University of Denver

A Shared History of Innovation between Winds and Electronic Instruments

A Graduate Studies Project to

The faculty of the music department

Lamont School of Music

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Denver, Colorado

February 19, 2023

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Introduction

What is a musical instrument? When you break down the words “music” and “instrument” you might not see any issues. The definition for music has expanded over decades to incorporate multiple meanings within the realms of science, philosophy, and anthropology. And what is the meaning for the term instrument, if not some apparatus, or a tool, used to help fulfill a need or achieve a goal? Even though the term for instrument is generally understood by consensus, the issue lies in the subjective nature within music, which grants a flexible definition for what is and what is not a musical instrument. If you are accustomed in music performance, then you might already know where this is going, but in case you are not, allow me to elaborate…

I argue that electronics are not just mere “toys,” but also a legitimate apparatus from which music can be created — the same in legitimacy as a piano and violin. The acoustic music community’s overall close-minded biases toward electronic music practice and performance can be derived from electronic music’s history, or seemingly lack thereof; its history is newer with little academic research in comparison to the entire history of acoustic music. Despite its short existence, their significant impact to modern music will undoubtably make electronic practice quintessential for future musicians, and severely jeopardize even the most experienced classical musician, should they choose to ignore this reality. To the individual reader (or readers) curious enough to dive into the realm of electronic music, there cannot be music progress going forward without first looking back in the electronic music timeline.

This paper will serve as a music history catalyst — specifically the comparative histories between devices such as synthesizers and guitar pedal and wind instruments in the 19th century. The first section will open with early orchestration and elaborate on its creation and purpose for modifying sound. Following the chronology of Western music history are case studies in rapid

modifications to 19th century wind instruments — to bassoon and contrabassoon, and the relinquishment of bassoon-like instruments called the ophicleide and sarrusophone. The history of wind instrument modifications segway into the foundations of early electronic instruments, their adaptations, and their transcendence into later forms of techno-classist fine art, popular and rock and roll genres, and integration into large ensemble compositions. At the conclusion, the reader will have acquired wind and electronic insights and newfound consideration for electronic music as equal to their acoustic counterparts, and not lesser.

Orchestration Influenced Organized Sound Experimentation

From an Indo-European lens, the history of acoustic music includes a wide variety of wind and non-wind instrument families. All members of the acoustic family — woodwinds, brass, percussion, strings, and keyboards — were created to produce and organize unique sounds, primarily for sacred and secular purposes. The pursuit to organize sounds led composers and musicians to experiment with various instrumental and choral pairings, expanding from duos and motets to chamber ensembles and the eventual creation of standard choir and orchestra. The overarching history of all acoustic music is not without its adaptations; two examples include the addition of fine tuners on violins and pedals to pianos. However, due to their uniquely similar and concise history of drastic modification, the specific focus of research is on case studies in wind and electronic instruments, starting with the studies in bassoon and contrabassoon.

Example of Wind Improvements — A Case Study in Bassoon and Contrabassoon

Although many brass and woodwind instruments today improved in quality and craftsmanship following the Industrial Revolution over the course of the 19th century, no other wind instrument went through as drastic of a physical change as the modern bassoons. Successor to the Italian dulcian in the 17th century, the French 4-piece bassoon was first constructed around

1685 with 2-3 keys and several tone holes covered by the fingers.[1] Despite having little key work, the bassoon's bore design improved tuning and keywork allowed a wide note range between Bb1 – Bb4, as displayed in Jean-Phillippe Rameau's opera titled *L* (1760).[2] Nearly 70 years after *Les Paladins*, only slight tuning modifications to the bore, tone hole placement, and select few keys were installed. Leading the charge of bassoon craftsmanship and improvement through the late Industrial Revolution was German bassoon maker Johann Adam Heckel (1812-77), German bassoon pedagogue Carl Almenräder (1786-1843), and German acoustic researcher Gottfried Weber (1779-1839). In 1831, based off his earlier brainstorming with Weber, Heckel and Almenräder collaborated to create a structured 17-keyed bassoon.[3] This improved key system, called the German system or Heckel system, was so successful by the mid-19th century that most bassoon manufactures today still utilize the Heckel system.

Rival to and conservatively improved at the same time was the French style bassoon, or Buffet system bassoon, named after the Paris instrument maker Dennis Buffet Auger, who is also regarded for his construction of the 13-key clarinet. The Buffet system bassoons went through a similar rigorous and rapid improvement as the Heckel system, but retained its lighter frame, bore design, and distinguishable brighter tone color.[4] One unique feature of the Buffet system bassoons was the invention of ring keys — keys that form a ring around the tone holes, allowing

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[1] James B. Kopp, "The Baroque Bassoon," In *The Bassoon*, (New Haven, CT: Yale University Press, 2012), 62.
[2] "The Baroque Bassoon," In *The Bassoon*, (2012), 68.
[3] Gina Michelle Moore, "Eighteenth and Nineteenth Century Tutors and Their Published Contributions to Bassoon Pedagogy" (Honors diss., JMU Scholarly Commons, Harrisonburg, Virginia. December 2017), 10.
[4] James B. Kopp, "A Tale of Two Systems, 1900-1990," In *The Bassoon*, (New Haven, CT: Yale University Press, 2012), 156.

both a specific pad to close and a finger to cover the tone hole.[5] Retaining older aspects of the French bassoon with ring keys distinguished the Buffet system from Heckel, yet both systems influenced each other and remained a staple for modern bassoonists through the 20th century. Nearly a hundred years later, the Buffet system would fall out of favor due to variables in marketing and competition among sprawling bassoon manufacturers.[6]

Both Heckel and Buffet systems improved the quality of bassoon greatly by design, but there is one design change to a member of the bassoon family that deserves an honorable mention. Still maintaining truth in its surname, another way to say, "double the length of bassoon," the contra or "double" bassoon is a massively heavy instrument that served more auxiliary purposes than soloistic purposes in its early existence. Before the modern contrabassoon, the contra's design mimicked the bassoon's physique standing around 2.7 meters tall. At the advantage of playing an octave lower than a regular bassoon, the disadvantage was its immense weight and muscle strain to anyone holding it. Several contra design variants were made by European instrument manufactures, but the most revered innovation made was by Johann and his son Wilhelm Heckel (1856-1905) with the creation of the U-tube in 1879 – essentially curving the bell joint over the rest of the contrabassoon and down toward the floor.[7] This in turn relieved the bell joint's stress on the left hand, and evenly distributed the weight to both hands. The shift from straight bell to curved bell had to have a new, more ergonomically unique left-hand key system installed. Curving the contrabassoon bell downward compacted its

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[5] Klaus Gillessen, "Ring Keys on a French Bassoon," *The Galpin Society Journal* 49 (1996): 274-75.
[6] James B. Kopp, "Two Systems," In *The Bassoon*, (New Haven, CT: Yale University Press, 2012), 162.
[7] "The Contrabassoon," in *The Bassoon* (2012), 202-03.

size made it convenient to include in opera pits — whereas before the whole bell would stick out from the pit and skew the stage view to audiences. The disadvantage, as one would guess by pointing the bell downward, is sound projection. Despite this design flaw, Heckel's redesign of the contrabassoon is prevalent even today.

As impractical as it may seem to bend a bell down toward the floor, or as ridiculous as it is to have some 13 thumb keys, these were necessary updates to keep bassoon and contrabassoon relevant in the 19th century and onward. The products of experimentation and discoveries made in the Industrial Revolution radically elevated craftsmanship, tuning, response, and ergonomics to many modern wind instruments in the span of a few decades. These technological experiments also brought the creation of new instruments, potential alternatives and substitutes for bassoons in certain performance settings.

Example of Wind Discardment — Ophicleide and Sarrusophone

The experimentation on winds was not without flaws. In fact, there are several series of instruments that fell out of favor with military bands and orchestras leading into the 20th century. At the rise of new nationalistic identities across Europe, accompanied by the same rapid improvements and production of brass instruments, military bands used several updated brass-variant instruments for their weather resilience, their cost of production, tone color, and sound projection. Even with their massive update in the mid 19th century, bassoons cannot directionally project their sound as far outward as their brass counterparts, and their wood bodies would be compromised under slight weather differences. To fulfill the band aspect of performance and combat specific issues with woodwinds — in this case, bassoons and their physical limitations — several variations of brass bassoons were invented.

According to several accounts and orchestral manuscripts, the ophicleide was a popular instrument during its time. First invented in 1817 by French instrument maker Jean Hilaire Aste, the ophicleide's design resembles a brass bassoon with a brass mouthpiece. The ingenuity of the ophicleide replaced the serpent — a predecessor brass instrument whose body resembles a snake with a metal tongue that shakes — in orchestra. Ophicleide was regarded for its bright tone and impressive note register, leading to prominent composers like Berlioz, Beethoven, Mendelssohn, and Wagner to incorporate ophicleide in their orchestral works. Their biggest design flaw was its response and pads which would need replacing compared to the lifespan of valve and piston parts on other brass family members; a common pad issue for all woodwinds. By the end of the 1800's, enough significant improvements on bassoon and other wind instruments had been made, and the realized, newly found capabilities of the tuba led to ophicleide falling out of favor.[8]

Similarly made like the ophicleide but with a double reed instead of a brass mouthpiece, the sarrusophone was also invented in France with one primary purpose: to act as a substitute for oboes and bassoons in military bands. The bandmaster behind the concept — Pierre-Aguste Sarrus — pitched the idea to instrument manufacturer Pierre-Louis Gautrot, and in 1856 the sarrusophone received its patent. The sarrusophone was constructed in several sizes, ranging from soprano to contrabass, transposing in comfortable band key signatures such as Bb and Eb except for one sarrusophone in concert C. Although the instrument was intended for band use, several orchestral composers incorporated them in their works; some substantial works include Maurice Ravel's *Scheherazade Overture* (1898), and Paul Dukas's *The Sorcerer's Apprentice*

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[8] "Music for the Ophicleide," *Wessex Tubas*, Accessed March 1, 2023, https://us.wessex-tubas.com/blogs/news/music-for-ophicleide.

(1897). Contrary to ophicleides which found retirement early on, sarrusophones are still used as a novelty instrument. Their novelty makes sarrusophones performance extremely rare; so rare in fact that band and orchestra repertoire will substitute original sarrusophone parts to be played by bassoon, saxophone, tuba, or euphonium — a common formality in standard wind band and orchestra publications today.

We are fortunate to have the progress made to wind instruments during the age of industrialization. Through rigorous trial and error, the decisions to add specific keys, design completely new instruments, and find substitutes for period instruments was fueled by desires older than the instruments that were created in the mid-19th century — desires inherent to organize sound and create new forms of collective sound. Leading into the 20th century, this desire to advance and elevate was so great that musicians, authors, and artists alike founded the art movement known as futurism. Without the philosophies and contributions by futurists, we would not have the second half of this paper.

The Electronic Music Pioneers

Electronic music history can be traced as far back as the 1900's, when the futurist movement began to sprawl from the decades of post-industrialization into a Technical Revolution. The philosophies in the realm of futurism are best displayed in Luigi Russolo's manifesto *The Art of Noise*.[9] Luigi Russolo (1885-1947) had already established himself as a futurist painter, musician, and sound designer, preceding the release of his manifesto in 1913. It is important to note, as Luigi Russolo does, that at the turn of the century the human ear had

[9] Luigi Russolo, "Chapter 1: The Art of Noise Futurist Manifesto," in *The Art of Noises*, (New York: Pendragon Press, 1986), 23-30.

become accustomed to the soundscapes of the urban jungle and all its industrious cacophony[10]. He continues by stating that the next evolution to music is to advance electronic instruments and incorporate their timbres with the timbres of the orchestra. Luigi Russolo accomplishes this by creating numerous noise instruments he called the Intonarumori, and performing the earliest form of experimental soundscape music. Unfortunately, due to the graphic and horrific outcome of advanced military technologies on a global scale from 1914-18, futurism and the perception of a techian modern age would not become popular again until decades later.

By the 1930's devices such as radio, tape recorders, and improved electronic transcription discs made music more accessible to a wider audience. Electronic instruments, like the theremin and the improved Hammond organ, showed new audiences their wonder as music oddities and their infinite potential for music-making possibility.[11] Improvements to recording equipment such as vacuum tubes, microphones, and audio speakers improved the quality of music production. These products of the 30's made music readily available, but the equipment needed to broadcast and record music could only be found in radio stations and music studios. Though electronic instruments like the Hammond organ were designed to be portable and accessible, creating such electronics required more scientific understanding than music study. Needless to say, those that had the most influence in electronic music during this time had connections to broadcasting stations, and education in studio mixing and sound engineering. The pioneers,

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[10] Barclay Brown, "The Noise Instruments of Luigi Russolo" *Perspectives of New Music* 20, no. 1/2 (1981): 32-3.
[11] Thomas Campbell Young, "A Note in Electronic Music," in *Making of Musical Instruments*, 2nd ed., (London, UK, Oxford University Press, 1947), 189.

Karlheinz Stockhausen and Pierre Schaeffer, had these connections and each branded different methods to electronic music composition which are still utilized today.

One method of electronic composition uses electronic instruments as the apparatus. In laymen's terms, the instruments themselves would generate sound using speakers and oscillators, triggered by an electric current received from a switch. The quality of sound production, veering away from analog signal to digital signal, was described as having synthetic properties, and thus the electronic keyboard that is associated today was appropriately named synthesizer.[12] Although he doesn't go in depth of science behind synthesizers, Karl Stockhausen (1928-2007) dives into his interpersonal relationship with music and motivations in *Elektronische Musick* in an interview following his world premiere of Sirius (July 15, 1976). Through his experience, Stockhausen states that electronic music is "in an early stage of development (as in early medieval times), where the musician is studying his material constantly and learning from the inherent laws in the nature of material... The medieval synthesis of the highest sciences — of music, astronomy, mathematics — is again in sight."[13] Like Luigi Russolo and the futurists, and like the medieval scholars of music and sound, Stockhausen embraced the inherent explorative tradition, ultimately expanding the potentiality of synthetic music into live performance.

Following close to Luigi Russolo's experimental soundscape method, Pierre Schaeffer (1910-95) created his own soundscapes by recording elements of the environment and sampling

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[12] Paulo C. Chagas, "The Creativity of Electroacoustic and Digital Music," in *Unsayable Music: Six Reflections on Musical Semiotics, Electroacoustic and Digital Music*, (Belgium: Leuven University Press, 2014), 108.
[13] "An Interview with Karlheinz Stockhausen," interview by David Fesher, *Perspectives of New Music* 16, no. 1 (1977): 94.

them to their basic, almost raw, musical state. Fixed on accentuating the inherent musical characteristics of captured sounds in nature and the environment, Schaeffer appropriately named this genre of electronic music *Musique Concrète*. In an interview with Tom Hodgkinson decades later, Schaeffer does not credit himself as a musician but as a sound sculptor, in which the practices of the Baroque are applicable today in regard to exploring new musical ideas.[14] Although he discredits *Elektronische Musick* and pop culture at the time, Pierre Schaeffer's comparison of this timeline of electronic music experimentation to early periods of acoustic music fall similar to Stockhausen's philosophies.[15]

Both Pierre Schaeffer and Karlheinz Stockhausen revolutionized electronic music and displayed examples in which electronics spur creativity and infinite possibility. Despite their compositional differences, their doctrines for what music could be coincide with each other. Still, the desire to go even further in electronic development was present, and by the 1950's electronic music expanded out from its pompous Ars Nova into the secular realms of jazz subgenres and rock and roll.

Distortion Effects and Synthesizers in Rock Groups

As a result of new electronic music devices and efforts made in *Elektronische Musick* and *Musique Concrète,* popular music in America and Europe incorporated electronics with acoustic music by the mid-20th Century. Music groups in the 1940's influenced by genres like country, blues, and jazz experimented with several electronic elements to create what would be the next

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[14] "Pierre Schaeffer Interview," interview by Tim Hodgkinson, *Recommended Records Quarterly* 2, no. 1 (1987). http://paul.mycpanel.princeton.edu/music242/shaefferinterview.html.
[15] "Pierre Interview," *Recommended Records,* 1978.

popular genre — rock and roll.[16] Despite its popularity reaching tops of charts on radio stations around the world, due to its provocative live performances and explicit nature in lyrics, timbre, and rhythm, rock's popularity was accompanied by persistent backlash. The apprehensive criticisms that followed rock and roll also followed the electronic instruments used by rock bands; not only were electronic instruments overshadowed by acoustic instrumentalist's superiority complexes, now the disaffection by technocratic elites on popular music imprinted complexes within the electronic instrument family.

Effect pedals were just one of several electronic devices utilized by rock guitarists, in which a pedal could change their volume and pitch quality. The board science behind operating an effect pedal involves a passing signal through a cable from the guitar to the effect box, which receives and modifies the signal before sending the signal out, until the output result is the manipulated signal manifested into audible sound by an amplifier.[17] The names given to different distortion pedals describe the type of tone manipulation; names like "whammy" bar and wah-wah are onomatopoeic names, while other names like chorus, delay, reverb, and looper gave clear definition for their modular sound properties. A large amount of credit goes to individual rock performers from America and Britain who trademarked themselves with their distinct electric tone with virtuosic solo performances. Eddie Van Halen (1955-2020), rock guitarist virtuoso for the band Van Halen for example, experimented with and set the foundation for his soloistic sound

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[16] Denna Weinstein, "Rock Guitar Gods – Avatars of the Sixties," *Archiv für Musikwissenschaft* 70, no. 2 (2013): 140.
[17] Paulo C. Chagas, "The Creativity of Electroacoustic and Digital Music," in *Unsayable Music: Six Reflections on Musical Semiotics, Electroacoustic and Digital Music*, (Belgium: Leuven University Press, 2014), 107.

using wah-wah and fuzztone effects.[18] Eddie Van Halen is just one of many distortion effect pedal enthusiasts; influenced by the bands before and an icon for rock bands after, reputable rock and roll bands members continually experimented with various distortion devices. Several other guitar experimentalists I find worth honorable mentions include Keith Richards of the Rolling Stones, Jimi Hendrix, Eric Clapton, David Gilmore of Pink Floyd, and Stevie Ray Vaughan.

Pierre Schaeffer, the founder of Musique Concrete, claims that rock music is brutal and violent in its nature. In his 1986 interview with Tim Hodgkinson for the *Recommended Records Quarterly Magazine*, Schaeffer compares the experience of rock and real music to that of drugs. In Pierre Schaeffer's words, "Real music is a sublime drug, but you cannot really call it a drug because it does not brutalize, it elevates. These two characteristics of rock, the violence of the sound and the drug-function, resolve on the basis of a musical formula which is impoverish."[19] Pierre Schaeffer exuberates a technocratic complex within the realm of electronic music similar in manner to acoustic music's aristocratic superiority.

Contrary to Schaeffer's philosophies on rock and roll, audiences across the world embraced rock groups and later synthpop groups, whose electronic songs and albums reached the top of charts and received numerous awards. One such synthpop group — Depeche Mode — heavily embodies synth sounds while maintaining traditional rock form. "Just Can't Get Enough" is a single constructed of simple lyrics, driving rhythm, and motivic synthesizers throughout. As simple in device as the song is, Depeche Mode's single was in the UK (United Kingdom) Top 10

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[18] Denna Weinstein, "Rock Guitar Gods – Avatars of the Sixties," *Archiv für Musikwissenschaft* 70, no. 2 (2013): 141. https://www.jstor.org/stable/24467204.

[19] "Pierre Interview," 1987.

chart, placed as number 8 in 1981.[20] The contributions made by Depeche Mode and other rock artists elevated electronic music, helped create several unique electronic music devices and music subgenres all while in character with their wind colleague's history of adaptation, modification, and experimentation. Simultaneously, the success of electronic music in pop culture inspired composers to finally incorporate electronics with wind ensemble and orchestra.

Electronic Music in Orchestra and Wind Ensemble

The repertoire for large ensembles and electronics may seem limited at first, but in reality there are plenty of compositions, as provided by Frank J. Oteri's from his catalog of orchestral and electronic essentials.[21] Going back as far as the 40's and 50's, the electronics used in large ensembles involved tape devices and sound samples, similar in practice to Schaeffer's *Musique Concrète.* Following European acoustic traditions featuring one instrument, concertos for electronic instruments emerged between 1970-2000; examples include an electric violin concerto by Michael Sahl (b. 1934), a concerto for electric wind instrument by Howard Sandroff (b. 1945), and a concerto for turntable by Raul Yañez (b. 1973) composed in 2001.[22] One composer – Michael Daugherty (b. 1954) – wrote 5 works between 1987-90 showcasing solo synthesizer performance with full orchestra. Wind Ensemble repertoire also branches out into electronic territory, most recent examples include Eric Whitacre's *Deep Field* (2015) and Steven Bryant's

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[20] Stuart Borthwick and Ron Moy, "Synthpop: into the digital age," in *Popular Music Genres: An Introduction* (Edinburgh University Press, 2004), 129-30. https://www.jstor.org/stable/10.3366/j.ctvxcrbm0.12.

[21] "Works for Orchestra & Electronics: A List of Essentials," NewMusicBox, accessed February 19, 2023. http://www.americancomposers.org/orchestratech/oteri_list.htm.

[22] "Works for Orchestra & Electronics," accessed February 19, 2023.

The Automatic Earth (2019).[23] Their success in large ensemble repertoire allowed electronic music to surpass the concert hall into multimedia; primarily music videos, film scores and stage musical productions. It took radical improvements and contributions by prominent rock musicians to pave the road forward, but once these devices had the capacity to fulfill the composer's musical intent the electronic music family found itself sharing a similar orchestral performance track to the classical traditions of European acoustic music.

Conclusion

A lot happens in a decade — more so in the last five or six decades, thanks to smartphones, tablets, and their digital age predecessors who established the global communications network. With the current combination of rapidly developed digital technologies and Western social-economic climate, we are living through the second digital revolution — the notion I propose primarily influenced by technologies fulfilling convenient procedures and services with as little to no human involvement; examples include video streaming services, artificial intelligence generating speech and artwork, and 3D printing. Technological advances have consistently shown time after time the infinite possibilities for creation and improvement. For music, perhaps the next evolution in organizing collective sound will create an entirely new ensemble — one with all electronic instrument performers, or an all-robotic orchestra with no human performers at all. But until that day, to those who are musically proficient or musically curious enough to have made it this far, I give you these final words...

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[23] "Category: Electronics," *Wind Repertory Project*, Accessed March 1, 2023. https://www.windrep.org/Category:Electronics.

Now is the time to incorporate electronic music studies in performance. You have the broad history of both wind and electronic instruments, and their impact on music today. Verbose as it may be to present studies in bassoons, ophicleides, and sarrusophones, mentioning their experimental past is necessary to legitimize and contextualize electronic music performance in a realm still dominated by acoustic music superiority. Although acoustic and digital music mediums respectfully distinguish each other, their instrument family branches stem from a large trunk rooted in the traditions and curious pursuits of organized sound. In order to enhance music in the 21st century, instrumentalists must set aside their prejudices, and invite futuristic curiosity in the practice room. Experiment with available devices as Eddie Van Halen and Luigi Russolo did, and just as 19th century industrialized winds had done to be prevalent today. Use what you learned here to plan the future of music tomorrow.

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