

Analog vs. Digital Music: A Never-Ending Struggle

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Spring 2023

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction:

Music plays an important part in nearly everybody's life. Everyone has a song that when heard, they are instantly transported back to a specific memory, and everyone has an artist or album that has helped them through a difficult time in life. Music has the power to influence people and whole cultures, and it has played a part in nearly every civilization since humanity existed. Given this, music listening technologies are a very important issue for most people. Whether it's listening to music live or on your phone, there are many different methods to hear your favorite songs that all have their pros and cons.

However, many of you may have noticed a recent resurgence of analog technologies like vinyl and cassette players. It has almost become a trend with many people turning to vinyl as their preferred method of listening. These people would tell you that their vinyl setup produces a much higher-fidelity sound or that they are listening to records as they were intended, and many of them are vehemently against digital counterparts like the CD, MP3, or streaming. While many may say that the vinyl craze is merely a trend, this is the first time since the introduction of the CD in early 80s where the vinyl is once again outselling the CD (Eagle, 2023). With the vinyl industry continuing to boom, it is currently expected to reach USD 2.6 billion by 2028 which is a compound annual growth rate of 8.4% (ESOMAR, 2022). Thus, the debate between analog and digital music is more prevalent than ever before. As a music lover and an engineer, this debate has always been intriguing to me.

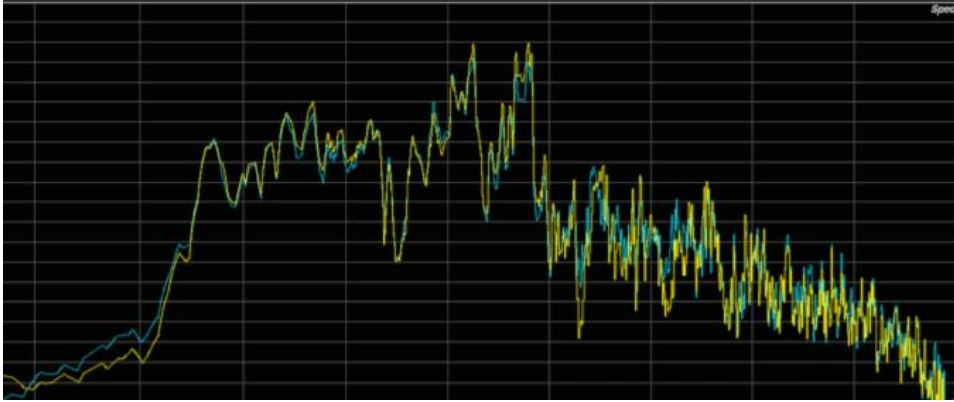
As a music fan, I want to believe that vinyl sounds better because that was the original method that many of my favorite records were recorded with, but the engineer in me knows that the digital technologies are much more sophisticated and often provide a much higher resolution in sound. Knowing this, I have always been interested in figuring out why the debate between

analog and digital music is so polarizing. Using articles, news stories, and studies, I have formed an analysis of how these technologies function, the biological limitations of what people can hear, the psychological reasons for people's preference, and a social study into people's opinions and why they hold them to get to the root of this issue. Through this research, I have found that most people's choices stem from personal preference. While there are slight differences in the technology and their physical signals, there isn't a noticeable difference to the human ear. Knowing this, there are much stronger mental and social forces that have driven this debate. By developing a framework to understand the technical, psychological, biological, and social aspects of this issue, the importance of the social and psychological forces over technical sophistication will be emphasized in the debate between analog and digital technologies.

Literature Review:

Prior to the introduction of the CD, every form of music distribution was analog. First it was vinyl, and then it was the cassette. Both technologies worked using physical parts that can record and transmit sound signals. A vinyl record works using a stylus and grooves. The stylus is placed into the grooves of the record. As the record spins, the grooves are nonuniform and outline the information of the desired sound signal. As the stylus moves along these grooves, it gains all the information it needs to produce the desired audio signal (Butcher, 2022). A cassette works similarly to a vinyl except it uses a magnetic tape to store and transmit the audio signal. Instead of a stylus, there is a magnetic head that also moves up and down according to the strength of the field on the magnetic tape. This movement is then converted into an audio signal that can create the desired music (Roemer, 2020). The fluid nature of these technologies is what makes them analog. The signal is continuous with no jumps or stops. This is what makes an analog signal analog.

A digital signal, on the other hand, is based off the ones and zeros that makeup the brains of a computer. Specifically, Pulse Code Modulation (PCM) is used to encode audio signals into binary information. PCM works by creating a “model of the sound waves by storing a sequence of numerical values that represent the amplitude at various points along a wave” (Mathias, n.d.). Basically, there are individual bits of data that help outline the audio signal. Think of these bits like checkpoints along the signal that let the computer know how to outline the desired audio signal. The main limitation of digital signals is the resolution or the sample rate. The sample rate is a recording of how often these “checkpoints” occur. The higher the sample rate, the more checkpoints there will be. When recording an audio signal, the standard sample rate is 44.1 kHz which is 24.1 kHz over the 20 kHz limit audible to the human ear. This means that despite this limitation of digital signals, it will not affect any perceptions by the human ear. One major issue with digital technologies is the act of encoding a recorded signal into a digital one. This is an area of research that has continued to grow as one-hundred percent accurate encoding has not yet been reached. However, in an article titled, “Perceptual Coding of Digital Audio” an outline of the previous and current research into encoding is provided saying, “audio coding algorithms have matured rapidly in less than a decade...new algorithms continue to advance the state-of-the art in terms of bit rates and quality” (Painter, 2000). Given that this article was made in 2000, it can only be assumed that encoding algorithms have continued to exponentially grow in quality. It is a field of research that will continue to develop, but it has reached a state where the losses are not discernable to the human ear. However, there are some physical differences that can be seen through this spectral analysis of an analog tape and digital recording from a professional recording studio at the University of Southern Mississippi.



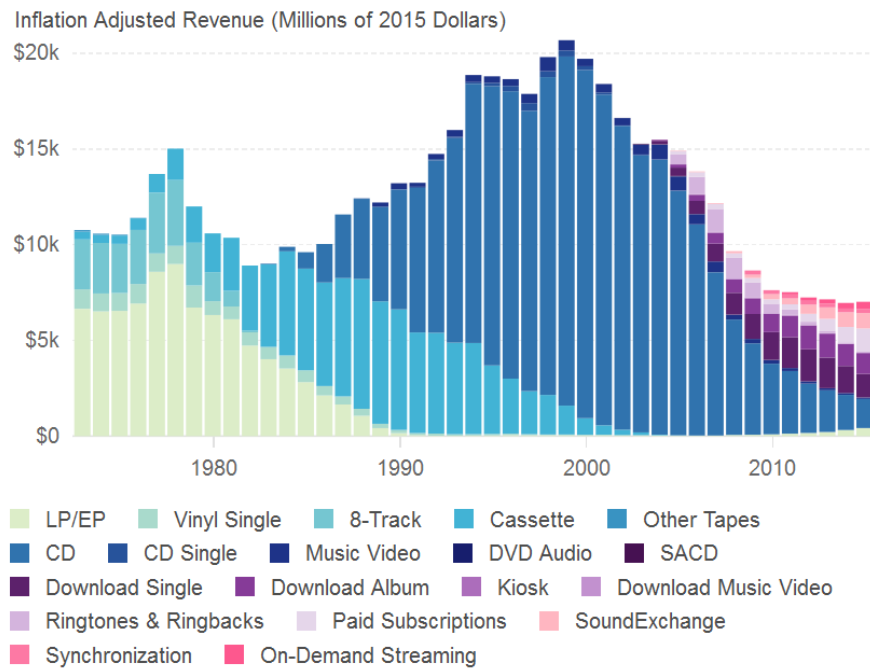
Note. Image showing spectral analysis of analog vs digital recording at the same time. From “Spectral Analysis and Comparison of Analog and Digital Recordings” by Hannah N. Frosch

As can be seen in the image, there is a difference in the two signals, but according to the article, these differences come from analog failures. The article said that any differences could be explained through “physical issues with the tape recorder” and “unwanted noise” that comes with analog technologies (Frosch, 2017). Given this technical understanding, digital signals are better because they can store twice as much information than the human ear can even hear, and they are not prone to mechanical failures like its analog counterparts.

When the CD was introduced, people understood that it was much higher quality. An article released around this time described its audio quality where “every flaw, both in performance and production, is ruthlessly exposed” (Walsh, 1983). At this time, everyone accepted digital technology as superior both in audio quality and convenience. People were able to hear every single aspect of a recording like never before, and most people were excited by this. This can be seen with CD sales completely dominating over vinyl and cassettes for most of the 90s as seen in the image below.

U.S. Recorded Music Revenues by Format

RIAA Year-End Revenue and Shipment Reports



Note. Graph showing recorded music revenues organized by the format sold. From “Recorded music sales by format from 1973-2015, and what that might tell ...” by M.J Perry, 2016

The overwhelming acceptance of the CD was perfectly stated in an article titled, “The Emergence of the Compact Disk” saying, “In 1982, CD players and CDs came on the market. Soon after that the music loving world embraced this new way of listening to music” (Peek, 2010).

This was, however, until the introduction of the MP3. The MP3 was the first technology that led to a decrease in audio quality. This is a direct result of the MP3’s focus of being distributed through the internet. This meant that there was a heavy focus on reducing the size of the created audio files. This in turn, reduced the quality of the produced audio signal (Rose & Ganz, 2011). Despite this, the MP3 managed to dominate because it was the most convenient

option for people. The creator of the MP3, Karlheinz Brandenburg, said it best saying, “convenience is the most important factor.” (Pitchfork, 2017). All someone needed was a computer with internet access, and they could download any song that they desired for little to no cost. The convenience of digital files continues to dominate to this day with the rise of streaming, but the recent vinyl craze has given rise to the debate this paper is focused on.

Rather than using a preexisting STS framework, I aim to create my own framework around the four focuses of technical, psychological, biological, and social analysis. Looking into most STS frameworks, none of them seemed to outline the depth of this issue accurately. Thus, it was decided that creating a new framework to analyze every aspect of this issue would be the best method to analyze this debate. Doing this allowed me to perfectly tailor my analysis to really outline all forces that are driving this debate, and ultimately formulate a better analysis and conclusion for my research.

Methods:

To gather information for this research, several methods were used to create a cohesive discourse analysis surrounding this issue. Mainly, research into articles, datasets, academic journal articles, and media/journalistic accounts were all used to create a solid foundational understanding. With the goal of gathering the opinions of the people that prefer analog over digital and digital over analog, gathering as much information about people’s opinions and exactly why they hold them is extremely crucial. This is why research into the technical, psychological, biological, and social forces behind this issue allowed for a cohesive understanding. Throughout my research, these four issues were the four main driving forces behind people’s technological preferences, so looking into these allowed for a comprehensive understanding. My analysis, however, is not purely discourse analysis. There is also some

historical analysis. Mainly this comes in the form of economic trends and analyzing the history of music distribution technologies' development. This historical analysis is, however, not the focus, and it is mainly used to supplement the discourse analysis by providing a foundational understanding of the overall trend. In doing this, a cohesive discourse analysis was able to be formulated.

Results:

One of the more interesting reasons that people could be choosing vinyl over digital technologies is the idea of psychological ownership. Psychological ownership is an interesting aspect of psychology that outlines the “possessive feeling that some object is ‘MINE’ or ‘OURS’” (Pierce et. al., 1992). People tend to feel a special ownership to objects that they perceive as being theirs. When thinking about people’s love for vinyl, this idea could be easily applied. In an article titled, “How a Desire to Say ‘This is Mine’ Propels the Vinyl Revival” Christopher Bergland does exactly this. He outlines how many record lovers become familiar with their personal record’s “unique skips, scratches, and the patina of their well-worn copies” (Bergland, 2020). Thinking about this makes a lot of sense. Many audiophiles claim that vinyl technology gives much better quality, but it may be the imperfections in their specific setup that makes them believe this. When they turn on their favorite copy of Steely Dan’s “Can’t Buy a Thrill” they can recall from memory exactly what is about to happen, but when they turn on the MP3 or CD version, they cannot seem to recognize it the same way. This attachment to the version that a person has heard countless times before would obviously skew their perceptions of which technology is better. Bergland goes on to say, “the loss of psychological ownership associated with using a subscription-based audio streaming service like Spotify or Pandora can leave some music listeners feeling less passionate about songs they don’t ‘solidly’ own.” The

idea of psychological ownership puts a name to the exact phenomenon that is causing many people to choose vinyl over digital technologies. It's more about the experience than it is the actual technology.

Biologically speaking, there are some interesting conclusions that can be made about what people hear when they are listening to different technologies. When thinking about the technical aspects of this issue, one may begin to wonder if an increase in resolution or quality is even audible by the human ear. A study titled, "Analogue Hearts, Digital Minds? An Investigation into Perceptions of the Audio Quality of Vinyl" sought to answer this exact question. This study involved a series of double-blind tests to conclude whether it was possible for people to hear any difference between analog and digital signals. With concerns of manufacturing flaws with their vinyl tests, a digital recording (16bit/44.1 kHz) was taken of a specific vinyl for comparison. They had listening tests where listeners heard audio and chose their preference and a usability test where a vinyl experience of placing the stylus was used with a digital signal and the original analog signal. Ultimately, they concluded that there is a "clear link between subjective audio quality assessments and an individual's appreciation of other attributes of vinyl such as the artwork, sleeve notes, or even their past experiences" (Ulwins, 2015). While there may be differences, it is not possible for the human ear to hear them unless the differences are a result of manufacturing or physical errors with the vinyl recording, and this study works to prove this. The physical surroundings or the scenario that people are in when they hear something is much more impactful towards their experience than the actual signal that they are hearing. The act of placing a record on a disk, dropping the pin, and getting to listen while you read through the album sleeve is a much more involved experience. Another experiment titled "Analog vs. Digital: what's the difference?" also sought to answer the same question. This

specific experiment sought to discern any difference between Direct Stream Digital (DSD) and high-resolution Pulse Code Modulation (PCM) which are two different methods of digitally encoding a recording. The experiment concluded that “no significant differences could be heard between DSD and high-resolution PCM (24-bit/ 176.4 kHz) even with the best equipment, under optimal listening conditions, and with tests subjects who had varied listening experience” (DiGiuse, 2016). While these are two different digital methods, the DSD method has much lower resolution than PSP. The fact that no difference could be heard further proves the limitations of what the human ear can truly hear. Ultimately, the human ear can only hear so much, and the pure differences between vinyl and digital is not part of that.

Socially speaking, there are three main groups that take part in this debate: engineers/tech-enthusiast, casual music listeners, and audiophiles. The first category of engineers and tech-enthusiast will often choose the highest technology because that is what interests them. In this case, this group would be largely in favor of digital mediums because of their higher resolution and consistency. Since the introduction of the computer, this group has largely been in favor of digital technologies because they provide extremely quick and accurate results. The second group of casual music listeners is the largest involved, and they have the widest variety of opinions. Many will choose analog technologies because of the improved experience, but many others will choose digital technologies because of their convenience. In today’s world, all someone needs is a phone and a Spotify subscription to access nearly every record in existence. The third and final group is the audiophiles. An audiophile is someone who, “values premium headphones, speakers, and other sound-producing equipment” they will often have a “special room design and treatment for the best acoustics” (What Is an Audiophile?, n.d.). Audiophiles are an interesting group of people who are willing to spend thousands of dollars to create the highest

fidelity analog setup possible. When thinking about this, it makes sense that they would prefer their expensive analog setup to an iPhone. Knowing this, it makes sense that audiophiles universally prefer analog recording methods because it allows them to get as close as possible to the original recordings of their favorite records. All three of these groups will continue to argue about this issue as long as music exists. Knowing these groups and understanding their perspectives will help us to better outline and understand the entirety of this debate.

At the end of the day, the intensity of this debate seems to stem from much deeper, socially driven reasons than which actually sounds better. The vinyl industry is often ridden with instances of controversy, and people seem to love it. One prime example is the class-action lawsuit against the reissue label Mobile Fidelity Sound Lab (Mofi). Mofi is a reissue company that focuses on taking classic albums and reissuing them on vinyl. However, they recently got into trouble with the audiophile world because it was discovered that they used a digital mastering to create their vinyl reissues. While this may not seem like a big deal, in the world of audio, this exploded, and Mofi managed to lose a significant amount of their credibility as a reissue company (Griffin, 2022). Mike Espito, the man that told the world about MoFi and their scandal, said that “in the world of audiophiles - where provenance is everything and the quest to get as close to the sound of an album’s original recording as possible - digital is considered almost unholy” (Edgers, 2022). This is an interesting case that shows how volatile the music world can be. Audiophiles are extremely particular about what they like, and they will often claim to have highly trained ears that can hear major differences in recordings. An audiophile is someone who, “values premium headphones, speakers, and other sound-producing equipment” they will often have a “special room design and treatment for the best acoustics” (What Is an Audiophile?, n.d.). Thus, it makes sense that they would be an extremely difficult group to

please. This specific case is an interesting one because audiophiles mostly enjoyed MoFi's releases until they discovered that they were digital. An article titled, "The MoFi-Scandal – Some Lessons" points this out perfectly saying, "the revelation that these one-steps are in fact sourced from digital files embarrasses them (audiophiles) to the bone" (Digitale Audio Systeme, 2022). This is a prime example of how even the most well-versed listeners are not able to hear any discernable difference between digital and analog recordings. It once again comes down to people's personal preference, and their understanding of a recording's history.

Looking deeper into this debate, the reason why the dispute is so prevalent stems from issues much deeper than which technology sounds the best. There are much stronger mental and social forces that cause people to hold vehemently to the opinions that they have. Looking purely technically, digital technologies allow for much higher resolution than the human ear can hear, and they have one-hundred percent consistency unlike analog technologies that often succumb to mechanical failures. Psychologically speaking, the idea of psychological ownership explains how people often hold a strong connection to their personal copy of a vinyl record which causes them to often prefer this to other digital methods. Biologically speaking, the human ear is not capable of hearing any difference between the technology, and people are much more affected by their surroundings than what they are actually capable of hearing. Finally, all social parties involved with this debate often butt heads in explosive manners.

Knowing all of this, an interesting understanding of people's technological preferences can be formed. Often engineers get caught up trying to improve their technology beyond what is actually necessary. In the case of music technology, many engineers began to focus on digital technology in an attempt to get the highest resolution with perfect consistency. In doing this, they began to lose the nuances that cause people to fall in love with music. Digital technology led to

music listeners losing the wonderful experiential aspect that came with a vinyl record. The physical experience of vinyl is what caused many people to fall in love with music to begin with, and it can explain why people are choosing to go back to it nearly fifty years later. However, digital technology did manage to make the experience of listening to music extremely convenient. The ability to listen to any record created with little to no effort is unheard of. For the casual music listener, this is an easy choice to make, and most of the world chooses to do this. Ultimately, there is no reason why this debate should be so prevalent. It has been proven time and time again that there really is no discernable difference between an analog recording and a digital one. It is the user that needs to decide what musical experience they want to have. Do they like the experience of studying an album cover while they get to watch their record spin around, or do they like the ability to listen to all their favorite artists wherever they are? The choice is up to the listener.

Conclusion:

Looking deeply into this debate allowed me to better understand people's technological preferences, and it allowed me to realize that people often pick technologies for many different reasons. In the case of music technology, it is the many nuances of each technology that cause people to choose which they prefer. It is vital that anybody involved with technology can understand analog and digital music as a case study toward people's technological preferences. While newer technology may be more sophisticated in many aspects, many people may not choose it over the previous iterations. Whether it's a dislike for change, nostalgia, or more physical experiential reasons, people choose what they do for personal reasons, and it is crucial to understand this. The debate between analog and digital technologies is simply just one case study of a common phenomenon. Thinking about streaming, phones, transportation, or financial

technologies, these are much larger phenomenon where people often choose different technologies for different reasons. Every user has a different background and preference, and it is impossible to provide a singular technology that satisfies all of these. Studying this further will help engineers to make better design choices, and it could help engineers around the world by creating a new framework for looking at technological developments. Making engineers think about this people who will actually be using their technology is something that should become common place, and every engineer should think about this while designing.

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