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Craft, Science, and Technology

Encoding Music and Its Impact on Society

Over the past several centuries, technologies such as the printing press, the sound recording, and the film camera all had immeasurable influence on the development of societies around the world. The most well documented impacts of these technological advances were the ways in which they enabled humans to encode and record, to progressively more complete approximations, their speech and behaviors. But running alongside these developments, over the last millennium, was the parallel evolution of the encoding of music, whose ultimate effects on world society and culture cannot be overstated. From early written religious chants to the current state-of-the-art in sound reproduction hardware, each advance in music recording technology improves on its predecessor, gradually increasing the control afforded to the original writer of the music, and subtly varying the nature of the writer-performer relationship in the creative process that births a song.

The initial recording device used to pass down music was, of course, the human memory, and prior to the existence of any sort of written records we must assume that what music there was passed on by ear between generations. Before widespread literacy and access to paper and ink, the formal performance of music in the Western world was relegated to the Church, and thus the task fell to the educated among the clergy to lay the foundations of reproducible musical encoding.

The earliest forms of musical notation, at least in the Western world, were far from reproducible, and far from what we might consider a readable form of notation today. Sheet music in the ninth century consisted largely of the lyrics to psalms and hymnals, containing mostly written words and song lyrics. The musical notation was designed entirely with written words in mind, intended for use by choral groups singing chants rather than any sort of instrumental performers.

The musical formation of Gregorian chants was tied, not to notes, but to syllables: a complex series of "neumes", syllabic units, represented by lines and embellishments sitting above lyrics on a four-line staff. Reading this notation properly takes extensive contextual study and rehearsal, showing clearly "how the chant reinforces the structure – but not the specific sentiments – of the text it clothes" (Kelly 15). Thus, the era's notation system grew out of the types of music that it was designed to encapsulate, and the use of the system to notate more music reinforced the continued creation of similar music.

The staff notation system that we use today, much like the Latin alphabet, moved through several stages of existence, beginning as a rather fragmented set of rules and coalescing over time into a more unified standard once its rules became more consistent. It originated from tablature-based systems, which, designed as notation for stringed instruments, give entirely mechanical instructions. Rather than offering any leeway in note choice or even describing what the piece might sound like, tablature functionally converts the musical performer into a part of the reproduction apparatus (Kelly 18). How the performer might reproduce that which could not be notated of the composer's original artistic intent was dictated, as before, largely by memory and custom. This system gives both more and less control to the performer: there is next to no note-to-note ambiguity, but there is a significantly smaller amount of attention paid to the intended delivery of a piece, meaning that in some ways the performer has more artistic liberty over the composer with regard to the way any individual note is expressed, and ultimately, how a piece comes across.

Ultimately, the modern Western staff notation system that developed over the next several hundred years strikes a balance between its more qualitative and quantitative predecessors. The five-line staff allows a composer to specify precise note values that, although hewing to a limited diatonic scale, provide for the encoding of notes at arbitrarily precise frequencies, times, and

durations. However, today's definition of a piece of music as a joint artistic endeavor between composer and performer, as well as qualitative notations like tempo markings, means that there is an implied amount of artistic leeway, allowing the performer to, at least to an extent, make a piece of music their own.

A separate musical encoding system that developed in parallel to our modern staff notation system was the musical automaton. The first examples of these were the automatic organs designed by Robert Fludd in the 1500s (Ord-Hume 17). His designs consisted of massive, rotating, water-powered barrels studded with pins corresponding to note and time; these pins then triggered individual notes of a pipe organ as the barrel rotated. Through the late 1700s and early 1800s, the idea of an automatic music-playing device was born out of the Enlightenment fad of the automaton - extraordinarily complicated, human-shaped clockwork curiosities geared to simulate a specific, repetitive task. Early automatic music players were, in fact, simply human-shaped automata whose set tasks were to play a short piece on a keyboard or other instrument.

These early musical automata brought a new type of encoding to the variety of ways in which music could be produced and conveyed. In a sense, they seek to obviate the role of the performer from the creative process, allowing the builder of the machine to create a performance that can be repeated indefinitely and directly to the audience. But in an implementation where the musical piece itself is tied so inextricably tied to its instrument of reproduction, it is difficult to argue that the designer of the automaton does not, to some extent, himself step into the role of the performer. And although there were few musical pieces composed explicitly for early musical automata, the mechanical constraints of the clockwork system severely limited the level of detail, timing, and expression that could be conveyed through its music, meaning that encoding a piece as jutting pins on a rotating drum rather limited that piece's expressive capacity.

Starting in the mid-to-late 1800s, a new variety of musical automaton began to appear. Any device that makes a pitched sound does so by vibrating some medium that tends to resonate at a certain frequency. Musical automata had all been above a certain size because the resonator used needed to vibrate in the audible frequency range; the crucial miniaturization step occurred when a watchmaker, Antoine Favre, decided to create sound not by striking gongs or hammers, but with a "sliver of steel, shaped, polished, tempered and then screwed into position so that projections on a rotating cylinder could pluck at its free extremity" (Ord-Hume 63). Such began the era of the modern music box, whose intricate clockwork finally brought the musical automaton into the homes of wealthy and upper-middle-class citizens, and, after the products were made substantially cheaper, ordinary folk as well.

This style of clockwork music also brought the world one of the first iterations of "encoded sound" – a standard procedure by which a craftsman could encode a piece of music into a physical device designed to play it back. Music boxes were also modularized – interchangeable metal cylinders (and later, circular plates) were made available that could be inserted into the body of a music box and made to play different pieces. This method allowed a craftsman-musician to set a piece into a modular medium via a predefined standard of recording – and while the method grew ever more flexible, it was certainly not a viable tool for notation or composition because of how cumbersome and difficult the construction process was, as well as the typical use in consumer products. However, this encoding method deserves recognition simply because of how it ties into the forthcoming generation of analog sound as well as the remarkable fusion of watchmaker and musician that it attracted. The recording method for devices like this has striking parallels to the earlier description of tabulature-based music notation: the responsibility for interpretation of a piece was shifted to the watchmaker designing the barrel or disc, and the musical encoding itself consisted

only of precise instructions for the eventual performer, whose role in this context was taken by a mainspring driving a set of clockwork gears. Yet this family of device also imposed significant limitations on the types of music that could be captured (and thus, the only music that could be reproduced automatically in the era before analog recording). For instance, from this 1826 watchmaker's reference: "long or slow, short or quick notes, such as the minum and demi-semi-quaver, are not well suited to bell-music … the minum and demi-semi-quaver may, however, be brought in at some parts. The time in which the barrel turns, after striking or lifting a hammer-tail … must be in the same proportion with the notes, according to their respective character" (Ord-Hume 98). The system was here limited by its shortest and longest possible note, given that everything else encoded by the music was linked to those durations by the rotational velocity of the drum or disc.

The ultimate musical encoding system, first developed in the last 25 years of the 19th century with major discoveries by Elisha Gray, Thomas Edison, and Emile Berliner, was of course the phonograph – a system through which, first via a cylindrical drum, and subsequently through a plastic disc, sound data could be encoded as grooves that were later read through a needle. Although its lineage is quite separate than that of the music box, bearing more common heritage with the electric telephone, conceptually the idea of continuous versus discrete audio encoding is quite fascinating. It can be viewed, on its simplest level, as simply a more advanced version of the music box – one who encodes a continuous series of acoustic impulses whose "minum", or equivalent to smallest possible note, is indefinitely brief. (Remarkably, the digital age of recording has returned to a discrete representation, whose "minum" equivalent is 1/44,000 seconds). The initial iteration of the gramophone was invented well before the mastering process was well defined, and the oldest commercial recording process consisted of searching for talent and recording a song through twenty wax cylinders simultaneously, ad nauseam. Fred Gaisberg was one of the first A&R men and

producers of the nascent recording industry, and he recalls that "to earn my $10 a week I had to find the artists, load up each of the twenty units with paper cylinders, set the recording horns, and play the accompaniments … Sometimes we would perform ["After The Ball Was Over"] as many as seventy times a day" (Moore 8). With the rise of the mastering process and affordable, serious musical reproduction, the phonograph finally eliminated the initial performer from the last phase of interpretation of a musical encoding. This allowed an audience to hear music consistently and repeatably, in the same way as it was originally intended. This was a hugely important advance, as the ability to capture a recording allows an individual performance to entirely describe the reference version of a song, allowing much greater spontaneity in a performance and the ability to "cement" a version of a piece which may not even ever have been composed in the traditional sense. The advent of affordable sound recording around the turn of the 20th century, and the ability to experience the art and science of others across space and time, also provided an important foundational basis for the connectedness of today's society. Socially, it also brought all types of music into an accessible space for people outside of the upper class, and publicly available gramophones, producing music for people that might not be able to afford the attendance at a live performance, became commonplace and well used.

Even the early analog recordings, however revolutionary they proved in both the composition and capture processes, imposed some limitations on the nature of the music that they could capture. For instance, early gramophone recordings were severely limited by the reproducible frequency range of which the gramophone itself was capable, meaning that early recordings would have to be done with some significant volume: in the early days of commercial recording, producers would seek out "someone to play the piano loudly and clearly enough for its sounds to be captured by the apparatus as the accompaniment to whatever musician might be chosen to 'record'" (Moore 3). This

foreshadowed the ultimate goal of high fidelity in the production of analog recordings, one extant to this day – and indeed, as recording technology improved, it rapidly became competent at capturing the entire audible human frequency range, as well as allowing for some equalization to make recording of certain sounds more palatable.

As recording technology matured and moved into the electric age, two important roles, well defined by the end of Gaisberg's lifetime, emerged: those of the recording engineer and the musical director. The first of which "concentrated on his meters and kept the dynamic range of the recording within the capabilities of the equipment" while the last of which "concentrated on tempos and arrangement" (Millard 269). These two roles added two previously undefined creative steps into the music reproduction chain, and each one was able to contribute his or her own artistic decisions into the final product as heard by their ultimate audiences – although "[the rapport between the two] often broke down because artistic and technical considerations did not necessarily coincide".

With the advent of tape recording, technology-aided composition took another quantum leap forward, allowing the recording engineer and the producer/director to assemble music in a non-linear order, both for simple convenience of recording and also for artistic purposes. The first serious, radically experimental use of tape-manipulated recording emerged in the 1940s and 1950s, pioneered by artists such as Halim El-Dabh in Egypt and Pierre Schaffer in France. This began the era, first predicted by André Cœuroy in *Panorama of Contemporary Music*, of a time when "a composer will be able to represent through recording, music specifically composed for the gramophone". The 1950s, being an important formative decade for both tape manipulation and analog synthesis, introduced important new layers to the encoding process. With synthesis, we feed discrete note data (which can be recorded or played live), today usually encoded with the MIDI protocol, into devices that spit out a continuous stream of sound. Are they instruments, or subsets of

encoding methods? Do their designers deserve as much credit as the pioneers of the turning-drum automatic organ, or should they be considered more akin to something like a piece of sheet music?

Ultimately, the way that today's music is produced is an amalgamation of techniques used in past centuries. A performer begins with sheet music, written perhaps by a composer or perhaps by herself. She can record this performance either via a continuous vocal or instrumental acoustic recording (a descendant of the gramophone) or through an intermediate encoding of note data (a descendant of the tablature method) - then processed by a synthesizer. Her ultimate representation of the piece is encoded over many sessions, and spliced together with a digital system (designed to mimic the functionality of a tape recorder) - then mastered and cut to physical media descended directly from the record. From there, it can be directly transferred to computers, smartphones, and digital players via physical storage or, more commonly, the Internet, which provides an ever broader range of consumption and distribution options. But every step of the modern recording and listening experience is directly beholden to the hierarchy of encodings on which its art and science are based, and the evolution of process over millennia has brought continuous change to the role of writer versus performer versus producer in the procedure of bringing music from the minds of the creators to their audiences.

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