Some Philosophical Problems of Music Theory (and some Music-Theoretic Problems of Philosophy)

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Abstract

Meter and tonality in the context of music theory offer fertile ground for a transfer of ideas between philosophy of science, aesthetics, and music theory itself. Firstly, there are well formulated models of the phenomena fit for philosophy of science-oriented analysis. Secondly, tonality and meter straddle the objective/subjective divide so that attempts to formally model them are left representationally ambiguous (as to *what* is being represented in the models). In this chapter I draw out, in a very preliminary way, these and other points of interest and suggest a way of resolving the ambiguity by employing Arthur Eddington's little-known position of 'selective subjectivism.'

Actually, I am not really sure what a 'theory of music' might be...
David Lewin (distinguished Harvard music theorist)

1 Introduction

Music has been investigated by philosophers for some time, especially (most recently) within the context of the metaphysics of music. Its ineliminable temporal aspects[1] as well as its ability to be multiply instantiated (via distinct performances or playings) renders it an ideal case study for matters ontological. Such studies have tended to restrict the focus to *works* of music, rather than general principles of music. For example, they might ask 'what *kind of thing* is Beethoven's ninth symphony?' This is an interesting question that has led to the application of many old viewpoints (nominalism, platonism, etc.), in addition to some novel positions linking to work originally carried out in modal metaphysics and the philosophy of time (and personal identity). Another area that has been investigated with interest by philosophers is the relationship between music and the emotions (and the puzzle of the expressiveness of music). However, as interesting as these topics are, this restriction leaves out much that might be of interest to philosophers of a different stripe, as well as leaving out aspects that might involve philosophy (of science) contributing something back to the study of music theory and musicology.

This chapter will shine a philosophical light (specifically: philosophy of science) on music theories and musicology (the more general study of music) and in particular the question of musical laws, models and theories.[2] To the best of my knowledge, philosophers of science have yet to include musicology or music theory amongst their objects of study.[3] This might be because

[1]These temporal aspects have been studied quite deeply in the context of a phenomenological (especially Husserlian) study of music—with the concepts of 'retentions' and 'protensions' (essentially the projection of past and future/expected events into present consciousness) playing a central role in explaining how a work of music (with its long melodic spans and temporally extended structure) can be experienced in a present moment. See, especially, Izchak Miller's *Husserl, Perception, and Temporal Awareness* (MIT Press, 1984). For a general bibliography of works dealing the relationship of time and music, see Jonathan Kramer's "Studies of Time and Music: A Bibliography", *Music Theory Spectrum* **7** (Time and Rhythm in Music), 1985, pp. 72–106.

[2]Note that often, in philosophy of science, when we think of 'theories' we think of the laws that form its basis (for example, Newton's laws of motion), and such laws are expressed through symmetries (for example, Galilean symmetries in the case of Newtonian physics), so I'll be ultimately thinking of the search for the laws of music as the search for invariances in music. Theories will then be characterised with reference to these laws.

[3]Matthew Brown, a musicologist, has tackled (in his *Explaining Tonality: Schenkerian Theory and Beyond* (University of Rochester Press, 2005)) the problem of explaining tonality (amongst other methodological issues) using tools from philosophy of science, but this study (and his other related work) appears to be an isolated exception. Two other books skirt philosophy of science issues are Mark DeBellis' *Music and Conceptualization* (Cambridge University Press, 2008) and Charles Nussbaum's *The Musical Representation*

musicology is in fact not to be considered a science. However, there are theories and models (especially of tonality and meter) that offer a good fit to the kinds of analysss carried out by philosophers of science, including various laws (or quasi-laws) and a central role played by abstract representation, often by the kinds of geometric spaces (such as configuration spaces, common in the physical and biological sciences[4]). We might note also that historically at least, musicology was certainly considered to be 'the science of music,' and this remains part of the most dictionary definitions (see L. Harap, "On the Nature of Musicology", *The Musical Quarterly* **23**(1), 1937: 18–25—though he attempts to impose a criterion of 'rigour' instead of 'scientificity'). Indeed, some influential approaches to music theory were modelled directly after the natural sciences, with the concomitant idea that music theories involve the discovery of natural laws that underlie the actions of composers (and that are involved in the listening process). Hugo Riemann's approach was especially explicit (see S. Burnham "Method and Motivation in Hugo Riemann's History of Harmonic Theory", *Music Theory Spectrum* **14**(1), pp. 1-14).[5]

Here we focus primarily on meter and tonality, key aspects of musical structure which have several features (philosophically interesting features) in common due to their more subjective natures—that is, neither meter nor tonality are strictly speaking a part of the auditory signal (the stimulus) in which music is (at least partially) encoded: one and the same signal can be interpreted as having distinct meter and tonality by different observers (perhaps a direct analogue of underdetermination of theory by data). Meter and tonality have also received highly mathematical treatments, as mentioned above, and are closest to genuine scientific theories.

Meaning, Ontology, and Emotion (MIT Press, 2007). Roger Scruton's *The Aesthetics of Music* (Oxford University Press, 1997) also considers, albeit briefly, music analysis from a philosophical standpoint.

[4]We might also note that there have been attempts to subsume music (and music theory) under other sciences (especially biology and neuroscience) as a natural phenomenon, much as is the case with economics, theology, and other human behaviours and behavioural sciences. For example, the 'Generative Theory of Tonal Music' of Lerdahl and Jackendoff (*A Generative Theory of Tonal Music*, MIT Press, 1983) explicitly treats music theory as a branch of theoretical psychology.

[5]Likewise Moritz Hauptmann, who in his *The Nature of Harmony and Meter* (London, 1888), writes that: "That which is musically inadmissible is not so because it is against a rule determined by musicians but because it is against natural law given to musicians from mankind, because it is logically untrue and of inward contradiction" (p. xl).

But, as we will see, we face an unavoidable problem: there exists a tension over what any such theories (and laws) might be referring to, and therefore over what music theory is a theory *of*. The problem is that there exists an ambiguity over whether a theory of music (and so the laws and symmetries) describes music qua objective structure (formal or otherwise) or qua subjective experience: objective musical structure versus experiential states of observers (phenomenology or the stuff of psychology and neuroscience).[6] Scruton distinguishes between "the intentional object of a listener's experience" and "the material organization of *sounds*" (*The Aesthetics of Music*, Oxford University Press, 1999, p. 415).

I argue that Arthur Eddington's little known position of 'selective subjectivism' (as outlined in his *Philosophy of Physical Science*, Oxford University Press 1939) is an appropriate response to this tension (it might in fact be one of the few sensible applications of Eddington's stance). Note that this is a tension that music theorists are themselves well aware of; it has usually been sidestepped by falling into one of two camps: either establish music theory as a theory of the mind and cognitive (perceptual) structure, or else entirely divorce music theory from the mental, cognitive structures that the theories generate (and/or are generated by).[7]

We begin in the next section with the fundamental materials of music theory, following which we consider some theoretical frameworks for dealing with these. We then develop the tension mentioned above (which already appears in the basic development of the musical materials and theories thereof), after which we proceed to show how selective subjectivism offers an appropriate resolution.

[6]As mentioned above, there are some overlaps with the scientific study of time here, in which it is ambiguous as to whether such features as 'flow' are 'in the world' or 'in the head'. Indeed, Zuckerkandl (1969) argues that music enables us to experience time as a concrete entity and, in some sense, highlights the reality of time. Comparing music to the 'visual arts' (spatial), Marvin Minsky wonders, given that music seems to have some stability to it when we experience it, "How [this can] be, when there is so little of it present at each moment?" (Music, Mind, and Meaning, p. 338). That is, as with more general experience (which has unity), music brings the problem of integrating experience across time into stark relief.

[7]I shall refer to these two camps as 'minders' and 'worlders' respectively. The Eddingtonian position brings the two together in a way that seems entirely appropriate to the curious nature of music.

2 Elements of Musical Structure

Firstly let us distinguish between musicology and music theory. There are many overlaps, but musicology is certainly more general than music theory, including aspects of history, style, notation, canon, and so on.[8] On the other hand, I take a music theory to be about purely musical *structure* (*pace* the ambiguity over whether this structure is objective or subjective). Meter and tonality form two central components of (western) musical structure, and are implicated in our expectations about the melodic and temporal organization of musical works—other important components include harmony, rhythm, melody, timbre, tempo, and pitch.[9]

Pitch is more directly observable than tonality or meter, and is at least an essential part of tonality perception. It is essentially the mind's way of representing the periodicity of sound waves. But it is relative pitch (the distance between different pitches) that is central to music perception (and musical structure); that is, one can change absolute pitch leaving relative pitches invariant and 'preserve the musical structure' in so doing.[10] This is an example of a musical symmetry. It seems that relative pitch is a basic

[8]Music theory is more closely related to 'music analysis' in this respect, though the latter focuses more on individual pieces of music, rather than *principles of music* in general—indeed, music analysis can be used to test theory, not offering predictions about other works but perhaps functioning as a confirmation of some music theory. As Ian Bent puts it, music theory consists of "that part of the study of music which takes as its starting-point the music itself, rather than external factors" ("Analysis", in S. Sadie (ed.), *The New Grove Dictionary of Music and Musicians*, London: Macmillan 1980, pp. 340-388: p. 341)—of course, this also faces the ambiguity previously mentioned, concerning whether "music itself" is something objective or subjective (or something else). There is a sense in which this distinction between music theory/analysis and musicology can be mapped to 'internalist' and 'externalist' approaches in the history and philosophy of science.

[9]Roger Scruton argues that the (cross-temporal) harmonic, rhythmic, or melodic organization of sound is what distinguishes a musical experience from a merely sonic one ("Thoughts on Rhythm", in K. Stock (ed.), *Philosophers on Music*, Oxford University Press, 2007: 226–255). This grouping of sounds into units and patterns is an essential part of the musical experience.

[10]Relative pitch most likely has a basis in 'intonation' perception in ordinary speech (e.g. a rise in pitch indicates a question, at least amongst non-Australian English speakers...). Those that are without 'music sense' (i.e. sufferers of amusia), also have a marked inability to process the intonation of speech—see P. Podlipniak's "The Ability of Tonal Recognition as one of Human-Specific Adaptations", in C. Maeder and M. Reybrouck (eds.), *Music, Analysis, Experience: New Perspectives in Musical Semiotics*, Leuven University Press, 2015, §4.

feature of the human perceptual system. For example, even infants can recognize transposed melodies as *the same* (hence, the symmetry). However, melodic contour information (the movements of a melodic line up or down for example) is easier to assess than specific interval information (though with the same deficits present in sufferers of amusia, who are also unable to register these shifts)—untrained listeners, for example, sometimes have difficulty distinguishing major from minor intervals (with octaves being a notable exception, for which there is universal ability to detect, even from a very young age, which is why octave separated notes get the same name).[11]

Even at this relatively low-level, in terms of the elements of musical structure, there is much cognitive processing going on. Pitch after all is not just frequency; it is linked to perception, and it *demands a subject*. Frequency does not. As one builds up to the concept of tonality (providing the sense of order and centeredness in a piece of music[12]), ever more cognitive load is involved. Thus, when Rameau declared, at the outset of his *Treatise of Harmony* (Dover, 1984, p. 3), that "Music is the science of sounds; therefore sound is the principal subject of music", he left a huge gap in understanding what sound is (himself leaving the problem of defining sound "to physics"). But, further, the reason why the sounds have that particular musical structure and organization (and why the composer made it so) has much to do with the human mind. For Rameau it was mathematical principles that were fundamental to this structure: the division of the string and the related

[11]The octave is divided into 12 semitones (in most Western music). This octave division is the foundation for musical scales: we divide to preserve consonance (which, of course, has a psychological element: consonance refers to what is pleasing to *us*! Harmony is essentially the study of the mathematical relations forming the structure of music that we find pleasing. Notes possess certain basic frequencies (specified in cycles per second, or hz), so that, for example, $A = 440$hz. The ratio between frequencies is essential to harmony; we achieve consonance when this frequency ratio is a ratio of small integers: 1:1 = unison; 2:1 = octave (880hz:440hz); 3:1 = perfect 5th, and so on.

[12]In more detail, 'tonal' refers to a class of music in which the organization of pitches singles out some special pitch (the *tonic*) which serves to pick out relative consonance and dissonance with respect to other tones. By contrast, atonal music involves the "method of composing with twelve tones which are related only with one another" (A. Schoenberg, *Style and Idea: Selected Writings*, Berkeley: California University Press, 1984, p. 218), so that the twelve pitches of the octave (unrealized compositionally) are regarded as equal, and no one note or tonality is given its classical harmonic significance. Schoenberg, who first developed this idea, regarded it as the musical equivalent of Einstein's relativity principles, much like the principle of background independence: no tonal background, only relative tones.

harmonic series could explain the nature of tonal music.

Rameau excepted, there are very few music theorists who view music theories as the study of raw physical sound signals. Most modern work on music theory acknowledges that music involves a certain amount of activity on the part of an observer. As Lerdahl and Jackendoff put it: "Insofar as one wishes to ascribe some sort of 'reality' to these kinds of [musical] structure, one must ultimately treat them as mental products imposed on or inferred from the physical signal" (*A Generative Theory of Tonal Music*, MIT Press, 1983, p. 2)

Including meter into our musical structure brings in even more 'mind stuff.' There is no sense in which meter 'exists in the physical signal' issued from a performance of music. As Danuta Mirka spells it out, "[T]he function of meter is to provide a cognitive matrix for rhythmic patterns in order to make their understanding possible" (*Metric Manipulations in Haydn and Mozart*, Oxford University Press, 2009, p. 22). Or, as Eric Clarke puts it, "[Meter is] a framework around which individual notes are organized, and through which they gain appropriate durational quantification" ("Levels of structure in the organization of musical time", *Contemporary Music Review*, **2**(1), 1987, p. 228). In this sense, meter is somewhat like a spacetime metric, providing the background in which physical processes occur. In the case of music, meter is the background against which heard rhythm and 'rhythmic surface' are defined. However, absolute Newtonian space (in the sense of a rigid container for processes) does not seem to provide the appropriate analogy here. Though we do often in fact infer the meter from the observable rhythmic surface, there's a strange bootstrapping in this case in which that very rhythmic surface is defined by the background meter. In this case, the cause/effect relation is unclear: the beats of an observable rhythmic structure generate a meter which shapes the pattern of those very same beats! It seems that a dynamical conception of meter more closely analogous to the metric in Einstein's theory of general relativity is more appropriate, in which the slogan 'matter tells space how to curve, and space tells matter how to move' sums up the embrace.[13]

[13]This is a well known phenomenon, though the entanglement of cause and effect has not been adequately discussed. Here's Justin London: "At some times a sense of accent flows from the musical surface to the emerging meter, and at other times from the meter to the unfolding musical surface" (*Hearing in Time*, Oxford University Press, 1993, p. 10). Or take Victor Zuckerkandl: "It is not a differentiation of accents which produces meter, it is meter which produces a differentiation of accents" (Sound and Symbol, translated by

However, such interesting parallels aside, what is important here is that meter, though a central piece of musical structure, is nowhere present in the sound signal entering the ear. As Martin Clayton puts it:

> Meter is more than a simple accentual pattern, and moreover it is not necessarily measurable or objectively demonstrable. On the contrary, meter depends for its existence on the agency of a human interpreter (*Time in Indian Music*, Oxford University Press, 2000, p. 33).

That is, meter is disconnected from observable pulses—music theorists usually call the pattern of (strictly unheard) accents in meter 'beats' to distinguish them from the directly observed pulses of rhythm. Musically, meter is essential to keep a sense of structure and organization as the pulses can drop out or shift pace, or syncopate (falling off the pulse). This idea that a central component of music (and music theory) is created by the brain will be important to the application of selective subjectivism later on.

This provides some sense of the elements of musical structure (along with some of their philosophically salient quirks), which a theory of music will attempt to describe and/or explain. In a particular music not all elements need be present. For example, African drumming music will have meter and rhythm present, and the drums will be tuned to some pitches, but harmony, tonic and melodic contours will, in general, not be present. Hence, it is difficult to provide models of the kind that one might give in philosophical discussions of spacetime theories.[14] But it is not impossible. After all music is, at one level (capable of formalization) just organized sound: pitches or tones laid out in space (harmonically) and in time (rhythmically). Though not presented in quite this manner, many modern theories of music perform in just this way, specifying the basic elements and their possible relations, along with a kind of dynamics (given by constraints that may or may not issue from biological/psychological features of listeners).

Willard R. Trask, New York: Pantheon Books, 1956, p. 169.).

[14]That is, in terms of structures $\langle \mathcal{M}, O_i \rangle$ consisting of a background manifold (a set of spacetime points with a topology and possibly a metric defined on them) and a set of geometric objects representing the kinds of matter one wishes to represent (e.g., particles, fields, or strings).

3 Theories and Models of Musical Structure

Music theories aim to describe different kinds of musical structure, and how these different kinds of music organise the materials of music. One usually has to make a distinction between tonal and non-tonal (or atonal) music, since theoretical principles and explanations don't tend to generalize to all musics, and indeed it is seen as a virtue of most theories that they have enough specificity to distinguish tonal music from non-tonal music. The notion of a 'grand unified theory' of music that encompasses all types of music without alteration of some fundamental parameters (akin to denying some postulate of Euclidean geometry to generate non-Euclidean geometries) is liable to be rather trivial.[15]

In his *Explaining Tonality: Schenkerian Theory and Beyond*, Matthew Brown considers theories of tonality from the point of view of theories in other scientific domains. He draws attention to the fact that even the most basic of methodological questions, that one might ask in other fields, face problems in the case of tonality (and, I would add, meter). For example, the question of selection and rejection of particular theories is difficult on account of the polysemicity of the central term 'tonality'. Because of this it is also difficult to know what such theories should be *about* and so what counts as success. There is even disparity over what a theory of tonality (and music theory) in general is supposed to achieve and how it is to be carried out: with focus on the purely musical structure ('internalist') or on the psycho-socio-cultural mileau ('externalist'). However, Brown *et al.* provide a list of desiderata for a theory of tonality (that can easily generalise to meter and other structural elements of music):

> [A] powerful theory of tonality should allow us to do more than merely separate the tonal sheep from the non-tonal goats; it should also enable us to predict how suitably qualified auditors might respond to features characteristic of tonal music. This list might include judgments about closure, completion, openness,

[15] As Brown *et al.* put it: "If Schenkerian theory [or replace with any other theory—DR] turns out to be powerful and fruitful because, like creationism, it is a universal technique that yields analytical results for any sequence of pitches whatsoever, then it is hardly worth regarding as a theory at all, much less a theory of tonality. Such a theory would be complete, but wildly unsound. A good theory is one that is not universally extendible to all music" (1997, p. 158).

stability, transition, goal-directedness, and many other related musical phenomena. The better the theory predicts such judgments, the more powerful it will be. Finally, we will say that a theory of tonality is fruitful if it also predicts (with relevant modifications) aural judgments about pieces that are not paradigmatically tonal. For example, it should explain the tonal tendencies of Debussy's music or Stravinsky's neo-classical works and indicate when and how the pieces deviate from common-practice conventions. (M. Brown, D. Dempster and D. Headlam, "The #IV(♭V) Hypothesis: Testing the Limits of Schenker's Theory of Tonality" *Music Theory Spectrum*, **19**(2), 1997), p. 157)

In this we find a focus on the "judgement" and experience of listeners. As we saw in the last section, this is entirely appropriate given the entangled nature of music theory in which the object of analysis is also partly subjective, such that the state of the analyst becomes part of the system analysed.[16] Lerdahl and Jackendoff quite explicitly take 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*" (1983, p. 1).[17]

This kind of approach, involving a probing of the 'fine structure' of music, as inferred from a 'musical surface' harks back to the ideas of Heinrich Schenker.[18] This is a view that, although not strictly formalised as such, has at least an affinity with theories in the natural sciences. It attempts

[16]Though it might be a stretch, there is some similarity between this situation and the way in which quantum states are conceived in the Qbist approach to quantum mechanics, in which both the perceiving subject and the perceived object are considered central. See N. D. Mermin, "QBism puts the Scientist back Science". (*Nature* **507**: pp. 421-423).

[17]The authors are well aware of the idealization involved in their experienced listener (see, e.g., ibid, p. 3), and they even introduce the concept of "a perfect listener" (a *homo musicus* which puts one in mind of the *homo economicus* from neo-classical economic theory). However, they take the composer to have in mind one who knows what they are doing...

[18]Milton Babbitt has written that "Schenker has contributed.., a body of analytical procedures which reflect the perception of a musical work as a dynamic totality, not as a succession of moments or a juxtaposition of 'formal' areas related or contrasted merely by the fact of thematic or harmonic similarity or dissimilarity!" (1952, p. 22). Schenkerian theory is really the default in musicology: it's a recursive theory in which musical structure is analysed in terms of successive pitches (voices) elaborating on previous ones. Levels of structure in a piece with a main 'urlinie' structure featuring stepwise descent, from mi, re, do usually (but sometimes this can be more complex: so, fa, mi, re, do, etc...). Lots of Husserlian ideas can be found in Schenker's theory, and it is based in key way on

to uncover various levels (a hierarchy) of music structure. Those 'surface' phenomena that we directly perceive are related in various ways to deeper layers of organization. In Schenkerian analysis one has, methodologically speaking, something that looks like the standard physicist's way of reducing a phenomenon to more fundamental units (though in this case the units are larger blocks). One extracts ever-more extended progressions from the 'musical surface'.

Similarly, in considering 'syntactic theories of music,' Marvin Minsky takes the aim of such theories to provide an answer to the question "Why do we like certain tunes?" (p. 336)—that is, he also indicates that music theory should concern itself with the experiences of listeners. He contrasts two answers, one involving *structural features* (encoding laws and rules of composition), and one involving the psychological fact that they match what we already know and have built expectations about (i.e. from hearing specific tunes during childhood). Minsky is not convinced that the former approach is viable since he doesn't see that such rules and laws exist, and so he focuses on the psychological (developmental) perspective—though involving AI and simulations of the development of melodic sense and preferences. However, in their scheme, Lerdahl and Jackendoff, for one, extract a set of rules for assessing the well-formedness of musical structure. These involve four basic principles:

- Grouping Structure: the mind's method of grouping together musical events that sound like they belong together, into a linear stream
- Metrical Structure: background beat structure, to which musical events are related
- Time-span reduction: the selection of important musical events
- Prolongational reduction: A global (Schenkerian) principle having to do with the analysis of tension and resolve, possibly over very long timescales (as related to shifts in pitch and rhythm).[19]

'retention' and 'protention' in analysing musical works—this is why philosophers of time are interested in this work, as mentioned earlier.

[19]For example, the movement away from the tonal centre of a piece can generate a tense of tension, which can be resolved by motion back towards the tonal centre, achieving closure when the tonic is reached again.

In addition to these, there are also "Preference Rules" for each well-formedness rule. These are based on the "relatively unchanging cognitive foundations of the musical mind" (*Tonal Pitch Space*, Oxford University Press, 2001, p. vii). In more recent work, Lerdahl and Jackendoff model a musical work as a trajectory through a 'state space' (involving relative distances between pitches and key signatures). One of the tasks they set themselves is that of figuring out how metric (that is, meter) interpretations are assigned to musical works, and what the constraints are on these. We needn't go into the details of these rules, but the overall scheme involves the search for patterns that will function as a grouping mechanism in musical material (i.e. the musical surface structure). These patterns allow expectations to emerge, which in turn allow listeners to make predictions about what is to come.

Another popular theory of music, intended to satisfy this condition of wide explanatory scope, is David Lewin's Transformational Theory (as expounded in his *Generalized Musical Intervals and Transformations*, Oxford University Press, 2007). As above, according to this approach the 'target system' for the theory is the musical experience of an observer/agent. What is modelled are relational aspects of this experience involving not just relations between pitches (standard intervals), but relationships (generalized intervals) between a host of musical objects.[20] The transformational aspect is supposed to refer to the active procedures carried out by an observer (now conceived as agent). This fairly metaphysical scheme sits atop of a very formal bed of representational machinery: musical objects are represented by sets and the intervals and transformations are members of groups. Hence, group theory provides the mathematical backbone. A musical work is analysed in two ways: passively or actively. The passive approach merely measures the various kinds of intervals, while the active approach using the notion of a motion shifting one musical configuration to another (providing the dynamics). Again,there is a sense of traversing a space of musical possibilities, to which we return in a moment.

[20]We can precisify this a bit via Lewin's generalised interval system [GIS], so that there is a basic set of musical/sonic-objects: pitches, durations, intensities (the raw materials of music). Of course, he also postulates a group of generalized intervals, linking these basic musical elements—as mentioned, Lewinian intervals are far more than distances in pitch or frequency ratios; rather, they model, among other things, transpositions between pitches, pitch classes, chords, and series; serial transformations; and rhythmic relationships. There is then a mapping [the "interval function"] that spits out an interval for each ordered pair of musical objects.

Lewin's GIS is an example of a musical structure. This gives us something more or less precise, that can figure in a scientific theory of music, but it leaves much unsaid. What is the representation relationship between this musical possibility-space and reality? Unlike the situation with physical theories a 'subjective vs objective' ambiguity infects even this clean system. Is it a model of the world or the mind, or something else? There is also a curious sense in which it is possible that there is so much theory-ladeness in this procedure that the theory generates the phenomena it is supposed to be describing (a kind of 'performative biolooping')—similar complaints can be made of Schenker's and Lerdahl and Jackendoff's approaches. However, this basic approach, involving group theoretic and geometrical (pitch space) ideas, has been extended by Dmitri Tymoczko in a way that eliminates some of this performativity.

Tymoczko's work is closely related to work on the psychology of pitch relations, as carried out by Carol Krummhansl, amongst others. The space of musical possibilities is a kind of sensory space, since it is heavily dependent on pitch perception. Such spaces encode implicit (or explicit for trained musicians) knowledge about musical structure. Matching the persistent ambiguity over whether music theory involves objective or subjective structure, the structure of such musical space/s have been analysed in two ways: 'objectively', via psychology and neuroscience; and 'subjectively', via music theoretical techniques (often based on a listener's introspective experience of a piece of music). Central to both approaches, is the notion of tonality.

There is a well-known set of experiments, known as 'probe tone tests', designed to examine a listener's representation of tonality (Krumhansl, 1990). The experiment involves priming the subject with some musical example (from the tonal repertoire), providing a background context, and then supplying the subject with a probe (a single tone taken from the 13 chromatic tones of the octave, with the octave tone included here). The subject must then make a judgement about the 'goodness of fit' (relative to a 7-point scale) with the earlier musical passage. The results suggest a fairly robust tonal geometry that matches music theoretical analysis (as represented in, e.g., the circle of fifths). As Krumhansl notes, "tones acquire meaning through their relationships to other tones" (1990, p. 370). In other words, musical context affects the perception and representation of pitch—so that multiple mental representations map to one and the same physical source. Tonic tones are perceived as "closest," then diatonic, then non-tonic (this generates a tonal hierarchy). It is precisely the interplay of tonal stability and instability that generates musical tension (produced by motions away from the tonal center) and release (produced by motion back to tonal center), just as is laid out in Lerdahl and Jackendoff's theory. The space (constructed through multidimensional scaling techniques on the data from these tests) is shown in fig. 1.

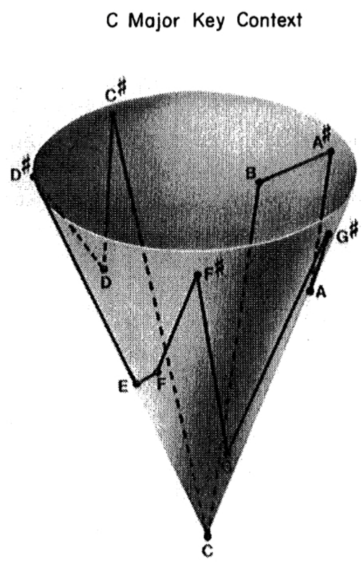

Figure 1: Multidimensional scaling solution from subjective judgements given in Krumhansl's 'probe tone test' for a given C major context—the tonic sits at the vertex, with distance away from the vertex representing goodness of fit: the further away, the poorer the perceived fit with the context. [Source: Carol Krumhansl (1990) *Cognitive Foundations of Musical Pitch*, Oxford University Press, p. 128].

Krumhansl's (ibid., pp. 112–119) space provides a geometrical model of the perceptual relations amongst the various keys. An important phenomenological factor that affects the topology of the representational space is octave equivalence ("the sense of identity between tones separated by octaves": ibid., p. 113)—this involves a doubling of frequencies: $f \sim 2f$. Such octave equivalent tones are represented by one and the same point (so that for any pitch p, any pitches that are integer multiples of 12 away [where each semitone amounts to one unit of distance] are considered 'the same').[21]

[21] Mathematically this reduction of the space of musical possibilities (by identifying

Dmitri Tymoczko (*The Geometry of Music*, 2011, Oxford University Press) has recently built these basic ideas up into a detailed geometrical framework for doing musicology, examining the 'shapes' of such musical spaces (and more complex counterparts, with extended symmetries) and their music theoretic (and musicological: historical analytic) relevance. As above, rather than thinking in terms of basic pitch space (simply: a space whose points represent different pitches, ordered in the traditional linear way, such that a musical work traces a path through it), following Krumhansl Tymoczko identifies *the same* pitches (e.g., middle C, C above, C below, and all other Cs), producing the "pitch-class" spaces rooted in octave-equivalence. Tymoczko recognizes, however, that now the corresponding space is mathematically an example of an "orbifold" (an orbit-manifold, where the manifold has been "quotiented" by octave equivalence, a symmetry, thus identifying certain points producing a 'non-simply connected manifold').

In an important extension, Tymoczko generalises this idea to *all* intervals and chords. For example, one could move from middle C to E flat by going up or down (and then jump any number of octaves up or down, so long as an E flat is reached) to get the *same* interval (tonally/harmonically speaking). Hence, these motions are also identified as musically the same, and so quotiented out reducing the size of the musical possibility space some more, thus producing a far more complex orbifold. As mentioned, one can also apply this to *chords* of any type, with each voice of the chord generating another dimension (axis) of the representational space: the same chord will simply be playable in many different ways, and these are to be identified too, again producing an orbifold when the redundant elements are eliminated through quotienting. There are five such musical transformations for quotienting out redundant structure which generate the various equivalence classes of 'musical entity' (e.g., chords, chord types, chord progressions, pitch classes, etc.). These are labeled OPTIC symmetries: **O**ctave shifts, **P**ermutation (reordering), **T**ransposition (the relation between pitches sharing the same succession of intervals, regardless of their starting note), **I**nversion (turning a sequence "upside down"), and **C**ardinality equivalence (ignoring repetitions: note du-

'musically identical' tones) corresponds to shifting to the reduced space $\mathbb{R}/12\mathbb{Z}$ (the reals with the set of multiples of 12 'quotiented out') and is what music theorists call 'pitch class space' (cf. Tymoczko, "The Geometry of Musical Chords." *Science*, 2006, **313**, p. 72.). *Sameness* here is couched in terms of 'musical structure' (though in such a way as to be related to the listener's experience, such as preserving the character of a chord in a transposition for example.) In this sense, octave equivalence is a symmetry of the model.

plication). These are embodied in the structure of the representation space in much the same way that the laws of Newtonian physics are embodied in phase space, with constraints (and symmetries) altering the shape of the space and the kinds of motion that are possible within it (in this physics-based case, with motions representing histories of particles).

Musical compositions can have their tonal structures modelled by such orbifolds, and we can judge the success or failure of compositions relative to them (and the trajectories through them *qua* state spaces). The geometry and topology of the same encodes psychological and physiological constraints (that manifest themselves as the symmetries that reduce the space of possibilities, much as laws of physics generate a dynamical possibility space from a kinematical one). With this model (embodying theory) we have a space of musical possibilities and therefore a means of testing which musical examples will 'work'. Though musicologists have argued that this geometrical approach kills the 'phenomenological complexity of musical experience' (e.g. R. Hasegawa, "New Approaches to Tonal Theory," *Music and Letters*, 2012, **93**(4): 574–593.), we have seen how at least aspects of this phenomenological experience filter in to constrain the shape of the possibility space.[22]

[22]There is neuroscientific data that maps the kinds of results obtained in music theory, by Lerdahl and Jackendoff, Krumhansl, Tymoczko, and others, onto specific brain areas. Janata, *et al.* ("The Cortical Topography of Tonal Structures Underlying Western Music." *Science*, 2002, **298**: 2167–2170) found, in fMRI experiments, "an area in rostromedial prefrontal cortex that tracks activation in tonal space" mapping onto the "formal geometric structure that determines distance relationships within a harmonic or tonal space" in the specific context of Western tonal music, where "[d]ifferent voxels [3D pixels] in this area exhibited selectivity for different keys" (ibid., p. 2167). This evidence supports the idea that our neural representations of music are relational: on a specific occasion some family of neurons will fire, say for the key of A minor, while on another occasion that family might fire for the key of C minor. But, the fact remains that the relational structure between the keys is preserved on each occasion, despite the fact that keys are not absolutely localised to unique assemblies of neurons and that the symmetries of the model are mapping to symmetries in reality. As the authors put it: "what changed between [fMRI] sessions was not the tonality-tracking behaviour of these brain areas but rather the region of tonal space (keys) to which they were sensitive. This type of relative representation provides a mechanism by which pieces of music can be transposed from key to key, yet maintain their internal pitch relationships and tonal coherence" (ibid., p. 2169). Again, this is closely related to the way in which symmetries in physics lead to relative representations of physical quantities. (For more on the philosophical significance of these observations, see Diana Raffman's "Music, Philosophy, and Cognitive Science," in T. Gracyk and A. Kania (eds.), *The Routledge Companion to Philosophy of Music*, 2011, Routledge, pp. 592–602.)

Meter, like tonality, is clearly a central part of the structural representation of a piece of (Western) music, but in terms of the neural mechanism that supports it, it is really a form of entrainment (that is, the synchronization of internal biological features with external aspects of the environment)—this inner/outer link is what causes bodily movements to become coordinated with music. As Justin London puts it, "[M]eter is not fundamentally musical in its origin... [Rather, it] provides a way of capturing the changing aspects of our musical environment as patterns of temporal invariance" (*Hearing in Time*, Oxford University Press, 2004, p. 4). Indeed, there are good reasons for believing that meter (and so rhythm) in music is a spandrel of an evolved capacity to model and predict the timing of events. The brain seeks regularities and patterns (invariances) in its environment to reduce cognitive load (energy minimization). However, as a biologically evolved mechanism (a feature of *us* rather than 'the music itself, whatever that might mean), it is subject to the limitations of biology which brings with it certain (average) temporal limits on processing and action.

London (ibid., p. 190) notes that there exists a "temporal window" of between 0.1 - 5.0 seconds (the 'specious present') that determines possible metrical cycles.[23] In other words, just as listener experience and capacities inform the modelling and theory of tonality, so they infect the modelling of musical meter: the measure (the units, or subharmonics of the beat) have to be within the limits of the present moment, lest it get bundled in memory. So the cycles in the meter must be compressed within the unit, especially for dance responses to occur—London also finds the threshold for perception of *tactus* (the level of beats that are *conducted* and at which we naturally coordinate body movement such as foot tapping) at 200 ms to 2000 ms (ibid., pp. 31-3).[24]

Very recent work[25] shows that meter emerges from the entrainment of neuronal populations resonating to the frequency of the beat, and at the

[23]In his words: "[T]he shortest interval that we can hear or perform as an element of rhythmic figure, is about 100 milliseconds (ms) [and] the upper limit is around 5 to 6 seconds, a limit set by our capacities to hierarchically integrate successive events into a stable pattern".

[24]Some musics have repeating patterns that exceed this threshold, e.g. the *tal* cycles of Indian raga. As the threshold is exceed other mechanisms come into play (see Martin Clayton, *op. cit.* for more on this complication).

[25]E.g. A. Tierney and N. Kraus, "Tagging the Neural entrainment to the Rhythmic Structure of Music", *Journal of Cognitive Neuroscience*, 2015, **27**(2): 400–8.

subharmonics corresponding to the metric interpretation of this beat (in ecologically or 'real' valid music). Neural entrainment to beat and meter can be captured directly in the human EEG as a periodic response (manifest a signal in the EEG) entrained at the frequency of the beat and meter, respectively.[26] For example, if the beat frequency is $f = 2.4$Hz, then binary/march meter (duple time) will be $f/2 = 1.2$Hz and ternary/waltz meter would be $f/3 = 0.8$Hz. On a single, given audible beat frequency (the auditory stimulus) it was found that subjects could induce a "voluntary metric interpretation" of this beat (with no accents) as binary or ternary (with the appropriate accents for that meter), which in turn induced a further periodic signal in the EEG, at the appropriate subharmonic of beat frequency. The idea that musical meter amounts to this kind of entrainment, with the human-side signal processing (i.e. adding accents that don't exist 'in reality') is known as 'the resonance theory' (for beat and meter processing). Like tonality perception, which involves various cognitive inputs onto a musical signal (which themselves contribute heavily to the music that is composed: the object of analysis), meter poses problems in making sense of what the theories and models are about, and so what music theory is about. This involves an account of what 'musical reality' is. We turn to this in the final section.

4 Musical Reality

> [M]usic theory and music itself is the creation of human beings. What does "reality" mean in such a context?
>
> Guerino Mazzola[27]

As we have seen, some, but not all of the objective structure of music will have subjective correlates. Some, but not all of the subjective structure of music will have objective correlates. This lack of isomorphism between the inner and outer of music is responsible for many of the difficulties and controversies

[26]As with tonality, a number of electrophysiological experiments reveal that humans have a marked preference for integer ratios in meter perception (see e.g., Pablos Martin et al., "Perceptual biases for rhythm: the mismatch negativity latency indexes the privileged status of binary vs. non-binary interval ratios", 2007, *Clinical Neurophysiology* **118**, 27092715.

[27]`http://www.encyclospace.org/special/answer_to_tymoczko.pdf`, p.4.

surrounding what a theory of music should be. It ought really to be involved in philosophers' debates about the ontology of music, but isn't... In this final section we consider what kind of interpretive stance can fit music theories in which the objective and subjective components are all mixed up in this way.[28]

This issue in fact relates superficially to a topic that has been discussed in some detail by philosophers: the extent to which listening to music is conceptual or given (see De Bellis *op. cit.* for a good discussion). To pose this issue, consider the following question. Suppose we could give a perfect sonic replication of Bach's music from his own period: would we hear it as they did? The idea is to invoke a problem similar to that raised by the notion of 'incommensurability' in the philosophy of science, according to which users of the theory of one paradigm cannot understand (see the world in the same way) as users of the theory of a different paradigm. In the musical case, the context is the idea of 'historical performance' and the notion that by playing on the instruments of the past (an approximation of sonic replication) one can get closer to a historical listeners *experience*. It is clear from the above discussion that listening to music is by no means simple, and involves all kinds of cognitive equipment and symmetries. But if these faculties were shared with historical listeners, then presumably they would hear the music in the same way at this low-level at least. As far as the higher (phenomenological) level, I tend to side with Roger Scruton that historical performance "cocoon[s] the past in a wad of phoney scholarship, to elevate musicology over music, and to confine Bach and his contemporaries to an acoustic time-warp" (*op. cit.*, p. 448).[29]

[28]Note also, that to a large extent, how we interpret basic musical structure will determine the kinds of theories we generate, so that philosophical work along these lines can have a direct bearing on music theory itself.

[29]But there is, of course, something to the strongly conceptual content of *any* experience. As Goodman and Elgin note: "A particular auditory event might be heard as a noise, as a piercing noise, as the sound of a trumpet, as a B flat, as the first note of a fanfare, or in any of indefinitely many other ways. To characterise what is heard as the sound of a trumpet or as the first note of a fanfare requires a good deal of background knowledge. But every characterisation relies on background knowledge of one sort or another. Even to recognise something as a sound requires knowing how to differentiate sounds from other sources of sensory stimulation, and how to segment auditory input into separate events. Sensation is sometimes supposed to be primarily given" (*Reconceptions in Philosophy and Other Arts and Sciences*, Hackett Publishing, 1988, pp. 9-10). Here I am more interested in the mind's projections onto incoming signals that operate at a lower level.

One way to frame this with the kind of issue I have in mind, distinct though related to this other debate on conceptualization of music is this: do we HEAR meter and tonality? Does it come in to our heads from outside of our heads? My preferred response (though not the details of interpretation) has already been revealed (we hear neither in this sense), but it is not standard amongst music theorists... Justin London distinguishes between two camps (with respect to the ontological status of musical meter), the 'structuralist' and the 'phenomenologist':

> The structuralist regards music as existing "out there," apart from the listener [what I called a 'worlder'—DR], and thus treats our listening and cognition experiences as our efforts to understand these external sound objects. [...] By contrast, the phenomenologist regards musical structure(s) as the product of the interaction between a sound object and our cognitive faculties [what I called a 'minder'—DR]; she disdains the notion that music qua *music* is only an external sound object, separate from the listener. ... While meter is *not* part of the sound object, it nonetheless may still be regarded as "part of the music."
>
> Meter is neither a parameter like pitch or timbre, nor is it part of a nested measuring of durational patterns and/or periodicities. It is something that is heard and felt. And this is of course why the physicist has so much trouble with meter, for physics is not phenomenology. The physicist's job is to describe the structure of physical objects in the world. Understanding our interaction with those objects is beyond the scope of the physicist's mission– at least if we stay above the quantum level. ("Loud Rests and Other Strange Metric Phenomena (or, Meter as Heard", 1993, *Music Theory Online*, **0**(2): `http://www.mtosmt.org/issues/mto.93.0.2/mto.93.0.2.london.art`)

I agree with most of this, though would quibble with the choice of labels. However, it is not true that physics has no frame of reference for dealing with such items as meter and tonality (and therefore, by extension, music itself). Recent work, especially in foundations of physics research, has begun to focus on the role of the observer (especially in the context of quantum mechanics and cosmology). Let me explain how by first showing a neat little picture (a 'self-excited circuit', fig. 2) due to John Wheeler (a physicist). This picture refers to the fact that, in quantum theory at least, our observations determine the very reality we are studying (by choosing which experimental questions to put to nature), so that we are in effect studying aspects ourselves when we examine the quantum world. I want to suggest that something similar can be said of musical reality, and a position (related to Wheeler's) was developed ('selective subjectivism'[30]), again in the context of physics, much earlier by the astrophysicist Arthur Eddington.

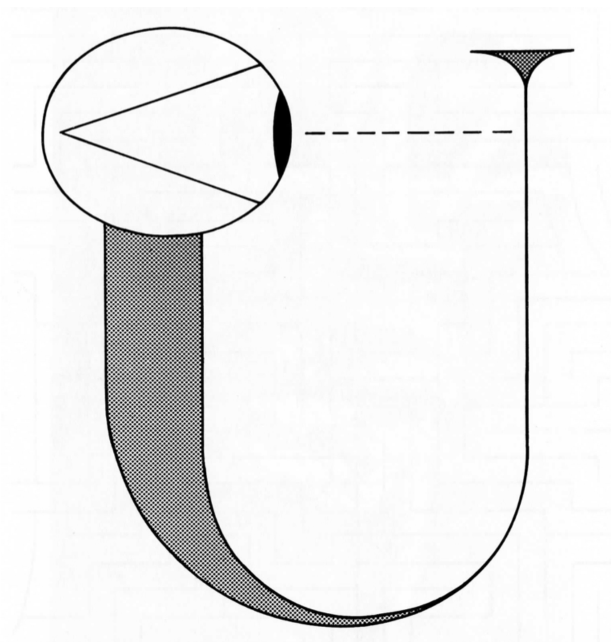

Figure 2: The self-excited circuit of John Wheeler, representing the idea that the universe 'bootstraps' itself into existence by making observing itself, thus creating 'phenomena'. [Source: J. Wheeler, "Beyond the Black Hole", in H. Wolf. (ed.), *Some Strangeness in Proportion*, 1980, Reading, MA: Addison-Wesley, p. 362].

Selective subjectivism is an epistemological theory that explicitly incor-

[30]In brief, in the words of its inventor: "Selective subjectivism, which is the modern scientific philosophy, has little affinity with Berkeleian subjectivism, which, if I understand it correctly, denies all objectivity to the external world. In our view the physical universe is neither wholly subjective nor wholly objective—nor a simple mixture of subjective and objective entities or attributes" (*The Philosophy of Physical Science*, 1938, Cambridge University Press, p. 27).

porates 'observer-selection effects' (the idea that in some sense our presence as observers influences *what* we observe).[31] It was intended to be employed in fundamental physical theory, but I propose it here as a novel position in musicology. The position is rather nicely characterised by one of Eddington's famous quotes on the subject:

> We have found a strange footprint on the shores of the unknown. We have devised profound theories, one after another, to account for its origins. At last, we have succeeded in reconstructing the creature that made the footprint. And lo! It is our own. (A. Eddington, *Space, Time, and Gravitation*, Cambridge University Press, 1921, p. 201)

In music theory we often think that we are probing some external and eternal realm, but what is happening here is that there is an invisible net underlying our theories, the musicological laws (for want of a better expression), so that what is really being studied is the constitution of this net and this is based on us and our cognitive and physiological makeup. The object of study (music) is entangled with the studiers (the observer). This is a selection effect: An observation selection effect exists when some feature of a thing is correlated with the observer studying the thing (an example of "anthropic reasoning").

In fact, there is an even more relevant quote that was written specifically to describe selective subjectivism, based on the concept of a net:

> Let us suppose that an ichthyologist is exploring the life of the ocean. He casts a net into the water and brings up a fishy assortment. Surveying his catch, he proceeds in the usual manner of a scientist to systematise what it reveals. He arrives at two

[31]Here is a quick example of a selection effect known as the 'fine tuning problem': in cosmology our thinking about the nature of the universe must take account of the fact that we are in a relatively special epoch of the universe's history in which complex organisms are possible, and slight differences (in, e.g., the values of the constants of nature) would forbid our existence. If such observers can exist only in universes in which the relevant parameters (gravitational strength, etc.) take on the observed 'fine-tuned values', then an observation selection effect can be used to explain why we observe a fine-tuned universe: if they didn't have these values, we wouldn't be there to observe them. Ditto with music: Why does music have the features we observe? Because our presence as observers with a certain constitution (with certain temporal thresholds on our conscious awareness, the presence of symmetries, and so on) necessitates certain features (the 'discovered' features) to be present in the music.

> generalisations:
>
> (1) No sea-creature is less than two inches long.
> (2) All sea-creatures have gills.
>
> These are both true of his catch, and he assumes tentatively that they will remain true however often he repeats it.
>
> In applying this analogy, the catch stands for the body of knowledge which constitutes physical science, and the net for the sensory and intellectual equipment which we use in obtaining it. The casting of the net corresponds to observation; for knowledge which has not been or could not be obtained by observation is not admitted into physical science.
>
> An onlooker may object that the first generalisation is wrong. “There are plenty of sea-creatures under two inches long, only your net is not adapted to catch them.” The icthyologist dismisses this objection contemptuously. ”Anything uncatchable by my net is ipso facto outside the scope of icthyological knowledge. In short, “what my net can’t catch isn’t fish.” (*The Philosophy of Physical Science*, 1938, Cambridge University Press, p. 16)

And we can likewise say, by analogy, that what our net can’t catch (i.e. that falls outside the scope of our cognitive powers, etc.) is not music. And, moreover, the catch (the musical object of analysis) to a large extent, takes the form it does on account of the constraints imposed by the net. Here Marvin Minksy is close to what I take to be an important truth: “[M]usic theory is not only about music, but about how people process it” and “to understand any art, we must look below its surface into the psychological process of its creation and absorption” (“Music, Mind, and Meaning”, in S. Schwanauer and D. Levittp (eds.), *Machine Models of Music*, p. 328). But Minsky thinks understanding comes from knowing how something is made. Here, however, absorption and creation go hand in hand, as a result of cognitive/neurobiological features of brains/observer: the creation aspect is *informed* by the absorption aspect. These aspects are well known amongst music theorists, especially those that favour a more psychological approach. As a pair of apposite passages, consider the following:

> [O]ne might argue that Schenkerian structures characterize both composition and perception. In support of this view, one might

> argue that the purpose of music, after all, is communication. Why would the great composers have bothered to create such elaborate mental structures if they thought that these structures would never be shared by listeners? (D. Temperley "Composition, Perception, and Schenkerian Theory," *Music Theory Spectrum* **33**(2), 2011, p, 147).

> [T]he various capacities and thresholds that have been studied and quantified in the psychological laboratory are commonsense aspects of everyday musical practice. They are intuitively known to composers when they write their music and to performers in their choices of tempo. (J. London, *Hearing in Time*, Oxford University Press, 2012, p. 198)

There is some precedent in the older music theory literature too, in the form of François-Joseph Fétis, who wrote the following oft-quoted passage:

> The ear perceives the sounds; the feelings find a priori the formulae of their associations, the mind compares their relationships, judges them, and determines the melodic and harmonic conditions of a tonality. (F-J Fétis, *Trait complet de la thorie et de la pratique de l'harmonie, contenant la doctrine de la science et de l'art*, 1867)

This is an over-used quotation, but I think he had in mind something like the kind of view I present. This passage captures the idea of the mind's "selective" action on objective structure (pitch and other materials), rather than passively registering that structure: this is essentially selective subjectivism (it clearly has strong links to Kant, and indeed Fétis was explicit about his debt to Kant, claiming that his was heralding a similar 'Copernican revolution' in music—the 'laws of music' are not derived from the world but imposed upon them by universal faculties of the mind). Christensen (*Rameau and Musical Thought in the Enlightenment*, Cambridge University Press, 2004) argues that Fétis viewed it as an *a priori* principle according to which the mind responds to sensory experience, and was of a purely metaphysical nature "tonality revealed itself before Fétis's eyes as a logical hierarchy of attractive relationships conceived and imposed upon selected pitch materials by the autonomous intellect, not some external object established by nature that we passively apprehend. (ibid., p. 39)". I fail to see how this implies that tonality is metaphysical, but in any case, like Eddington, Fétis too was largely rejected as overly speculative and overly *a prioristic*.

However, in this way, Fétis accounts for music as a merging of objective (external) and subjective (interior) forces. Likewise, Eddington's *a priori* scientist does not introspectively analyse the contents of his head, or blindly observe the external world, but instead observes observers and the necessary conditions demanded by the construction of whatever class of observables or phenomena interest him.

We can refer back to the work on meter to see how the Eddingtonian framework provides a good fit for the ontological ambiguities that plague music theory. What is curious about meter, you will recall, is that it is part of the essential structure of a piece of music, and yet we do not directly hear meter. There is some strange sense in which the mind is active in creating the piece of music, in contributing an essential part. And yet, in being part of musical structure it is taken up in music theories: an aspect that comes from the active participation of humans in projected into the theory itself. We end up modelling aspects of our own constitution (Eddington's net). As London nicely puts it, "Under this framework meter is a listener-generated construct that is intertwined with the musical surface. Meter is not 'part of the music' in the same way that pitch, timbre, and duration are. This commitment may be more troubling for some theorists than others..." (London, "Loud Rests and Other Strange Metric Phenomena (or, Meter as Heard", 1993, *Music Theory Online*, **0**(2): `http://www.mtosmt.org/issues/mto.93.0.2/mto.93.0.2.london.art`). For Eddington, "whatever is accounted for epistemologically [such as the understanding of tonality and meter obtained by observing observers—DR] is ipso facto subjective; it is demolished as part of the objective world" (loc. cit., p. 59)—prime material for selective subjectivist interpretation. Let us finish by paraphrasing another famous quote of Eddington's:

> The ~~physicist~~ musicologist might be likened to a scientific Procrustes, whose anthropological studies of the stature of travellers reveal the dimensions of the bed in which he has compelled them to sleep (*Relativity Theory of Protons and Electrons*, Cambridge University Press, 1936, p. 326).

Though physicists did not like this imposition of the mind on reality, it seems much less controversial (and indeed mandatory) to allow this in the case of musical reality.

5 Conclusion

Regardless of whether or not selective subjectivism is to be taken seriously as a philosophical stance in the case of music and the interpretation of music theory, it can readily be seen that music theory (along with the peculiarities of certain structural elements of music) contain several areas of interest for philosophers of science. Indeed, the awkwardness of music as revealed in tonality and meter studies (neither fully subjective nor fully objective) might provide new data for those (naturalistic) philosophers interested in the ontology of music and that wish their ontology to be continuous with the best results in the theory of music.

A remaining problem, also one that philosophers of science might contribute too (and that is important for music theorists) is the question of what a theory is supposed to be modelling. There are two levels to this problem: firstly, is it the objective structure in the sound signal itself, or is it the experiences of observers (listeners)? If the latter, then we have further complications since it is not clear which listeners we have in mind: untrained or trained? How well trained? An ideal perfectly trained one? In this brief review, I have been most concerned not with describing and analysing the details of music theories (which is an enormous subject), but in highlighting those tension and issues which I find might be of most interest to philosophers of science.

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