Sound Quality and Striking Position of a Conga Drum

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Abstract

The relationship between the location at which a drum membrane was struck and the quality of sound produced was investigated by striking the drum at several distances between the center and the rim. Through analyzing the harmonics of the wave produced from the impact, it was shown that as the striking location changes, the relative amplitudes of different modes of vibration also changes. It was found that sound of a higher pitch is produced at the rim of the drum than anywhere else on the drum head due to higher modes of vibration becoming dominant.

Introduction

Percussionists often strike the different areas of a drum to change the qualities of the sound produced. Striking the rim of a drumhead can produce a tone that sounds higher, while striking the center produces the original tuning of the drum. This investigation hopes to describe how the position at which the drum is struck affects the sound produced.

Drums have a "head", the membrane that covers the top of the drum, where the striking takes place, and a "shell", the wooden form that the rest of the drum is made of. The air column within the drum serves the purpose of allowing the wave that is created on the membrane to resonate, producing a loud sound[1]. The waves that are created on the membrane of a drum are different than waves on a guitar string as they are formed on a two-dimensional plane.

According to a study of the modes of vibration on a circular membrane done by Thomas D. Rossing of Northern Illinois University[2], ideal membrane theory can be used to model drum head behavior. According to Rossing, the ideal membrane theory states that, depending on the radius, tension and mass per unit area of the membrane, a particular mode of vibration will form. These modes of vibration are described through ordered pairs, such as (0,1), where the first number indicates the number of diametric nodes and the second indicates the number of circular nodes (see Figure 1). However, in *Acoustic Drum Exploration*, a study done by Theodore Argo IV[3],

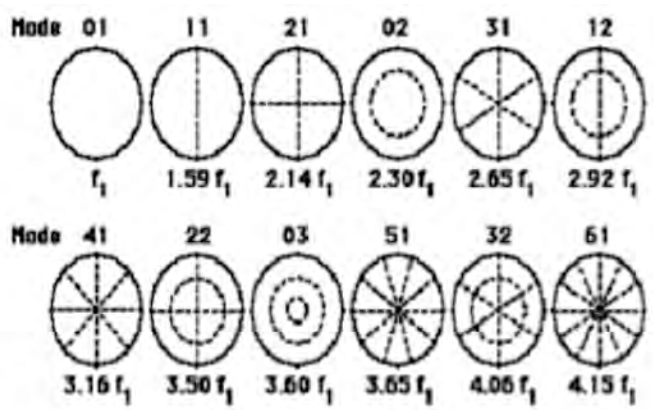

Figure 1 Different expected modes of vibration on a flat membrane. The frequency of mode 0,1 is defined as f_1 and the rest have frequency f_1 multiplied by the indicated coefficient.[3]

it is shown that drums do not always follow the ideal membrane theory. Argo found that factors such as the type of drum sticks, the striking angle of the drum stick, and the type of head all affect the actual mode of vibration that the drum produces.

In this investigation, we will be studying how the relative amplitudes of the different modes of vibration of the sounds produced from a strike depends on the position of the strike on the drum membrane. It is hoped that this will quantify and explain the well-known phenomenon of the drum producing higher tones when struck near the rim. It should be noted that identifying which mode of vibration is being produced or measuring deviation of our drumhead from ideal membrane behavior is not relevant to our purpose, and thus will not be addressed.

Method

A conga drum with a 26.5 cm diameter head was placed on wooden blocks to maximize resonance. An electromagnet release mechanism, used to drop a 44.6 g steel ball consistently, was fixed 35 cm above the center of the drum. A microphone, set to 100,000 samples per second, was secured facing the conga to record the sound of impact. The ball was then placed on the release mechanism and aligned so that the ball impacted at various points on the head, as shown in figure 2. The sound of the ball being dropped onto points ranging from the center (13.3 cm from the edge) to 0.7 cm from the edge was recorded three times for each point.

The FFT graphs that the program generated were analyzed, and the frequencies that were consistently present were recorded along with their amplitudes. In the sample FFT shown in figure 3, the selected modes are shown.

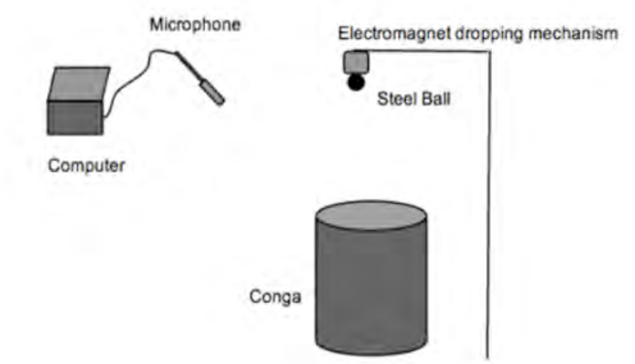

Figure 2 Experimental setup

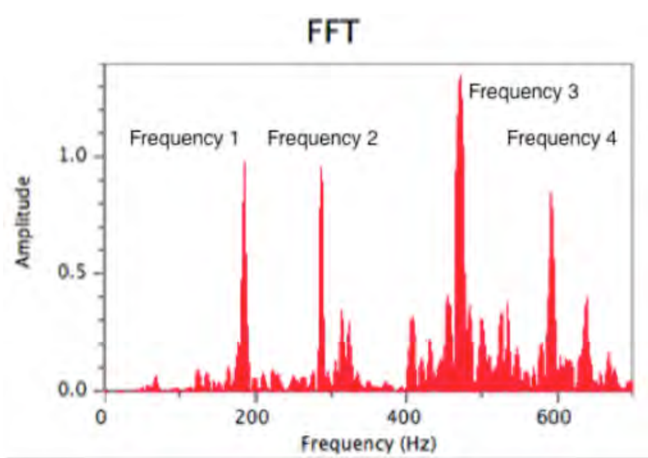

Figure 3 An example FFT graph from a strike near the rim, where upper modes of vibration are more dominant.

Results and Discussion

For each striking position, the relative amplitudes of each of the four main modes was determined by dividing the amplitude of each mode by the amplitude of the fundamental mode. The results are shown in figure 4. The red shows the relative amplitude of the lowest mode, used as the base of comparison and hence shown with a relative amplitude of 1. The other three lines show the amplitude of each higher mode relative to the amplitude of the lowest mode at that striking position.

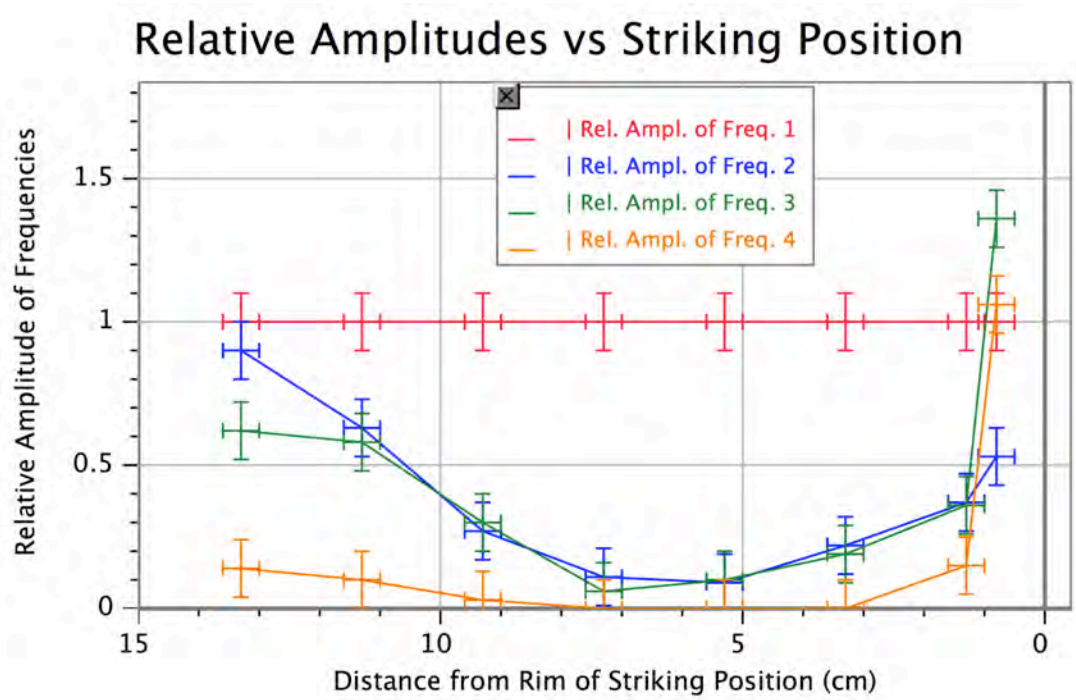

Figure 4 Amplitude ratios of the major frequency modes of the drum when struck at different positions on the head.

The data shows that as the striking position was changed along the radius of the drum, the relative amplitudes of the different modes of vibration changed. At the center of the drum (13.3 cm from the rim), frequency 1 had the largest amplitude, with frequencies 2 and 3 slightly lower and frequency 4 almost non-existent. Half way between the center and the rim (5-7 cm from the rim), the quality of the sound changes dramatically, with the amplitude all upper modes of vibration reduced almost to nothing, leaving only the lowest mode of vibration. At the very rim of the drum, the amplitudes of the two higher frequency modes are greater than the fundamental mode of vibration. This explains why the sound heard when striking the conga at different positions on the head changes. The sound sounds full and rich to the ear when struck at the center, as there are multiple frequencies. In the half way area, the sound seems ‘thin’, as there is effectively only one mode of vibration. And at the rim of the drum, the sound heard is of a much higher pitch, as the amplitude of the two highest modes becomes greater than the lowest mode.

Two other aspects of the sound are worth noting. Firstly, the frequencies of the lowest three modes of vibration for an ideal membrane were calculated based on the lowest drum frequency measured and the relative modal frequencies shown in figure 1. The results (Table 1) show that the behavior of the conga drum does not follow the ideal membrane theory, supporting Argo's findings.

	Ideal Frequency (Hz)	Actual Frequency (± 10 Hz)
Mode 0,1	180 (f_1)	180
Mode 1,1	286	320
Mode 2,1	385	460

Table 1 Frequencies of the first three modes of vibration for an ideal membrane compared to the actual frequencies produced by the conga.

Secondly, the frequencies of each of the modes was not stable as the conga was struck at different positions, as shown in table 2. The lowest frequency mode, Frequency 1, was quite stable at 179 Hz when struck near the center, but then jumped to 184 Hz when struck closer to the rim. Frequency 2 behaved differently, decreasing from 328 Hz to 311 Hz from the center to the rim. Frequency 3 gradually increased from 450 Hz to 470 Hz

Striking Distance from Rim of Conga (± 0.3 cm)	**Frequency 1 (± 2 Hz)**	**Frequency 2 (± 5 Hz)**	**Frequency 3 (± 5 Hz)**	**Frequency 4 (± 9 Hz)**
13.3	179	328	453	626
11.3	179	325	454	620
9.3	179	324	456	621
7.3	179	325	461	-
5.3	179	311	463	-
3.3	184	311	466	-
1.3	184	312	466	592
0.8	184	313	470	592

Table 2 Frequencies of each of the four modes investigated at different striking positions.

as the striking position moved closer to the rim. Finally, frequency 4 started at around 620 Hz near the center, before disappearing, and then returning at 590 hertz when close to the rim. We do not have an explanation for the behavior of the different harmonics.

Further research into the changes of frequency of the sounds produced as the striking point moves closer to the rim is suggested. It is also suggested that the sound quality at different positions be investigated for a range of different drums.

Conclusion

It has been shown that striking a conga drum at different locations produces sounds of different pitches and quality because the amplitudes of several modes of vibration changes significantly, producing an audible difference. The lowest frequency mode is dominant when struck near the center of the drum, but when struck near the rim, two higher modes of vibration become dominant, making the drum sound higher pitched.

References

1 Rossing, Thomas D. (1992). *Science of Percussion Instruments*. World Scientific Publishing, Singapore.

2 Rossing, Thomas D. (1992) "Acoustics of Drums." *Physics Today* 45.3

3 Argo, Theodore. "Acoustic Drum Exploration - Basis for Investigation." *University of Illinois Department of Physics.* Retrieved from https://courses.physics.illinois.edu/phys193/NSF_REU_Reports/2002_reu/Ted_Argo_IV_REU_Report.pdf