Justus, Timothy & Hutsler, Jeffrey (2005). Fundamental Issues in the Evolutionary Psychology of Music: Assessing Innateness and Domain Specificity. *Music Perception* 32/1: 1-27

All uncolored (black) type reflect the content and ideas in Justus & Hutsler (2005), on pages represented in parentheses on the margin.

Colored type is background and disciplinary context, or other observations, by BC.

(p 1)

I. INTRODUCTION

A. Justus and Hutsler's primary goal is to describe key forms of evidence and argumentation that distinguish claims that music is an *adaptation,* from claims that it is an *exaptation.*

B. In comparing researchers' claims about that distinction, "methodological distinctions encourage conceptual distinctions"; i.e. there is an association between *the ways and methods employed in studies of this issue* ... and ... *how they conceptualize the problem.*

1. Consider an analogy to basic categories of error in data interpretation — [[BC: Type I errors: asserting an effect when none is present, and Type II errors: asserting no effect when one is present.]] Justus and Hutsler point out that "the majority of the recent evolutionary treatments of music have primarily favored the approach of...guarding against the possibility that an adaptation [i.e. an adaptative function for music] might be missed...a Type II error.

(p 2) 2. "We adapt a fundamentally different perspective...the present review...**guards against the premature acceptance of music as an evolutionary adaptation,** when exaptation and culture may be sufficient to explain its emergence...we are guarding against a Type I error."

C. **Overview of the "modularity of mind"** (MoM) **thesis** (associated with Jerry Fodor (1983)), **and its implications for music as adaptation/exaptation**

- [[BC: this thesis is perhaps *the* foremost polemic in the philosophy of mind in the last half-century; "modularity" is normally opposed to "plasticity." The modularity thesis essentially states that features of the brain are "hard-wired" to particular tasks for which the brain evolved, and that those features (modules) have limited capacity to serve novel functions. Counterarguments for "plasticity" emphasize that **cognition is fundamentally conditioned by values, experiences, and "theories"** (held by the individual cognating), **i.e.** plasticity advocates tend to argue that **perception and cognition are** "**theory-laden.**" The two arguments (modularity and plasticity) are not mutually exclusive, but

Fodor's analysis advanced a deeply *materialist* account of human thought, which minimized the role of "higher-order" notions like free will and consciousness, and maximized the role of the brain's "ecological" functions; i.e. functions borrowed from its pre-historic evolutionary purposes.]]

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1. **MoM speculates that four related qualities of mental mechanisms are strongly associated:** some aspects of cognition are performed by **mental modules:** mechanisms that are

    a) specific to processing only one kind of information,

    b) by and large innately specified,

    c) fast, automatic, and unaffected by the content of other representations, and

    d) implemented by specific, localizable brain regions. We shall refer to these qualities as

(a) *domain specificity* (a quality of a mental mechanism being "specific to processing only one kind of information"—information in only one (cognitive) "domain."

(b) *innate constraint* (a quality of a mental mechanism being limited to, and oriented around, a specific function, innately, i.e. as a function of its construction at birth)

(c) *information encapsulation* (a mental mechanism's relative independence, and separation, from other mechanisms; its ability to work quickly/efficiently in a narrow domain of function, as a result of its not being impacted by information not directly associated with that function.)

and

(d) *brain localization* (the quality of a mental mechanism being organized in "specific, localizable brain regions.")

- [[BC: The MoM thesis is generally pessimistic and reluctant about the roles of cultural phenomena, morals, "superstructural" and "higher-order" cognition in shaping human psychology. **An MoM advocate, upon considering music's pervasiveness in human cultures** and in individual human development, **would guess that music is a part of our biological legacy,** i.e., it is an evolved, rather than culturally transmitted, brain function.]]

2. **MoM arguments in music tend to conflate the four features described above, as though they necessarily go together...**

- [[BC: Justus and Hutlser want to complicate that assumption by challenging

classical MoM premises, especially about domains and innate constraints. Granted: clearly *some* functions of the brain are domain-intensive, and *some* are innately constrained ...but what if brain functions having one characteristic tend not to have the others?—in Justus and Hutlser's words "*Most currently available arguments about music and modularity have not considered the separateness of these issues*." (3) What, in other words, if "mental modules" dissociate those four traits and mix them with traits associated with neural plasticity and (see below) *distributivity*?]]

- "The idea that **innateness and domain specificity** are dissociable, for instance, is supported by the possibility that many of the innately constrained mechanisms that we use for word learning are not specific to language, resulting largely from more domain-general constraints on conceptual representation (Bloom, 2000)."
- "The dissociation of **brain localization and innateness** has been shown with specific cortical areas that come to process information in learned domains such as reading (e.g., orthography-specific visual cortex, Farah, 1999; Polk et al., 2002)."
- "**Brain localization, innateness, and particularly domain specificity can also dissociate from information encapsulation**. Language may make use of cortical organization that is modular in the sense of information encapsulation, resulting in separate processing for some aspects of syntax and semantics (e.g., Friederici, 1995, 2000). However, neither this cortex nor its encapsulated structure is necessarily domain-specific for language; the syntax-semantics distinction might be better explained as the result of distinct neural systems for procedural and declarative knowledge (Ullman, 2001)."
- Dick (2001) introduces "**distributivity**" as an alternative to (modularity/) localization and its traditional alternative "equipotentiality." -- "cortical regions ...are recruited based on the computational demands of the domain, but are not necessarily devoted exclusively to it."
- thus "...given that brain localization and information encapsulation each can dissociate from the other facets of modularity, we feel that it is incorrect to conclude that the relevant cortex is domain-specific for music or that any domain-specific cortex that might emerge during development is genetically determined."

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D. Exaptation and Adaptation

- First: distinguish **genotype** (= the genetic code) /**phenotype** (= observed structure and behavior) of a species. [[BC: A phenotype is the present, contemporary manifestation of a species, and all its features, including both adaptive and exaptive traits.]] E.g. assume

that the genetics of perisylvian cortex are the result of selection pressures for speech; making speech an adaptation. The cortex is activated in reading [[BC: and writing]] behavior, but if no selection pressures have modified it for that purpose, reading/writing is an exaptation. [[BC: literacy distinguishes one phenotype from another, in the same genotype. Reading and writing might be widespread practices with numerous advantages in the environment, but might never respond to selection pressure; being illiterate is likely to make you poor, but is not likely to reduce your chances of rearing progeny to their reproductive age. (In fact, poverty might increase your participation in the future gene pool!]]

1. "On one hand, the genetics and corresponding developmental processes underlying musical processing and behavior may have been modified because of selection pressures for music itself, making music a function of the relevant cortex as well as an **adaptation**. [[Two paragraphs later: Accompanying this claim, we should seek an explanation of *"the origin and construction of a trait through evolutionary time*."—"much of evolutionary psychology has been explicitly concerned" with this origin issue (Justus and Hutsler's choice of focus), that has great "implications for neurocognitive development and organization."]]
2. On the other hand, the relevant genes and developmental processes may have arisen exclusively through selection pressures in other cognitive domains, making music one of perhaps many uses or **exaptations** of these mechanisms." [[Two paragraphs later: Accompanying this claim, the "modern fitness school of thought" addresses or queries the "*current existence, inclusive fitness, and maintenance of a particular phenotype*."]]

    - [[Between the two paragraphs--]] Another *type I error* emerges here —the type of error J&H want to avoid: an approach "prone to characterize traits incorrectly as nonadaptive," overvaluing "processes other than direct selection," simply because they are numerous and easy to find. [[BC: All environments have features other than those applying pressure for survival, but the mere presence of those features in connection with a trait does not mean one causes the other.]]
    - [[Three paragraphs later--]] Two problems:
        i. "...**any increased reproductive success in response to an expressed trait** (selection of a phenotype) **does not mean that the trait is heritable** (the genotype); individual differences on a given trait may be due entirely to environmental-cultural differences (Lewontin, 1998, 2000; Howe et al., 1998).

ii. *Regardless,* "one must consider how many cognitive domains are affected by this variability. **If the variability is not domain-specific, the correlation...may be spurious, connected only by relation to another domain** that is the true source of the selection pressure."

[[BC: — (i) even if Mary's increased writing ability were to increase reproductive success, her variable capacity for **writing might not be encoded genetically** (i.e. the capacity might not be ***innately constrained/specified***) -- she might not pass any writing-ability genes to her children.

Conversely (ii) **even if writing ability is innately constrained in genetic code, it might not be *domain specific,*** i.e. the same *heritable* code that increases Mary's writing ability might also increase speech ability. Mary's children might reproduce more successfully than Anna's, increasing the likelihood of inheritable writing-skill in the future of the population, but this may be exaptive. It might be that speech abilities (from the same genetic code) increased her children's chances of finding a good mate, and/or increased the chances that they would survive a famine or a plague—due to circumstances having nothing to do with writing. See also example re: musical behavior in pp 5-6.]]

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E. Two questions re: combining Cognitive Science & Evolutionary Biology

1. How **innately constrained** is the development of the domain? (Hold this answer to a high standard of genetic specificity, *not* to a standard that could involve "the internalization of culturally transmitted information by more general mechanisms.") ---> [[To answer, use evidence converging from "computational approaches, cognitive development, cross-cultural studies, and cognitive neuroscience."]]
2. Are any of these constraints **domain-specific**? "Constrained developmental processes must have been directly shaped by natural selection in response to (music), and not shaped in their entirety in response to other domains." [[To affirm, use "evidence of domain-specific mechanisms that distinguish it from sister domains."]]

II. Determining the Degree of Innate Constraint in Musics

(pp 5-6)

A. Cultural transmission (as a converse, or confounding, variable)

1. Consider an 18th-c musical convention—scale degree pattern ^1, ^7, ^4, ^3—that—if we had observed it repeatedly across several decades of history and in several musical situations, we might have thought perception of this pattern was innately constrained in the cortices responsible for melodic perception—especially if we noticed information-encapsulated, localized brain regions responding uniquely to those patterns.
2. But knowledge and behavior of the type envisioned in that 18th-c example, need not be innately constrained or domain-specific to be biological. Indeed "cultural knowledge must be biological"; must be "stored in a distributed manner in the structure of the brains of its members, in combination with the vast systems of external information storage that humanity has devised (Donald, 1991)." Such knowledge's biological manifestation does not guarantee that it is *evolved.*

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B. Types of Innate Constraint: Representational, Architectural, and Chronotopic

"Elman et al. (1996)... argued that innate constraints may manifest themselves in at least three ways during development: *representational constraints*, *architectural constraints*, and *chronotopic constraints*.

1. *Representational constraints* are predetermined patterns of synaptic connectivity, such as the microcircuitry of the cortex or the strength of the connections in a neural network.
2. *Architectural constraints* exist on increasingly macroscopic scales and include differences in the kinds of neurons found in different areas of cortex and the ways in which the different regions of the brain connect with inputs and outputs.
3. *Chronotopic constraints* manifest themselves during development and control the relative timing of the onsets and offsets of different developmental processes (see also Gould, 1977).

C. Computational Approaches

[[BC: A number of scholars model musical knowledge in machine networks that resemble neurobiological structures but, being machines, are not subject to cultural transmission.]]

1. **Poverty of Stimulus Arguments:** Neural network models help grapple with the issue of how much detail is necessary in an innately constrained system. In a "poverty of the stimulus" argument (cf. Chomsky 1957, 1975),

there isn't sufficient environmental condition or stimulus to justify or explain independently how a detailed form of cultural knowledge could emerge; i.e. there must be neural mechanisms structuring our perception of this knowledge, structures that innately aid in our perception of them. [[BC: MoM advocates argue that a "neutral, unconstrained" brain's repeated sensory exposure to our physical world and environment would not be sufficient to learn how to distinguish types of information in our visual field—for example, the difference between a line that marks contact between two objects, and lines that mark the edge of an object in front of another. We need an innately constrained visual cortex to help us manage this information.]]

(p 9) 2. But ... no poverty of the stimulus arguments seem to apply well to music; indeed "evidence often suggests that ... the development of many kinds of musical knowledge," including knowledge represented in theories like Lerdahl & Jackendoff's GTTM "can be successfully modeled by self-organizing neural networks."

3. **Low (Innate) Constraint: Acquisition of tonal-harmonic representations:** "Tillman, Bharucha, and Bigand (2000) successfully used an unsupervised learning algorithm incorporating Kohonen's (1995) self-organizing maps (SOMs) to model the acquisition of knowledge of Western music...the network developed layers representing the chords and keys of tonal-harmonic music, and...could then model the results in a large body of behavioral experiments on musical expectation (Figure 3).

4. And ... "Krumhansl and colleagues have ... used Kohonen self-organizing maps [[SOMs]] to model the musical expectations of three different musical-cultural backgrounds: musicians of the Sami or Lapp culture, Finnish music students with some exposure to Sami music, and other European music students with no exposure to Sami music. The SOMs correctly modeled the knowledge of the three groups, depending on the kind of music with which they were trained (Krumhansl, Louhivuori, Toiviainen, Järvinen, & Eerola, 1999; Krumhansl et al., 2000; Krumhansl, 2000b)."

D. Cognitive Development Studies

1. "...**aspects of musical knowledge that appear early** with minimal exposure **are more likely to be** the result of **innately [constrained]** specified developmental programs" (but not necessarily—bear in mind e.g. that "auditory experience begins well before birth")

(p 11) a. Octave, P5, and simple pitch ratios in general

- Perceived similarity of simple intervals develops in the first few

months of life, and are culturally ubiquitous

- But ... "neural network models suggest that innateness arguments may not be required" e.g. general perceptual learning mechanisms along with physical/acoustic features of the intervals, are enough to explain why the intervals have "special status."

b. Scale categories & melodic contour:

- Western infants show no advantage in perceiving major scales vs. Javanese *pélog* at 6 months (Lynch et al., 1990), but do differentiate a variety of distinctions between scales at 12 months (Lynch & Eilers, 1992; Lynch, Short, & Chua, 1995; also see Lynch et al., 1991).
- Infants recognize/identify melodic contour across transpositions, and intervalic transformations [[BC: presumably modal shifts, intervalic augmentations and diminutions]], but "discriminate...between melodies with different contours", [[BC: in other words, contour alone bears identity, independent of tonal or intervallic structure]]

c. Tonal-harmonic logic: But ... "other forms of musical knowledge are apparent only later in childhood.

- Including "full internalization of ...diatonicity or key membership (Trehub et al., 1986; Trainor & Trehub, 1992) ...and the concept of harmony (Krumhansl & Keil, 1982; Trainor & Trehub, 1994)."
- "converging evidence from computational work showing the learnability of these concepts (e.g. Tillman et al. 2000) and...the fact that these aspects...are culturally relative allow us to make a reasonably strong inference that these aspects of tonal-harmonic knowledgeare heavily influenced by learned, culturally transmitted information."

d. Grouping and meter

- Drake (1998): "there may be two basic temporal processes in music that are universal: segmentation into groups and temporal regularity extraction."
- "Evidence from infant listeners suggests that they attend to the grouping as a salient feature by at least 4.5 months (Krumhansl & Jusczyk, 1990; Jusczyk & Krumhansl, 1993) and that they are sensitive to slight tempo changes by 2 months (Baruch &

Drake, 1997).

- Drake and Bertrand (2001): five candidate (innate) constraints in temporal processing
    i. the grouping of similar events occurring close in time,
    ii. a preference for temporally regular sequences,
    iii. tempo- ral organization relative to real or perceived regular pulses,
    iv. an optimal zone of processing around a 600 ms interonset interval, and
    v. a predisposition for intervals with simple duration ratios, 2:1 or 3:1 (see also Fraisse, 1956).

E. Cross-Cultural Musicology

- Cultural universality does not guarantee innate constraint
- Innate constraints might be soft, and "may not manifest themselves in every culture."
- "...however, aspects of music that are found in multiple systems are more likely to be shaped by innate constraints than those that are not."

1. **Tonal material and tuning systems** are highly variable across musical systems.
2. **(Loose) regularities in scales** do appear, "which may be interpreted as innate constraints (e.g. Dowling & Harwood, 1986", esp. "the number of categories [of octave-space division] may be limited." In spite of debates about the relevance of e.g. 12-semitone space and 22- or larger interval cardinality spaces, "there is likely a minimum interval size that can be handled by our systems of categorization, and beyond which a musical system would become incoherent." Other regularities:
    i. most systems choose 5 or 7 pitches
    ii. "the majority of scales in these and other systems use tones corresponding to the perfect fourth (4:3 ratio) and perfect fifth (3:2 ratio) above the first [[root]] note of the scale)"
    iii. "most scales imploy different interval sizes such that within the context of the scale, each pitch is unique."
3. "**...tonal hierarchies** may be an important aspect of musical processing

cross-culturally."

- Westerners rate the tonic & perfect fifth as highly stable following major and minor contexts (Krumhansl, 1990);
- "Similar findings appropriate to the musical system in question have been found using listeners from India (Castellano et al., 1984), Indonesia (Kessler et al., 1984), and the Sami of northern Scandinavia (Krumhansl et al., 1999, 2000; Krumhansl, 2000b)."

F. Cognitive Neuroscience

1. "Unfortunately, much of the nativist argument within cognitive neuroscience suffers from the conflation of the issues discussed in the introduction: innateness, domain specificity, information encapsulation, and brain localization....Predictable regions of cortex may become information-ally encapsulated and/or domain-specific at the end of the developmental process, without this outcome having been 'planned' by the genome."
2. **Again e.g. written language** "For example, consider that there is evidence for orthography-specific regions of visual cortex in literate Western adults (Farah, 1999; Polk et al., 2002)...we know based on independent evidence that we are not evolved, nor did we coevolve, to read and write. Yet one would be tempted to come to the opposite conclu-sion based on evidence from cognitive neuroscience if it were not already known to be false."
3. "...cases of acquired amusia and related disorders (e.g., Peretz, 2001b) do not inform us about innateness, even when the deficit is arguably specific to the domain of music."
    - (Peretz, 2001a, p. 161): If it were true that music "recruits free neural space" opportunistically in response to "cultural pressure and not biological factors," then "a highly variable location and distribution of the musical networks should be observed." Peretz argues that music can't be a "squatter" because amusia is associated with damage to particular corticies ("the left temporal lobe and right frontal operculum.")
    - J & H disagree: "Certain regions of cortex, by virtue of input sources and other architectural constraints, will consistently win the competition as the home of choice for a cognitive 'squatter' with particular information processing requirements."
4. **"Deficits from congenital abnormalities versus acquired lesions":** "tone-deaf individuals [sic]"... "had no difficulty discriminating spoken lyrics or environmental sounds but did have difficulties with simple melodic

discrimination tasks."

Summary (Cognitive Neuroscience)

"The findings of Peretz and colleagues complement the converging evidence from developmental and cross-cultural work that the basics of pitch perception and relational pitch processing may be shaped by innate constraints, thus having the potential to pass the first of our requirements for labeling as an evolutionary adaptation: innate constraint in development. Although computational research shows this information to be readily learnable, these are still among the strongest candidates for innate constraints relevant to music."

Summary (Innate Constraints)

"We suggest that computational approaches, developmental psychology, and cross-cultural studies, together with carefully interpreted cognitive neuro- science, are the most promising tools for determining the degree to which specific aspects of music are evolved innate constraints. The currently available research in these areas suggests that the strongest candi- dates include the special status of the octave and perfect fifth, pitch processing relative to scales and contours, basic principles of grouping and meter, and unequal interval sizes in scales and the tonal hierarchies that result from them. Only innate constraints and not cul- turally transmitted information require further consid- eration in light of natural selection."