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Language as a Window into the Mind

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Music and Artificial Intelligence: A Creative Combination?

When the lights flood the stage at *Tommorowland*, there are no instruments. There are no bands. Hardly a note is sung by a human being. In fact, at the world's largest electronic music festival, attended by more than 180,000 in 2013, the biggest acts drive the crowd into a mesmerized frenzy with little more than laptop computers (Hendrick & Maclean, 2013). While it may seem like the men behind the machines are surely musical geniuses, in reality it is the complex synthesis algorithms of the software and the logic of computer processing that create the sounds which make hearts pump fast, heads bob, and dopamine flow. It's a bizarre scene that would have surely fascinated the imaginative science fiction authors of the past, but shouldn't surprise a modern music industry that is increasingly reliant on technology. However as the bass drops at electronic music festivals and dance clubs throughout the world, questions are raised. How long before the last biological component in the musical creation chain, *the composer,* is replaced by a computer? While the idea of a computer program selling out Madison Square Garden with an original, emotional composition might seem absurd to traditionalist musicians (Lawson, 2009), I argue that when examined closely computers are already capable of possessing qualities of musicianship. However unpleasant the idea may be to some human musicians, with the integration of artificial intelligence techniques, computers do in fact have the potential to be just as musically creative as humans.

The idea of computer musical composition is not a new one, partially because of the close relationships between the rule-based structure of classical music theory and the algorithmic processes of early computers. In his 1980 article "Artificial Intelligence and Music," Roads traces the first experiments in computer music composition to as early as 1955, with the primary motivation being developing a system that could carry out the basic rules of composition. Because of the development of artificial intelligence focused programming languages such as LISP, computer composition, especially of classical music, has become a much more attainable goal (Roads, 1980). Traditional music theory is a rigid rulebook for composition, and concepts such as key, chord progressions, counterpoint, and figured bass can be easily programmed and represented algorithmically in modern programming languages. In spite of these possibilities, Roads however expresses doubts about the prospects of the implementation of AI in music:

> "One cannot expect miracles from this new surge of interest in applying AI concepts and techniques to music, just as one does not expect miracles from similar endeavors in the most heavily researched AI field, natural language processing." (Roads, 1980)

In saying this however, he overlooks the vast differences that exist between language and music. While language is uniquely a human phenomenon, whose cognitive processes and organization exist deep in the recesses of our minds, it can be argued that music is a phenomenon based on the natural laws of sinusoidal harmonic motion. It should be much easier, in theory, to design a program to obey the physical, mathematical laws of harmony and dissonance which subsequently creates a pleasant sounding melody than it would be to design a program with an understanding of language that can construct a sentence with meaning behind it. It is within the compatibility of the physical laws of mathematics and music that allow for computer musical composition in the first place, and which ultimately give possibility for computers to possess attributes of human musicianship and creativity.

In order to consider the plausibility of actual human-like computer musicianship, it is important to understand the cognitive aspects of human musical composition. While the mental processes behind any human act of creativity have by no means been confirmed, works such as Pearce and Wiggin's "Aspects of a Cognitive Theory of Creativity in Musical Composition," shed light onto the often-mysterious subject of composition. The authors propose that creative musical composition in humans is facilitated by the composer's ability to take into account multiple features of a developing piece of music all at one time. The authors also explain that works of musical creativity are largely based on derivations of the works of music that influenced a composer. Thirdly, over the course of a composer's lifetime creativity is maintained with each successive composition if the composer continues to modify his compositional techniques (Pearce & Wiggins, 2002). As I will argue, these three criteria of human creative musical composition are indeed fundamental to the creative success of historical and modern musicians, and can be used to evaluate the possibility of computer musical creativity.

Some of the more ambitious efforts made to model human musical creativity exist as part of the Canadian Metacreation and Multi-Agent Systems (MAMAS) project. The project, dedicated to researching the possibility of artificially creative musical systems (metacreations) and constructing models of human creativity, has made many interesting advances in creative artificial intelligence. "Realtime Generation of Harmonic Progressions Using Controlled Markov Selection," authored by project members Arne Eigenfeldt and Philippe Pasquier, is of particular prominence to my argument. The article describes an experimental program designed to compose harmonic progressions that considers and quantifies complexity and tension in the developing piece in order to construct an interesting, coherent composition (Eigenfedlt & Pasquier, 2013). While the program relies on human input to set loose guidelines for a desired bass line, the importance and innovation of this program are not subdued because of its lack of automation. While considering complexity and tension, the program exhibits the ability to simultaneously consider multiple aspects of the developing piece at once—one of the aspects of human musical creativity discussed by Pearce and Wiggins. In doing so, it shows that the mathematical ways in which the brain operates during music composition are easily replicated in a computer program, and the result can be shown to demonstrate aspects of human level creativity. In fact, modern advances in computers that allow for parallel processing (Hwang, 2013) only increase the ability of computer programmers to emulate human musical creativity, and in many ways exceed the multi-tasking abilities of the brain.

Of all of the computational models of musicianship created, possibly the most accurate and effective composition programs have been developed by a human composer. When David Cope, a classical composer turned computer programmer, began to run out of ideas for new compositions, he turned to his knowledge in programming to create innovative software he affectionately named “Emmy” (Cope, 2013). Emmy is built on a musical database of classical compositions, which the computer analyzes and draws influence from, to construct original works. The resulting compositions that Emmy creates are dynamic depending on the pieces of music in the database. The program is particularly known for its ability to “resurrect” classical composers (Cope, 2013). For example, if the database is strategically filled with music composed by musicians that Mozart might have heard in his time, the composition generated by the program will possess the characteristics of a Mozart composed piece. Possibly the most groundbreaking aspect of these compositions is that they have shown the ability to pass a sort of “musical Turing test”; they cannot be distinguished from human compositions (Wilson, 2010). Probably the reason the program is so effective is because its structure accurately models the human creative process. Emmy’s use of a musical database places it in agreement with Pearce and Wiggin’s model: that musical creativity is based on modification of the works that influenced a composer. This model of influence can be confirmed by observing the obvious influences drawn from Joseph Haydn in Mozart's early compositions (Rosen, 1980). If Emmy's database were to be filled with Haydn pieces in the same way that Mozart's human auditory memory was, then Emmy is not merely emulating, but using the exact same creative process as Mozart, and demonstrating human caliber musicianship. It is this realization that computers can in fact show musical creativity that lead Cope to believe that he had not created a computer to write music like a human, but in reality it is humans who compose like computers (Wilson, 2010).

Cope's idea leads to the deconstruction of many hypotheses that claim human composed music to be more legitimate than computer composed music, including those that center on the "emotion argument." Many musicians would propose that a computer program would be forever doomed to produce music that is in a sense emotionally "sterile", because the program would fail to understand human emotions (Lawson, 2009) and thus could never be truly musically creative. If Cope's theory is true however (as the evidence points towards) that humans do take such a computational approach to music composition, then music's ability to effect emotion does surely not lie in its human origins, as computer-composed music is created in an identical process. Rather it seems that it is the listener's responsibility to interpret a piece and assign emotions based on their own previous listening experiences and cultural preconceptions (Williamson, 2013). All attempts made to claim that computer composed music is unemotional are surely a result of bias. It is helpful to pose the question: would a human-composed minor chord progression sound any more melancholy than a computer-composed minor progression? If the listener was unaware of the progression's origin, it surely wouldn't. In this way, a computer program's ability to be musically creative is not limited by its inability to understand emotion.

In addition to Cope's original Emmy program, his newest program "Emily" also has features that show evidence of musicianship. Emily is a more cooperative, interaction-based program compared to Emmy, and uses a progressive, transformational method of developing unique compositions (Cope, 2013). Although Emily is not as reliant on a musical database as its mother program Emmy, the most important aspect of its function is its ability to seemingly develop its own unique style through a series of compositional methodology adjustments. While the initial work produced by Emily is largely unoriginal, it slowly transforms into its own style in a way not unlike how the work of Mozart progressively began to develop defining qualities over the course of his career. The flexible nature of Emily allows for the program to consistently produce increasingly creative compositions that still remain in its own style (Cope, 2013). It is this defining characteristic that Emily shares with human musicians like Mozart which has led Cope to release entire albums of composed music credited to the computer program. The human attributes in this type of progressive compositional development are not found only in comparison to Mozart however; the program also demonstrates human-like musicianship because of its relationship to a Pearce-Wiggins aspect of human creativity. As stated by Pearce-Wiggins, creativity is maintained by the ability of the composer to modify his compositional techniques over time (Pearce & Wiggins, 2002), a method that Emily uses to its advantage when producing unique compositions. If Emily didn't emulate this human technique, it would surely fall into a "compositional rut" and continue to create boring regenerations of similar pieces of music. In this way, Emily proves that not only can a computer program demonstrate isolated human-level musical creativity as Emmy did, but can exhibit enough repeated creativity to produce multiple albums, enough to algorithmically generate a *career* in composition.

It might be argued that the reason that programs such as Emily and Emmy have no difficulty composing original music lies in classical music's rigid structure and rule system, that when given the task of creating actual innovative, experimental music, a computer cannot be relied upon to create anything original. In addition to being forced to imply that classical music composition does not take much musical creativity, those who pursue this argument would also overlook the fact that the Pearce-Wiggins principles of human musical creativity (which I argue computer programs have been proven to possess) also apply to composers who generate "experimental" music. These principals can be observed when examining the chronological case study of Radiohead, a band widely considered to have generated some of the most innovative music of its time. Initially, the band utilized simple structured chord progressions and drew heavy influence from arena rock and grunge, and as a result were considered unoriginal by critics (Krepes, 2013). With each additional album however, the group began to take more and more influence from less-structured electronic music and eventually became renowned for their own "experimental" style (Krepes, 2013). This type of progressive influence combines multiple aspects of the Pearce-Wiggins human creativity model: the band's changing influences led to a constant change in their compositional methods, which allowed for increasingly different compositions to be produced in turn. This is important because in theory, a computer program that models multiple aspects of the Pearce-Wiggins model could be designed to emulate the "experimental" creative music composition processes of bands like Radiohead. A program such as this would be programmed to continually "break rules" in its compositional techniques to create such experimental music. Ultimately such a program could construct experimental music, regardless of whether those compositions were bounded by rules of traditional music theory, purely based on its ability to analyze patterns of structure (or lack of structure) in the pieces of influencing music in its database.

One of the most important aspects of human musicianship, and subsequently one of the most difficult challenges for artificial intelligence, is real time improvisation. In "Interactive Music Systems In Ensemble Performance," Robert Rowe investigates the possibility that a computer program might be able to musically interact with performing human musicians (Rowe, 2000). In the article, Rowe describes a program he wrote, coined "Cypher," and its ability to respond to a human performer through improvisation. Importantly, he explains that his program implements a programmed self-criticism system, which allows for a sort of pre-screening and refinement of musical ideas before the program plays them (Rowe, 2000). This sort of musical self-evaluation is not a mere novelty of the program's construction; it is fundamental to its accurate emulation of the human creative process. Attributes of self-assessment are necessary for the success of all human musicians, who must be able to recognize what musical ideas are appropriate for the corresponding key and style of a piece. In this way, Rowe's program exhibits an aspect of human musical creativity, the real-time musical evaluation abilities critical for improvisation.

Regardless of what computers can be proven to accomplish, there will always be skeptics that will affirm that human musical creativity can never be matched by a machine. These "musical humanists" will always doubt the progress made by artificial intelligence and belittle the proven successes of machine musicianship. For some, it seems that a romanticism will always exist with the idea of human creativity. Regardless, the evidence is overwhelming; computer programs *can* show actual musical creativity. The reality that David Cope expressed, that composition, and musicality in general are not the sacred, untouchable human traits that many hold them to be is undoubtedly humbling for even the largest musical egos, and borderline depressing for those who have chosen to dedicate their lives to composition. Has the magic of music somehow been lost on the discovery that it might not be uniquely human? I conclude by contending the exact opposite. Just as humanity's fascination with the universe increased even while watching two men land on a disappointingly waterless, lifeless moon, we can similarly find wonder behind the discovery of the realistic truths of music. It is inherently wonderful that the physical phenomenon of sound pressure has the power to effect our emotions and even *change lives* regardless of its compositional origin, whether it be man… or machine.

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