own work with animals and gave us advice on how to improve our experiments. Pepperberg questioned the group size we were using in our tests and, above all, the length of time between the test periods. She also pointed out that her own parrots had a very individual taste in music. Clara Mancini also suggested adjusting the musical beats (BPM) to the heart rate of the grey parrots, which lies between 340-600 BPM. Since this is very fast, it seems more advisable to just halve or quarter this speed.

Figure 4. Laboratory Environment at Salzamt

CONCLUSION AND FUTURE WORK

Our 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 our experiments, interacted with the provided test devices and gave positive feedback by bobbing their heads or making utterances. Thus, our efforts are a step towards the acoustic enrichment of grey parrots in captivity. Through digital logging, video recordings and observation of the grey parrots' behavior, we are attempting to determine what kind of sonic and interactive experiences the individual parrots prefer in their interaction with the proposed test environments. Our future work will focus on designing a series of experimental musical interfaces and instruments that are adapted to the physical capabilities and sonic preferences of grey parrots in captivity.

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