Why the Theremin Fell By the Wayside

A case study in the evolution of paradigms in music

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Abstract

The theremin was the first major electronic musical instrument. Players cause the theremin to produce sound without contact at all by manipulating electromagnetic fields with their hands. This unique design often sparks interest in those that learn about it, but despite this fact, the theremin has remained in relative obscurity since its invention. This paper discusses the history of the theremin and explains why it failed to gain widespread adoption, drawing on research in the growing field of memetics.

Contents

Figure 1: Lev Termen playing the theremin.

1 The Theremin

> *"The Theremin... can produce a sound not unlike an eerie, throbbing voice. Or perhaps a cello, lost in a dense fog and crying because it does not know how to get home."* - New York Times, April 25, 1967, "Music: Leon Theremin"

In 1920, Lev Sergeivitch Termen of Russia invented a new musical instrument that changed the world. Or did it? The theremin, named after Lev's Americanized name of Leon Theremin, was the first instrument of its kind. It was the one of the first purely electronic instruments in a time when the world was only beginning to understand and adopt electricity. Its interface was unique as well: the theremin is played without touching it at all. The instrument utters a sound something like a cello or a violin, and the player controls the pitch and volume by the proximity of their hands to two antennas. The antenna on the right side controls the pitch, and the one on the left controls the volume. This gives the instrument a distinct portamento and an eerie wavering quality.

Lev Termen trained himself to play his instrument and began giving concerts across Russia in the early 1920s. He touched off a craze wherever he went, and people thronged to see this instrument of the future being played. Upon hearing a description of the theremin, many musicians and engineers alike are taken in and want to learn more about it.

Termen was born in 1896 in Leningrad. From a young age he learned to play the piano and cello and showed an interest in physics. In his memoir, he expressed his opinion that traditional instruments create a gap between the actions of the player and the sounds that result. As an example, he cited the playing of the cello by moving the bow in a saw-like motion and pressing on the strings [1]. He saw a chance to bridge this gap by using his strong knowledge of electricity. He wanted to create an instrument that would be controlled in three-dimensional space, whose player does not directly mechanically produce the sound through their actions. He likened this concept to the way a conductor produces sound from an orchestra: the individuals in the orchestra produce sound through mechanical means, of course, but the conductor himself "just moves his hands, and his movements have an effect on the artistry [of the orchestra]" [2].

Termen felt that his instrument would more closely couple its players to the sound they were producing than any other instrument had before. There were no strings or valves to get in the way, and the instrument was not limited to a specific set of notes. In an interview, he predicted that his instrument would open many new doors because the music was "created with a simplicity and directness matched only by singing. There is no keyboard to obtrude itself, no catgut, no bow, no pedal, nothing but simple expressive gestures of the hands" [3]. This very directness was what intrigued me to learn about the theremin and build my own.

Termen predicted that the merits of his new instrument would vault it into the public eye and lead to its adoption as a new instrument. Why, then, is it more than likely that you, the reader, have never heard of the theremin before now, unless perhaps you are researching its history? The theremin has remained largely in the background of the music scene aside from a short burst of interest in the 1920s, relegated mostly to enthusiasts and researchers in electronic music. What could cause such a seemingly good idea to fail to gain a large amount of popular interest? How do musical instruments evolve, and what determines which new instruments are adopted by the general public and which are left to gather dust in the uninteresting corners of human history? In this paper I will detail the various factors that may have led to the failure of the theremin to gain common interest. This is a case study in the evolution of musical instruments with emphasis on the underlying question: what determines how ideas and inventions are adopted into the common practice of music?

2 Background

Before I can begin to tackle these questions, I must give a brief history of the theremin and events that transpired after it was invented. It will become clear that specific circumstances in the life of Termen and others would have an effect on the instrument's spread through society.

2.1 The Invention

Lev Termen was a physicist by education but an inventor at heart. While directing the oscillation laboratory of the institution of Physics, Technology, and Radio sciences in the Soviet Union, he invented several important devices, including an early form of television. His work in devices to detect the presence of a human body using electrical capacitance led directly to the invention of the theremin. His later inventions included many interesting music-related devices such as the rhythmicon, which can play any spacing of beats against any other at the press of a button; a piano tester, which can measure the evenness of a piano's scale electronically; a pedal graph, which measured and recorded the pedaling used by professional pianists as they perform; and even a room-sized version of the theremin that was played by dancing.

The theremin has an extremely large range that "exceeds all other instruments, including pipe organs" according to a Popular Electronics article [4]. Thereminist Clara Rockmore stated in an interview that the concert range of the instrument was about four and a half octaves, but more are possible [5]; in his memoirs, Termen claims "approximately 34[1] octaves." The theremin itself produces only an electric signal that is turned into sound by a loudspeaker, so the dynamic range is limited only by the amplification and playback equipment. The theremin also has the interesting quality of being the only instrument that can hold a note without any action on the part of the player. Most reviews of the theremin ranged from favorable to awe-struck, although one Globe Toronto article claimed that the continuous wavering tone, "like a radio crooner's, became rather monotonous" [6].

Word of the instrument he then called the *termenvox* spread, and in May of 1922, Termen was given an audience with Vladimir Illyitch Lenin. Lenin was so impressed with the performance that he tried it for himself. According to Termen, Lenin had a keen pitch sense and was quickly able to grasp the nuances involved in playing [1]. He gave Termen the right to travel across the Soviet Union freely to give performances, and he ordered the production of several hundred instruments to be distributed across the country.

In 1924, Termen was sent abroad to do further scientific research and to give performances with the termenvox across the world. His tour brought him across Europe, with concerts in Frankfurt, Paris, and London. In late 1927, he crossed the Atlantic to the United States, where he settled in New York city to start a workshop. He intended to further his research, create new inventions, and train students to play the theremin. He continued to give concerts, and he felt that his work "certainly helped to increase the prestige of the USSR in the United States".

He was granted a United States patent in February of 1928 for "a method of and apparatus for the generation of sound". His patent described the electrical concepts behind the theremin and listed various modifications that could be used to produce different effects, such as the addition of overtones to strengthen the timbre. It also described his technique of displacing the phase of individual loudspeakers in a concert hall to make the sound seem to come from behind the audience, much to their amazement [7]. He assigned his United States patent to the firm of M. J. Goldberg und Söhne of Berlin, Germany. Rumor has it that he signed away his rights in the theremin for a small amount of money to the firm, in which he had a stake [8]. His friend and partner in the firm Julius Goldberg was active in advertising the instrument, but there is not much historical information to be found on him.

M. J. Goldberg und Söhne licensed the RCA Victor Corporation to produce and sell a commercial version of the instrument. The instruments were actually produced under a subcontract with General Electric and Westinghouse Corpo-

[1]It is my belief that this is a typographical error that has been reproduced in several sources. Human hearing itself extends over only 10 octaves, and while it would be possible, electronically speaking, to produce a theremin with a range of 34 octaves of frequency, its variability over the human range of hearing would be so great as to make it highly impractical.

rations and then sold under the RCA Victor label as the Victor Theremin. RCA started selling theremins in 1929, just months before the stock market crash in October of 1929 that heralded the Great Depression. RCA sold only 500 instruments before halting production, and now they are collectors' items. This is believed to be the direct result of the Great Depression, because most people could not afford what would have been seen as a frivolous expense [9].

2.2 Clara Rockmore

> *Very fine violinists have a long bow. But as long as their bow may be, mine is longer.* - Clara Rockmore, 1977

Clara Rockmore, born Clara Reisenberg of Russia in 1911, was a violin virtuoso from a very early age. At 9 years she was granted permission to tour internationally and began giving violin concerts across Europe. In 1927, she arrived in the United States and met Lev Termen. Due to medical problems, she was unable to continue playing the violin, and the theremin provided a perfect opportunity to continue her musical career. She became Termen's student, quickly learning how to play the theremin and mastering her own personalized technique.

Rockmore played a major part in shaping the way theremin music is played and composed. Her unique style made use of an "aerial fingering" technique to produce repeatable, constant pitches from the instrument. She held the first finger and thumb of her right hand in a circle to produce a steady vibrato. Her crisp, direct finger movements allowed her to produce notes without slides in between, a problem that plagues novice thereminists such as me. She emulated a violinist's bow with her left hand to produce staccato, legato, and other articulations. Her perfect pitch sense enabled her to find and quickly adjust pitches before the audience was able to hear them [5].

Her classical music background gave her the knowledge, skill, and impetus to turn the theremin into a respected instrument. In an interview with Robert Moog in 1977, she said that her intention was to make artful music with the theremin. She expressed concern that electronic instruments had been exploited to produce "eerie, strange, and new sound effects". She wanted to use the theremin "to make real music" [10].

She trained with Lev Termen from 1927, gave her first concert in 1935, and went on to give many more. Termen designed and built a special instrument suited to her needs and abilities that far exceeded the capabilities of the RCA theremin. According to Rockmore, she was the only one authorized by Termen to teach the theremin, and to this day she is recognized as the greatest thereminist in the instruments early decades. Despite Termen's authorization, she repeatedly turned away prospective students because they did not have instruments that would function well enough to allow the precise control she felt was required to play the theremin well. In the early nineteen nineties, she released a collection of exercises spanning fourteen pages meant to train new thereminists to use her technique. It is available free of charge on the Internet [11].

2.3 Termen Returns to Russia

The details are different depending on whom you ask, but one thing is certain: Lev Termen left the United States in 1938, and spent the next fifty years in Russia. He finally returned to the US in 1991 and died in 1993.

Termen did not mention in his memoirs the fact that he spent the majority of his years in Russia, an omission that is somewhat conspicuous. In an interview in 1989 in France, given just after his emergence from Russia, Termen had this to say about leaving the US:

> I left New York because – Of course, I was there on assignment all the time, but the assignments dealt with seemingly unimportant issues for military purposes. But at that time the war was coming. The military troops of the fascists were approaching Leningrad, etc., and I asked to be sent to the Soviet Union so as to make myself useful. I asked many times. For a whole year I asked to be sent back. The war had already started. And they didn't send me, they didn't send me. Then at last they permitted me. They assigned me to be an assistant to the captain of a large motor ship. So I went home, but they did not take my wife...
>
> They took me on this ship, yeah. And after I arrived, my wife– they would not send her. We exchanged thirty letters. Then I was arrested, and I was taken prisoner: not quite a prisoner, but they put me in a special lab in the Ministry of Internal Affairs. There I worked in this lab just as others worked. Topolev [airplane designer] was imprisoned in such a way too, if you know about that. He was considered to be a prisoner, and I was considered a prisoner too...
>
> I was arrested, first, for them to find out– We were all under suspicion, all the people. And I as a suspicious person was assigned to be under investigation. The investigator was occupied with my case for about a month or more. He and the magistrate asked me all kinds of questions. This was all very formal, and they congratulated me [and said] that everything was O.K., but they said that unfortunately there would be a second investigation. There was a second investigator, who also asked [questions]. And they wrote down that everything would be fine. But after that, together with the other prisoners, I went with Topolev. Officially I was considered a prisoner, but as soon as I arrived they made me the supervisor of a group of prisoners...
>
> Even when I was interned I was treated well. I was not considered to be in prison, but worked as a normal person. I was the head of the lab, and when they liberated me I still worked in the same lab. Then I got married. It turned out that when I was free it was much more difficult to work in the lab. When I was considered to be imprisoned

> I had a supervisor, and they would say to me that I had to do this and that. Then, when I was freed, I had to do it myself. Then I had to fuss, do much more paperwork, keep an office in order; the work became much worse [2].

In these excerpts, Termen puts a somewhat good face on his treatment in the Soviet Union. He claimed that he asked to be transferred there, and they finally allowed him to come back. However, many people tell the story differently; they say he was kidnapped right out of his studio and forcefully brought back to the Soviet Union and ordered to work on spying devices for the war. He was credited with inventing the first electronic bug during this time.

Clara Rockmore herself, during an interview, claimed that Termen was kidnapped by men in dark clothing as she watched. She said that she was shocked that such a thing could happen [15]. It is my personal opinion that Termen may have been putting a rosy face on the true circumstances of his return in order to avoid trouble with the authorities in the Soviet Union.

What exactly he did during his time there is not clear. It is known that he was ordered to produce certain inventions used in World War II and during the Cold War. He also did some work on musical instruments, but he ran into some opposition: at one point he was removed from his position in the Moscow Conservatory after his superior, upon finding out that electronic instruments were being created there, stated "electricity is not good for music; electricity is to be used for electrocution," and had Termen and the instruments removed from the institution.

This much is clear: for most of its life, the theremin has been without its inventor.

2.4 The Mid-Century

During the 1950s and 1960s, the theremin saw use as an eerie background accompaniment to such science fiction thrillers as Spellbound. Its futuristic sound was used to instill nervousness in audiences or to produce sound effects. This, perhaps, led to Clara Rockmore's feelings that the theremin was being misused and its reputation was being tarnished.

Around this time, Robert Moog, born in 1934, was just learning about electronics. From the age of 14, he was fascinated with the theremin, and he built his own from a kit in an electronics magazine. By then the patent on the theremin had lapsed, so he was able to begin selling his own kits to those who wanted to build there own theremins.

The theremin inspired him to invent his configurable synthesizers, the foundation of the electronic music revolution. His equipment, while not without competition, grew in popularity quickly and was adopted widely. His Minimoog synthesizer was his most important product: it provided his configurable sound synthesizers in an affordable package. Moog was quoted in Mark Vail's book, Vintage Synthesizers [12], saying, "This is a lesson you learn when you

go into consumer electronics: the most important parameter of any product is price...".

Interest in the theremin still waxed, although there were several articles published in consumer electronics magazines that described how to build a theremin [4, 13, 14]. Rockmore continued to perform theremin recitals, and a new virtuoso, Lydia Kavina, was born in 1967. She gave her first theremin performance at age 14, and continues to perform to this day.

2.5 The Present Day

With Termen's return to the US in 1991, we are beginning to see some renewed interest in the theremin. In 1994, a documentary video on the instrument, Termen's life, and his other inventions was published by MGM/UA Home Entertainment [15]. Bob Moog's company, Big Briar, sells the Etherwave Pro, a professional theremin with a linear pitch response. Early theremins produced pitches with an exponential relation to the position of the player's hand due to the nature of the circuitry, but modern advances allow Big Briar to surpass this difficulty to provide a linear response, which may be more intuitive. The Etherwave Pro currently sells for $1495, although theremin kits can be had from manufacturers such as PAiA Electronics for less than $100.

It is this renewed interest that brought the theremin to my attention and led me to wonder why such a fascinating instrument as this has failed to achieve more than a modest following over its lifetime. In recent decades, various musicians and groups have used the theremin in performances, including Stereolab, Portishead, Quickspace, Tom Spencer Blues Explosion, the Beegees, Flaming Lips, and Led Zeppelin, among others. While there is more interest than in the middle of the century, the theremin is still by no means thriving in our culture, and this does not appear likely to change any time soon.

3 Why the Theremin Failed to Thrive

Many people find the theremin to be an intriguing instrument and a fresh new way of creating music. Albert Einstein is purported to have said that the theremin is as musically important as the first harp [16]. Lev Termen invented the theremin with the purpose of opening up a whole new paradigm in musical instrument design. His instrument more directly coupled the player to the sound produced than any before it, and he felt that this would "open up an entirely new field in composition" [3]. As we have seen, the theremin did lead directly to the quickly growing field of synthesized music, which in turn has led to computer music. The theremin itself, however, found itself left in the dust after it sparked the electronic music revolution.

3.1 Interface Problems

Ironically, the theremin's user interface, which Termen vaunted as its key attribute, may have been the cause of its failure to thrive. Amateur players may find that they can produce nothing but raucous squealing and wavering tones. The theremin requires great dexterity from its players. They must be able to control their left and right arms individually, and they must do this with great dexterity in order to play anything but a simple, slowly lilting accompaniment. Clara Rockmore cautioned that the theremin was in no way a good instrument for a beginning musician. She suggested that a budding musician should learn to play a traditional instrument, which would give them quicker access to the fundamentals of classical music that Rockmore felt were a prerequisite to producing meaningful music from the theremin [10].

Termen was attempting to produce what he felt would be a very intuitive interface. Patrick Rashleigh [3], who studied the interface of the theremin, feels that Termen actually accomplished nearly the opposite of his goals, producing an instrument that is, in fact, much harder to play than a traditional instrument.

Termen's goal was to create an instrument that coupled the player as closely as possible to the sound production process. He separated the musical note into its component parts: pitch, volume, and timbre. Pitch and volume were to be controlled by one hand each, with full control being given to the player. Timbre is the "quality" of a note, also known as brightness. In scientific terms, the timbre of a note is the collection of overtones that are combined to make the sound of a note. Timbre is the fundamental difference between the sounds produced by two different instruments. Later versions of Termen's instrument produced sound with an enhanced timbre resulting from the addition of overtones to the sound wave produced, and some even had a knob that could adjust the tone quality further. However, generally speaking, timbre remained static during playing.

The instrument gave its players an unprecedented level of control over the pitch and volume of the tones it produced. However, as Rashleigh pointed out, an electronic instrument can do no more than it is designed to do. The player is at the mercy of the theremin's circuitry and can only do exactly what the instrument allows them to do. This means that subtle nuances available in other instruments, such as tone quality that can be produced by a different embouchure, are unavailable. It is arguably true that the theremin in fact gets in the way of musical expression simply by its rigidity and lack of functional flexibility.

Furthermore, in a traditional instrument, the player is coupled to the physical sound-producing phenomenon, such as a vibrating column of air in brass and wind instruments. When playing the instrument, the player acquires a sense of how the instrument is performing through sensory feedback. For example, playing a soft note on a trumpet can be difficult, because the sound wave has a tendency to break down, resulting in either a "frack" as vibration is lost completely, or the trumpet may even slide down to a lower note played with the same fingering. Accomplished trumpet players have a familiarity with the signs

of impending vibrational failure and can quickly adjust their playing to avoid this before the audience is aware there is any problem. Vibrational failure such as this is not a problem for the theremin, but by its design, the theremin has absolutely no points of reference. There is no indication what hand position will produce a specific note, and the only feedback the player receives is the sound the instrument is producing. A mistake likely cannot be sensed before it has already happened.

Even Clara Rockmore was not immune to the effects of the theremin's lack of physical reference points. She primarily solved the problem by developing her set of "aerial fingerings", in which she associated a set of finger, hand, and arm positions to each note. Even still, she had to constantly listen to the sound produced by the theremin and adjust her hand positions accordingly. Her sense of perfect pitched helped her to make these adjustments so quickly that the audience was unable to tell. A player without Rockmore's innate pitch sense may find this process more difficult or perhaps impossible.

Yet more circumstances combine to make the theremin's lack of reference even more severe. Its circuitry has no way of choosing between the hand of its player or any other object in the environment that carries an electric field. A thereminist must take into account the playing environment because objects in the vicinity of the theremin will affect its tuning. Players must hold their bodies absolutely still, because they, too, will affect the response of the theremin. Early theremins were built using vacuum tubes whose electrical characteristics changed drastically as they warmed up during use, yet again affecting the tuning of the theremin. As a result, no assumptions can be made about the theremin's tuning before it is played.

Already we can see that Termen's intended liberation of the performer from the limitations of traditional instruments actually results in a much greater level of required skill, yet there are still more negative implications to this seemingly laudable goal. A traditional instrument limits the player to a specific set of notes by nature of its physical makeup. All of music theory has been developed around these characteristics that Termen perceived as limitations. Limiting though they are, it is almost as if traditional instruments have musical theory built into them. A piano's keys, for example, are arranged in a staff, making it easier to understand and produce music that makes sense to ears that are used to hearing traditional music. Notes Rashleigh, "the 'liberation' of the performer means that the music theory implied in tangible interfaces is no longer present. The performer is liberated from limitations, but is *still expected to perform within the constraints of music theory.*" [3, his emphasis].

This is a very telling quote. When presented with such great freedom of control as I initially tested my theremin, my first thought was to wonder just what to do with it. I thought, as Termen did, that the theremin's close coupling between player and sound would allow me to create music in a direct, intuitive manner. My experience with the trumpet's seemingly random progression of fingerings made me feel that I would never be able to pick notes and play them in an improvisational manner. The theremin, on the other hand, seemed to allow me to quickly and easily play any note I chose to. However, even with

the gift of perfect pitch, I find myself completely lost in the interface of the theremin. With great power comes great responsibility, as it does with high controllability. Despite Termen's greatest efforts, the high degree of integration in the theremin's interface requires that players keep many more things in their minds as they play.

Also implicit in traditional instruments is the attack of a note. A thereminist has direct control over the volume of the *tone produced*, meaning that they must directly articulate notes and the gaps between them in terms of volume. Clara Rockmore likened this to the need to "play the rests as well as the notes" [5]. In a wind instrument, the separation of notes is much more natural: if the player does not blow air through the instrument, the instrument does not make a sound; this process is likely to be a lot easier to control. However, the theremin has an advantage in this case: it is possible to hold a note for an indefinite period of time, not limited by the air capacity of the player. Wind instruments and percussive instruments such as the piano also have a more natural interface for the production of differing note attacks. Through the use of tonguing, a wind player can generate staccato, legato, and slurred note articulations. Again, these actions are likely to be a lot more natural than the direct volume-control articulations of the theremin.

Yet another apparent weakness in the theremin's interface can be seen when considering the development of eccentric playing techniques in traditional instruments. For example, a technique used to great effect in this century's jazz movement is the breakdown of vibration in the saxophone. A player can use the raucous noises resulting from what would traditionally be termed an improper playing style to effectively express a powerful emotion. As mentioned earlier, the theremin does no more than it is designed to do, and this rigidity may mean that it has fewer possibilities for more expressive forms of play that were not intended by the maker of the instrument. Of course we cannot be sure that no such possibility is available in the theremin until someone demonstrates it, but it would seem by its pure simplicity of design that the theremin has little capacity for creative deviations from intended use.

In Termen's defense, as Rashleigh points out, theremin players are required to play music that is palatable to ears trained by traditional music theory. Perhaps this requirement is unreasonable. One of Termen's greatest regrets was that there was very little music composed for the theremin. While it may be difficult for a thereminist to perform some tasks that are very simple on other instruments, the theremin undoubtedly has strengths that could be exploited to great musical effect. Popular composers Edgar Varese, Joseph Schillinger, and Grainger included theremin parts in their orchestral compositions. Perhaps if more composers had taken into account the unique features of the theremin in their composition, its popularity would have grown.

Rashleigh was quick to point out that the theremin cannot in any way be considered a failure. By spawning the electronic music revolution, it had a lasting effect on music that we still see to this day. The theremin represents an important deviation in musical instrument interface design. All instrument interfaces previous to the theremin derived directly from the physical necessities

of the physical vibrational phenomenon on which they were based. Valved instruments are valved because valves were the most practical way of effectively changing the length of the resonating air column in the horn. A piano's keys must be pressed hard because the strings must be struck hard enough to vibrate. Ergonomical concerns are of a lower priority than the constraints inherent in the mechanical properties of the instrument.

The theremin was the first instrument whose interface was designed before its sound generation mechanism. Termen conceived of a space-controlled interface first, and only after this did he seek an electronic means to achieve that end. Rashleigh feels that this is an important break from history that has consequences reaching far into the future. The theremin represented the ideal that the interface of an instrument may be completely separated from the sound production. We can see much further exploration of this idea in the standard digital music protocol MIDI. MIDI turns information gathered from a human interface into a set of pieces of information describing the pitch of a note, the volume, the attack characteristics, and many other properties. A MIDI synthesizer can then take these data and produce any number of different kinds of sound, often emulating traditional instruments. Most important is the flexibility of this system: one can produce midi data from any midi interface, process it in a variety of ways, and then produce sound in any manner imaginable. MIDI data that was produced from a piano keyboard can be synthesized to sound like a trumpet, a full orchestra, or even a choir. This represents a separation of interface and sound-producing equipment even more complete than that of the theremin.

3.2 Instruction

As mentioned briefly earlier, learning to play the theremin is largely a matter of self-teaching. Clara Rockmore never took on a student because none that approached her had an instrument that satisfied her exacting standards. There are standard methods and bodies of knowledge used to instruct budding players of more traditional instruments, but the theremin had nothing like this. Rockmore did eventually publish a workbook of exercises for beginning players, but this was only released recently and it is in no way a complete description of her unique techniques. Even using this workbook, one would essentially have to develop their own techniques from scratch as Rockmore did during the early to mid 1930s. This means that new thereminists face the incredibly difficult hurdle of learning to play the instrument without the benefit of the centuries of experience and wisdom available to players of other instruments. This, perhaps, is yet another reason why the theremin failed to thrive: a lack of instructors and a steep learning curve.

3.3 A Series of Unfortunate Events

Astute readers may have noticed the unfortunate concatenation of events in the history of the theremin. Termen arrived in the US in late 1927 to continue

his tour of theremin concerts that served to broaden the popularity of the instrument. He was granted his patent in 1928, but he gave control of it to M. J. Goldberg Und Söhne, GmbH. Shortly after, the Goldberg corporation contracted with RCA Victor to produce a commercial version of the theremin. It began selling Victor Theremins in 1929, but a completely unrelated factor conspired against RCA: the stock market crashed in October of 1929, leading to the Great Depression, and the market for theremins dried up shortly afterward [9]..

At this time, the US patent for the theremin still belonged to M.J. Goldberg. Information about this firm is scarce, and it is unclear whether or not they continued to try to produce a commercial theremin through other channels. During this time, Lev Termen did not control the patent, so he was unable to directly produce a commercial theremin in the US. In fact, no one could even sell a kit to build a theremin until the patent expired.

In 1938, history again conspired against the theremin. Termen's return to the Soviet Union led to a period of time in which little was heard from him; in fact, a book on Termen incorrectly reported that he died in custody in the Soviet Union in 1945 [2, 17]. He did not die, but nevertheless, the theremin was deprived of its champion. He was forced to work for the government and was unable to continue touring or teaching others how to play his instrument. Without his energy to spread the word about the theremin, it slowly fell out of popularity. Rosalyn Tureck, a former student of Termen's, feels that "the whole future of music and electronic instruments would have been different had he not been prevented for [sic] living in the States where he could have had all the artistic freedom and material means to develop his ideas and have them spread, as they deserved." [18]

It is clear that circumstances unrelated to the idealogical merits of the theremin conspired against it to further prevent it from gaining popularity.

3.4 Memetics

Memetics is a new and growing field of social science that seeks to model the spread of ideas in a society. The rest of this paper will be dedicated to introducing memetics and using it as a tool to analyze the spread of the theremin in the 1900s.

3.4.1 Universal Darwinism

> *"A chicken is just the egg's way of making more eggs."* – unknown

Biologists have come a long way from the theory of natural selection laid down by Charles Darwin in the *Origin of Species*. In the early days of evolution theory, writing focused on mutations and behaviors as beneficial to the species as a whole. For example, if an individual animal was born with a mutation that helped it survive, this would benefit the species as a whole because more animals would be born with this mutation. In contrast, recent theories in evolution are concerned with the mutation and spread of individual genes.

Richard Dawkins, author of *The Selfish Gene* [19], discussed evolution from the imaginary viewpoint of the genes. A gene is a segment of DNA roughly responsible for an individual feature in a living organism. During reproduction, genes from the parent organisms are joined together and copied to produce the child organism. At this point, slight inaccuracies in duplication can result in changes to a gene, or mutations. If the gene's contribution to the organism's physiological makeup results in an organism that has a higher likelihood of survival, then it is more likely that this organism will reproduce and thus more likely that the gene will spread. The entire collection of genes of all organisms on the planet is known as the gene pool, and a gene that is highly beneficial to the survival of those animals that have it will become more widespread in the gene pool.

Dawkins' other important breakthrough was the theory of Universal Darwinism. He narrows the cause of natural selection down to three critical factors which, when combined, inevitably result in a system that naturally selects more and more organized units. First, there must be a unit capable of making copies of itself, called a replicator. Second, the replicators must duplicate with accuracy in most cases but occasionally introduce changes. Finally, the replicators must exist in an environment that exerts pressures on them such that some are capable of replicating and some are not. Given these three factors, natural selection occurs: replicators that are most fit for the environment spread, and those that are not do not. This is a very simple conclusion with important ramifications: order is produced from chaos simply as a byproduct of the juxtaposition these three factors.

I have purposefully generalized my phrasing in the last paragraph such that it does not necessarily only apply to genes. Genes obviously satisfy these requirements: they make copies of themselves in chemical reactions at a molecular level, they duplicate accurately in most but not all cases, and they interact with an environment composed of organisms competing to survive and reproduce. Dawkins' point was that genetics is not the only evolutionary system possible; it is merely an example of a greater phenomenon that produces order out of chaos without a conscious designer. In the last chapter of his book, he cited an example in the spread of ideas in society. He merely intended to show that genetics was not the only stage for natural selection, but as a side-effect he also created the new field of memetics.

Dawkins introduced readers to another kind of replicator that he called a "meme", a word derived from the Greek word *mimeme*, meaning "something imitated". Memes are behaviors in society that spread among human brains through the mechanism of imitation. One example would be a joke you've heard from your friend. You might tell it to another friend, and they might tell it to their friend, and so on, and at each step the joke remains in generally the same form. Sometimes the joke may be embellished, changing form slightly. Sometimes the joke will fall flat, as it encounters a person who simply does not find it funny. Already we have the three factors of Universal Darwinism: a replicating unit (the meme), mostly accurate duplication with occasional modifications, and an environment in which the replicators may not always survive

or spread. On this we can base another theory of natural selection, separate (but interacting with) genetic evolution [19, 20].

This leads us to some intriguing conclusions. A meme can be any behavior in society that is imitated, such as eating breakfast in the morning, brushing teeth, or using a new word such as "groovy". We can see how memes like these spread, and we can easily cite examples of memes that are highly popular and those that have failed. For example, the current meme of anti-terrorism in the United States is a highly effective meme with the ability to rapidly spread from mind to mind. The meme of the BetaMax video recording system, however, failed to spread and eventually all but died out. Memes are not always beneficial, just as genes are not. A virus can infect an unwilling host and cause its DNA to be added to the host's, possibly to its detriment. Similarly, a meme can infect us, causing us to spread it whether we like it or not, such as a song we cannot evict from our minds no matter how hard we try.

Just what is a meme, then? There is still much work being done in the area. Initially, Dawkins suggested that memes were, in fact, neural wiring patterns in human brains that caused themselves to be reproduced in the brains they inhabited. This is perhaps a dangerous path to take because we still have very little knowledge about how ideas are represented in the human brain. Memeticist Susan Blackmore instead writes that we should not make any assumptions about how memes are stored other than to agree that they are in fact stored and spread. We do not have to understand the mechanism to know that some mechanism must exist [20]. Memes are simply patterns of behavior that can spread between humans through imitation. Not all memes spread, which leads us to question what techniques might a meme use to gain a foothold in more brains. This will be discussed in the next section.

The parallels between genetics and memetics are many, although Blackmore warns us not to attempt to draw out the analogy to the breaking point and come to false conclusions about the accuracy of the theory of memetics. However, we can still learn some general things about memetics from genetics, and we can begin to understand why certain memes spread and certain memes die out early. There is one very important difference, and that is time-scale. Memetics operates very quickly as compared to genetics, with huge memetic variations taking place in the span of an individual's lifetime. While a gene may take many generations to mutate and propagate through a species, with modern information-spreading innovations such as the Internet, a meme can develop and spread over the course of weeks or even days.

3.4.2 Techniques Memes Use

Blackmore's book *The Meme Machine* is devoted in a large part to discussing various techniques memes use to spread. The preceding use of personifying language is possibly confusing, and she takes great pains to reiterate that a meme does not actually have any mind of its own, and cannot have intention. When we say a meme "tries to spread", we're using a form of shorthand. The memes that exhibit a certain quality are the ones that will continue to exist

and spread due to natural selection. In the interest of brevity, I will use phrases such as "memes use this technique" to mean that memes that exhibit such a quality are the ones that spread and therefore survive.

What, then, are the techniques that memes use to spread? What are the critical characteristics that result in an effective meme?

In his discussion of genetics, Dawkins listed three fundamental characteristics that result in an effective gene: longevity, fecundity, and fidelity. These same characteristics can be applied equally well to memes. Longevity means not only how long a given animal resulting from a collection of genes survives, but also how long the gene itself survives in the gene pool. Fecundity is a gene's effectiveness at spreading in the gene pool, and fidelity is the ability of the gene to be copied without error. Fidelity can be effected by the length of a gene's DNA, as longer genes are more likely to be copied with mistakes. Without all three of these qualities, a gene is doomed, and the same applies to memes. Dawkins notes, "Some memes, like some genes, achieve brilliant short-term success in spreading rapidly, but do not last long in the meme pool. Popular songs and stiletto heels are examples."

These are three general characteristics of memes lead us to a few observations. A meme that is easily remembered is more likely to spread than one that is not. A meme that entices its host through some means to spread it may also be more effective. Jokes may not exhibit longevity as they become victims of their own success. Once a joke has spread to a significant portion of the population, its attempts to spread itself will more likely meet with hosts that already have the joke. Once everyone's heard your joke, you become less likely to tell it, and so the meme becomes less effective.

Advertisers, politicians, and other purveyors of information know a lot about what it takes to craft effective memes. There are many effective techniques used repeatedly by advertisers to make us more likely to buy their products. Looking at this another way, advertisers associate their memes with characteristics that result in higher spreading potential, making them more likely to infect our minds. One obvious example is sexuality. An advertiser that associates their product with a sexual theme creates a meme that is more likely to survive in the environment of minds that are predisposed by genetic evolution to respond well to sexuality. Note here that it is not the genes themselves that determine our thoughts, they merely help determine the competitive environment in which memes are more likely to spread to our minds. Sexuality is an example of a meme's use of biological characteristics of humans in order to spread. Memes having to do with sex, food, excitement, power, and avoiding danger get a boost because of our instinctual urges [20].

Another advertising technique that will be important later is endorsement. Blackmore models endorsement as it effects our likelihood to pick up a meme. If a meme is held by a popular and well-liked person, we will pay attention to their actions and become more likely to spread their memes. This is effective even if an endorser *pretends* to hold a meme, such as a paid television endorsement. Blackmore also cites the example of altruism: if I hold a meme that leads me to behave in an altruistic manner, my friends will likely benefit directly from my

altruism. They may then like me more, spend more time with me, and become more likely to acquire the altruistic meme from me [20].

Memes, just like genes, often spread in groups called memeplexes. A memeplex is a group of memes in which each meme spreads more effectively in conjunction with the others than it does by itself. This symbiotic relationship between memes results in complex cultural formations such as language, writing, and religion. Similarly, groups of genes spread together to form various organs and systems in our bodies.

Religions are effective memeplexes that spread through a variety of techniques. One technique is to help explain a phenomenon or to help us deal with our lives. Specifically, religions provide an explanation for life, death, and morality. Religious memeplexes also contain memes that urge followers to act in specific ways with negative or positive consequences for failure to cooperate. They spread themselves through memes that urge their hosts directly to spread the religion and with reinforcing memes such as compassion and eternal damnation for non-believers.

Importantly, it should be noted that memes need not be true, right, or beneficial to their hosts in order to succeed. The meme of suicide is most definitely not directly beneficial as it results in damage to its host and ultimately loss of life if successful. Why does the idea of suicide still spread, if it kills its hosts? Perhaps the death of one host is nothing compared to the ability of the meme to spread, and perhaps the death of that host actually helps spread the suicide meme in the neighborhood of the host. Conversely, memes based on ideas that seem great to us will not necessarily spread in the meme pool. It would be quite easy to invent a religion full of good intentions and consistencies which would utterly fail to spread.

3.4.3 Instrument Interfaces as Memes

The next step toward the ultimate goal of modeling the theremin's spread in society is to apply memetics to musical instrument interfaces. To do this, we must prove that they behave like memes. They must spread through imitation, they must mutate like memes, and they must be subject to some form of environmental pressure that results in selecting certain instrument designs and causing others not to spread.

Musical instrument design can be clearly seen to spread through imitation. While instruments are made by a variety of manufacturers, every clarinet is of the same basic design. Rashleigh showed that instrument interfaces change slowly, with "each innovation 'built' upon the advances of the last". While the advent of valves in horned instruments was a breakthrough, it resulted from experimentation in a variety of different methods of producing a chromatic trumpet [3]. Finally, we must merely look through a history of musical instruments such as Karl Geiringer's [21] in order to see that some instrument designs in the past have been discarded in favor of modern instruments. We have no need to determine what those selection pressures may be, only that they exist.

Why do musical instruments even exist at all? They arise from a memeplex

of artistic expression, which drives us to try to express our feelings through various means such as painting, poetry, and music. Musical instruments are a part of this memeplex, and we can see that individual instrument designs spread memetically through society by their nature. As such, we can apply memetic theories to individual musical instruments to determine what characteristics may have caused them to spread or fail to spread.

3.4.4 The Theremin Meme

Up until now, the discussion of the theremin has been purely a matter of historical accounting. Rashleigh's work gives a few compelling reasons why the theremin may not have succeeded, but I want to go a step further to discover just what is involved in the success of a musical instrument and what factors caused the theremin to fail to become commonly used in music. Fundamentally, I ask: why would an instrument that is highly interesting to me and other musicians and scientists fail to gain widespread use?

I will now review the positive and negative characteristics of the theremin and map them to the theory of memetics to ascertain the qualities of the theremin meme that help or hindered its spread. Termen felt that his instrument's greatest success was its interface and that its unique timbre and sound production qualities warranted new music to be composed for it. Never before has there existed an instrument with such a coupling of the user to the sound-producing device, although we have already seen the disadvantages of this. Memetically speaking, the theremin's interface could lead to utility in producing aesthetically pleasing music. The current meme pool creates pressure to produce beautiful music, and a meme for an instrument to do this more easily could be expected to spread.

As we have seen, though, the theremin's interface did much more to prevent its adoption than to aid it. The difficulty in learning to play the theremin must have led some that tried it to give up in frustration. These people would not have been likely to say good things about the theremin to their friends, and this negative publicity probably had a significant effect in dampening the theremin meme's ability to spread.

The theremin's uniqueness helped the meme spread, simply because it was unique and new. Numerous memes spread simply by virtue of being new and popular, such as popular songs and hairstyles. The theremin was the first effective musical use of electricity in a time when electricity use itself was only beginning to spread, and devices that used electricity were popular simply because of the fact that they used electricity. Propagandists used words such as "futuristic", "eerie", and "from the aether" in publications about theremin concerts, clearly showing the use of newness to spread excitement about the theremin [7, 22]. In the middle of the twentieth century, the theremin's sense newness led to a partial revival as it was used in movies for its futuristic sound.

However, this newness may also have been detrimental to the theremin meme. As noted earlier, some memes that spread like wildfire find their ability to spread dampened much like the wildfire's as it burns up its own fuel. Newness

can be very effective in helping a meme to spread, but it cannot make up for longevity. A meme with newness going for it and not much else might spread well initially and then fall into obscurity. Blackmore wrote that memes must not only infect their hosts, but also stay in the forefront of their minds in order to continue to spread [20]. Newness may achieve this initially, but eventually a meme relying on newness will be replaced by the next new meme.

In some cases, newness can work to the disadvantage of a meme. A new and good idea can be rejected before it spreads simply because it is new, and people tend to resist some forms of change. An example of this was the fact that the spread of anti-racism and anti-segregation was hampered because people were unwilling to accept such a new and radical idea into their minds, adversely affecting the meme's ability to spread.

People tend to be more likely to accept an idea if it is not a radical departure from previous ideas. The theremin did not directly derive from any instrument, and this may have hampered its ability to gain widespread support. The collection of memes in society, known as the meme pool, is itself part of the environment in which memes compete, just as the variety of animal species is in genetics. A meme that is hampered by the existence of memes unlike it that are already widespread in society is less likely to survive. Memes for new musical instruments that are significantly like older instruments can take advantage of the memes that already exist in society to spread. Memes that represent drastically new ideas may find it more difficult to spread because they are not able to take advantage of existing memes. If a new instrument broke from tradition and was easier to use than all previous instruments, it might do very well, but this was not the case with the theremin.

Clara Rockmore is a person, but she was also a tool in the hands of the theremin meme. From the point of view of the theremin meme, she and Termen were simply tools that could be used to spread itself. They both gave concerts and interviews and devoted a portion of their lives to spreading the word about the theremin to as many people as possible. This is an example of endorsement, and Clara Rockmore's background in classical music clearly helped the theremin to gain respect in the music community [3].

This is why Termen's disappearance had such a detrimental effect on the theremin's ability to spread. This is an example of a chance event unrelated to a meme's merits having an impact on its ability to spread. The most effective meme ever could be produced in the mind of a person just as he died, and the meme would be unable to spread despite being otherwise perfectly suited to survive in the meme pool. Chance events such as the meteor impact that destroyed the dinosaurs are a part of the environment that affects the ability of memes to spread, and the theremin had its share of bad luck in the stock market crash and Termen's disappearance.

The theremin meme had one final factor on its side that I can see in my own thinking process. When I first learned about it, I thought it was a good idea, and other people I have talked to have reacted similarly. I wanted to tell my friends about this interesting new instrument, and I wanted to learn how to play it so that others would see me and ask what it was. However, my interest

quickly waned as I discovered just how difficult the theremin was to play. I still carried the meme with me, and the fact that I am writing this analysis may mean that the reader may be more likely to learn about the theremin and spread the meme to their friends, but this paper is one of only a few in-depth analyses of the theremin. It may not be enough.

The theremin seemed like a good idea, but as is the case with many ideas that seem good, its memetic aspects simply did not lend it the ability to spread effectively in the meme pool. For every memetic advantage that can be determined, a corresponding and much stronger disadvantage exists. Even were it not for its additional disadvantages, the theremin meme would not be able to spread. Memes do not exist in a vacuum; they must have significantly high spreading potential in order to survive in society. Being mediocre or being "not bad" is simply not enough, but the theremin meme did not even accomplish that. It had many more characteristics that hindered its spread than those that helped it, and it is no wonder that it failed to gain popular acceptance. Its primary success was in sparking the development of electronic music before falling into further obscurity.

Musical instruments, then, must not only be a good solution to the problem of facilitating musical expression, they must also have memetic qualities that allow them to spread widely. It is not enough that they are new and different, they must have the fundamental memetic qualities of longevity, fecunditity, and fidelity in order to become popular. The theremin was not a successful meme, and so it spreads very weakly and may eventually disappear from society entirely.

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