

Further Study of Music Visualization: Chladni's Figure

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Abstract. By applying the principle of standing waves, the various scales produced by a piano within music software can be transformed into Chladni figures. These figures, which visually represent the vibration patterns of a surface, can be captured using photographic equipment. By carefully selecting the most accurate patterns and organizing them into a comprehensive table, it is possible to create a visual representation of Chladni figures corresponding to each musical syllable. This method provides a unique way to visualize the acoustic characteristics of different musical notes.

Keywords: standing waves, Chladni's figure, music visualization.

1. Introduction

In contemporary discussions, music visualization has emerged as a captivating subject of exploration. Numerous prior experiments have delved into diverse methodologies, employing elements like fire, to illustrate distinct visual phenomena that coincide with the production of music. Such approaches have proven invaluable in aiding scholars and physics researchers in intuitively grasping the underlying principles governing the formation of music, specifically the transmission and modulation of waves. Consequently, in the context of this study, an alternative method will be employed to visually depict the unique phenomena associated with each musical note. This innovative approach aims to enhance our understanding of the intricate interplay between sound waves and visual manifestations, contributing to a richer comprehension of the dynamics involved in music creation.

2. Background Information

Standing wave, combination of two waves moving in opposite directions, each having the same amplitude and frequency. The phenomenon is the result of interference; that is, when waves are superimposed, their energies are either added together or canceled out. In the case of waves moving in the same direction, interference produces a traveling wave. For oppositely moving waves, interference produces an oscillating wave fixed in space [1]. In history, several attempts were made to experimentally test the graph of standing waves. Taylor and Geoffrey Ingram visualized the formation of standing waves on the surface of water in a tank [2]. Hasegawa, Y., and Ph Avouris observed the standing wave in a different medium, namely electron gas [3]. Chladni patterns are also a topic in physics education where teachers present the patterns by using drumheads [4].

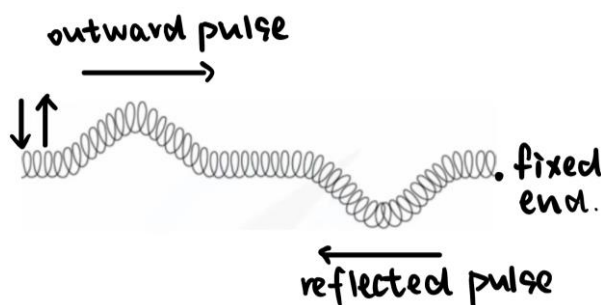


Figure 1. Formation of a stationary wave on a stretched spring fixed at one end [5].

In this study, the properties of standing waves are investigated. A vibrating rope tied at one end will produce a standing wave, as shown in figure 1. In figure 2, the diagram of stationary waves is

presented. The wave train (line B), after arriving at the fixed end of the rope, will be reflected back and superimposed on itself as another train of waves (line C) in the same plane. Because of interference between the two waves, the resultant amplitude (R) of the two waves will be the sum of their individual amplitudes. Part I of the figure shows the wave trains B and C coinciding so that standing wave R has twice their amplitude. In part II, 1/8 period later, B and C have each shifted 1/8 wavelength. Part III represents the case 1/8 period still later, when the amplitudes of the component waves B and C are oppositely directed. At all times there are positions (N) along the rope, called nodes, at which there is no movement at all; there the two wave trains are always in opposition. On either side of a node is a vibrating antinode (A). The antinodes alternate in the direction of displacement so that the rope at any instant resembles a graph of the mathematical function called the sine, as represented by line R. Both longitudinal (e.g., sound) waves and transverse (e.g., water) waves can form standing waves.

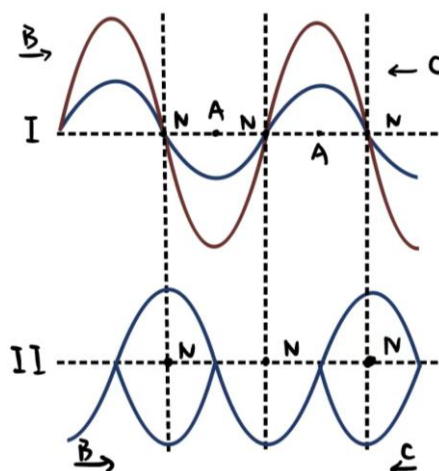


Figure 2. A graphical representation of how stationary waves are formed [1]

3. Experimental Arrangement

Table 1. The Equipment used in the experiment

Equipment	Quantity	Use
Sand	Plenty	Used to form the desired pattern
Tape	Plenty	Used as a tool to connect paper with audio
Brush	1	Used to lay the sand evenly on the paper
Paper	Plenty	Used as a pattern for placement
Sound	1	The beginning of the wave
Scissor	1	Used to build the paper into the desired shape
Camera	1	Shooting experiment results
Compass	1	Used to draw circles on paper
Computer	1	Used to provide different syllables
Gradienter	1	Make sure the test unit is in a horizontal position
Connecting Line	1	Connect the computer to the stereo

4. Set-up Diagram





Figure 3. Set-up Diagram









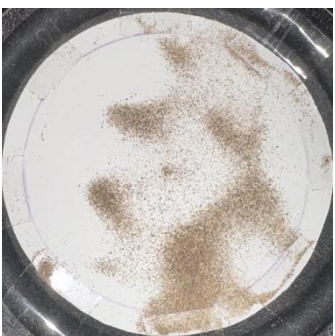

5. Method and Procedure











1. Prepare the experiment materials in table 1.
2. Set up the experiment as shown in figure 3.
3. Use a compass to draw a circle with the same radius as the sound on the white paper.
4. Cut several pieces with scissors.
5. Cut the tape with scissors and stick the tape evenly on the paper.
6. Tape the tape round to the stereo.
7. Use a level to check whether the disk is in a horizontal position.
8. Place the appropriate amount of sand on the disc.
9. Apply evenly with a brush.
10. Connect your stereo to your computer with a cable.
11. Open GarageBand and select a classic piano
12. Click the button from the high pitch.
13. After several clicks, a stable pattern is formed and recorded with the camera.
14. Click the next button.
15. Repeat steps 11 to 12 four times.
16. Repeat steps 3-13 several times until all registers have been recorded











6. Data Collection











Table 2. Visualized pattern by octave and key

Octave	Key	Figure	Octave	Key	Figure
C6	J		C4	S	

C6	H		C4	A	
C6	G		C3	L	
C6	F		C3	K	
C6	D		C3	H	
C6	S		C3	G	

C6	A		C3	F	
C5	L		C3	D	
C5	K		C3	S	
C5	H		C3	A	
C5	G		C2	L	

C5	F		C2	K	
C5	D		C2	H	
C5	S		C2	G	
C5	A		C2	F	
C4	L		C2	D	

C4	K		C2	S	
C4	H		C2	A	
C4	G		C1	L	
C4	F		C1	K	
C4	D		C1	H	

7. Uncertainties

In the experiment, different attempts were made to get more accurate results. First of all, through the experiment found that compared with the relatively hard cardboard paper, the softer A4 paper can better display the specific pattern of syllables. Secondly, in the adhesive tape, compared with the entire circle tape, paste eight adhesive tapes with the same length and width on the circle, and the same contact area with the circle can better show the pattern and reduce unnecessary errors. In the whole experiment, a very important condition to ensure the accuracy of the experiment is in the horizontal position, and through the use of the level, you can avoid the error caused by not many levels to the greatest extent. The disc is replaced many times in the experiment, but also to ensure that the connection between the disc and the sound is close and will not be separated with the vibration of the sound. The result of the experiment is listed in table 2.

8. Conclusion

From the experiment, we intuitively feel the different patterns brought by different syllables through the medium of sand. By recording, we can get different Chladni's figures for each syllable, to achieve the purpose of music visualization.

References

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