Cassette Abuse

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ABSTRACT
This paper explores the manipulation of sound through the physical abuse of cassette tapes, using various physical experimentations. The authors investigate the potential of a 4-track recorder with various inputs and outputs, and test the limits of cassette technology to produce novel musical effects. Additionally, the authors will discuss their experimentation process, and analyze the newfound effects. Drawing off the works of various cassette artists/innovators, the authors aim to demonstrate the untapped potential of cassette tapes as an instrument in themselves. Using newly acquired strategies instead of modern technologies, the authors will attempt to create a musical composition with a unique sound.

1. INTRODUCTION
Alongside technology, music has evolved into a concept far past tangibility. Kids find themselves disillusioned that modern musicians sit in front of a screen to turn abstract ideas into reality. We want to backtrack that mindset, and demonstrate how music exists physically in the domain of analog electronics. Cassette tapes, a tangible storage format that impacts perception of time and space, were once a widespread necessity, but now a source of hipster nostalgia. How can the listener's perception be manipulated through physical stress on these tapes? In this project, we experiment with different forms of physical abuse on cassette tapes in order to manipulate sounds in a novel way, with magnetism as the impetus for exploration. Consequently, the musical potential of a studio-grade 4-track recorder is tested. The recorder has an abundance of inputs and outputs. Moreover, we intend on demonstrating these new effects with an original composition.

2. BACKGROUND
The musical world of tape experimentation is massive. People love the low-fi feel of the analog technologies, yet none of this art seems to target the science of the magnetic tape. Regardless, the field of cassette mutilation is active and popular, and comprises several artists who grant us a better understanding of what we are beginning. First, it is important to summarize the work of artists in the field of tape. Then cassette technology is researched, to inform our future hypotheses.

2.1 Influences
Nowadays, one of the most notable cassette artists is Howard Stelzer. There does not exist much literature about what Stelzer does to his cassettes, but his clear intention is to alter sound beyond recognition. In an interview, he said: “I’d record some sound to a tape, and instantly hear how the medium radically altered the acoustic source. I could dub and overdub tapes, splice them with pause buttons, overload a sound into a condenser microphone and right away hear something utterly separate from whatever initiated the signal in the first place” [1]. We personally feel very similar with cassettes, and while our first author has not done nearly as much stretching of their capabilities, we have been attracted to some unique sounds that emerged while just overloading the signal in the 4-track Fostex XR-7.

Artist G Lucas Crane is also noteworthy. Likewise, the sounds of his music are dystopian, and unrecognizable. In many ways, it feels similar to Stelzer’s music; very acousmatic, hypnotic, and mysterious. As described by Crane himself, his music is “information anxiety, media confusion, sonic mind control and time skullduggery” [2]. Like Stelzer, it is unclear exactly how Crane mutilates his cassettes, but it seems to be a mixture of sampling, collaging tape, and signal overloading. The mindset of this man is highly influential to us. Music is a sonic representation of time and space, and cassettes offer us a physically tangible way to manipulate that environment. These ideals must be somewhat accepted by us, since our musical exploration can turn out to be super dystopian.

There are several other artists we could have described, such as Form a Log or Lauren Pakradooni, but, because this scene is so obscure, it is difficult to find specific information. All this research, though, has been very formative to our mindset about our own project. The cassette deserves respect as an instrument itself. Reading all of these artist’s bios, they all say something similar: traditional instruments can be boring and modern musical technologies are suffocating, but cassettes are an untapped medium with barely any research nor innovation applied to them. We are adopting that mindset, which is making us more excited by our project.

2.2 Background Research
The specific mutilations we have tried are relatively untested. One non-professional YouTube video does show off some similar ideas to this project, but certainly not to the extent we do [3]. Additionally, the video creators certainly broke their machine which caused most of the distortion effects.

Magnetic recording is a fundamental technology for permanently storing data. Moreover, magnetic tape can be easily erased and rewritten. A magnetic audio recording system consists of a recording and playback device, and the data-storing tape. The tape is made with a thin, flexible plastic base. Adhered to the tape is a coating of ferromagnetic powder. Ferromagnetism indicates how well a material responds to an applied magnetic field. In this case, the powder becomes permanently magnetized by applied fields. When recording, a tiny electromagnet is powered by an input audio signal. The magnetic flux becomes stored on the tape, and the audio signal can be played back. During playback, the tape passes under a magnetized head, which bobs up and down according to the stored audio signal.

There are many types of ferromagnetic powder used to create tape. In this study, we will be using Type 1 & 2 tape. The Fostex XR-7 manual recommends that users record with Type 2 cassettes. Though, it ought to work reasonably well even with Type 1. The powder used on a Type 1 tape is ferric oxide, a cheap and highly ferromagnetic material. Type 2 tape infuses the powder with chromium dioxide, giving it a higher necessary bias than Type 1 to avoid distortion. We hypothesize that incorrect biasing, in addition with overloading, may produce desirable distortion, particularly of the lower frequencies [4].

Given that we have selected five initial modes of tape mutilation, it is important to address what they may do or issues they may cause. Water and bleach have been tested by others with great success, though the tapes must be completely dry before being set in the Fostex. The effect of ovens and freezers upon magnetic tape is unresearched, and may damage the plastic base of the tape. Lastly, there was no research found concerning the effect of electrical current through magnetic tape. Though it poses no threat to the Fostex, it will likely be challenging to determine a current that will not destroy the tape, while providing acoustically useful changes. Guided by the work of previous artists, we will push forward the understanding of magnetic tape and its potential as a compositional tool.

3. PROJECT DESCRIPTION

In order to maintain scientific consistency, we specify a strict process, and plan out each abuse.

3.1 Process

First and foremost, we created one 6-minute track of different samples and sounds to manipulate. This included different permutations of drums, bass, guitar, vocals, synth, white noise, sine waves, square waves, and a full song ("Creep" by Radiohead). The track summed up to about 6 minutes of somewhat non-musical sounds.

Prior to any cassette stress, we recorded our sample track onto track 1 of the cassette. Next, we would commit the desired abuse on that recorded-on cassette, then record the output of the tape back into the computer to be studied. To be thorough, we recorded the original sample track onto the cassette yet again after the abuse, in the case of any new interactions, and finally, back into the computer to be examined further.

Many of the stresses required specific, case-by-case care. Oftentimes the cassette would be left wet, and we'd be required to dry it out prior to reinserting into the recorder. A good chunk of the stresses required opening up the casing and targeting the tape itself to maximize the effect. Altogether, a priority was to ensure our recorder was left unharmed throughout.

3.2 Materials

We used two primary types of cassettes. Firstly we used some wiped Maxell XL-ii type 2 off ebay, directly from the 90's. Additionally, we used blank type 1 Spartan MKII tapes to test any differences in fidelity. The tape recorder we used was the Fostex XR7, a 4-track, multichannel recorder created in 1994. Finally, we used Pro Tools for all recording onto the computer, along with a Scarlett Focusrite to input the signal. Audacity was used for later analysis.

Figure 1: The Fostex XR7

4. Abuses

When planning the project, each stress needed to test a different condition on the cassette; no overlapping concepts. We will describe each abuse applied, as well as the entailed process.

4.1 Water

As the first experiment in our project, room temperature water served as a proof of concept for our process. We learned how to handle the tape, opening the casing when required, and how to properly dry off the device prior to reinserting into the recorder. We first soaked the cassette for 5 minutes, only to find nothing. Thirty minutes also proved null. After leaving the cassette in a water bowl for over 24 hours to no avail, we deemed that the tapes are too resilient for water.

4.2 Bleach

First, we left the cassette in bleach for one hour. After seeing no effect, we left the cassette in bleach for 24 hours. Due to having to open the casing to dry out the tape, we had to spend time respooling the tape. Notably, all kinds of dark chemicals stained our fingers, and the tape itself was losing color; we believe the iron was rubbing off onto our hands due to the bleach. Despite this abnormality, no sonic effect was noticed due to bleach.

Figure 2: Chunks of black chemicals fallen off the tape, laying in the tub of bleach.

4.3 Isopropyl Alcohol

We did not bother testing a small duration for isopropyl alcohol. After soaking the cassette for 24 hours, we noticed that physically, the tape was different. It was rigid and curved, and insanely annoying to respool. Despite the strange shape, yet again, we have noticed no effect.

Figure 3: Rigid tape after isopropyl alcohol

4.4 Heat

At this point, we deemed that liquids altogether were going to continue to prove ineffective. In turn, we attempted to heat up the tape. After deliberating over which heating method would be most feasible, we decided to focus a hair dryer directly onto the tape itself. This was certainly a mistake, and we ended up blowing around a good chunk of the tape, unspooling it; we required a couple hours to set the tape back into place only to find no effect.

4.5 Cold

Freezing the tape proved to be the least eventful strategy. We left the tape in the icebucket of a freezer for over 24 hours. Not having to open and respool the tape, though, proved awfully convenient. Still, however, no sonic effect was discovered.

4.6 Scratching

After the temperature manipulations proved uneventful, we realized we needed to begin more intense abuses. All the original strains we had planned until this point seemed useless, and we needed to get more creative to harm these resilient devices. To perform scratching, we jammed sandpaper inside the casing, such that as the tape was moving, it would rub against the sandpaper. We then placed the cassette into the recorder and fast forward and rewound the tape 2 times. What we noticed was that one line was being etched into the tape from the point of most pressure. When listening back to the tape, we heard no effect, likely because the etched line did not cross track 1 (with our recording). We displaced the sandpaper and repeated this process a few times, to try and scratch over our sound.

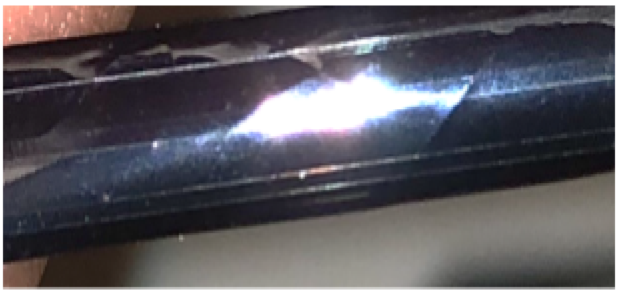

Figure 4: Zoomed in to show etched lines along the tape caused by scratching

After continuously hearing no effect, the tape itself eventually snapped. In theory, scratching could still have an effect if we were to find a way to affect the whole width of the tape at once. In the scope of our experiments, however, we deemed scratching to be inconclusive.

4.7 Rubbing

Similar to the sandpaper, we jammed a pencil eraser into the casing. This one was tricky because we had to cut the eraser to the perfect shape and size. Listening back, we noticed that we no longer heard the cymbals from the drum loop. It seems that a lot of the higher frequencies were being cut out somehow. The effect is most comparable to a low pass filter. Finally, we discovered an effect, but it sounded very dull. By now, we were relieved that some form of manipulation was possible, but

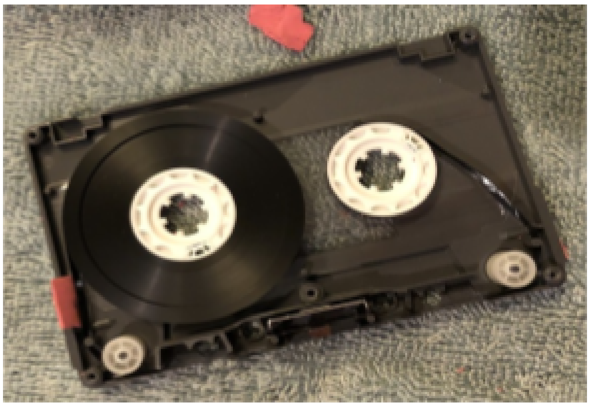

Figure 5: Eraser jammed on left rubs against the tape as it spins

disappointed that it was not very interesting.

4.8 Magnetism

Magnets proved to be most fascinating. Notably, we always required extra care because magnets can irreparably harm the recorder's reader. For our first attempt, we used a thin fridge magnet, placing it at several points within the cassette's casing. No effect was noticed after running this weak magnet across the tape. We met again, and this time brought heavy duty magnets. Our first instinct was to disassemble the cassette and rub the magnets against the tape itself. It should have been obvious that the magnetism was too strong when the tape was sticking to the magnets and unraveling. When listening back, the sound had been completely erased. Through some stroke of luck, we had used type 1 cassettes that day, because the next attempt was with a type 2, and we noticed an enormous difference. The magnetism was extremely weak with the latter because of the chrome compounds on the tape. At this point, we were confident that magnets were our destiny.

The optimal strategy we found was to place the type I cassettes into the reader, and then place one or two magnets directly on

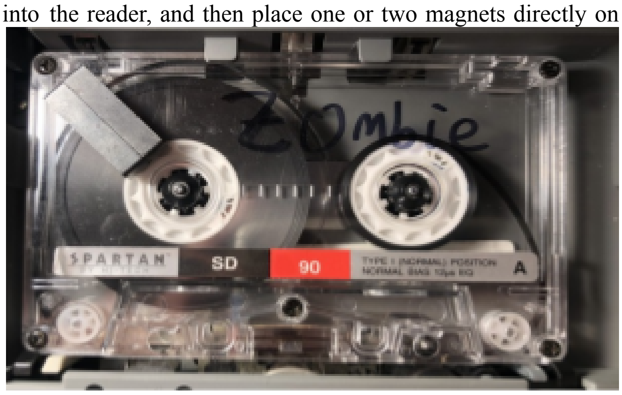

Figure 6: Magnets are placed atop the cassette as it spins. Later called the "Original" configuration.

top of the cassette's casing; the casing serves as a buffer so that the whole sound is not immediately erased, but still allows enough magnetism through.

5. DISCUSSION

5.1 Scope

Given that most attempted abuses do not provide noticeable or musically useful effects, our research focuses on the impact of magnetism upon the tapes. Water created no discernable change, and did not affect the physical integrity of the tape. Bleach caused the ferrite to strip substantially, but to no perceptible avail. Isopropyl caused the tape to become significantly more rigid, making it crimp easily, though it resulted in no sonic effect. Cold had no effect, while heat is unreasonable to test given the cassette format. Though scratching visually damaged the tape, an extreme amount of abuse caused no audible effect. Lastly, a pencil eraser did create a steep low-pass effect around 8k Hz. We presume this is because the eraser can give off small, adhesive particles that block magnetic waves.

5.2 Magnetic Effects

The effects of magnetism are many, comprising both predictable and noisy changes. The tests were run using the thin, clear plastic of a type 1 cassette. During tests with type 2, it was discovered that the chrome compound is far more resistant to stray magnetism. The inner guarding plastic sheet is removed, as it blocks magnetic interaction. The test magnets are up to four grade-5 ceramic ferrite blocks.

First, to gauge what effects we could achieve intentionally, a looping testing sound file was created using five-seconds of our test vocal separated by five-seconds of silence. The file loops eight times. The magnets were initially laid in three test positions: two in the top-left corner, some on the right of the left reel, and two uniting the left and right reels (Figs. 6, 7, & 8).

Figure 7: The "Beak" configuration

Figure 8: The "Bridge" configuration

Immediately, upon laying the magnet anywhere during playback, the sound level drops substantially (typically -18 dB). After a few seconds, the signal has developed both a prelay and delay. Leaving the magnet for many loops causes the echo to strengthen, creating quiet swells between the recorded test vocals. Laying the magnets across the reels causes the effect to intensify further and more rapidly. Lastly, laying a group of magnets on the right side of the left reel causes the most attenuation with the littlest noticeable effect. This configuration can also be used to pull the tape so hard it slows down, even to a stop, creating pitch shifts and wobbles. During testing, we opted for a fourth configuration, "the Eagle," as shown in Fig. 11, to produce all effects.

Second, understanding that magnets immediately dampen the signal and cause an echo, a new test file was made out of the guitar recordings, including heavy strumming, light picking, and long harmonics. This file differs in that it has much less looping material. In these tests, much less echo was created with the same magnet configurations. However, sections of audio expected later in the tape began to appear as prelays. We conclude that the magnet not only causes delay, but can "pull" audio through layers in the tape. Thus, the test file was looped six times and we began our analysis of magnetic effects using Audacity.

5.3 Spectral Analysis

Viewing the difference spectrographically, three changes are noticed: temporal blurring, high-frequency damping, and full-spectrum noise. It is apparent when the magnet interacts strongly with the tape; a salient section of noise is noticeable. This can be seen around 30 seconds, 2 minutes and 45 seconds, and near the end of the file. Heavy interaction causes steep attenuation of the high frequencies and an overall decrease in intensity. Following the initial placement, magnets were set across the reels. As the tape rolls, it does not lose quality continually without a strong interaction. Rather, the echo becomes repetitive and predictable. Lastly, we attempted to erase the tape using magnetism. Through the case, it took approximately 1 minute to wipe the tape of discernable material even with strong interaction.

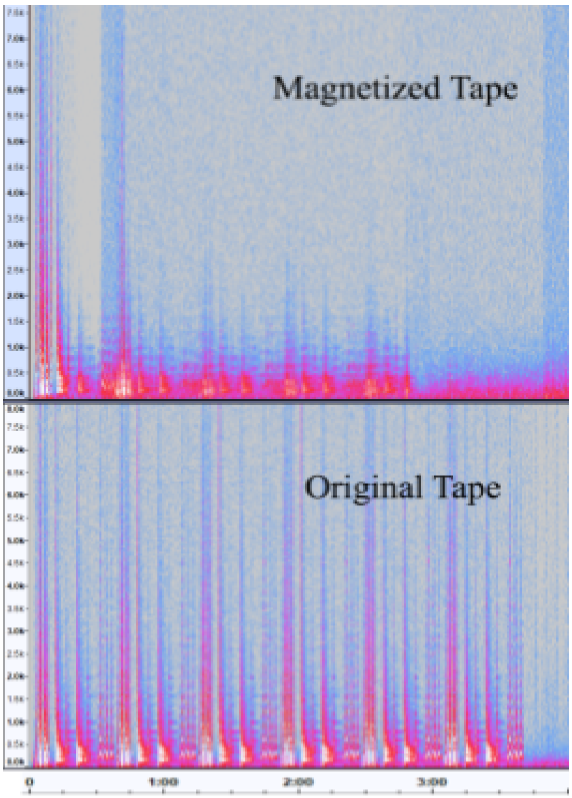

Figure 9: Magnetic effect on tape

5.4 Temporal Analysis

Understanding that the echo effect can be predictable within a 3-minute timeframe, we sought to understand the distances of the delays. So, the magnetized tapes are analyzed in the time domain to determine the frequency of the echo. It is found that the prelay and delay often share similar timing: about 1.4 seconds. This is sufficiently consistent across the 3-minute test.

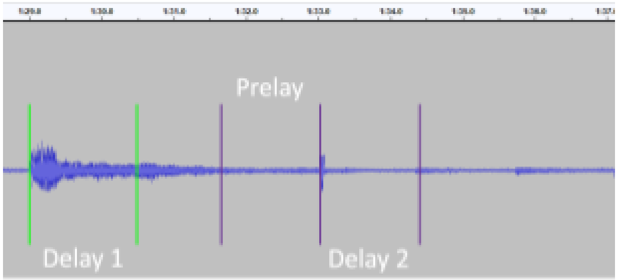

Figure 10: Echos on magnetized tape

Given a 1.4 second delay with one pass through the magnet, it is concluded that tempos of a factor of 36 are most compatible for recording, at least within a 3-minute song.

6. MUSICAL USAGE

We began the process by creating a drum track electronically, and then playing bass and guitar over it. To truly stretch the sonic palette, we experimented thoroughly with a variety of guitar pedals including pitch shifter (Whammy), chorus, EQ, and compression. As we arranged these instruments, our personal hard rock inspirations became clear, but we also kept in mind that a psychedelic edge would become clearer when applying magnetism.

We found it useful to divide the instruments and apply magnetism uniquely to certain ones. An example was during our introductory section. We had drums, bass, pitch shifted bass, guitar, and bongos. We extracted the guitar alone onto a cassette, and applied magnets in the “Eagle” configuration (shown in Fig. 11). As we’ve noticed, the sonic effect of the magnets could be unpredictable. In this case, we discovered a new sound: a combination of a wah, delay, and reverb.

Figure 11: The “Eagle” configuration

The process of songwriting with magnets blended quickly with experimentation. We found ourselves only using the computer for arranging and holding samples, and most of the sonic effects were fully created using magnets and our recorder. What if we isolated the guitar track and put 4 magnets in the middle and analog pitch warped, with extra low end? What if we repeatedly applied the same magnetism to one sample? What if we applied magnetism on the whole song at once? The ideas kept coming organically because the sounds kept proving unique and unpredictable. We are excited by the novel sound distortions, especially with the lofi feel in conjunction to the sound quality of the recorder itself. In the end, our composition became a proud representation of our experimental process.

7. CONCLUSIONS AND FUTURE WORK

Magnetic tape is a robust medium that is not easily damaged, except by controlled magnetism. It proved to survive temperature fluctuations, virulent chemicals, and mechanical aberration without losing information quality. Its weakest component is its thin plastic base. Because magnets can produce multiple desirable effects, do not harm the plastic base, and do not require removal of the case, they are the best and, thus far, only method to musically abuse cassettes.

In our work, we identified three different usable effects: low-pass filter, echo, and pitch flutter. These can be accomplished through four configurations described in this paper. Greater levels of magnetism, as in the "Original," (Fig. 6) cause more filtering and volume attenuation. Magnets in the "Beak" configuration (Fig. 7) produce the most discernible echoes with the longest tails. The frequency of the echoes is dependent on the diameter of the tape and the play speed. Pitch bend is produced by forcing a part of the tape upwards, creating friction as it rubs against components. Though it can be controlled manually, it often causes a tape stop. To create automatic pitch flutter, the magnets must be set in a stable but resonant way, such as in the "Eagle" configuration (Fig. 11).

For further development, the experiments may show vastly different results if the affected tape is of different or lower quality. We conclude that the magnetic tape used in our experiments is too challenging to damage and re-reel to any audible effect. Older formats may prove better. Further, magnets of different shapes may produce somewhat different effects or may aid in producing a predictable outcome. An electromagnet would grant far more control over the predictability and control of the abuse.

Regarding musical exploration, it is recommended that individuals reproducing this experiment come ready with patch cables and a bay of effects. Studio-level cassette decks come equipped with many inputs, outputs, and auxiliary channels. Combining the described magnetic effects with external devices in real-time can push this artform to another level.

We have deemed this experiment to be a wild success. Many times throughout the process, after hours of rereeling tape to no effect, we believed that our experiments were destined to fail. Our morale was low until, through a series of miracles, we stumbled onto magnets. Very little research had been done in this field prior and we are excited by the discoveries we have made.

8. REFERENCES

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