

Caging the Animal: An Unfortunate History of the Theremin

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Abstract:

The Theremin was an electronic instrument invented by Leo Theremin in 1920. It was a genuinely unique instrument, built without consideration to contemporary musical standards. Its innovative potential was quickly ended, however, as the Theremin was contorted to fit within conventional western musical practice. Using the Theremin, this case study will demonstrate how western musical conventions arise from habitual consumption.

Biography:

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Music is a concept that exists within the phenomenon of sound. This concept is constructed through various cultural means that reproduce selected aural phenomena; these selected phenomena being labelled Music. As cultures and the means to produce sound change, so does the concept of Music. Within North America the means to produce sound and, consequently, Music has changed drastically in the 20th century with many scientific explorations into electricity's effect on sound production. However, North American culture had already begun following a very singular path of what aural concepts fit within the structure of Music. This led to a conflict between the new aural possibilities found within scientific discovery and the creative possibilities people's perceptions of Music would allow. Through an examination of the history of the Theremin, a 20th century electronic instrument, the path dependent nature of Music in the 20th century and the aforementioned conflict will be seen as powerful forces not only shaping Music but depriving it of aural opportunities never before seen in the age of electricity and "Ether Music."

Path dependency was a concept developed by the American Economist Paul A. David.¹ Path dependency, when put simply, occurs when an object or idea, with different uses and abilities, conforms to a single function due to historical events that essentially lock the idea or object in with that particular function. The purpose of studying such a "path" can show how social perspectives, rather than an items inherent abilities, conform the said object from one function to another. As well, since this object is not necessarily functioning based on its potential but based on popular perception it may be in fact lessening the objects function to improve the society which perceives it. This is the case of modern music as its function is most commonly now to be consumed.

¹ Path Dependency, David

If a linguist were to develop an analytical system to study the nature of the English language as spoken and written from 1600-1900 and then have the presumption to call the system the totality of an understanding of 'English,' men of intelligence everywhere would call him mad... and should someone have the temerity to inform him that there was English spoken before 1600, and our scholar replied 'Well, of course, there was English spoken before 1600, but people didn't really hear that way,' we would doubtless remove ourselves from his presence lest we become mad as well."² (Edward Norton)

The function of music, although many faceted, has mostly become singular. Though music has the potential for intellectual, scientific and creative experimentation it has become locked within the single function of being easily recognizable and transferable through a system that was erected in the 1600's. This system that existed between the 1600's and 1900's, frequently called the "common practice" period, has come to define quite rigidly the common man's and woman's perception of music. It is also interesting to note that the erection of this system occurred parallel with the ascendance of capitalism and the development of the modern nation-states of the Western world.

To define this system more it is the era which began creating and producing "key-centred music." One reason this system grew so powerful was due to the fact that it occurred during the imperialistic wave of Western culture. During this time music was seen within an evolutionary model, one that defined music in deterministic terms. Thusly "key-centred music" was considered an offspring of the music before it, and the music before that and so forth and had ultimately reached an "ideal state" where the current paradigm of Music had shed away all superfluous and erroneous functions within its nature. Thus this current paradigm was less a shift in Music but a discovery of the "correct attitude".³

According to Leo Trietler every ideology of music will eventually disintegrate, its "musical materials... 'used up,' their potential fully explored, before style can move ahead on the

² Norton, preface i

³ Norton, 13

long line of history... the material already introduced has to be shredded down to its constituent fibres, all its meaning extracted, before new material will seem meaningful.”⁴ Thus when music reached the late nineteenth century, this disintegration began to unfold with tonality being torn apart by excessive chromaticism. However this expected paradigm shift from tonality to its negation through atonality did not occur. The reason was simply due to tonalities marketability through ever more concrete perceptions of music. Although these new fundamentals of music were “interesting” they were not readily available for consumption both emotionally and intellectually. At this point music had steadfastly gained a single function, to be a consumable.⁵

Music is at first born from pitch selectivity, these pitches being chosen to oppose the chaos of sound. In reality the amount of pitches to be chosen are virtually infinite⁶ but when we run our fingers along a piano we bring into play one of the most finite systems of pitch data created, echoing the original sentiment of shedding off all useless and erroneous musical material. It is however possible for the average human being to hear over thirteen hundred different pitches⁷. No culture in recorded history has ever made use of this however since pitch selectivity is to reduce the chaos of sound and throughout history human beings have been quite conservative in doing this. However, as much as music theorists have attempted to create rational forms from the irrational, pitch selectivity has been most irrational.

There is often a certain teleology that states that Western tonality was born from the discovery of the overtone series however this is entirely false. When Jean-Phillipe Rameau, who in his “Treatise de l’Harmonie”⁸ discussed among other things the proper tuning system of what

⁴ Treitler “On Historical Criticism” p.200

⁵ Norton, 16

⁶ the only physical limits being the ability of our senses to perceive pitch, in most cases this duty belonging to our ears

⁷ Between the areas of 20 Hz and 20,000 Hz lies the average human beings aural capacity. Within this structure there are 1378 just noticeably different pitches. The piano plays 88 of these.

⁸ Rameau treatise

we hear today, discovered that the true 7th, 11th, 13th, and 14th were out of tune with the *already* tempered system of pitches, he completely discarded them. In reality, to allow for the current system of equal tempered tuning these pitches *had* to be discarded. The current system of tuning of course allowed for rapid succession of key centres without having to account for a change in intervallic relationships but this also eliminated the characteristic qualities found in each key.

It is not only the selection of pitches that have been stripped of possibility but also their registers. From inspection of the Greek's Greater Perfect System evidence has been shown that some consideration was given to the female voices often higher register however most medieval notation reveals most registers were fixed around the male voice and then developed upward. This is not unexpected though as most singers were predominantly men. By the time of the renaissance these pitches moved higher to account for secular, female voices. This is roughly where register exploration stopped however. Even the baroque composer, with access to the finest violins of their time, failed to explore the higher registers of their musical system. Although even more registers exist today we do here them but they are highly unexplored. Simply put, the amount of piccolo, contrabassoon, tuba and even bassoon concertos are relatively scarce.⁹ Of course, once again, simplicity allows for more rapid consumption, leaving the consumer in need of more material to consume.

This quality of moving through key centred music within the common, human vocal range has begun to surround the modern listener. It is because of music's **durational eminence** however, not its "correct attitude," that it has become so ingrained in our culture to the point of habit. The need for habit is of course important because the more a person is introduced to something the more simple it is to understand but this can lead to a cycle of consumption for the sake of readily available comfort, rather than gaining understand. This shows largely why

⁹ Norton 60-61

Western tonality has reigned over music in North America; the more available it is, the simpler it becomes to understand, and the simpler it is to understand, the more rapidly it can be consumed, which leads to easily attained comfort. It is within this consumerist backdrop that the Theremin, a genuine breakthrough towards the means of producing sound, is studied.

Lev Terman (anglicised as Leon Theremin, 1895-1993)¹⁰, inventor of the theremin (one of the earliest electronic instruments), was born in St. Petersburg, Russia. By 1914 Theremin entered St. Petersburg University in the disciplines of physics and astronomy while still studying the cello at the conservatory. By 1917, the time of the Russian Revolution, he had been working at Detskoye Selo, the most powerful radio station in Russia until his transfer to the military radio-technical laboratory in Moscow.¹¹

In the 1920's the Physio-Technical institute was organized, a centre to bring together the greatest engineers and scientists in Russia. Among these scientists was Leon Theremin and he was quickly assigned to use radio methods to measure different densities and dielectric constants of gases at different pressures and temperatures. By using a cathode relay, a device to convert the frequencies of the gases, Theremin was able to detect the output not with a dial indicator but with headphones. The instrument thus began emitting sound that not only changed frequencies in reference to the gas but in reference to the distance between Theremin's body and the instrument as well. Soon Theremin began performing the various repertoires he knew from his music conservatory training on the instrument thus the first concert of Ether Wave music took place within the laboratory of its accidental discovery.¹² Theremin quickly patented the device that would later be known as the theremin.

¹⁰ Ether Music 338

¹¹ Faustus, 574

¹² Faustus 574

The theremin was a unique instrument in that it was performed without ever physically touching it. The performer would simply place one hand near a radial antenna and the other near a side mounted, looped antenna. When the one hand moved closer to the antenna the pitch would rise, and when it moved away the pitch would fall. The other in turn did the same to control the volume. The sound of the Theremin was also unique in that it was not produced of the mass overtones that voice, strings or wind instruments created but in fact mixed two pitches together to create a pure sine tone, unfound in nature.

In 1928 audiences at the Metropolitan Opera and Carnegie Hall began seeing theremin performances for the first time in the United States. Not long after, the companies of General Electric and Westinghouse Electric began producing commercial theremins through the Radio Corporation of America. On September 20th, 1929, 500 commercial RCA theremins were shipped all over the United States.¹³ At this time Theremin had already established a studio for study and by 1938 there were 700 “thereminists” registered under the musicians’ trade union, not the least of which was Clara Rockmore.¹⁴

Clara Rockmore was born in Vilna, Russia in 1911 before the area gained its independence in 1918 and became Lithuania. Clara Rockmore studied violin at the St. Petersburg Conservatory at the young age of 5, the youngest student ever admitted to the conservatory. Following the Russian Civil War Rockmore’s family pulled her from the school to retreat back to Lithuania. In 1921 the Rockmore family left Lithuania to settle in New York with American relatives. It was 1928 that she first witnessed the theremin. Although Rockmore was intrigued by the theremin she continued her studies on violin until she discovered a severe weakness in her right arm making the violin difficult to play. She discovered that due to malnourishment when

¹³ Ether Music, 99

¹⁴ Faustus 576

she was young her bones had formed improperly. This new condition stunted her abilities as a violinist but did not detour her musical abilities and in 1932 she began studying the Theremin professionally. It was during her early years that Rockmore developed the aerial fingering technique, the common performance technique used by thereminists to this day. After only a few lessons from Leo Theremin she began exploring the instrument on her own and soon became Theremin's star pupil until his disappearance in 1938.¹⁵

Most the world assumed Theremin was dead after mysteriously being taken away by Soviet government officials.¹⁶ In some older texts his dates are marked as 1896-1938¹⁷. The truth of the manner came out more than two decades later when he was released from Russian imprisonment, having spent most of his time within the walls of a forced labour camp. Theremin's reasons for leaving America were much less dramatic as he left of his own volition due to piling debt and unpaid taxes, not to mention an expired work visa. He left under guise to escape these debts and this is what had led to the controversy.

Clara Rockmore continued to play the theremin in absence of Leo Theremin; continually giving tours and playing public concerts. She had a fairly conservative taste however, opting out of most romantic music written in the US and playing mostly classical and early romantic pieces composed by larger names in the musical tradition. Clara Rockmore continued to lead the artistic study of the Theremin until her death in 1998.¹⁸ Most classical recordings of the Theremin before the 1990's feature Rockmore. She has also become the standard of excellence today in terms of virtuosity on the Theremin. Rockmore continued the popularity of the theremin through her

¹⁵ Ether Music, 141-144

¹⁶ Holmes, 23

¹⁷ Faustus 573

¹⁸ Ether, 340

virtuosic performances but it was Robert Moog who carried on Theremin's innovation of electronic instruments.

In 1949 a young Robert Moog, only fifteen years old, ordered a theremin kit from a hobby electronics magazine. Moog quickly assembled the theremin and began creating his own design for it. By 1951 Moog had developed his own theremin design, a much more sophisticated version than the one he had ordered through his magazine.¹⁹

Moog was similar to Theremin in that he had a passion for scientific research that was coupled with music theory training, which he received at the Manhattan School of Music Preparatory Division. By nineteen Moog had published his own article on building his specified theremin and began the R.A. Moog Company out of his bedroom where he began selling readymade theremins. Moog sold ten to fifteen units of the model he had developed and by 1954 had sent out a brochure featuring two different models, both more advanced and sophisticated versions of the old. For the first time in history readymade theremins were available to the public.²⁰

By 1957 Moog had graduated with two Bachelor of Science degrees from Columbia and Queens College and began pursuing a Ph.D. in physics at Cornell. While in university Moog developed two new models of theremin yet again and began selling them out of his apartment. Moog made a decent enough living on selling theremins that he had no other need for employment during his university years.²¹

After Moog graduated he rented out an abandoned furniture store where he expanded his business to sell all kinds of electronic instruments. Through this business he met the experimental composer Herbert Deutsch, who owned one of Moog's portable theremins. They

¹⁹ Ether, 283

²⁰ Ether, 283-284

²¹ Ether, 287

quickly became colleagues and designed instruments. This led to the envelope generator, a synthesizer that was controlled by a keyboard that could control attack and decay. As he and Deutsch displayed their new instrument at the Audio Engineering Society convention in the fall of 1964, it received mass attention and soon they were both receiving suggestions and demands for the new instrument. Soon the instrument grew into a multi faceted conception built on many different musicians' needs; inherently growing out of supply and demand. Although the sound and the original process of the theremin is what spawned the company's new synthesizer technology, the new technology overshadowed the theremin, due to its user friendly interface. By 1965 the R.A. Moog Company discontinued all production of its Theremin models.²² The Theremin began to fade away from the public eye, replaced with electronic instruments capable of imitating its unique sound while trading its musical potential for the concrete safety of the piano keyboard. Thus the sound of the theremin lived on in the public's ear however, caged within their aural demands.

The potential of the theremin lies in its novelty. The uniqueness that the instrument possessed allowed for a change in musical practice, both in performance and composition. With its lack of a fixed tonality, historical tradition and new sound, the theremin opened a path towards new innovations in the twentieth century. These features were the making of a possible musical revolution.

The theremin was developed accidentally and was not therefore created to fit into the current musical paradigm; even with Theremin's background as a classically trained cellist he did not change the design of the theremin to fit into Western musical principals. This factor, a large reason for the theremin's potential, was also much of the reason why it was ultimately unaccepted as a commonly used instrument. Although its inherent design escaped much of

²² Ether, 291-293

Western music's traditional tonal system it was often used, quite difficultly, to play classical and romantic repertoire of the 18th and 19th centuries. As well, most repertory written for the theremin was still composed within the traditional octave of the Western scale. Furthermore, many of the theremin's chief advocates did not do much to expand the nation's idea of its capabilities.

The Clara Rockmore "Method for Theremin,"²³ republished in 1998, describes the Theremin as "another voice... to interpret **real music** (bold added by author), not a magic toy for producing strange and eerie **sounds**." This opening paragraph of the method tells the reader very quickly how absorbed Rockmore is within the Western tonal system; she indicates she has a very strict idea between Music and sound. Already this shows a sense of conservative thought where she very adamantly separates the notions of sound and Music and quickly discredits the theremin's ability to reproduce both. She then continues in the manual to suggest piano lessons to adapt one's mind to classical training and as well one's ear. Again she encourages the reader to ignore any potential the theremin has to perform outside of the Western musical spectrum by first having them conform to the said system. After these introductions Rockmore presents scale studies to be performed with glissando. These studies describe the position of the hand briefly but do little to inform the reader of her aerial finger technique until the fifth exercise. As well, all of the twelve studies further enhance the player to work within the Western tonal system. All these studies are similar to studies found on string instruments with no mention of microtonal or "non-musical" sound production. The recommended repertoire is also similar, usually indicating melodies from voice or violin scores that are "suitable" for the Theremin. Rockmore's conservative sense of music as unrelated to sound is in large part a reason for the theremin being

²³ Clara Rockmore Method for Theremin, introduction

lost within traditional Western music, only performed by the most virtuosic and dedicated player, rather than being allowed to exist within the freedom of sound.

Although Robert Moog played a large part in caging the theremin's sound within Western Tonality there was an even earlier offspring of the theremin named the ondes martenot, which was invented in 1928. Much like the theremin, the device became synonymous in name with its inventor, Maurice Martenot. Unlike the theremin, the ondes martenot was not conceived of accidentally but instead was created to surpass the theremin as an orchestral instrument. It was the intention of Martenot to create an instrument that both, looked more like a "musical instrument" and functioned within tonality more easily.²⁴ This was accomplished by adding a string which attached to the performer's finger via a ring. The right hand would move the ring along the string and the measured distance of the performer's hand would result in a pitch. The left hand was left free to press a small, pressure-sensitive key that controlled volume. To accomplish the task of giving the ondes martenot the status of a "real" instrument it was formed within a keyboard structure with a piano keyboard backdrop to guide the ring towards tonal pitches. It is not to say this instrument could not produce the full gradation of the scale; the very first piece written for ondes martenot used eighth and quarter tones,²⁵ however, with the instrument being built into a keyboard frame with a keyboard backdrop influencing the musician, the freedom that the theremin had through the novelty of its touch-less interface had begun to be censored. To date the instrument has "more than 300 (contributing) composers...includ(ing) no fewer than 100 chamber works, 50 operas, 100 symphonic works, numerous ballets, and over 500 incidental scores for films and theatres."²⁶

²⁴ Holmes 25

²⁵ This was Dmitri Levidi's *Symphonic Poem for Solo Ondes musicales and Orchestra*; commissioned by Martenot in 1928 so that the instrument would be seen, early on, to establish the ondes martenot as a "real" instrument.

²⁶ Holmes, 27

As an instrument, that used the same principals to create the theremin's sound but developed it against the backdrop of a keyboard, it replaced the theremin because it was more tonally relevant. The ondes martenot began to take the place of the theremin in the film and symphonic worlds respectively. Although these instruments moved the sound of the theremin into a more easily tonal realm, there were innovations still to be had.

The ondes martenot resembled a keyboard instrument through its design, however it still bore the pitch selection principles of the theremin, that of distance being translated to pitch. This last remaining artefact of the theremin, besides its characteristic sound, was eventually removed by Robert Moog in exchange for the common keyboard interface. This was achieved through the Moog synthesizer. As stated before, Moog created his voltage-controlled synthesizer in 1964 and by 1965 his company mass marketed the device and discontinued its theremin product-line. The synthesizer however went through many changes before it became cemented into the keyboard synthesizers today.

The early Moog synthesizers were small and modular, allowing for many different modules to be linked up or removed from the instrument. Also the voltage could be sent to different modules and used to control their effects. This early synthesizer developed by moog was unlike any other as its modular, voltage-controlled interface allowed it to be small and versatile; soon synthesizers were being called "Moogs," showing how dominant his design was. Moog soon added a keyboard interface due to the keyboard's symbolic nature and familiarity within western music culture. Many rock bands, such as the Beatles, the Rolling Stones, and Emerson, Lake and Palmer, began featuring these synthesizers in the recording studio and on tours. This coupled with Moog's desire to mass market his inventions led to a market that had

standardized the synthesizer into a keyboard interface.²⁷ Thus, all that remained of theremin by the end of the 1960's was its unique sound; now only heard within the Western tonal landscape.

The voice of the Theremin is, today, as popular as its interface isn't, surrounding the Western world with only a taste of the potential that was removed from it by Western Music's consumable nature. Although by total accident, the theremin opened a new threshold for music but within half a century it was imprisoned within eighty eight keys. There was no great revolution, no changing of the guard, the ends came, like many ends, with a whisper. Music's current function of consumption has now consumed all remnants of the theremin and mangled it amongst its vast repertory of non-complacency. It is in some hope that this paper has help shed light on the nature of music and the tyranny of the eighty eight keys that have been imposed upon it. It has never been my intent to discredit such a system but discredit its infallibility. The landscape of sound is plentiful, well beyond what we as individuals perceive as valid. With the theremin was not a method to destroy our current paradigm but to corrupt it just a bit, to allow for new possibilities to creep in when technology began appearing at an alarming rate. Today, this technological boom has not ceased in the slightest and yet music has not benefitted from this apart from easier transmission of an already easily transmitted system. There is no one system that will satisfy all but there is room for multiple systems. No language on the face of earth covers its entire surface and yet it appears music has become a universal doctrine. There is no need for one sound to represent the whole of human existence, because the whole of human existence is in fact quite splintered.

References:

- Bach, Johann Sebastian (1977). "Aria mit verschiedenen Veranderungen (Goldberg-Variationen)" in Vierter Teil der Klavierubung. Ed. by Christoph Wolff as reproduced in "Klavier- lautenwerke" in Neue Ausgabe Samtlicher Werke. Ed. By Johann-Sebastian-Bach-institut Gottingen und Bach-Archiv Leipzig Kassel, Germany: Barenreiter, 1977, Serie V, Band 2, pp. 69-115
- Collins, Nick and Julio d'Esquivan (2007). Ed. The Cambridge Companion to Electronic Music. Cambridge: Cambridge University Press.
- David, Paul A. (1985). "Clio and the Economics of QWERTY." The American Economics Review. Tennessee, USA: American Economic Association, Vol. 75, No.2, May 1985, pp. 332-337
- David, Paul A. (2007). "Path Dependence: A Foundational Concept for Historical Social Science." Cliometrica. Ed. Claude Diebolt et al. Berlin: Springer, Vol. 1 No.2, July 2007.
- David, Paul A. (2007). "Path Dependence and the Quest for Historical Economics: One More Chorus for the Ballad of QWERTY." Discussion Papers in Economic History. Ed. Liam Brunt et al. Oxford, UK: Oxford University Press, 2007, No.20, 1997
- Deutsch, Herbert A. (1993). Electroacoustic Music: The First Century. Miami, Florida: Belwin Mills.
- Emmerson, Simon (2007). Living Electronic Music. Hampshire, English: Ashgate Publishing Company.
- Galyev, M. Bulat (1991). "L.S Termin: Faustus of the Twentieth Century." Leonardo Music Journal. Michigan, USA: MIT Press, Vol. 24, No. 5, 1991, pp. 573-579

- Galeyev, Bulat M. (1996). "Soviet Faust: Lev Terman, Pioneer of Electronic Art." Leonardo Music Journal vol.6,1996, pp. 70-71.
- Glinksy, Albert (2000). Theremin: Ether Music and Espionage. Chicago: University of Illinois Press.
- Glinsky, Albert Vincent (1992). "The Theremin in the Emergence of Electronic Music." [Ph.D. Dissertation] Dissertation Abstracts International. New York: New York university, Vol.53-08, Section A, 1992, pp.2593 ff.
- Gordon Charlton (2008). "The Beat Frequency Method: Theremin for the Sonic Explorer." ScribD <http://www.scribd.com/doc/12949949/The-Beat-Frequency-Method>
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- Holmes, Thom (2008). Electronic and Experimental Music: Technology, Music and Culture. 3rd. New York, NY: Routledge.
- Manning, Peter (2004). Electronic and Computer Music. Oxford, UK: Oxford University Press.
- McClary, Susan (2000). Conventional Wisdom: The Content of Musical Form. California: University of California Press.
- Miller, David and Jeffrey McFarland-Johnson, Transcr. (2005). Clara Rockmore: Method for Theremin. [np]: [self-published] Site Address <http://www.electrotheremin.com/Method.pdf>
- Norton, Richard (1984). Tonality in Western Culture: A Critical and Historical Perspective. Pennsylvania: The Pennsylvania State University Press.

- Pinch, Trevor (2007). "Emulating Sound. What Synthesizers Can and Can't do: Exploration in the Social Construction of Sound." Wizzen Und Soziale Konstruktion. Ed. Claus Zittel. Berlin: Akademie Verlag GmbH, pp. 109-129
- Pinch, Trevor (2001). "Why Go to a Music Store to Buy a Synthesizer: Path Dependence and the Social Construction of Technology." Path Dependence and Creation Ed. Raghu Garud et al. New Jersey, USA: Lawrence Erlbaum Associates, Publishers, pp. 381-399.
- Roberge, Marc-Andre (1991). Ferruccio Busoni: A BioBibliography. Connecticut, United States: Greenwood Press.
- Taylor, Timothy D. (2007). Beyond Exoticism: Western Music and the World. Durham and London: University Press.
- Truax, Barry (1996). "Computer Music as Commercial or Public Culture: A Personal View." Computer Music Journal Michigan, USA: MIT Press, Vol.20, No.4, Winter pp. 27-28
- Walczyk, Kevin M. (1997). Electro Acoustic Music: A Brief Historical and Recorded Anthology. USA: Keveli Music.
- Wilkinson, Scott R. (1988) Tuning In: Microtonality in Electronic Music. Milwaukee, Wisconsin: Hal Leonard Books.