Recursion in Music and Language, with Mozart as a Reference

## Ben Roberts (2011)

A significant school of thought in the field of generative linguistics, initially inspired by Chomsky,<sup>1</sup> posits that the use of recursion is an integral component of the human language faculty. Recursion is also an essential element in one the landmark books on musical grammar, *A Generative Theory of Tonal Music* (GTTM), by Lerdahl and Jackendoff.<sup>2</sup> Both music and language are found in all human cultures, and there is a growing body of research comparing and contrasting the two domains and their relationship with each other. This paper explores the role of recursion in GTTM and generative linguistics, and considers its function as a vehicle for expression, communication, and creativity in the domains of music and language. Selections from Mozart's work will be analyzed with GTTM to investigate these topics within music, while the literature from generative linguistics will be surveyed with regards to language.

Music and language are part of a small group of universals found across human societies. Patel notes that, though the Pirahã tribe of the Amazon lack many of the social traits found in other cultures, such as a creation myth or an interest in art, they have both music and language.<sup>3</sup> For Chomsky, music is part of our "highly differentiated learning system" with a grammar of its own that, like language, seems innate.<sup>4</sup> In part because humans can understand and communicate an "indefinite number of expressions that are new to one's experience," he believes that "the normal use of language is, in that sense, creative."<sup>5</sup> Music combines discrete expressions together in at least a similar manner, with similar affect.<sup>6</sup> Adding the assumption of an innate grammatical system, we can postulate that the normal use of music can therefore be defined as creative, much like

language. We can use the connections between these two domains to examine a central component of generative linguistics theory, that of recursion, within the idiom of music.

Recursion has always been part of the framework of Chomskvan-influenced linguistic theory, though it has gained further prominence over time. In Syntactic Structures (1957), Chomsky wrote that a sequence of "a+s1+b" could be expanded in a recursive way within the "s1", by a self-similar sequence of "c+s2+d."<sup>7</sup> Therefore, he argued that language had non-finite qualities and was not a Markov process. The importance of recursion was "if grammar does not have a recursive devise ... it will be prohibitively complex."8 In this phase of Chomsky's thought, according to Bickerton, recursion was involved "only in the transformational component,"<sup>9</sup> that is, "a" and "b" were not recursive in nature but rather static phrase-structures. In The Minimalist Program (1995), Chomsky modified his framework with a concept called Merge, which postulated that sentences were formed through a serious of binary combinations between words. Merge utilizes a process of "combining discrete elements in an infinite way" and contains "an aspect of recursion."<sup>10</sup>According to *The Minimalist Program*, humans organize words into sentences through this series of binary combinations, "feature checking" along the way so that the words match tenses, etc. If the set of words cannot "Merge" they "Crash". In a later article from 2002, written with Hauser and Fitch, Chomsky placed recursion alone in a category called Faculty Language Narrow (FLN): "[T]he core recursive aspect of FLN currently appears to lack an analog in animal communication and possibly other domains as well"11. The recursive process in FLN "takes a finite set of elements and yields a potentially infinite array of discrete expressions."<sup>12</sup> In this view, the use of recursion is what separates the human faculty of

language from the communication systems of other animals.

A Generative Theory of Tonal Music (GTTM), published in 1983, has recently been described as "still the most complete and insightful account of tonal music structure"<sup>13</sup> and a work that "represents a landmark in Music Cognition."<sup>14</sup>Authors Lerdahl and Jackendoff take the Chomskyan methodology in linguistics as the initial inspiration for their explorations, including in their preface that "our generative theory of music can provide a model of how to construct a competence theory (in Chomsky's sense) without being crippled by a slavish adherence to standard linguistic formalisms."<sup>15</sup> Their book predates *The Minimalist Program*, by a decade, and Chomsky's later emphasis on FLN by two decades, yet recursion plays a key role in several aspects of their theory. These similarities were also noted by Katz and Pesetsky, who wrote that "we see that the syntactic structures of both music and language are the result of iterating, binary recursive Merge with the additional property of endocentricity (headedness)" and that "in all other respect music and language are identical."<sup>16</sup> The commonalties with Lerdahl and Jackendoff's GTTM and Chomskyan generative grammar are perhaps fundamentally cemented by an antipathy to behaviorism. In linguistics this is commonly summarized as the "poverty of stimulus" argument, and is fleshed out in GTTM: "the assertion that exposure alone suffices for learning is tantamount to blind faith in the most radical form of behaviorism."<sup>17</sup> There is therefore in GTTM an assumption of a kind of universal grammar, or a set of hard-wired abilities that all humans have with respect to music (or at least, its comprehension). Within linguistics, also Chomsky proposes qualities of innateness: "the ability to acquire language is basically a fixed, uniform species property."<sup>18</sup> Yet Lerdahl and Jackendoff are careful to not draw parallels too

closely, noting that "tonality in music provides evidence for a cognitive organization with a logic all its own,"<sup>19</sup> and that "pointing out superficial analogies between music and language ...is an old and largely futile game."<sup>20</sup> While recognizing this, it can also be stated that recursion makes up an integral part of their theory at several key points and might therefore have some ties to its proposed role within *The Minimalist Program*, and FLN. There might be more than a superficial similarity and instead something deeper and more fundamental in common within the context of human creativity.

GTTM divides its analysis into four components: grouping and metrical structure, and time-span and prolongational reduction. Recursion is mentioned explicitly as an aspect of two of these components, that of grouping structure and prolongational reduction. Of the former Lerdahl and Jackendoff write "because of the uniformity from level to level, we can assert that grouping structure is recursive, that is, it can be elaborated indefinitely by the same rules."<sup>21</sup> Grouping structure, like the other components within the theory, is guided by a set of rules (GTTM Rules): Well Formedness, Preference, and Transformational. Utilizing the GTTM Rules, the components build upon each other, with grouping structure shaping metrical structure, metrical structure influencing time-span reduction, and finally time-span shaping prolongational reduction.

Prolongational reduction relates to what could be called the overall shape of harmonic tension and relaxation within a selected sample of music, and utilizes recursion as well: "every event ... is either the prolongational head or a recursive elaboration of the prolongational head."<sup>22</sup> In Western music, this is traditionally expressed as harmonic progression, but the authors hint that the idea of cadence extends to non-Western music

as well, and may be applicable.<sup>23</sup> The longest branches of a prolongational reduction typically point to moments of stability within the music, and each region within "represents an overall tensing or relaxing in the progression from its beginning to its end."<sup>24</sup>

In the below example, therefore, e(8) is the prolongational head while e(1) acts as its recursive elaboration. However, e(1) is also defined as a direct elaboration of e(8): "An event e(i) is a direct elaboration of another event e(j) if e(i)'s branch terminates on e(j)'s branch."<sup>25</sup>



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The following prolongational diagram exemplifies the provision that "An event e(i) is a recursive elaboration of another event e(j) if it is a direct elaboration of e(i) or its branch leads upward through a sequence of direct elaborations to e(j)'s branch."<sup>26</sup> Therefore, e(3) is a recursion of e(1) and (e8), and a direct elaboration of e(1), while e(5) is a recursive and direct elaboration of e(8) only.



And the last schematic presents a more complex series of branching.



In this example, e(1-7) are all recursive elaborations of e(8). Branch e(2) is a direct elaboration of e(3) and recursive in regards to e(8), e(3) and e(1), but not e(4). Branch e(7) is a direct elaboration of e(6) and a recursive elaboration of e(5-6) and e(8).

Again, for Lerdahl and Jackendoff, within the context of GTTM, recursion is something that "can be elaborated indefinitely by the same rules."<sup>27</sup> These previously mentioned GTTM Rules relate to each other a variety of ways. For instance, Prolongational Preference Rule 1 (PRPR Rule 1) states that "in choosing an important event e(k) of a prolongational region, strongly prefer a choice which e(k) is time-span important."<sup>28</sup> At this point, the theorist must refer back to the section on time-span reduction whose focus, roughly speaking, is on melodic contour. Time-span reduction is itself governed by a series of rules which, in part, relate to grouping and metrical structures. Given the theory's definition of recursion, the application of GTTM Rules should be similar regardless of their stage in the branching process. However, this standard seems to have some measure of flexibility: for example, when it is stated that "typically, melodic influences are more marked at smaller levels of reduction, and at large levels play a relatively insignificant role in comparison with harmonic connection." <sup>29</sup> Whether this variation is a result of an inconsistency within what is described as a recursive process, or whether it arises from within the music itself, is not made quite clear. However, it would seem that in the case of prolongational reduction, at least, an overarching measure of recursive consistency can be found in its reference to "points of relative tension and repose and the way music progresses from one to another."<sup>30</sup>

The opening of Mozart's Piano Concerto # 23, K.488, offers the opportunity to explore his use of phrase extension and possibly draw a parallel between this process and those found in *The Minimalist Program*. The piece begins with an eight-measure theme, A, which is immediately repeated with variation in what could be called A'.

The opening theme A from measures 1-8 is:



Utilizing GTTM Rules, the grouping structure of the theme is as follows:



Grouping structure combines musical ideas in a binary fashion in a way that is, at least superficially, comparable to Merge and the type of sentence structures articulated in *The Minimalist Program*. For instance, the following sentence can be created using Merge:

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{with + aplomb}
{performed} + {with aplomb}
{the + violinist}
{the violinist} + {performed with aplomb}
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The violinist performed with aplomb.

Or, as represented in a diagram:



The preceding musical phrase, A, and many others of the Classical era, utilizes a technique called elision. In elision, ideas overlap each other, frequently as a way to facilitate a smooth transition between sections. GTTM notes this as an idiosyncrasy of music when compared to language, although considering it as a possible linguistic parallel a sentence such as "the dead duck."<sup>31</sup> In this sentence, the two "d's" are not each pronounced separately, but rather, slide into each other. In a similar manner, measures 1-

3 and 3-4 are connected in their smallest grouping at the downbeat of 3, which also happens to be the tonic chord of the section.

الم وقر به او م او م

However, the parallel breaks down in some respects, for while the former is more a shortcut in speech, the use of elision is a crucial element to the Classical style. We can pronounce both d's in "dead duck" and it might only be noticed as a formalized manner of speaking. Restating elisions within music changes the very nature of the piece.

The immediate repetition of the opening theme, in measures 9-18, or A', varies in length as well as shape.



It can be grouped according to GTTM Rules in this manner:



The phrase A' is extended past the standard eight measures in a manner not unusual in the Classical style. As Allanbrook puts it, in the context of Mozart's operas, "The identification of phrase extension as a metaphor for revolution would be enticing, were not expanded forms the norm in the last of the eighteenth century."<sup>32</sup>

Implementation of the practice is of most importance, and the extension is cleverly disguised in this example. Measures 13-14, 15-16, 16-17, or 17-18 could all be considered extensions, in the sense they could be taken out and the section would still maintain its integrity, though stripped of an element of creativity and interest.

The utilization of recursive extensions in GTTM is echoed in the role played by recursion within FLN. Sentences can theoretically be extended infinitely, in an infinite number of ways, not unlike musical phrases. For example:

The violinist performed with aplomb.

The violinist performed Mozart with aplomb.

The violinist performed Mozart with aplomb while the fire truck wailed outside. The violinist who wore pajamas performed Mozart with aplomb while the fire truck wailed outside.

In other words, a "finite set of elements," when combined recursively, yield "a potentially infinite array of discrete expressions."<sup>33</sup> And, as we can imagine a sentence without elements of its recursion branching, we can imagine A' without one of its possible extensions; in the following example measures 15-16 have been excluded.



The limits to the length of the recursive process in music and language are placed more by the expectations and endurance of the listener than by any internal structures. This democratic process in communication seems to be a crucial element in both domains. By adding "while the fire trucked wailed outside" to "[T]he violinist performed Mozart with aplomb", the speaker takes the audience to another place in the imagination. The location of the violinist is more firmly placed inside and his or her abilities of concentration are given greater weight. For some, the dichotomy of the two images may be humorous, while for others it may bring back memories of a similar event that provoked annoyance. Similarly, by further communicating that the violinist "wore pajamas," a formerly distinguished mental image, or mood, may be rendered farcical. There is an element of personal experience that goes into shaping our response to language, and the more unusual an expression, the more the reaction would seem less predictable. The less likelihood there is of a set of shared experiences the less chance there is for a successful exchange of ideas.

At this point, we can probe some assumptions about recursion within the framework of *The Minimalist Program* and FLN, returning to the sentence, "The violinist who wore pajamas performed Mozart with aplomb while the fire truck wailed outside." Reducing the recursive qualities of this sentence leads us to a series of shorter ones.

The violinist performed with aplomb. The violinist performed Mozart. The fire truck wailed outside. The violinist wore pajamas.

This recalls the ongoing debate over the possible lack of recursion in the language of the Pirahã.<sup>34</sup> Everett's research concluded that this language was not recursive, and therefore the hypothesis of recursion as a FLN was null.<sup>35</sup> While Bickerton labeled this debate "pointless," we can also ask if recursion significantly adds complexity to a linguistic idea. Is the sentence in question more descriptive as the sum of its parts? It seems initially perhaps smoother and more efficient, but an infinite amount of recursion within a sentence is not efficient because it exceeds the demands of the audience. And despite the efficiency that seems initially apparent, to a large degree the same amount of information is communicated.

If the A' theme is given a similar treatment, if it is broken up into smaller parts, the effect is different. Namely, the parts seem to communicate much less than the sum.

Consider measures 13 and 14 taken together:

Or even measures 13-16:

In generative grammar, the smallest chunks quite rapidly create something that, if not a sentence, have a certain foundational stability to them. This seems to be less often the case in music. A NP and VP (Noun Phrase and Verb Phrase) can consist of two or

three units with a level of descriptive integrity that measures 13-14 with two units, or 13-16 with three units (see grouping structure of A'), do not have. For instance, "The violinist" is a NP in the example sentence and "performed with aplomb" is a VP. It is true that the notion of antecedent and consequent has some parallels in this linguistic combination of NP and VP. But language seems to require fewer combinations than music to achieve synthesis, due to the greater internal stability of its grammar. The smallest grouping structures of music act more as kernels dependent on further development. The most famous of motives, the opening four notes of Beethoven's 5<sup>th</sup> Symphony, fits as an example. Therefore, we can state that recursion, as defined within the aforementioned frameworks, is more important in music than language when it comes to increasing descriptive power for the speaker or composer.

One possibility when examining the grouping structure component of GTTM is that we may be looking an "artifact of analysis," to adopt what Bickerton wrote of recursion as a FLN.<sup>36</sup> Binary structures are, after all, common throughout the realm of human analysis. The author recalls a chart of the historical concentration of financial power in the United States as a similar example of binary merging.<sup>37</sup> The method may be so general that it does not lead to significant insights in the grammars of language and music. Binary merging could be a method of routine organization, not a vehicle towards of creativity.

We now move from the grouping structure of phrase A' to its prolongational reduction:



Recall that prolongational reduction "relates to the overall pattern of tension and repose and the way music progresses from one to another."<sup>38</sup> More specifically, prolongational reduction is usually shaped around the harmonic progression of a passage, within the context of its melodic elements, or its time-span reduction. Equivalent chords are called strong or weak elaborations, depending on the similarity of their voicing. The connections between the weak elaborations are indicated by black dots in the preceding passage; there are no strong elaborations. The points of relaxation in a section of music will generally be more closely related to the prolongational head. They will also tend to

disproportionately branch from the beginnings and endings of what the listener experiences as a musical phrase.

By Lerdahl and Jackendoff's definition, branching in the GMTT prolongational framework is considered recursive, and "can be elaborated indefinitely by the same rules."39 Specific instances which show a similar pattern of rules applied in different settings can illustrate these recursive qualities. For instance, Prolongational Preference Rule 3 (PRPR 3) states that "A progression that descends along the circle of 5ths or produces a subdominant-to-dominant relationship is most stable as a left branching structure."<sup>40</sup> Even in this brief passage, A', there are several instances of this type of branching. From measures 9-11 there is a V/IV, IV, ii, V, I progression that, because of PRPR 3, creates a V/IV,IV,V, I branching into the downbeat of measure 11. Note that the ii is not part of this branching, but flows into the V, as it acts as a preparation to the V and is not part of the global progression.<sup>41</sup> We can see another instance of PRPR 3 within measures 15 and 17, with a quick progression from I, vi, IV, ii, V, I. Note that the vi branches back to the I, as it does not create the tension that leads to another moment of harmonic relaxation. A recursive match is found in measures 13 and 14, where local branching parallels each other in the manner of PRPR 5, which states: "Prefer a prolongational reduction in which parallel passages receive parallel analyses."42 Harmonic movements differ within the two measures, but they are similar in the manner of their tension and release, as well as their time-span reduction. Thus the diminished chord on the third beat of measure 13 has the same affect within its relative region as the Neopolitan-like movement in the third beat of measure 14.

One of the questions of this paper is how well recursion corresponds with what we experience as human creativity. In terms of the prolongational branching structures of the passage A', they certainly reflect a level of complexity that creates interest for the listener. A passage without any branching would have none of the "tension and repose" which one expects in music. To what extent the specific rules of GMTT can be considered recursive in an absolute sense is another matter. Lerdahl and Jackendoff acknowledge the complexity of their system of rules, which has only been lightly touched upon in the preceding paragraph.<sup>43</sup> For instance, an analysis of a passage from Chopin in the GMTT acknowledges that "the piece should be treated as ambiguous" (between two interpretations).<sup>44</sup> And if there is ambiguity within a passage of eight measures, this can of course be amplified within a large-scale work. While the larger formal structure of a piece, especially within the established traditions of the Classical era, may usually meet certain branching specifications, within it will be a myriad of interpretations. This is what gives music its interest and complexity, but to some extent it renders the idea of a specific set of recursive rules null. It may be best to look at the larger picture, that of music being at least partly expressed as regions of "tensing or relaxing,"<sup>45</sup> whether in terms of harmony, rhythm, or any combination of aural event.

We can approach this complexity further by analyzing another section of Mozart's music, this from the Adagio of his String Quintet, K.516. The passage is initially stated in measures 22- 27, beginning in Bb minor and ending in Bb major. It is restated from 59- 66, beginning in Eb minor and ending in Eb major, with an internal two measure extension. Rosen writes that this extension "is one of Mozart's most passionate and intense ideas."<sup>46</sup> Below is a prolongational reduction of measures 22-27.



The deceptive cadence on the first beat of measure 24, moving to the Gb major chord from an implied Bb minor tonic, serves to normalize the Neopolitan Cb major chord on the third beat as a dominant within a 'new' tonic. This recalls the normalization of the dominant key center in the second theme of a standard Sonata Allegro form of the Classical era. The downbeat of measure 26 acts as both an enharmonic V7 within the Cb major tonality as well as a German augmented 6<sup>th</sup> chord within the Bb minor tonality. This augmented 6<sup>th</sup> is resolved as it traditionally is with an inverted tonic Bb minor chord, before a V7 chord allows for a transition to a Bb major chord on the downbeat of 27. The Gb in the cello in measure 25 is a kind of pedal tone that serves as a way to connect the harmonic movement between 25 and 26. However, there is a clear break in the grouping structure and time-span reduction of measure 25 which influences the prolongational branching. A resolution of tension is heard on the i 6/4 chord on the third beat of measure 26 which enables it to be interpreted as a significant prolongational branch. But it seems clear given its voicing that the Bb major chord in measure 27 resolves the passage, while also leading into the next as an elision; it therefore has been treated as the prolongational head.

The complexity only mounts in the restatement of the passage from measures 59-66, this time opening in Eb minor.



Rosen writes of this section that the "harmony draws its pathos from being conceived as an expressive appoggiatura."<sup>47</sup> The "astonishing"<sup>48</sup> movement of the cello

in measures 63 and 64 acts as a recursive elaboration underneath the framework of a German 6<sup>th</sup> - i 6/4 progression that extends to the third beat of measure 65. Appoggiaturas within the context of time-span reduction act as a "structural delay", and the branching backwards in measures 64 and 65 to the downbeat of measure 63 reflects this.<sup>49</sup> The pedal tone B in measure 62 acts in a parallel fashion with the Gb in 25. The passage is subject to a number of other parallel interpretations with its predecessor in measures 22-27. For instance, all material from the fourth beat of measure 61 through the first beat of 65 could be considered a suspension in the release of tension first initiated on beat 3 of 61, and therefore branch back to that point. The German 6<sup>th</sup> – i 6/4 branching could be considered a recursive elaboration of the prolongational head Bb major chord on the downbeat of measure 66. However, as in original thematic statement considerations of grouping structure, metrical structure, and time-span reduction lead to the interpretation put forward here.

By looking at measures 63 and 64, we can see how recursive qualities, as defined by GTTM, strongly correlate with phrase extension, variation, and creative impetus. The second violin's melodic contour serves to anchor the area of prolongational importance around the downbeat of 64 (PRPR 3 (3b)) while it branches back to the downbeat of measure 63 due to its aforementioned quality as an "expressive appoggiatura." Eliminate measures 63-64, and the passage maintains much of its integrity but serves mostly as a repetition of measures 22-27, in a different key.

The more branching is eliminated in a prolongational reduction, the more the music is left with its barest harmonic features. In the preceding example, prominent branching features remaining at the core of the interpretation include a deceptive cadence

in measure 61, and a Neopolitan chord on the third beat of 62. However, in many sections of music, one would be left with a preponderance of tonic and dominant chords. It is generally the recursive branching that adds interest to a piece of music and without it the listener is left with what Imberty calls a "skeleton... devoid of aesthetic value."<sup>50</sup> This can be contrasted with language which, when pared down, more often leads to "deep structures<sup>351</sup> such as the Verb Phrase alluded to in the discussion on grouping structure. While an adverb may add a descriptive frosting to a sentence, its counterpart within a musical prolongational reduction is more likely what creates the primary interest in a section. It therefore seems clear that recursion, as defined by GTTM, does have a bearing on the level of creativity and descriptiveness found in musical output. But the exact nature of the recursion is where the inspiration comes in. Not just any elaboration will do, as in language, where we can recall Chomsky's "[C]olorless green ideas sleep furiously." <sup>52</sup> Music, too, has a semantic as well as a grammatical form. How the limitations on a composer or speaker are determined seems to be a matter of what can be understood and the relationship between the audience and the communicator. There is a democratic element in the communication of music and language that is perhaps not as examined as it should be.

The central role of recursion within the Chomskyan school has not been universally accepted in linguistics. For instance, Bickerton challenges Chomsky's definition of recursion when he writes that, "Merge is in fact an iterative not a recursive process."<sup>53</sup> This is because in Merge, words are combined together in binary fashion regardless of their syntactic class. And, in fact, at least one instructional book has examples of what it specifically classifies as "recursive Merge sentences," utilizing

repeated operations within the same syntactic class.<sup>54</sup> Similarly, the binary process of grouping structure in GTTM seems too broad in scope to be considered uniquely recursive. Bickerton proposes that the reason for Chomsky's (and perhaps, others) attachment to recursion is that iteration is a process that "lies within the capacity of a wide range of species"55; this opposes the tradition in generative linguistics of considering language a domain exclusive to humans. However, for Bickerton, recursion is not necessary to explain human uniqueness for, in referencing Deacon, "we can assert that symbolic units are unique to humans and aspects of the lexicon are unique universals".<sup>56</sup> This element of symbolism may have its roots in humanity's origins as "confrontational scavengers," who were required to reference food sites many miles away from their home base.<sup>57</sup> For Bickerton, iteration plus the symbolic nature of words is what gives rise to language.<sup>58</sup> Words are symbolic in part because they have dependences, as do units of musical material.<sup>59</sup> We expect to hear certain musical ideas follow previous ones, though not to such an extent that they become predictable. Therefore the symbolic aspects of music, combined with the iterative process, could give rise to different musical languages. In this light, we could consider Mozart's phrase extensions as examples of iteration rather than those of recursion.

We are left with a murky theoretical sense of what distinguishes humans from animals in these faculties, starkly contrasted with the reality we see around us -- that of humans operating at vastly higher cognitive levels. There is a complexity to human action that seemingly continues to elude us, for if super computers cannot match the abilities of bees when it comes to the "traveling salesman's problem,"<sup>60</sup> it would seem that the structures facilitating human behavior are far more complex and harder to define than

commonly accepted. What seems vital is the democratic process that humans engage in within music and language. For, though both domains have "discrete elements that can be continued infinitely,"<sup>61</sup> they are not. Despite the numerous scale systems present in human cultures, in a given musical section around five to seven pitches are used because of both "a desire for aesthetic variety and universal constraints on the number of distinct categories the human mind can relatively keep track of."<sup>62</sup> What regulates both music and language ultimately is their ability to communicate and describe. The standards that govern this regulation probably come from a myriad of concurrent social conditions with origins throughout history as well as natural selection. In the case of the latter, music has been argued as possibly developing from the process of sexual selection, parental care, or the bonding required for group cohesion.<sup>63</sup> The democratic process necessary in communication would seem to equalize and incorporate the Pirahã language within the parameters of other human societies. While their argued lack of recursion has at times been cast as something primitive <sup>64</sup> to be discarded or subsumed within current linguistic models, they just might not find it necessary in their day-to-day existence. This paper has argued that recursion, as defined within modern generative linguistics, is not a sole decisive factor in describing complex situations or maintaining a system of efficiency. As defined within A Generative Theory of Tonal Music, recursion is more essential, yet there too it is regulated by an interaction between the participating parties of listener, performer and composer. It would seem that a valid point of further investigation would be the social parameters and conditions upon which these communicative processes are set.

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Endnotes

<sup>1</sup> See bibliographic references to Chomsky's work. The paper continues with further details.

<sup>2</sup> See bibliographic reference to Fred Lerdahl and Ray Jackendoff's work. The paper continues with further details.

<sup>3</sup> Aniruddh Patel, "The Music of Language and the Language of Music" (Lecture at the Library of Congress as part of their series: Music and the Brain, Washington, D.C., November 7, 2008), accessed November 8, 2011, http://www.youtube.com/watch?v=2oMvtw4aeEY. Also discussed in:

Aniruddh Patel, *Music, Language and the Brain* (Oxford: Oxford University Press, 2008), 3. <sup>4</sup>Noam Chomsky, "The Ideas of Chomsky," with Brian Magee (BBC, 1977), accessed October 20, 2011, www.youtube.com/watch?v=EksuA4IAQIk.

<sup>5</sup> Noam Chomsky, *Language and the Mind*, 3<sup>rd</sup> edition (Cambridge, UK: Cambridge University Press, 2006), 88.

<sup>6</sup> Aniruddh Patel, "Language, Music, Syntax and the Brain," *Nature Neuroscience* 6,7 (July, 2003), 674.

<sup>7</sup> Noam Chomsky, *Syntactic Structures* (The Hague, Netherlands: Mouton and Company, 1957), 22.

<sup>8</sup> Chomsky, Syntactic Structures, 24.

<sup>9</sup> Derek Bickerton, "Recursion: Core of complexity or artifact of analysis"? in *Syntactic Complexity*, ed. Givon and Shibatami (Amsterdam: John Benjamins Publishing Company, 2008), 534. <sup>10</sup> Chomsky, *Language and the Mind*, 183.

<sup>11</sup> Marc Hauser, Noam Chomsky, W. Tecumseh Fitch, "The Faculty of Language: What Is It, Who Has It, and How Did It Evolve?" *Science* 298 (November 22, 2002): 1571.

<sup>12</sup> Hauser, Chomsky, Fitch, 1571.

<sup>13</sup> Jonah Katz, David Pesetsky, "The Recursive Syntax and Prosody of Tonal Music" (Handout for lecture at the University of Massachusetts Recursion Conference, May 2009), accessed November 8, 2011, http://web.mit.edu/jikatz/www/RecursionHandout.pdf.

<sup>14</sup> Emmanuel Bigand, Philippe Lalitte, Jay Dowling, "Special Issue – Music and Language: 25 Years After Lerdahl and Jackendoff's GTTM," *Music Perception* 26, 3: (2009): 185.

<sup>15</sup> Fred Lerdahl and Ray Jackendoff, *A Generative Theory of Tonal Music* (Cambridge, MA: The MIT Press, 1983), preface.

<sup>16</sup> Katz and Pesetsky,"The Recursive Syntax and Prosody of Tonal Music".

<sup>17</sup> Lerdahl and Jackendoff, A Generative Theory of Tonal Music, 301.

<sup>18</sup> Chomsky, Noam, *Powers and Prospects* (Boston: South End Press, 1996), 20.

<sup>19</sup> Lerdahl and Jackendoff, A Generative Theory of Tonal Music, 293.

<sup>20</sup> Ibid, 5.

- <sup>21</sup> Ibid, 16.
- <sup>22</sup> Ibid, 214.
- <sup>23</sup> Ibid, 295.
- <sup>24</sup> Ibid, 210.
- <sup>25</sup> Ibid, 214.
- <sup>26</sup> Ibid, 214.
- <sup>27</sup> Ibid, 16.
- <sup>28</sup> Ibid, 220.
- <sup>29</sup> Ibid, 225.
- <sup>30</sup> Ibid, 179.
- <sup>31</sup> Ibid, 62.

<sup>32</sup> Jamison Wye Allanbrook, *Rhythmic Gesture in Mozart: Le Nozze di Figaro and Don Giovanni* (Chicago: University of Chicago Press, 1983), 345.

<sup>33</sup> Hauser, Chomsky, Fitch, 1571.

<sup>34</sup> John Colapinto, "The Interpreter: Has a remote Amazonian tribe upended our understanding of language?" *The New Yorker*, April 16, 2007, accessed November 8, 2011, http://www.newyorker.com/reporting/2007/04/16/070416fa\_fact\_colapinto.

<sup>35</sup> Ibid.

<sup>36</sup> Bickerton, "Recursion: Core of complexity or artifact of analysis"?, 531.

<sup>37</sup> David Seymour, "Concentration of Capital," accessed October 10, 2001, website address at leninology.blogspot.com/2011/10/concentration-of-capital.html. (Note: "author" in the referenced sentence refers to Ben Roberts.)

<sup>38</sup>Lerdahl and Jackendoff, A Generative Theory of Tonal Music, 179.

<sup>39</sup> Ibid, 16

40 Ibid, 225.

<sup>41</sup> Ibid, 200.

<sup>42</sup> Ibid, 226.

<sup>43</sup> Ibid, 249.

<sup>44</sup> Ibid, 239.

<sup>45</sup> Ibid, 211. (Note: This concept within prolongational reduction is extrapolated in this paper as having possible applications for other areas of music.)

<sup>46</sup> Charles Rosen, *The Classical Style* (New York: W.W. Norton 1971, 1997), 88.

47 Ibid, 88.

<sup>48</sup> Rosen, *The Classical Style*, 88.

<sup>49</sup> Lerdahl and Jackendoff, *A Generative Theory of Tonal Music*, 130.

<sup>50</sup> Michel Imberty, "Music, Linguistics and Cognition," in *Music and the Mind, Essays in honor of John Sloboda*, ed. by Deliège and Davidson (Oxford: Oxford University Press, 2011), 7.

<sup>51</sup> Ibid, 7

<sup>52</sup> Chomsky, *Syntactic Structures*, 15.

<sup>53</sup> Bickerton, "Recursion: Core of complexity or artifact of analysis"?, 536.

<sup>54</sup> Joseph Galasso, *Analyzing English Grammar: An Introduction to Feature Theory (A companion Handbook)* (California State University, Northridge, 2002), accessed October 13, 2011, www.csun.edu/~galasso/handbook1.pdf

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<sup>55</sup> Bickerton, "Recursion: Core of complexity or artifact of analysis"?, 537.

<sup>56</sup> Ibid, 538.

<sup>57</sup> Derek Bickerton and Eors Szathmary, "Confrontational Scavenging as a Possible Source for Language and Cooperation," *BMC Evolutionary Biology* 11 (2011), 261, accessed November 8<sup>th</sup>, 2011, http://www.biomedcentral.com/1471-2148/11/261.

<sup>58</sup> Bickerton, "Recursion: Core of complexity or artifact of analysis"?, 542-543.

<sup>59</sup> Koelsih S., Gunter T.C., Witlforthm M., "The Interaction Between Syntax Processing in Music and Language: An ERP Study," *Journal of Cognitive Neuroscience*. 17: 1565-1577.

<sup>60</sup> UK Guardian, "Bees' tiny brains beat computers, study finds," October 24, 2010, accessed on October 13, 2011, http://www.guardian.co.uk/world/2010/oct/24/bees-route-finding-problems.

<sup>61</sup> Hauser, Chomsky, Fitch, 1571.

<sup>62</sup> Patel, Music, Language and the Brain, 20.

<sup>63</sup> Aniruddh Patel, "Music, Biological Evolution, and the Brain," Connexions (on-line journal) (June 16, 2010), accessed on October 20, 2011, http://cnx.org/content/m34255/1.7/ (June 16, 2010).
<sup>64</sup> John Colapinto, "The Interpreter: Has a remote Amazonian tribe upended our understanding of

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