WAVE OF THE BANJO

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Visual Image Processing

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ABSTRACT

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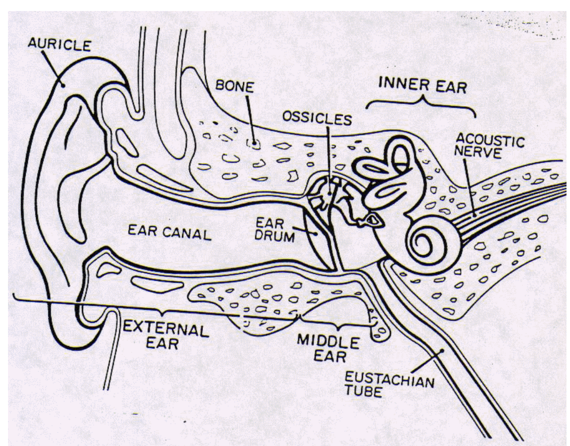
This study reveals that certain keys played in music are preffered by human listeners over others. A banjo will be used to produce the music needed. Human observers will be presented with a song played in different keys on the banjo. Through a survey the observers will be allowed to rate each song based on personal preference. The information gained from this study could be very helpful to companies that use sound in their products as it would allow them to make a product that would be more beneficial to the consumer.

Introduction

In today's society there is a large variety of music. Everyone has their own favorite music and songs. Based upon many various reasons an individual could like a song because of its speed, the lyrics or even because a favorite instrument is in the song. This study will attempt to discover if there is a relationship between different keys in music and what people like. It is expected that the lower the key of a song the more people will like it. The banjo will be used to produce the music for this study by playing the same song in different keys for observers to rate on personal preference.

Background

In humans, the sound waves travel through the ear first vibrating the ear drum. Moving fluid caused by the vibrations of the eardrum bends thousands of hair-like cells, which convert the vibrations into nerve impulses [5]. Nerve impulses are then carried to the brain by the auditory nerve [5]. Figure one displays the image of the human ear. Once the nerve impulses are carried to the brain they are converted into what we hear as sound. The purpose of this research is to discover if there is any type of relationship between different musical keys and what people like. The banjo is a stringed instrument developed by enslaved Africans in the United States, adapted from several African instruments [1]. The banjo can either have five or four strings. In this study a five string banjo will be used to provide the



music that is needed. The sound waves from a banjo are created by the strings, tone ring and head of the banjo. On the head of the banjo there is a wooden bridge. As can be seen by looking at figure two. The wooden bridge is about 3 1/8" in length and about a 1/4" thick [3]. The bridge is attached to the head of the banjo by the pressure of the strings. Each string slides into grooves on the bridge putting pressure on it as they are tightened. The banjo that will be used in this study has a tone ring and a resonator. The tone ring slips over a wooden rim, and then the plastic banjo head goes over the tone ring [2]. Both the banjo head and tone ring are held together by metal hooks that go all the way around the banjo head. The tone ring helps the banjo sound much brighter and crisper by coupling the head vibrations to the resonator [2]. The resonator is a wooden piece that is put on the very back of the banjo. A resonator helps the sound to be projected or to resound. Tone rings are very resonant and can actually enhance the vibrations of the head, therefore making the banjo much louder [4]. The material for the banjo head is the same material used for a drum head. Mylar is the material that serves as the base of most modern plastic banjo heads [2]. It has 1/3 the tensile strength of steel [4]. The method of playing the banjo is to pluck the strings with the right hand while using the left hand to press down strings on the neck. When each string is plucked the energy from the string is carried from the string, through the bridge and into the head. Sound waves are then created from the transferred energy of the strings to the head and tone ring. This

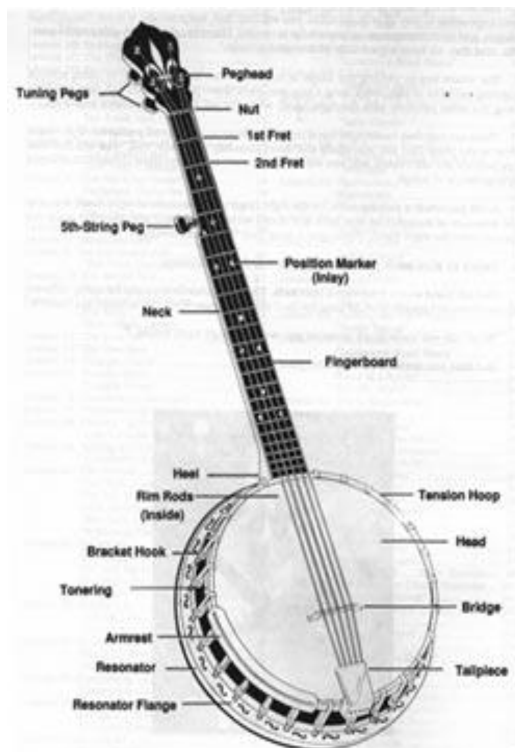


Figure 2- Banjo components

transfer of energy vibrates the plastic head. The tone ring captures the vibration of the head coupling the vibrations to the resonator. The resonator helps the sound to resonate or to resound. The sound waves are then formed and reflected into the air.

Methods

To start the experiment two songs were recorded in three different keys on the banjo. The three keys were G, C and E. These keys were recorded then entered in Matlab for evaluation. A Matlab script file was created to put all of the commands needed to graph the signals in so they could all be completed at once. The first command used was the "wavread" command. The wavread command reads a wave file specified by the string file returning the sampled data in a variable. An example of the wavread command in the Matlab file is shown in figure three. The second command used was the fft command. The fft command stands for Fast Fourier Transform [6]. It is a specific algorithm, but used to indicate any algorithm attempting to determine

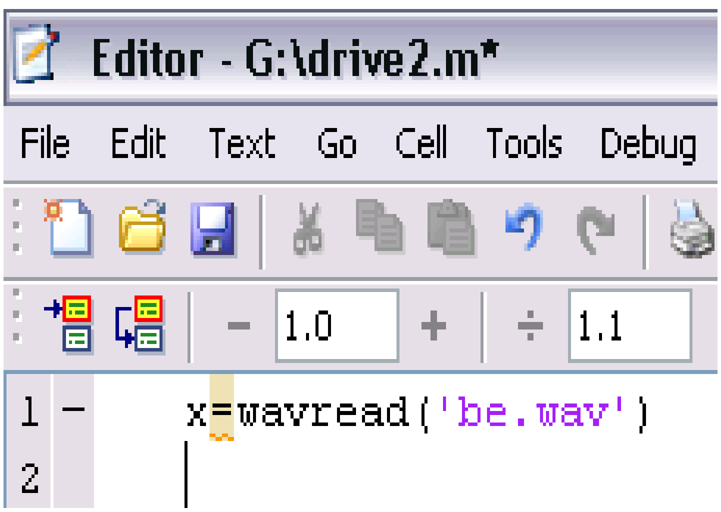


Figure 3

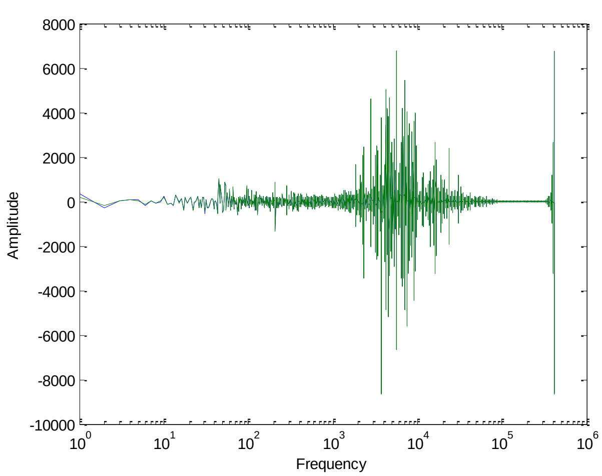
the power versus frequency graph for a signal. So to use the fft command, X=fft(x) was typed into the Matlab file window. Where x stands for the audio data. The last command that was used was the "semilogx(real(X))" command. This command takes the data and allows you to see the actual signal of the sound. The graph this command displays has an x axis of frequency and a y axis of amplitude. For each of the recordings all of the commands were used to show the signal of the sound. After all of the recordings had been plotted, a survey was created according to the two songs and three different keys. The students who were taking the survey had to rate each performance in each key from one to ten. With one being the worst and ten being the best. The students taking the survey were not allowed to compare each performance with the previous one, only on what they thought of the song. The survey also included demographic questions for the students to answer such gender, if they played an instrument, where they lived, and if they enjoyed music. To visualize the survey data, it was entered into a spreadsheet using Microsoft Excel.

Results

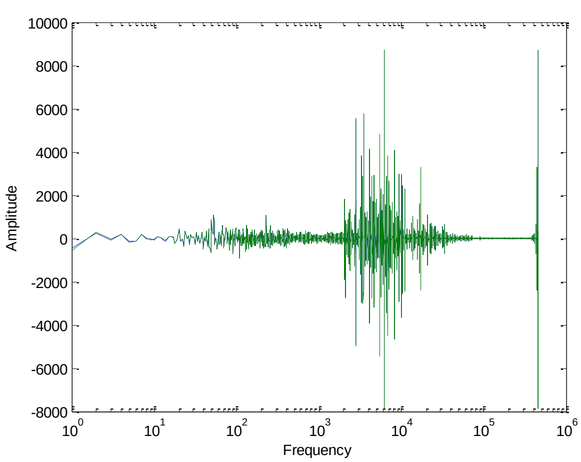
The signals in each key for each song all have the same basic shape. This is because it is the same song but just in different keys.   By looking at the signals for song one it is possible to see that the higher the key it was played in the more compressed the signal looked. This was the same result for song 2. The higher the key got the more compressed the signal looked. Here are the signals for both song one and song two for each of the three keys where G is the lowest and E is the highest pitched key.

Song 1

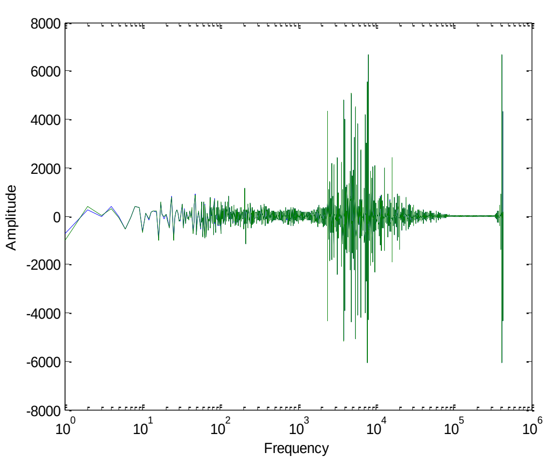
Key of G



Key of C

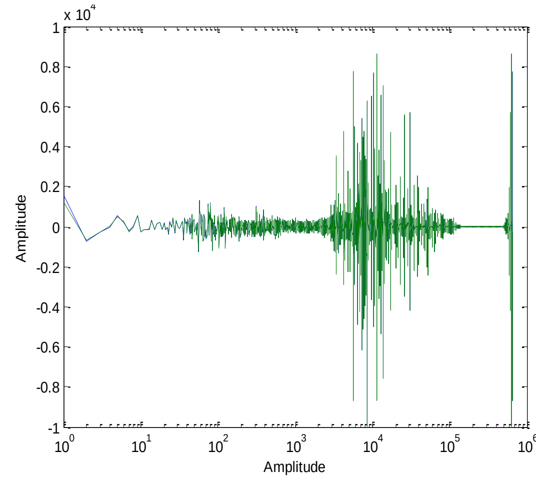


Key of E

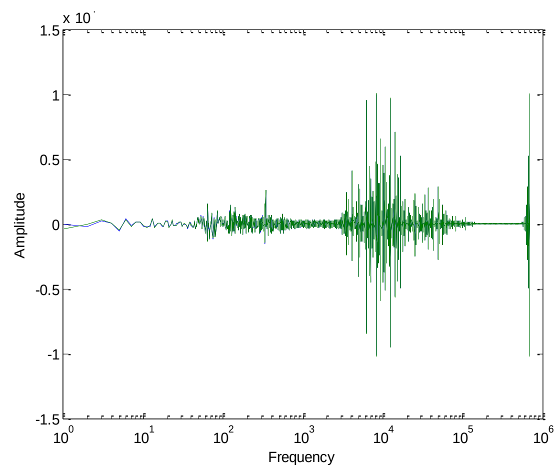


Song 2

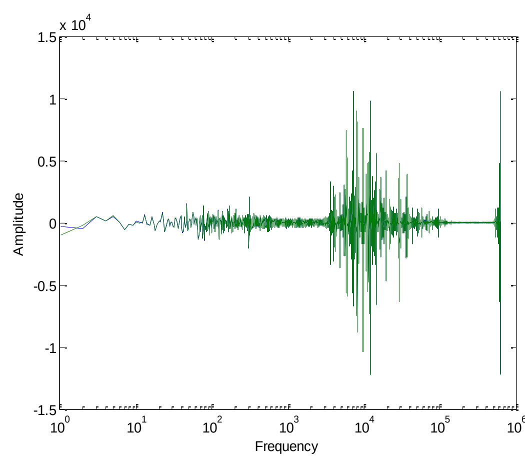
Key of G



Key of C



Key of E



On the banjo the higher you play up the neck the higher the frequency of the sound waves. So each time the song was played in a higher key, the frequencies of the sound waves produced became higher. By looking at the graph of song one in the key of G, one can see that the peak of its amplitude is at about 10^3 on the x axis. Now look at the graph of song one in the key of C, the peak of its amplitude has moved to the right on the x axis. It is at about $10^{3.75}$. Compare song 1 graphs of C and E. The key of E has its peak of amplitude at 10^4 on the x axis. This indicates that the higher the pitch of the key is, the higher the frequency of the sound waves will be. After plotting and seeing the graphs, the survey data was put into a Microsoft Excel spread sheet. The data that was inserted in the spreadsheet is shown in figure 4. In columns A-C is each key of song one, starting with the lowest pitched key (G) at the left. In columns D-F is each version of song two in each key also starting with the lowest pitched key at the left. After entering all of the data the averages of the ratings were calculated for each version of the songs. The averages are shown in the last row of the spreadsheet. As can be seen, the people that were surveyed preffered the lowest key for both songs. Figure 5 shows the average score that the people gave for each of the three keys in song one. As can be seen by looking at figure five the most liked key was G. One can also see that the least liked key out of the three was E, which is the highe y.

Song 1-g.	Song1-c.	Song1-e.	Song2-g	Song2-c.	Song2-e.	Gender	Region of North Carolina	Likes Music	Plays Instrument	City	County
8	6	9	7	9	4	male	East	yes	yes	Cary	Wake
9	9	7	9	10	6	male	West	yes	yes	Cramerton	Gaston
9	7	8	10	7	8	female	West	yes	no	Boone	Watauga
8	7	9	8	7	5	female	West	yes	no	Sherrillsford	Catawba
6	5	6	7	5	6	male	West	yes	yes	Hickory	Catawba
10	2	1	3	10	6	female	East	yes	no	Greenville	Pitt
6	6	7	5	4	5	female	West	yes	yes	Asheville	Buncombe
9	6	4	7	5	4	female	Central	yes	no	Charlotte	Mecklenburg
7	8	8	6	6	3	male	Central	yes	yes	Chapel Hill	Orange
10	8	6	8	7	10	female	West	yes	no	Statesville	Iredell
9	5	2	7	9	8	male	West	yes	yes	Wilkesboro	Wilkes
8	6	5	8	7	5	male	East	yes	yes	Cary	Wake
6	9	10	4	4	6	male	West	yes	yes	Robbinsville	Graham
7	5	6	6	7	4	male	East	yes	no	Raliegh	Wake
8	9	7	6	8	7	female	East	yes	yes	Greenville	Pitt
10	5	3	10	5	2	male	West	yes	no	Mocksville	Davie
8.125	6.4375	6.125	6.9375	6.875	5.5625						

Figure 4

In figure six the results for song two are revealed. In figure six the song played in G and C almost have the same average of ratings, but G has the highest average. Females seem to prefer the lowest pitched key. Figure seven shows the results of female's ratings on each of the keys. Out of the people surveyed seven were female and nine were male. Females rated the G key at an average of 8.6, C with 6.4 and rated the E key six. Males also liked the lowest key (G) better. They gave the G key an average of 7.7, the C key at 6.4 and the E key at 6.2. Out of the people that were surveyed nine played an instrument and seven did not. Figure 8 shows the results of the people who do not play an instrument. People who do not play an instrument greatly prefer the lowest pitched key. The average of the lowest key compared to the highest was a difference of four.

Figure 5

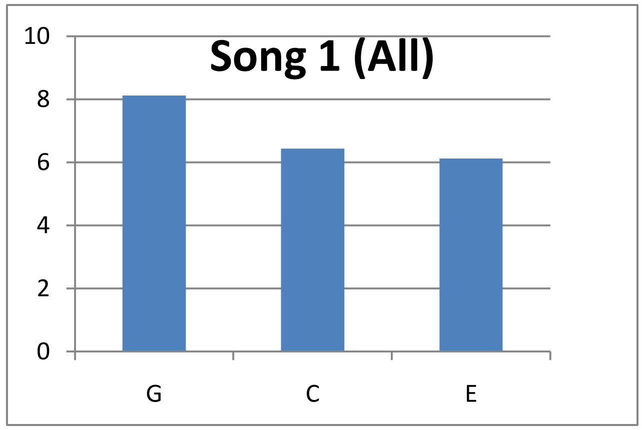


Figure 6

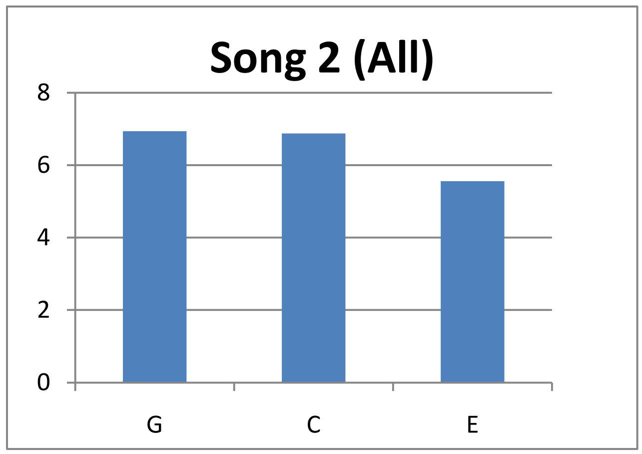


Figure 7

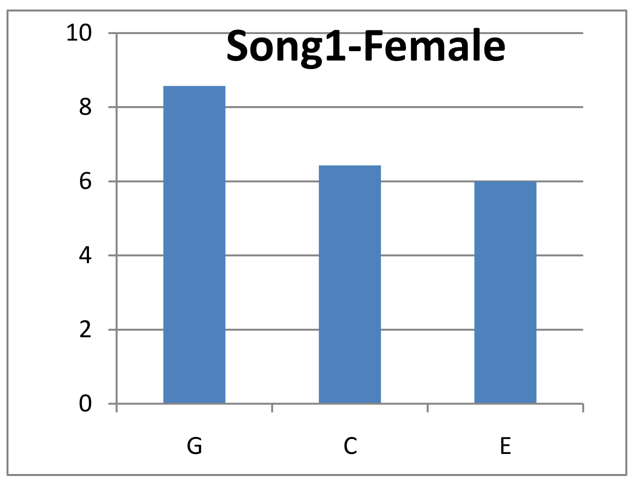
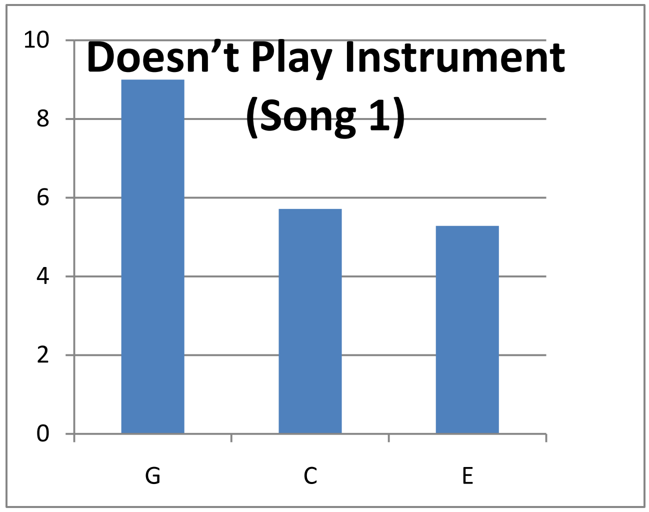
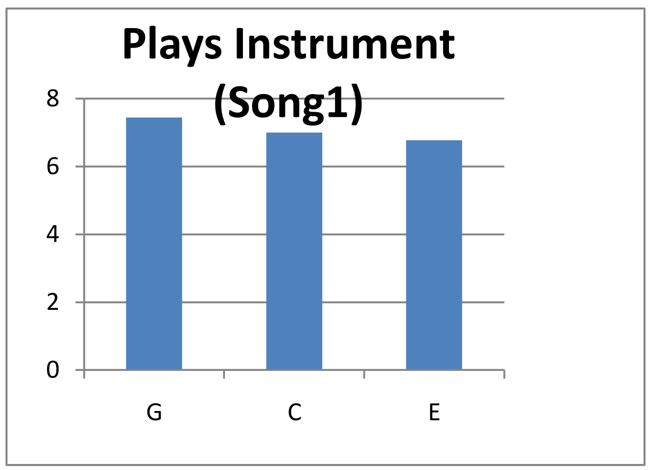


Figure 8



Then the results from the people who do play instruments were looked at. The results are shown in figure 9. This bar graph shows that the averages of the likeability of the three keys are very close. Compared to the people who do not play instruments, the people who do play, seem to have a higher range of appreciation for the different keys.

Figure 9



Conclusion

The conclusion of this study is that people like songs in lower keys more than they do in higher pitched keys. It also was found that people who do play instruments have a greater range of appreciation for the different keys than people who do not play instruments. The results of this study proved the hypothesis correct. Frequency was also a factor in this study. Each song that was played in the three different keys had its own set of frequencies. The higher the key, the higher the frequency of the sound waves became. The result that this study shows is that the higher the key of the song the less people like it. This is probably why the siren on a fire truck plays such a high note. They use a high note which has a high frequency to get your attention.

Future Work

In the future the results and information from this study can be used by businesses and companies that use music or sound. An example would be a ring tone company. A ring tone company could use this information to create more alterative ring tones by making ring tones with high pitched notes and high frequencies.

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