2016 STANSW Young Scientist

Our Ultrasound Environment

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When my Aunty came over for lunch, she brought her two dogs Gus and Max. Then an aeroplane flew overhead. Gus barked liked mad at it, and Max kind of half-heartedly barked at it. The next week my Aunty was over for afternoon tea, and a helicopter flew over. Max barked at it again, but Gus didn’t bark at all.

Dogs have a wider range of hearing than humans. Were they upset by something we couldn’t hear?
Aim for 2016

1. To explore the natural and man-made ultrasonic environment, and its possible effect on certain animals, such as dogs and bats. In our garden there are also bandicoots, which I believe might emit ultrasonic “beeps”, when they are searching for food.

2. To see if dogs are sensitive to high frequency sound emissions from aeroplanes and not helicopters, as Gus the dog barks at aeroplanes but not at helicopters, whether Max, who is younger than Gus, barks at both, and Bob, who is the youngest, does not care that much about either aeroplanes or helicopters.
Creating And Detecting Ultrasound

To create ultrasound, a transducer vibrates at ultrasound frequency creating a sound wave at that frequency. This is the same as how audible sound is created, eg in a human voice box or in a musical instrument.

The simplest example of ultrasound is a dog whistle, where the dog can hear it, but we can’t. A transducer in reverse is a microphone. Most microphones only work in the audible range but they can be made to work at ultrasound frequencies.

In order to “hear” ultrasounds we can display them electronically, or convert them to frequencies in the audible range. An example of this “converting” is a bat detector, where bat noises are converted to audible noises so that we can hear them.
Uses of Ultrasound

There are many uses for ultrasound in our human world. Doctors and nurses use ultrasound for scanning inside bodies, and engineers use ultrasonic range-finders. Many people also might have an ultrasonic bug scarer. Some people have invented things that we use in everyday life, such as an ultrasonic dog collar, remote controls, burglar alarms, even automatic light switches.
Experiment 1: Creation and detection of ultrasound

Apparatus:

- Ultrasonic rangefinder: This cheap tool measures distance by bouncing ultrasonic signals off objects and measuring the time taken for the returned reflection. A visible laser helps direct the sound wave. Range about 100m.

- Noise-cancelling headphones: These headphones cut out unwanted noise so you can hear the signal better. They are useful in aeroplanes to cut out the cabin noise while watching the movie. In my experiment they help cut out audible noise while I listen in to the bat detector.

- Metal Pudding Bowl: I thought a parabolic dish might help, so me and my Dad went to IKEA and bought a so-called “dish” which was actually a metal pudding bowl.

- Bat Detector: This is the real thing you can’t do without. It is the piece of apparatus that converts ultrasound into audible sound.
Experiment 1: Creation and Detection of Ultrasound

Method:
With ultrasonic rangefinder, calibrate bat detector i.e. check frequency 40kHz as stated in rangefinder specification). Then measure range and frequency of rangefinder with bat detector. The metal bowl was used to see if it improved the range by acting like a parabolic satellite dish.

To improve detection, the bat detector was opened up and a headphone socket was soldered across the speaker terminals. This allowed the use of the noise-cancelling headphones.

Result:
The rangefinder could be detected up to 100m away. The metal bowl made no difference, perhaps because it wasn’t a very good approximation to parabolic!

The bat detector showed the peak frequency to be 40kHz, which agrees with the specification. It also showed that it could be detected over a wide range from 20-60kHz.
Experiment 2: Detection of Natural Ultrasound

Using the bat detector, some sources of natural ultrasound were recorded. I couldn’t detect any bats - the only bats we seem to have are fruit bats, that don’t use echo-location.

You can hear the wind in the leaves of trees, and sounds you make yourself like walking on grass, sucking in air or clicking your fingers.

<table>
<thead>
<tr>
<th>Natural Source</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind rustling through trees</td>
<td>wide range</td>
</tr>
<tr>
<td>Rushing water (from a tap)</td>
<td>wide range, peaking at 40kHz</td>
</tr>
<tr>
<td>Waves on a beach</td>
<td>wide range, peaking at 40kHz</td>
</tr>
<tr>
<td>Rubbing fingers</td>
<td>peaking at 40kHz</td>
</tr>
</tbody>
</table>

I also recorded the ultrasound of waves on the beach, using the bat detector and an iPhone app called “voice memos” which displays the recorded sound waveform.
Experiment 3: Detection of Aircraft Sound and Ultrasound

First, I used the bat detector to record ultrasound from aircraft flying overhead. Planes taking off from Sydney airport often pass over our house. I researched the aircraft noise and found that there might noise given off by the engines at 35kHz, in the ultrasound range. My Dad estimated the big planes like the Airbus A380 were about 1500m up. No ultrasound was detected, so maybe the planes were too far away. We went to Tempe near the runway, where the planes taking off would be more like 500m up. Although it was very noisy there was no ultrasound detected.
Experiment 3: Detection of Aircraft Sound and Ultrasound

Reasons for Result:

I researched the way that sound and ultrasound are absorbed in air. My Dad found a useful website by the UK National Physical Laboratory which allows you to calculate how much sound is absorbed in air at different frequencies.

These graphs shows that sound gets much more strongly absorbed at high frequencies. In fact, sound at 35kHz is absorbed at 1.5dB/m or about 30% every metre - so we might detect the ultrasound from an aeroplane 20m away but not 500m away.

Ultrasound is heavily absorbed in the air, so ultrasonic noises from planes are undetectable to us. This explains why we can’t detect ultrasound from aircraft at all. So we don’t know what the dogs were barking at, just that it isn’t ultrasound!
Experiment 4: Ultrasound in the House:

My mentor pointed out that you can detect ultrasonic noise from some light bulbs. This made me think I should do a survey of the house to see what else is emitting ultrasound.

Survey of household ultrasound emitters:

<table>
<thead>
<tr>
<th>Technological Source</th>
<th>Frequency</th>
<th>Strength (1 to 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer</td>
<td>peaking at 35kHz</td>
<td>1</td>
</tr>
<tr>
<td>Headphone battery charger</td>
<td>peaking at 110kHz</td>
<td>2</td>
</tr>
<tr>
<td>Desk light (compact fluorescent)</td>
<td>peaking at 40kHz</td>
<td>4</td>
</tr>
<tr>
<td>Television in playroom</td>
<td>peaking at 80kHz</td>
<td>3</td>
</tr>
<tr>
<td>Radio</td>
<td>peaking at 45kHz</td>
<td>1</td>
</tr>
<tr>
<td>Telephone landline</td>
<td>peaking at 70kHz</td>
<td>1</td>
</tr>
<tr>
<td>iPod</td>
<td>peaking at 30kHz</td>
<td>1</td>
</tr>
<tr>
<td>Plasma lamp</td>
<td>peaking at 30kHz</td>
<td>5</td>
</tr>
<tr>
<td>Noise reducing headphones</td>
<td>peaking at 40kHz</td>
<td>3</td>
</tr>
</tbody>
</table>

I have found that the loudest ultrasonic sources are the plasma lamp and the compact fluorescent lamp. This may be because the lamp’s electronic circuits vibrate at very high frequencies and this vibration is amplified by the glass of the bulb. I have also found that many electronic devices emit around 30-40kHz. So, our house is full of sound at ultrasonic frequencies. Dogs and cats must be able to hear a lot of these sounds and some may be affected by them. There is some evidence from the internet that compact fluorescent lamps may be annoying to some animals.

http://www.science20.com/science_amp_supermodels/cfl_bulbs_save_planet_make_your_pets_insane-5820

This could be the subject of a future project.
Experiment 5: Frequency analysis of ultrasonic noise

My mentor suggested I use a piece of software called “Audacity” to graph sound traces. This software can do frequency analysis as well, so that you can see what frequencies make up a noise signal. Because we are using the bat detector, we can use this tool to see what ultrasonic frequencies.

**Apparatus:**
The diagram shows the experimental setup used for ultrasound analysis.
Experiment 5: Frequency analysis of ultrasonic noise

Method
Recordings were made of various ultrasonic sources. The .wav file from iphone voice memo was imported into audacity and displayed. Audacity was also used to display the frequency spectrum.

Results
Diagrams below show the measured signal from a few sources, as well as the frequency plot. By making measurements containing several audible signals, it is possible to relate these to the original ultrasonic frequencies and identify them.
**Experiment 5: Frequency analysis of ultrasonic noise**

**Method - recording of compact fluorescent lamp**
The recording was made while the frequency of the bat detector was adjusted through the full scale. In this way it is hoped the .wav file from iphone voice memo will contain the full frequency spectrum.

**Results**
The chart shows the signal versus time, with peak frequencies identified.

![Signal chart](image)

- 20kHz
- 35kHz
- 40kHz

(time about 10 s)
Experiment 5: Frequency analysis of ultrasonic noise

Frequency Chart - Compact Fluoro Lamp

Audacity was used to display the frequency spectrum, shown below. The peak at 3kHz might match one of the ultrasound peaks, but it's not clear. More work is needed to see if this is real. The sharp cut-off at 15kHz may be caused by the limitations of the equipment, for example the iPhone.
Experiment 5: Frequency analysis of ultrasonic noise

Method - recording of plasma lamp
The recording was made while the frequency of the bat detector was adjusted through the full scale. In this way it is hoped the .wav file from iphone voice memo will contain the full frequency spectrum.

Results
The chart shows the signal versus time, with peak frequencies identified.
Experiment 5: Frequency analysis of ultrasonic noise

Frequency Chart - Plasma Lamp
Audacity was used to display the frequency spectrum, shown below. The peak at 500Hz might match one of the ultrasound peaks, but again its not clear. More work is needed to see if this is real. The sharp cut-off at 15kHz is again seen.
Conclusions

Using simple tools and free software it is possible to carry out a detailed survey of the ultrasonic environment.

It may be possible with more work to investigate the frequency spectrum of ultrasound from various sources and identify causes.

I hope to continue this work by investigating the effects of ultrasound on animals.

Also, human noises create lots of ultrasound, and I would like to look into this further, as I'd like to know how we emit such high frequency noises.
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