The Musico-Linguistics Meme: Recursion and Musical Meaning since Bernstein in Boston

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Leonard Bernstein's Norton Lecture Series of 1973 have played an critical role in helping to define a particular landscape of thought which might be best described by Bernstein's own (admittedly nonacademic) term, "musico-linguistics".[1] While not a formal discipline, the term characterizes and encompasses the body of thought upon which he speculates in six multi-hour lectures at Harvard. It is important to note from the outset that my research goals were initially designed to document the ways in which a Bernstein's thesis for a universal musical grammar represented an idiosyncratic musical worldview: fitting in his time but no longer operative in light of more recent discoveries. However, a careful reading of the literature tells a different story. The lectures themselves do not represent rigorous scholarship; however, due to their enormous cultural influence via nationwide broadcast,[2] I argue that Bernstein's perspective as

[1] Leonard Bernstein, *The Unanswered Question* (Cambridge: Harvard University Press, 1976), 9.

[2] 2 Jackendoff, "Review: The Unanswered Question by Leonard Bernstein", 883.

portrayed in *The Unanswered Question: Six Talks at Harvard* went on nonetheless to become a meme that has served to inspire, direct and at times outright define a course of scholarship for many researchers across a diverse range of disciplines. This work continues to yield fruitful discoveries in areas such as the study of recursion.

While not a discipline, the term "musico-linguistics" (hereafter denoted without quotation) can rightly be thought of as a scholarly landscape; It is an interdisciplinary terrain over which American scholars in diverse fields as such as Neurology, Linguistics, and Music Theory have explored nearly 40 years. Very little of the source content is original, and none of it academic. The work was not universally well-received; Joseph Horowitz writes that Bernstein, "strains for intellectual credibility as an original thinker."[3] Even major proponents of some of his ideas must admit of its numerous flaws. Jackendoff writes,

> …a reader who expects serious intellectual inquiry will undoubtedly be disappointed. It is a trivial, boring, and sometimes even embarrassing exercise to find holes in [Bernstein's] argumentation. The final effect is unfortunate: [Bernstein] has great insight into the essential issues, yet he undermines himself needlessly in ineffectual attempts to make his speculations explicit.[4]

However, it almost immediately began to make an impact in the work of serious researchers who envisioned the melding of "Chomskian"[5] linguistics with so-called music theory into a new and more purely scientific theory of music. A crucial line of research developed. "As

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[3] Joseph Horowitz, "Professor Lenny," *New York Review of Books* 40.11 (1993), Available: http://memory.loc.gov/ammem/collections/bernstein/lbarticle4.html.

[4] Jackendoff, "Review: The Unanswered Question by Leonard Bernstein."

[5] Fred Lerdahl and Ray Jackendoff, *A Generative Theory of Tonal Music* (Boston: Massachusetts Institute of Technology, 1983), ix.

a result of these [Norton] lectures, many people in the Boston area took a fresh interest in the idea of an alliance between music theory and linguistics…"[6] Inspired in part by the series, Professors David Epstein and Irving Singer (one of the few linguists specifically credited by Bernstein, but only in the Author's Note prefacing the six lecture transcripts)[7] offered a one-week seminar at the Massachusetts Institute of Technology in the fall of 1974 studying linguistics, music, and aesthetics.

Digressing briefly, MIT was and is also the academic home for linguistics professor Noam Chomsky, upon whose work in generative grammar (*Language and* Mind, in particular)[8] Bernstein based much of his lectures.[9] Importantly, Chomsky is not known to have endorsed or encouraged this work, nor did Bernstein claim him as a collaborator. In fact, Chomsky wrote that, "the problem of extending concepts of linguistic structure to other cognitive systems seems to me, for the moment, in not too promising a state, although it is no doubt to early for pessimism",[10] but later, "It is quite possible that the lack of analogy testifies to our ignorance of other aspects of mental function, rather than to the absolute uniqueness of linguistic structure; but the fact is that we have, for the moment, no objective reason for supposing this to be true."[11] This threshold of objectivity is not minimally met by Bernstein, a point buttressed by the literature, as seen above. Notwithstanding, the interest generated by these lectures was enough for Allan Keiler to warn, "…certainly the attention they have received and the

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[6] Ibid.
[7] Bernstein, *The Unanswered Question*.
[8] N Chomsky, *Language and Mind*, 3rd ed. (Cambridge University Press, 2006).
[9] Bernstein, *The Unanswered Question*.
[10] Chomsky, *Language and Mind,* 66.
[11] ibid., 79.

misconceptions they are likely to create if taken too seriously or followed too closely warrant discussion."[12] Fortunately, the exciting scholarship in the years to follow moderated the initial excitement of scholars with hard data and rigorous analysis, as will be demonstrated.

Invited to this seminar were Linguist Ray Jackendoff and Composer Fred Lerdahl, whose subsequent collaboration produced a radical departure from music theory orthodoxy best represented by their book, *A Generative Theory of Tonal Music,* co-written in 1983. Their collaboration began at MIT, but the opening phrase of their preface points back to the Norton Lectures as the impetus for the very existence for the seminar.[13] With the work of Chomsky explicitly in mind,[14] the two, "…took the goal of a theory of music to be a *formal description of the musical intuitions of a listener who is experienced in a musical idiom*" [emphasis in original].[15] This introductory definition relays an understanding of the points arising out of Keiler, who writes, "The most basic distinction that underlies linguistic research is that of competence and performance, the distinction between what is known and how it is used."[16] The interaction between these authors is further made explicit in a footnote to a previous statement citing important recent and forthcoming research in the area, including a then-unpublished paper by the duo titled "Toward a Formal Theory of Tonal Music".[17]

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[12] Allan Keiler, "Bernstein's 'The Unanswered Question' and the Problem of Musical Competence," *The Musical Quarterly* (1978): 198.

[13] Lerdahl and Jackendoff, *A Generative Theory of Tonal Music,* xi.

[14] ibid., xiii.

[15] ibid., 1.

[16] Keiler, "Bernstein's 'The Unanswered Question' and the Problem of Musical Competence": 198.

[17] F Lerdahl and R Jackendoff, "Toward a Formal Theory of Tonal Music," *Journal of Music Theory* (1977).

This paper later served as a foundation for *A Generative Theory of Tonal Music* (hereafter referred to as GTTM).[18] This through-line from Chomsky's competence runs through to the defined goals of GTTM and the precise meaning of "experienced," GTTM highlighting that, "The 'experienced listener,' is meant as an idealization," and, "The concept of the 'experienced listener,' of course, is no more than a convenient delimitation."[19] They are cautious in terminology in an effort to be in a position both to make use of linguistic tools customized for use in the study of music, and be in a position to make comparative analysis with linguistics,[20] which is precisely what they and others later do.[21]

What follows is a chapter on rhythmic structure, in which the notion of "hierarchical organization" between "subordinate and dominating groups" is presented.[22] Examples are given of the way in which pairs of eighth notes pulses nest into quarter notes pulses, which may in turn nest into half notes pulses,[23] demonstrating that with this, "uniformity from level to level, we can assert that grouping structure is *recursive;* that is, it can be elaborated indefinitely by the same rules" [emphasis in original].[24] It is with this the concept of recursion that significant progress in the understanding of tonal musical structure has come forward. Recursion is an often-pondered phenomenon which could be said to have been promoted from

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[18] Lerdahl and Jackendoff, *A Generative Theory of Tonal Music, xi*.

[19] ibid., 3.

[20] R Jackendoff, "Parallels and nonparallels between language and music," *Music perception* (2009).

[21] A D Patel, *Music, Language, and the Brain* (New York: Oxford University Press, 2010), 280-283.

[22] Lerdahl and Jackendoff, *A Generative Theory of Tonal Music,* 15.

[23] ibid., 19-25.

[24] ibid., 17.

a bug to a feature of human consciousness, a principle that is simple, humorous, and on the surface could seem almost inconsequential. Take for example a humorous definition:

Recursion (riˈ-kər-ZHən) *noun.* See **recursion.**[25]

Example 1. Recursion in Language

A mathematical function learned by algebra students is that of factorial, most often expressed as $n! = n * (n - 1)!$.[26] The exclamation mark denotes a function, and by being on both sides of the equation, implies that the function may only be described in terms of itself. For instance:

$$
\begin{aligned}
4! &= 4 * (4 - 1)! \\
&= 4 * 3 * (3 - 1)! \\
&= 4 * 3 * 2 * (2 - 1)! \\
&= 4 * 3 * 2 * 1 \\
&= 24
\end{aligned}
$$

Example 2. Recursion in Mathematics

[25] Michael C Corballis, *The Recursive Mind: The Origins of Human Language, Thought, and Civilization* (Princeton: Princeton University Press, 2011), 1.

[26] For mathematical precision, it should be added that the equation holds true only where $n > 0$, and further where $0! = 1$; these conditions in no way alter or create exception to the recursive properties of the ! function.

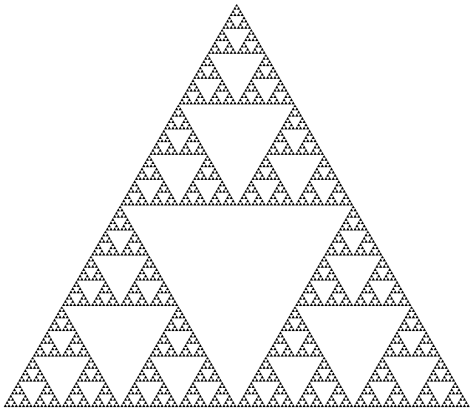

Figure 1. Sierpinski triangle. (fair use)

A graphical variant would be the well-known Sierpinski triangle (see fig. 1), which can itself be expressed as a mathematical algorithm. All of these examples help to create a working definition that cases of recursion, as Corballis puts it,

> …can take its own output as the next input, a loop that can be extended indefinitely to create sequences or structures of unbounded length or complexity. In practice, of course, we do not get caught up in infinite loops-life is simply too short for that. For the purposes of this book, then, we shall no be interested so much in the generation of infinite sequences as in a definition that might apply usefully to human thought. A definition that meets this requirement is suggested by Steven Pinker and Ray Jackendoff, who define recursion as "a procedure that calls itself, or …a constituent that contains a constituent of the same kind."[27]

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[27] Steven Pinker and Ray Jackendoff, "The faculty of language: what's special about it?" Michael C Corballis, *The Recursive Mind: The Origins of Human Language, Thought, and Civilization* (Princeton: Princeton University Press, 2011),

Reflexively, in composing this essay, I had originally intended to give the earlier portion of that quote, and skip ahead to make a segue back into the scholarly through-line of Bernstein's musico-linguistic meme (via Jackendoff) as there is no need to include the middle portion describing the outlook of the book. However, it occurred to me while writing that this in itself is a perfect example of the latter Pinker/Jackendoff definition: in order to define recursion, a passage from a source is quoted in which: in order to define recursion, a passage from another source is quoted. Further, the previous sentence itself is both a description of recursion and is itself recursive. Lastly, and at the risk of absurdity, it is worth pointing out that the very act of composing this paragraph occurred to me as an exercise in recursion in which I am composing a paragraph in which I discuss the act of writing that very same paragraph. This multivalent form of recursion is a linguistic analog of the famous *2 Hands Drawing* by M.C. Escher. However, in order to proceed, the advice of Mr. Corballis must be followed and the essay must now withdraw from the loop in order to proceed.

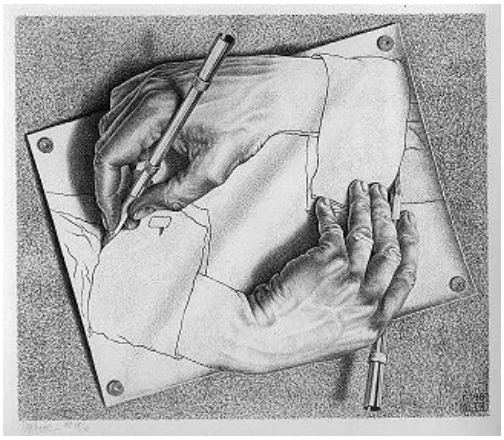

Figure 2. M.C. Escher, *Drawing Hands,* 1948 (fair use)

Returning to GTTM, it is no accident that the one of the chief musical examples chosen to demonstrate the principles of recursion as applied to music is Mozart's G Minor Symphony, K. 550. In fact, it is precisely the same study piece that preoccupies the first two of the six Norton Lectures.[28] Below are the first four measures of the melody played by the violins (the second violins play the passage an octave lower), although transcribed originally for the essay, they it is essentially identical to one of the many Mozart musical examples in GTTM, in this case, example 3.19.[29]

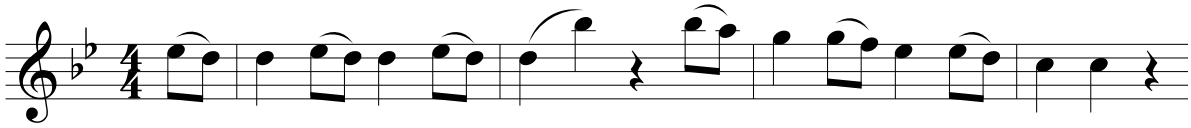

Figure 3. W.A. Mozart, Symphony in G Minor, mm. 1-4 (melody only)

Perhaps one of the most pedagogically unique and useful portions of the first two Norton Lectures demonstrates well the limits of recursion for aesthetic purposes.[30] By working out the opening of the opening of the Symphony, *absolutely* symmetrical phrases, and by playing a performance of this altered version, Bernstein illustrates to the layman and to Lerdahl and Jackendoff's "experienced listener" to let their intuition detect the inherent non-aesthetic nature of such a pedantic passage.[31] Bernstein says:

> Of course my musical repeats were made in the name of symmetry. But Symmetry is not necessarily balance: that's a precept we all learned long ago,

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[28] Bernstein, *The Unanswered Question,* 39-115.
[29] Lerdahl and Jackendoff, *A Generative Theory of Tonal Music,* 47.
[30] Bernstein, *The Unanswered Question,* 95-97.
[31] Lerdahl and Jackendoff, *A Generative Theory of Tonal Music,* 3.

> and it's worth saying again. What Mozart has done-as any great master does-is to make the leap from prosy symmetry into poetic balance, that is, into art. And he accomplishes this leap through those very principles of transformation so deftly enunciated by Chomsky; only Mozart achieves thereby not the mere grammar of a sentence, but the *super*-grammar of an aesthetic surface. [Emphasis in original][32]

While Bernstein is attempting to speak to "nonprofessional music lovers who don't know a stretto from a diminished fifth",[33] it is important to determine what value these propositions might have to music scholars with a rigorous, analytical approach to studying symmetry. What substantive value may there be in his nested pyramid diagrams, which are very similar to the aforementioned Sierpinski triangles (fig. 1) in appearance.[34] In reality, this has been the work of a number of others both before and after Bernstein. Crucially, the process of analytical diagramming hierarchically nested musical phrase structures is an idea widely known to musicians by association with Heinrich Schenker, the theorist credited largely for having developed what has later been called reduction.[35]

Later, GTTM tackles precisely this topic in the fifth chapter, the second section of which describes formal approaches to reduction asking plainly what is required to convert Schenkerian theory into formal theory."[36] Of course, an almost endless series of problems arise

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[32] Bernstein, *The Unanswered Question,* 97.

[33] ibid., 53.

[34] ibid., 92. Admittedly, the visual representation seen here is a binary recursive form while the Sierpinski triangles form an example of a ternary recursive form.

[35] Heinrich Schenker, *Five Graphic Music Analyses* (New York: Dover Publications, 1969).

[36] Lerdahl and Jackendoff, *A Generative Theory of Tonal Music,* 111-113.

when attempting to apprehend to precisely what degree Schenkerian reduction is an accurate prediction of what the listener actually takes in. Of Beethoven's *Eroica* Symphony, writes Lerdahl and Jackendoff, "Most likely, he will hear fairly accurately the details (except when his mind wanders) and the largest connections, but will be vague about some intervening relationships."[37] This parenthetical exception is unfortunately a tremendous problem when attempting to map an analytical framework to actual listener perception.[38] Wolpert states, "The question is not what people *can* hear given specific directions, but what they *do* hear when listening to an intact piece of music."[39] It is clear, according to GTTM, that "one hears music in organized patterns",[40] and research since that time has focused in large part

Though work such as that by Wolpert describes experimentation that may seem to make large-scale reductions, such as the "Tree Notation for Reduction", [41] left as yet another possibly useful analytical tool for musicianly insight than an actual predictive perceptual model. In this case it would fail to serve the authors' wish to accurately predict the substance of perception for the experienced listener. However, the authors admit from the beginning that much work would remain to be done in any case.[42]

This process of discovery has, as cited, continued without pause. As the GTTM authors stated, it was "intendended as an investigation into human cognitive capacity," and the

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[37] Lerdahl and Jackendoff, *A Generative Theory of Tonal Music,* 111.

[38] Jordan Smith, "Musical Perception and Alban Berg's *Drei Orchesterstücke*, Op. 6," Unpublished (2007): 4. The methodology for the research design was based on Rita Wolpert, "Attention to key in a nondirected music listening task: Musicians vs. nonmusicians," *Music perception* (2000): 225-230.

[39] ibid., 225.

[40] Lerdahl and Jackendoff, *A Generative Theory of Tonal Music,* xii.

[41] ibid*.,* 112.

[42] ibid*.,* xiii.

theories and lines of reasoning, so brilliantly intuitive but germinal and unpolished in Bernstein, so promising and developed but untested in Lerdahl and Jackendoff, proceeded to ripple across disciplines further and further afield, getting deeper into experimental results and stimulating new and more refined theories. As previously mentioned, Ray Jackendoff, a linguist, wrote many other works in the field both alone and in collaboration with others including Fred Lerdahl, and the aforementioned Steven Pinker. (The previously mentioned collaboration, incidentally, was itself a response and rebuttal to work by Chomsky and company.)[43]

Pinker, a noted psycholinguist, cognitive scientist as well as popular science author, is also noted for work in visual cognition, which is a natural field to study comparatively with music cognition. His worldview interestingly leads him to a very different place. In his bestselling book, *How the Mind Works,* Pinker-like Bernstein-speaks to a general readership about the inner workings of the mind as through the prism of his own specialties and in light of his research and that of others to which he gives credence. However, he makes a point that has struck many as peculiar. He writes that, "As far as biological cause and effect are concerned, music is useless…it is a technology, not an adaptation."[44] Evolutionary biology may seem far afield from recursion and further still from musico-linguistics, but it this is exactly where recursion as an organizing property becomes powerful and meaningful.

Unlike Pinker, Elizabeth Tolbert argues for simultaneous evolution of both language and music in her, "Music and Meaning: An Evolutionary Story," demonstrating how a wide variety musico-cultural contexts across the globe share in common an understanding of music as,

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[43] Steven Pinker and Ray Jackendoff, "The faculty of language: what's special about it?," *Cognition* 95.2 (2005): 201–236.

[44] Steven Pinker, *How the Mind Works* (New York: W. W. Norton, 1997), 529-539.

"woven into the social fabric of everyday life, and is valued primarily for its extra-musical meanings."[45] Interestingly, Tolbert uses the term "musico-linguistic genres", although in this case denoting hybridized communicative forms that conform strictly to neither patterns of speech nor music but share attributes of from each idiom.[46] Also worth noting is that Pinker and Chomsky find themselves generally in disagreement about evolution's role in language, this time Chomsky estimates perhaps a 100,000 year history of spoken language (only minimally a product of adaptation and Pinker imagines more like six million years.[47]

Central to integrating seemingly unrelated lines of thought is yet another of the multiple thousands of documents which cite GTTM is Steven Mithen's, *The Singing Neanderthals.*[48] In it, he discusses the evolutionary theories that linguists like Chomsky and his colleagues (see note 47, below) posit, the role of recursion in complex language structures, and notes that, "recursion is one of the most critical features of music," a fact they seem not to notice. [49] The significance here is that evidence continues to build for the notion of innate musical competence. Like the more mature linguistics, there is much debate. Like language, there is enough diversity to offer exceptions to most rules, but essentially, it seems that a theory of

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[45] Elizabeth Tolbert, "Music and Meaning: An Evolutionary Story," *Psychology of Music* 29.1 (2001): 85.

[46] ibid.: 85-85.

[47] Marc D. Hauser, Noam Chomsky, and W. Tacumseh Fitch, "The Faculty of Language: What Is It, Who Has It, and How Did It Evolve?," *Science* (2002): 1569-1579. Also, Steven Pinker and Ray Jackendoff, "The faculty of language: What's Special about it?," *Cognition* 95.2 (2005): 201–236.

[48] Steven J. Mithen, *The Singing Neanderthals* (London: Weidenfeld & Nicholson, 2005). Full Disclosure: 44 and 45 above are both similarly discussed here on p. 8, although I came to be familiar with Tolbert more than a week before reading Mithen and I purchased and read the Pinker a year prior to that.

[49] ibid., 16-17.

universal musical competence (although by no means a universally shared expression of that competence) has gradually become a credible model which experimentation can challenge, renew, reinforce, and retune.

Important to consider, most of the scholarship mentioned so far (with the exception of Tolbert and Wolpert) has been sequestered from empirical study. Krumhansl and Palmer, after GTTR in 1983, rather quickly designed and implemented experiments that yielded partial confirmations of some of the predictions made by Lerdahl and Jackendoff, results which they published in two studies in 1987.[50] Krumhansl, in her monumental *Cognitive Foundations of Musical Pitch* of 1990, herself documents these studies in a chapter, "A Keyfinding Algorithm Based on Tonal Hierarchies".[51] She notes that:

> …important for the present discussion is that these studies found that judgments of temporal patterns were independent from judgments of pitch patterns. For the particular musical selections employed, tonally strong events did not consistently occur at points of rhythmic stress.[52]

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[50] Caroline Palmer and Carol L. Krumhansl, "Pitch and temporal contributions to musical phrase perception: Effects of harmony, performance timing, and familiarity," *Perception & Psychophysics* 41.6 (1987): 505–518. Also, Caroline Palmer and Carol L. Krumhansl, "Independent temporal and pitch structures in determination of musical phrases.," *Journal of Experimental Psychology: Human Perception and Performance* 13.1 (1987): 116–126.

[51] Carol L Krumhansl, *Cognitive Foundations of Musical Pitch* (New York: Oxford University Press, 1990).

[52] Carol L Krumhansl, "A Keyfinding Algorithm Based on Tonal Hierarchies," in *Cognitive Foundations of Musical Pitch* (New York: Oxford University Press, 1990), 38.

She returns to further lend credibility to GTTR in a later chapter, "Pitch Organization and Pitch Memory," by using the values predicted by GTTR that showed high correlation in tests.[53] By far the most interesting chapter in terms of the relation of Krumhansl's experimental work to the theories and models of GTTR is the chapter, "Tonal Hierarchies in Atonal and Non-Western Tonal Music."[54] It is by far the most speculative and least certain of the chapters discussed. The atonal music discussed mirrors latter portions of Lerdahl's *Tonal Pitch Space* of 2001, (another highly important theoretical treatise built atop GTTR and equally deserving of thorough treatment equally as much attention as GTTR). While valuable and while a fruitful direction for further inquiry, some of the most relevant content comes in the study of Non-Western Tonal Music. Revealed there through her work, and through the work of her colleague and sometimes collaborator, Jhamshad Bharucha, which provide interesting prospects for future research. Krumhansl writes, "To summarize, Indian music theory suggests that well-defined tonal hierarchies underlie its melodic component."[55] Again, pointing to common structural features across dissimilar musical cultures. Then, surprising similarity in performance between inexperienced western listeners and Indian listeners in foreign music on certain probe tone tests demonstrate the first hints at hard evidence legitimating the direction Bernstein set out to begin with. Krumhansl writes:

> This result indicates that one strategy the inexperienced Western listeners applied to this style was that of registering the relative salience or emphasis

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[53] Carol L Krumhansl, "Pitch Organization and Pitch Memory," in *Cognitive Foundations of Musical Pitch* (New York: Oxford University Press, 1990).

[54] Carol L Krumhansl, "Tonal Hierarchies in Atonal and Non-Western Tonal Music," in *Cognitive Foundations of Musical Pitch* (New York: Oxford University Press, 1990).

[55] ibid., 18.

> given the various tones in the musical contexts. In this case, this strategy produced style-appropriate tonal hierarchies. Thus, it could be used to achieve a sense of tonal organization that, when refined solidified through experience, would serve as the basis for appreciating and remembering more complex and subtle structural features.[56]

These are just a few isolated tests. These two musical cultures seem to share a few raw ingredients that happen to be salient cognitive features when performing the tasks required. But it is the final connecting link between linguistics, evolutionary biology, neuroscience, ethnomusicology, and music cognition. It is only the final link in that some minimal connections between these disciplines demonstrate that there is room to move along them. This alone cannot be taken for granted. Together, these various disciplines across the terrain of the so-called musico-linguistic meme instigated by Leonard Bernstein have slowly contributed fruitful collaborations of which only a few have been enumerated here. They have slowly but steadily explored the terrain and a working map across a few of the well known arteries between them can now serve to help further inform and refine the approaches going forward. The common thread between these approaches is emerging in the form of the study of recursion, explored here through the lens of many disciplines. Recursion itself also serves as a lens through which to understand the similarities between music and language, and in so doing, steadily ascertain more knowledge about the character of the human musico-linguistic mind.

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[56] ibid., 23.

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