

On The Acoustic Characteristics of Athabasca Falls, Canada

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Abstract — People's health is closely related to the living environment. In natural environments, most white noise has the effect of relieving stress and relaxing the body and mind, whereas prolonged exposure to metropolitan noise can be harmful to health. The sound of Athabasca Falls studied in this paper is also one of the sounds that convey health to humans. Analysis of the spectrum of the Athabasca Falls sound reveals an acoustic characteristic that resembles white noise and has three prominent resonant formants. We also experimented with measuring the listener's EEG to find out how sound acoustics affect human psychology. As a result, the Athabasca Falls sound stimulated more α and β EEG. This is what tells us that the cascading sound reduces stress and keeps the brain active and healthy.

Keywords — Athabasca Falls, Frequency, EGG, Resonance frequency, White noise

I. INTRODUCTION

As society progresses, health care and living standards have improved, but many are still in sub-health conditions associated with high-load work environments, greater social pressures, and unhealthy people. The living environment is closely related to people's health. People's hearing system, in particular, is a keen warning system and works even during sleep. Research on the psychological effects of sound has shown that sound can influence emotional changes in people. For example, listening to calming songs can make people comfortable, and listening to rock songs can get them excited. In other words, sounds can have a direct effect on human emotions, which can greatly affect people's mental health. The psychological effects of these sounds are directly related to their acoustic properties. For example, urban noise mainly corresponds to low-frequency, high-energy noise. Long-term exposure to such a noisy environment can reduce people's cognition and behavior, make life tired, and cause negative emotions such as mental and physical irritability, anger, and depression. Therefore, it is very important to improve people's healthy environment.



Figure 1. Breathtaking view of Athabasca Falls from the bridge.

For those who live in the city, there are great ways to stay healthy on weekends. Far from the city, you can enjoy the richness of the five senses while experiencing nature through hiking, beach or forest walks, outdoor camping, and outdoor activities close to nature. If not, you can bring the sounds of nature to the city center and enjoy. Most of the sounds in the natural environment are comfortable and consist of white noise. For example, when you hear the sounds of wind, rain, flowing streams, waterfalls, etc., people feel comfortable, and as a member of nature, the sound is beneficial to health.[1][2]

This paper is a study of the human body effect on the sound characteristics of the world-famous waterfall Athabasca Falls. The Athabasca Falls is one of the waterfalls in the northern part of the Rocky Mountains and look like Figure 1. The flow of water collects a large area upstream and merges into a strong flow, pouring into the breath of the waterfall and falling into the valley. The drop is within 20 meters, but a huge amount is collected and flows with a loud roar. Just standing on a nearby crossing bridge is truly magnificent and magnificent in harmony with the surrounding landscape. And because of the terrain, unique acoustic properties appear.[3][4]

Because this paper studied the acoustic and psychological characteristics of Athabasca Falls, it mainly deals with Athabasca Falls' sound frequency spectrum analysis and EEG analysis. In Chapter 2, the characteristics and applications of white noise were introduced, and in Chapter 3, waterfall sound spectrum analysis was performed. In Chapter 4, while introducing EEG, we measured and compared city noise and EEG map of Athabasca Falls. We concluded in Chapter 5.



II. USE OF WHITE NOISE

The sound energy of white noise is evenly distributed over most of the human ear audible range (20Hz ~ 20000 Hz). In other words, white noise has an almost uniform frequency spectrum. In general, white noise is widely present in natural environments such as rain, waves, windy leaves, waterfalls, etc. In city centers, air-condition sound, fan sound, empty channel TV sound, vacuum cleaner sound, reading room noise, cafe noise, etc. [5][6] Since the wide frequency spectrum of white noise provides all the frequency components that the human hearing can feel, these sounds are generally considered natural and relaxing sounds. Many papers, such as medical physiology and human psychology, have shown that white noise can have a positive effect on people. White noise is often used as a means of sound therapy in the treatment of tinnitus, inducing sleep, and treating mental disorders in some hyperactive children. White noise is also used in industries and offices because the energy distribution in the frequency spectrum is almost uniform. It is used to increase the concentration of learning in the reading room or reading room. It is also used in banks and insurance companies to protect personal privacy and block neighboring wiretappings. In particular, white noise is also used to neutralize the noise between floors in the home.[7] White noise is classified into pure white noise, brown noise, and pink noise according to the characteristics of the spectrum. These are classified according to whether they are more suitable for the characteristics of human hearing. As the frequency increases compared to pure white, the amplitude decreases to -10dB/decade, -20dB/decade, etc. So, the pure white sound is a white noise with characteristics that sound soft and pleasant compared to white noise that sounds very rough. Therefore, white noise in nature is closer to pink noise than pure white noise.[8][9] In the time domain, white noise appears as a continuous non-periodic waveform with uniform amplitude, as shown in Figure 2(a). In other words, there are no special rules and rhythms, and multiple waveforms form a complex structure. Also, in the spectrogram of white noise, energy is more evenly distributed in the frequency range of 20Hz to 20KHz, as shown in Fig. 2(b), and a specific distribution of resonance energy does not appear.

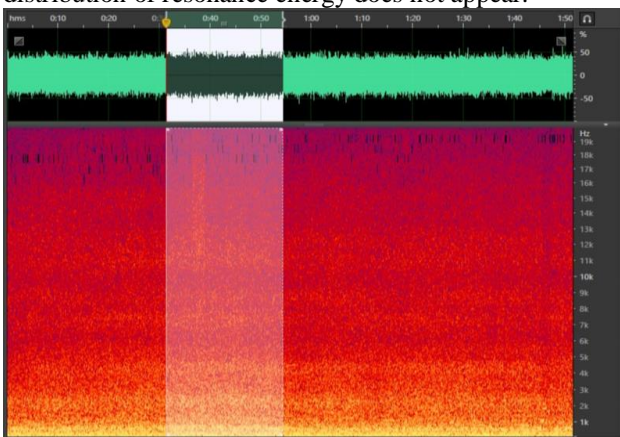


Figure 2. Waveform and spectrogram of the white noise

III. SOUND SPECTRUM ANALYSIS

Figure 3 uniquely shows the resonance spectrum of Athabasca Falls. This spectrum shows the characteristic of a uniform white sound in the frequency range of 20Hz to 20KHz, but it also shows the resonance characteristic of waterfall sound. In other words, 6 resonance formants appear prominent in the locations of 170Hz, 300~700Hz, 2KHz~3KHz, 6~9KHz, etc. This is closely related to the topography of Athabasca Falls, the flow of water, and the sound of splashing.



Figure 3. Resonance Spectrum of the Athabasca Falls sound

The first formant (100 ~ 300Hz) is formed by the sound of water flow in a large space and the resonance of the surrounding geographical spatial environment. The second formant (300 to 700 Hz) forms a turbulent flow by converging two water streams, and because the turbulence has a high sound wave frequency, it forms a higher frequency formant with the surrounding geographic spatial environment. The third formant (6-9KHz) is a high-frequency acoustic resonance that occurs when a stream of waterfalls from a height and hits rocks and water. [11][12] The acoustic properties of Athabasca Falls include not only the acoustic properties of white noise but also other properties brought about by the three formants. This constitutes the unique acoustic characteristics of Athabasca Falls. Sounds with different acoustic properties can have different psychological and physiological effects on people, so listening to the sounds of Athabasca Falls is a unique experience. White noise induces α brain waves, quickly making people quiet and comfortable. At the same time, β brain waves, induced by the high-frequency formant structure, improve people's attention and cognitive abilities. It will put people into a state of quiet and comfortable meditation with high concentration and cognitive ability, which is very suitable for thinking. [13][14]

IV. BRAIN WAVE MEASUREMENT

EEG signals respond to the activity of cortical neurons. EEG observation is an important means of obtaining information about brain activity and is an objective indicator that reflects the state of brain function. According to EEG studies, according to the frequency and amplitude characteristics of the EEG signal, it is mainly divided into four types of EEG waves: δ wave, θ

wave, α wave, and β wave. β waves are usually divided into low β waves (β_L) and high β waves (β_H). These brain waves correspond to a range of different frequency domains. In order, the frequency of the δ wave, θ wave, α wave, β_L wave, and β_H wave gradually increases, and the amplitude gradually decreases. The appearance of different brain waves reflects different brain function activities.[15][16] δ wave, frequency 1-3 Hz, amplitude 20-200 μV , mostly appear in a state of deep sleep, cortical neurons are in a state of simultaneous relaxation and do not participate in the process wave of information processing. θ wave, frequency 4-7Hz, amplitude 100-150 μV , brain waves appearing between waking and sleeping. And it has to do with the memory process. It also occurs when emotionally aroused, especially when you are disappointed or frustrated. α wave, frequency 8-13Hz, amplitude 20-100 μV is the main waveform recorded in a normal quiet state, sober and closed eyes, indicating that in a quiet state, the cortical neurons are relaxed and ready for activity. Since the advent of α waves can quickly make people comfortable, many people take a break while listening to α wave music. The β wave frequency is 14-30 Hz and the amplitude is 5-20 μV . It appears when people perceive actions and actions. Usually the brain thinks about problems or performs intelligence. Waves are converted into these waves during cognitive activity. The β wave reflects the state of alert in the human brain. Cortical nerve cells are in a state of intense activity-cortical excitation. The continuous appearance of a large number of β waves will put a lot of pressure and tension on people. The experiment first recorded the sound of the traffic environment and the sound of the Falls for 1 minute each. The EEG test site is in a quiet laboratory and the subject is a 22-year-old male. The test instrument is a two-channel EEG measurement instrument with a sampling rate of 512 Hz and a bandwidth of 45 Hz, created by Neuro Harmory S. After setting the meter for the test subject, the test subject remains silent with eyes closed. After making a sound for 3 minutes, measuring the EEG, after a 5 minute break, the operation is repeated. Finally, the EEG measurements of the two sound environments are completed. The waterfall sound seen in the EEG reduces the θ wave, and more α and β waves appear. This means that waterfall sounds can stimulate α and β waves in our brain and suppress θ waves. The α wave puts people's brains into a state of quiet relaxation. At the same time, since the θ wave decreases and the β wave increases, the brain is awake and has high concentration. At this time, people will have a comfortable and clean mind. This is a very comfortable state and has a positive effect on people's health. Conversely, the sound of city traffic makes the brain more visible θ waves, suppresses the production of α waves, and slightly reduces β waves. Many studies show that having more θ waves and less β waves can make people tired and lose concentration. These brainwave patterns are prone to depression for long periods of time. It also shows that different sounds have different effects on people's brainwave activity. So for those who have been in the city traffic noise for a long time, hearing the

sound of a waterfall can relieve stress and concentration. Table 1 shows the voltage values of the various brain waves of the two sounds. Figure 4 compares various brain waves of the two sounds. [17] [18]

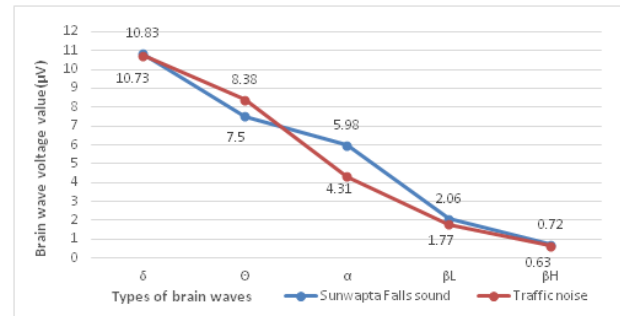


Figure 4. comparison of various brain waves of two sounds

Table 1. Voltage values of various brain waves of two sounds

Brain wave(μV)	δ	θ	α	β_L	β_H
Sound type					
Athabasca Falls sound	10.83	7.50	5.98	2.06	0.72
Traffic noise	10.73	9.08	4.31	1.77	0.63

V. CONCLUSIONS

A healthy environment is closely related to people's health. Especially for people living in cities, noise pollution is a serious problem that harms both mental and physical health. In fact, there are various healthy sounds in nature. They not only make people feel comfortable and comfortable, but they can also keep people healthy. For example, the sound of wind, rain, waves, waterfalls, flowing water in nature. Hearing these sounds can relieve people's stress and relax. The sound of the falls studied in this paper is also a sound that is beneficial to health. Because of its unique terrain, it constitutes unique acoustic properties. Spectral analysis showed that the frequency density curve was flat, similar to white noise. There are also three resonance formants. Therefore, due to these acoustic properties, Athabasca Falls sounds have their own psychoacoustic properties. White noise can stimulate α brain waves, and formants appearing in the high-frequency band can stimulate β brain waves. Even in the EEG test experiment, it has been proven that hearing the sound of the line wapta waterfall can stimulate more α and β EEG and suppress θ EEG. People will be relaxed and focused, and the body will be full of vitality. So, those who have been exposed to city noise for a long time stay away from the noisy city and get closer to nature. Hearing the sounds of nature can improve the sound environment. In this healthy acoustic environment, it can reduce people's stress, increase attention and benefit their health. And hiking, hiking, camping, and other activities are healthy sports. Participating in these activities is good for our physical and mental health.

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