Explanations in Music Theory — Lessons from Biology and Physical Geology*

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Abstract. Does music theory produce only interpretive statements, or does it produce statements that resemble scientific explanations as well? Peter Kivy has argued that music theory is unlikely to produce explanations analogous to scientific explanations, while Mark DeBellis has responded with what he takes to be music theoretic explanations analogous to those found in the sciences. In the current discussion, I challenge Zsolt Bátori's defence of Kivy's position. For although Bátori demonstrates successfully that DeBellis' examples lack certain properties that many scientific explanations possess, these very same properties are lacked by mechanistic explanations in biology and physical geology as well. I argue that DeBellis' examples are analogous to certain mechanistic explanations found in biology and physical geology. Consequently, music theory does produce explanations that resemble scientific explanations.

1. Introduction

Does music theory ever produce explanations of musical works, or is it merely in the business of offering interpretations? Peter Kivy (1990) has argued in support of the latter disjunct, while Mark DeBellis (1995) has argued for the former[1], offering what he takes to be music theoretic explanations that resemble scientific explanations. Nevertheless, DeBellis'

* I am grateful for those who commented on this paper at the annual meetings of the European Society for Aesthetics and the Alabama Philosophical Society.

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[1] There is some inconsistency, in the literature, over the exact presentation of what is being contested. In this discussion, I assume that the debate concerns whether or not music theory presents explanations that resemble those produced in the sciences. Instead of expressing DeBellis' position as 'music theory produces scientific explanations', I am using the locution 'music theory produces explanations', where explanations are 'explanations that resemble scientific explanations'. When the various authors in this discussion

examples have been challenged by Zsolt Bátori, who has, in his (2012), argued that they fail to challenge Kivy's position. Bátori's response is motivated by the observation that DeBellis' examples fail to resemble scientific explanations of a particular sort. While DeBellis' examples purport to explain audible musical phenomena by appealing to underlying musical phenomena that are *perceivable*, Kivy and DeBellis both agree that the scientific explanations most likely to be analogous to the statements of music theory refer to *imperceivable* underlying microstructures.

I will argue that Bátori is successful in showing that DeBellis' examples do not resemble explanations that refer to an imperceivable microstructure. Nevertheless, Bátori's success is limited by the fact that DeBellis' examples resemble scientific explanations of another type. Ultimately, the claim that music theory does not produce explanations is motivated by a limited consideration of cases that overlooks mechanistic explanations commonly found in biology and physical geology. An examination of such cases provides undeniable evidence that perceivable lower levels are not unique to DeBellis' examples, but are found in scientific explanations as well. I will argue that DeBellis' examples do resemble explanations found in the sciences, and that their failure to appeal to an imperceivable microstructure amounts to the failure to satisfy a criterion that many scientific explanations would fail to satisfy as well.

2. Kivy's Dilemma, DeBellis' Response, and Bátori's Defence

Kivy's (1990) project was to engage with music theory insofar as it was relevant to music appreciation[2]: "as the present essay concerns the musical work as heard, what cannot be heard is not part of the work, nor is what was not intended to be heard" (194). To be clear, Kivy is not claiming

claim that a music theoretic explanation resembles scientific explanation of a particular type, I am understanding them to be making a claim that would be falsified if one were to find any statement, expressed in subject-neutral terms, that is true of all scientific explanations of that type, but not of the music theoretic explanation in question. The only exception to this potential for falsification is the fact that all scientific explanations of any given type are produced by scientific disciplines, while music theory is, in general, not acknowledged to be a scientific discipline.

[2] Roughly, this is the activity of perceiving the aesthetic properties of a work while listening to it.

that musical works must only be thought of as the bearers of non-audible properties; nor is he claiming that the only discussion ever worth having is a discussion in which musical works are thought to be the bearers solely of audible properties. His aim, rather, was to offer a description of the limited scope of the particular discussion in which he was interested in engaging at a particular time. The first step in Kivy's argument is to assume, purely for the sake of discussion, a limited scope:

(i) Assume: all properties of musical works are audible.

Kivy's second step involves a claim about the sorts of explanations that music theory would be likely to produce, were it to produce any explanations at all. He begins by noting the following:

> 'But there certainly is one kind of scientific theory or explanation that will be very familiar to all; in form it was already known to the Greek atomists. It is the kind of explanation that attempts to account for some perceivable, gross property of something on the basis of its inner structure: for example, Lucretius's explanation of the viscosity and liquidity of fluids in terms of the roughness or smoothness of the "atoms" he imagined material substances to be composed of' (124-125).

One way of characterising explanations of this type is to say that facts about a higher level entity are explained by appealing to facts about the lower level things out of which that entity is composed[3]. The viscosity and liquidity of fluids is simply a consequence of the properties of their constituent atoms. Explanations of this type are *mechanistic explanations* according to William Bechtel and Robert Richardson (2010):

> 'By calling the explanations *mechanistic*, we are highlighting the fact that they treat the systems as producing a certain behavior in a manner analogous to that of machines developed through human technology. A machine is a composite of interrelated parts, each performing its own functions, that are combined in such a way that each contributes to producing a behavior of the system. A mechanistic explanation identifies these parts and their organization, showing how

[3] By "composed", I mean any of the various 'making-up' relations (i.e., relations in which one entity is 'made out of' another) in which entities can be said to stand.

> the behavior of the machine is a consequence of the parts and their organization' (17).

Now, Kivy does not indicate merely that music theory would likely produce mechanistic explanations if it were to produce any explanations at all; as Bátori (2012) notes, his claim is much more specific:

> 'Although, of course, there are several ways and methods of scientific explanation, there is at least one kind that seems to be an initially plausible candidate for being analogous to what music theory is often argued (or assumed) to do. Specifically, it is the kind of scientific explanation, as explicated by Searle, which aims to account for the readily available, perceptible "surface" properties of some phenomena in terms of their microstructure. In this special case of cause and effect relationship, the surface feature is both realized in (or consists in) and caused by the micro-level properties" (71).

In mechanistic explanations of this more specific type, the higher level composed entities are "those properties we have dealings with in our everyday lives", while the lower level composing entities are "those properties or entities which scientific theories postulate as explanations of the former' (Kivy 1990, 126). Crucially, microstructures are imperceivable[4]. In the foregoing, I will refer to all explanations of this specific type as *micro-macro explanations.*

We're now ready to present the second step:

> (ii) Assume: if music theory produces explanations of musical works that resemble scientific explanations, then these explanations are likely to be micro-macro explanations.

Another way of phrasing this assumption is to say that explanations produced by music theory, were such explanations to exist, would be likely to resemble micro-macro explanations found in the sciences. Note that anyone committed to (ii) is also committed to the following:

[4] It is not exactly clear what is meant by imperceivable; what seems to be meant by a property's being perceivable is that it is 'observable to experienced human observers via the use of unaided senses', where 'experienced' refers to one's having had sufficient training to recognize the relevant properties.

(ii.a) If music theory produces explanations of musical works that resemble scientific explanations, then these explanations are likely to be mechanistic explanations.

The reason for this additional commitment is that (ii.a) is a logically weaker abstraction of (ii).[5] The third step[6] is a straightforward application of the law of the excluded middle:

(iii) Law of Excluded Middle: either the lower levels referred to in music theoretic explanations are perceivable or they are imperceivable.

This leads us into the fourth step, which is a dilemma:

(iv) Dilemma: Explanations of musical works, should they resemble scientific explanations, are unlikely to refer to perceivable lower levels (due to (ii); and explanations of *musical works* cannot refer to imperceivable microstructures (due to (i)).

Finally, either horn of the dilemma leads to the following conclusion:

(v) Conclusion: it is unlikely that there can explanations of musical works that resemble scientific explanations.

For ease of exposition, I present the entire argument here:

(i) Assume: all properties of musical works are audible.

(ii) Assume: if music theory produces explanations of musical works that resemble scientific explanations, then these explanations are likely to be micro-macro explanations.

[5] If one is committed to the belief that X is likely to be a square, then one is also committed to the belief that X is likely to be a rectangle.

[6] While steps (i) and (ii) were based on explicit claims from Kivy's text, (iii)-(v) are based on logical (or otherwise innocuous) inferences from Kivy's premises. These inferences are based on Bátori's (2012) interpretation of Kivy, and it is necessary to present Kivy's argument this way so as to motivate Bátori's response to DeBellis.

(iii) Law of Excluded Middle: either the lower levels referred to in music theoretic discourse are perceivable or they are imperceivable.

(iv) Dilemma: Explanations of musical works, should they resemble scientific explanations, are unlikely to refer to perceivable lower levels (due to (ii)); and explanations of *musical works* cannot refer to imperceivable microstructures (due to (i)).

(v) Conclusion: it is unlikely that there can explanations of musical works that resemble scientific explanations.

To be clear, nothing in this argument shows that music theory cannot produce explanations of musical works; it simply shows, given certain assumptions, that such a production is unlikely.

Nevertheless, DeBellis (1995) offers several example of what he takes to be musical explanations, and he means for his explanations to fit Kivy's micro-macro model:

> 'This follows Kivy's analogy of microstructural reduction, such as that of heat to the motion of molecules. On the present account, then, the presence of closure is identified with some complex structural condition in terms of scalestep properties and the like. The explanation, on this account, depends on an explication of closure, an account of what it consists in' (122-123).

Besides closure, DeBellis also discusses changes in emotional tone: "a change of emotional tone is often explained by a change in mode from minor to major or vice versa; appealing to change of mode means applying music theoretical terms in the explanation of surface properties of music" (Bátori 2012, 75).

As Bátori (2012) notes, DeBellis' case faces a significant difficulty:

> "the analogy between scalestep properties on the one hand and molecular structure on the other, for example, breaks down from the point of view of their availability to (bare) perception" (78).

This is to say, changes from major to minor are perceivable to trained auditors; consequently, such modulations do not resemble the "microstruc-

tures" found in micro-macro explanations in the sciences. If changes between the major and minor modes were not perceivable to trained auditors, then such properties would not count (in this discussion) among the properties borne by musical works (due to (i)). Thus, explanations appealing to such properties, even if they were bona fide scientific explanations, would not be explanations of *musical works.* To put it simply, mode modulations are either perceivable (in which case they are inappropriate candidates for the microstructure of a micro-macro explanation) or they are not (in which case they are inappropriate candidates for musical explanations): either way, the possibility of classifying DeBellis' examples as micro-macro explanations (*qua* (ii)) of music (*qua* (i)) has been precluded. Bátori puts the point succinctly:

> "It is not clear, therefore, why DeBellis holds that his examples and arguments establish the scientific explanatory status of music analysis, and why they would refute Kivy's position" (79)

To be clear, this is not simply an argument against DeBellis' particular examples; the argument leading to dilemma (iv) can be generalised to any proposed example. Any explanation from music theory will either refer to perceivable properties (in which case, due to (ii), it is unlikely to be a scientific explanation) or to imperceivable properties (in which case it cannot be about music *qua* (i)).

It should be evident, at this point, that Bátori is correct in concluding that the analogy breaks down between micro-macro explanations and purported music theoretic explanations. What I want to now question is the appropriateness of the analogy. What I suggest is that DeBellis' apparent failure is not due to music theory's lacking explanations; the failure is due to the fact that (ii) has led to a focus on the wrong sort of scientific explanation. Scientific explanations of a different variety, those found in biology and physical geology, resemble those of DeBellis. In the next section, I present two such explanations from the sciences.

3. Lessons From Biology and Geology

If all mechanistic scientific explanations appealed to an imperceivable microstructural lower level, then assumption (ii) and (ii.a) would, effectively,

do the same work. After all, if it really were the case that both (a) all scientific explanations of a specific type have a certain property, and (b) music theory is incapable of producing statements with that property, then this would count as evidence against the capacity of music theory to produce explanations of that type. Nevertheless, no such support is available for those who wish to endorse the effective equivalence of (ii) and (ii.a). On the contrary, many scientific mechanistic explanations are such that higher level phenomena are explained by appealing to *perceivable* lower level phenomena. Consequently there is no reason why one should assert that musical statements must resemble the micro-macro explanations found in the sciences if they are to resemble the mechanistic explanations found in the sciences. To show that scientific explanations often refer to a perceivable lower level, I offer mechanistic explanations from biology and physical geology.

Figure 1. The Woodhoopoe.

3.1. Biology

My first example is that of the woodhoopoe [Figure 1], an African bird with a complex social hierarchy, presented in Grimm and Railsback's (2005):

> The social groups live in territories where only the alpha couple reproduces. The subdominant birds, the "helpers," have two ways to achieve alpha status. Either they wait until they move up to the top of the group's social hierarchy, which may take years, or they undertake scouting forays beyond the borders of their territories to find free territories. Scouting forays are risky because predation, mainly due to raptors, is considerably higher while on a foray (5).

In this example, there is a higher level individual (a population of birds) with higher level properties (population size, density, geographical distribution, & etc.) composed of lower level individuals (individual birds) with lower level properties (risking being eaten by a raptor, having a specific social position, having a specific age, & etc.).

Grimm and Railsback's procedure is as follows: first they identify the bird-level properties, such as 'age' and 'social rank', of the birds. Second, they examine the distribution of birds that would result from each individual bird's attempting to maximise its chance of survival (given its bird-level properties). Third, they compare that distribution with actual distributions of populations of birds that can be found in Africa. They find a match between the population-level distribution predicted by a consideration of bird properties and the distribution found in nature, so they assert that the population-level properties may[7] be explained by the bird-level properties. Importantly, this would be a mechanistic explanation in the sense that we could refer to lower level bird properties when answering the question 'why is the population distributed in the way that it is'? The higher level population properties are consequences of the constituent birds and their properties.

[7] Obviously I have been vague here. Additionally, further work would be necessary to determine whether this putative explanation (when fully specified) is superior to other explanations.

Crucially, explanations of this sort are acceptable candidates for explanations of the phenomena in question. This is to say, nothing about the *form* of the explanation disqualifies it from being deemed a scientific explanation (and, indeed, Grimm and Railsback present it as the correct explanation for the observed phenomena). However, notice that woodhoopoes are quite perceivable (see figure 1); not only can they be seen, but they can be heard as well (Radford and Du Plessis 2004). Thus, this explanation is a mechanistic explanation, but not a micro-macro explanation.

3.2. Physical Geology

Mechanistic explanations that focus on perceivable lower level entities are not unique to biology: such explanations are found in physical geology as well. Imagine that I am pouring sand through a funnel above a plate. Assuming that I hold the funnel steadily, what will be observed is cone-shaped pile of sand. One physical quantity of the cone-shaped pile is its slope; for sand, this slope will not exceed 34°. In the terminology of physical geology, the *critical angle of repose* of the pile of sand is 34° (Glover 1998) [Figure 2].

Sand dunes are composed of sand, and, just as with the case of the woodhoopoes, we can explain the higher level sand dune property 'having a critical angle of repose of 34°' in terms of the lower level properties of sand. The critical angle of repose of the sand dune is largely[8] a function of the arctangent of the coefficient of static friction[9] of its constituents: $\tan\theta \approx \mu_s$, where θ is the angle of repose and μ_s is the coefficient of static friction (Lindeburg, 2010). There is nothing mysterious about this relationship; it is intuitive that particles that slide easily against each other will be difficult to place on top of each other into a cone-shaped heap with a large slope (imagine trying to form a cone-shaped heap by dropping smooth glass marbles onto each other). It is comparably easier to stack particles that do not slide easily against each other into such a heap.

[8] This function serves as a close approximation.

[9] Static friction is the force of friction between two objects that are not moving with respect to each other. The product of the normal force and the coefficient of static friction is the maximum amount of friction that can occur between two objects before the objects will move with respect to each other.

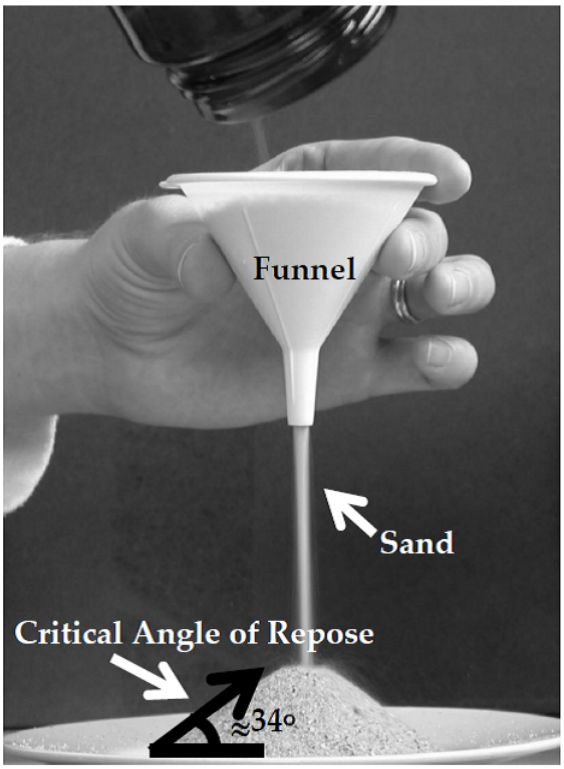

FIGURE 2. Sand is poured through a funnel onto a plate, resulting in a cone-shaped pile with a critical angle of repose of about 34°.

The sense in which we have a mechanistic explanation is the sense in which we can appeal to facts about lower level sand particles when answering the question 'why is the critical angle of repose of a sand dune what it is'? The answer is that the properties of the dune are a consequence of its constituent sand particles and their properties. The way that the sand particles interact with each other results in a sand dune with a particular angle of repose, and this is analogous to the way that the interacting parts of a machine result in the machine's behaviour. Since sand particles are perceivable, this is another example of a mechanistic scientific explanation that is not a micro-macro explanation.

4. Implications

Thus it simply is not the case that the lower level entities referenced in scientific explanations are always imperceivable microstructures. On the contrary, explanations of biological populations and geological sand dunes appeal to lower level entities that are perceivable. Consequently, the fact that changes from the major to the minor mode are perceivable does not disqualify such phenomena from playing the role of lower level entities in explanations. Rather than distinguishing such musical phenomena from the entities that populate the lower levels of scientific cases, perceptibility is quite common in scientific lower levels. Thus, while the musical statements of DeBellis may fail to resemble micro-macro explanations found in the sciences, they do not fail to resemble explanations found in biology and physical geology.

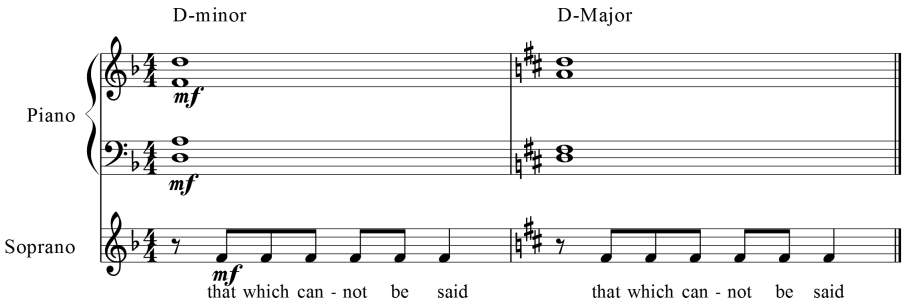

Figure 3. A change in mode.

DeBellis' examples resemble mechanistic scientific explanations, then, because they provide answers of a particular form to certain questions. For example, consider a short musical work for soprano and piano that lasts for two measures [Figure 3]. The first measure is in the key of D minor, while the second is in the key of D Major. Other than the change in mode, both measures are nearly identical; the tempo, dynamics (volume), and lyrics remain constant. Nevertheless, when this work is heard, there will very plausibly be a change in emotional tone between the first and second measure. When we ask the question 'why was there a change in emotional tone?' the answer is 'because of the change in mode'. The

emotional tone property (i.e., the property of having a changing emotional tone) is a consequence of the underlying mode property (i.e., the property of having a changing mode). In this way, DeBellis' example is analogous to the mechanistic explanations found in the sciences.

The problem, then, as I suggested, was the acceptance of (ii) rather than (ii.a) (or, rather, the failure to distinguish between (ii) and (ii.a). Let us see what happens when we replace (ii) with (ii.a) in the original argument:

(i) Assume: all properties of musical works are audible.

(ii.a) Assume: if music theory produces explanations of musical works that resemble scientific explanations, then these explanations are likely to be mechanistic explanations.

(iii) Law of Excluded Middle: either the lower levels referred to in music theoretic statements are perceivable or they are imperceivable.

(iv) No Dilemma: explanations of musical works are likely to refer to perceivable lower levels (due to (ii.a)).

(v) Conclusion: the explanations of musical works are likely to refer to a perceivable lower level; in fact, they do!

Two qualifications are worth noting. First of all, it is quite compatible with my position that much, or even most, of what is done in music theory would count as interpretation and not as explanation. I have argued, merely, that we can resist the argument inspired by Kivy that would conclude that DeBellis' music theoretical statements, as well as all other such statements, are unlikely to resemble scientific explanations. Secondly, the claim that music theory produces explanations analogous to scientific explanations is distinct from the claim that music theory is a scientific discipline, and this discussion has addressed the first claim, but not the second. A discussion that deals with the second claim will have to adopt a framework regarding scientific demarcation, and then use that framework to evaluate music theory. While I have not here been concerned with this issue of demarcation, the preceding remarks are not entirely irrelevant to it. For should one wish to argue that music theory is a science, one will,

quite plausibly, have to demonstrate that music theory can produce explanations that resemble those found in the sciences[10]. If my arguments have been successful, then I have shown that this aspect of such a project is not impossible.

5. Responses to Criticisms

In this final section, I will briefly respond to two criticisms raised against this discussion[11]. The first criticism challenges the appropriateness of the example of the woodhoopoe on the grounds that the explanation I cited resembles those found in the social sciences rather than the natural sciences. The second criticism challenges DeBellis' example on the grounds that it is neither analogous nor reducible to fundamental physical explanations. While I take both criticisms to be misguided, both are motivated by plausible premises.

5.1. Social Scientific Interpretation

One criticism of my discussion, offered by Bátori himself (personal communication, 2013), is that the example of the woodhoopoe comes from a scientific discipline that has more in common with the social sciences than the natural sciences. Since Kivy and DeBellis were interested in explanations from the natural sciences, it is simply inappropriate to cite a social scientific explanation; any analogies will, in effect, be irrelevant to the discussion at hand. This objection is motivated by several underlying premises, and it will helpful to draw these out. First of all, in Kivy's (1990) essay, Kivy explicitly contrasted interpretations with explanations; the question under consideration was whether music theory was in the business of producing explanations (analogous to those produced in the sciences) or interpretations. Consequently the only statements from the

[10] A Popper-inspired (1989) project, for example, would lead one to evaluate the falsifiability of particular theories and explanations proposed by music theorists.

[11] These criticisms are what I took to be the strongest versions of the criticisms offered by participants at the annual conferences of the European Society for Aesthetics and the Alabama Philosophical Society.

sciences worth comparing to statements from music theory are explanations; it is simply irrelevant whether music theoretic statements are analogous to scientific *interpretations*. Therefore, it is irrelevant if music theoretic explanations are analogous to statements from sciences concerned solely with interpretation.

One way to respond to Bátori's challenge is to deny the existence of any real distinction between explanations, descriptions, and interpretations. While I am not unsympathetic to this sort of response, I will avoid it here. My reason for avoiding it is that the discussion between Kivy, DeBellis, and Bátori depends upon our ability to make at least a rough distinction between explanations and interpretations; refusing such a distinctions would be tantamount to refusing to engage in the discussion on its own terms, and it is undesirable to adopt such an uncharitable stance. Regardless of reasons to deny the distinction between interpretations and explanations, however compelling they may be, I will assume that we can point to uncontroversial cases of interpretations and uncontroversial cases of explanations.

Uncontroversial examples of interpretations can be found in the social sciences. Consider, for example, Clifford Geertz's (1983) characterisation of anthropological description: "...descriptions of Berber, Jewish, or French culture must be cast in terms of the constructions we imagine Berbers, Jews, or Frenchmen to place upon what they live through, the formulas they use to define what happens to them.... They [the descriptions] must be cast in terms of the interpretations to which persons of a particular denomination subject their experience, because that is what they profess to be descriptions of; they are anthropological because it is, in fact, anthropologists who profess them" (221). What Geertz is characterising is a particular sort of endeavour; that of offering descriptions of experiences of the world, such that these descriptions track the way that persons in particular cultures interpret their own experiences.

Nevertheless, the existence of anthropology conducted in the style of Geertz does not mean that the social sciences never produce explanations. For many social scientists do not engage in projects that resemble those of Geertz. Psychologists who work within the Terror Management Theory research program, for example, explain certain behaviours based on the assumptions that people fear death and certain behaviours prevent

people from consciously experiencing that fear (Pyszczynski et al., 1999, 837). These are causal explanations, such that the fear of death (and the effects of certain behaviours) causes people to commit certain behaviours; in terms of 'why questions', we can say that the reason why these behaviours are committed is that people fear death and these behaviours protect them from that fear. All of this is to say that even if Bátori *could* argue that population biology is a social science (and it is not obvious that he could do so), this alone would not establish that all of the statements made by population biologists are interpretations. Since not all social sciences are engaged in interpretation, one would still need to look at individual statements from population biology and evaluate whether they more closely resemble the interpretations of Geertz or the explanations of the Terror Management Theorists.

When we examine explanations of the woodhoopoe, we do not find interpretations analogous to those of Geertz; we do not find an attempt to describe a cultural practice of birds in terms of how individual birds interpret their experience of that practice. What we find, rather, is a prediction about how a bird population will be distributed based on assumptions about the individual properties of birds. In other words, we find statements that make predictions and answer the 'why question' "why are the properties of the population what they are"? Such statements certainly looks like explanations. If we do wish to argue that the explanation of the woodhoopoe population is analogous to those from the social sciences, we will find a much stronger analogy with social scientific *explanations* (e.g., the case of psychologists using Terror Management Theory) than with the social scientific *interpretations* (e.g., the case of Geertz).

5.2. Fundamental Physical Explanations

There are certain reductionist pictures of scientific explanation in which all explanations that refer to perceivable phenomena are expected to be ultimately reducible to the explanations of fundamental physics that refer to imperceivable entities. While I may have shown that music theory can produce explanations analogous to those found in physical geology, the properties of the latter are explained in terms of the properties of the molecules that constitute the sand particles, the properties of which are

explained in terms of the properties of atoms and ultimately in terms of fundamental physical laws governing the behaviour of imperceivable entities. This motivates two problems that have been raised against my analogy between music theoretic explanations and scientific mechanistic explanations. The first problem from fundamental explanations is that music theoretic explanations are not analogous to those of fundamental physics. The second problem is that music theoretic explanations are not likely to be reducible to those of fundamental physics, and thus are dissimilar from scientific explanations (on the assumption that scientific explanations are reducible).

Just as it would have been possible to respond to the previous criticism by denying the distinction between explanations and interpretations, it is be possible to respond to the problems from fundamental explanations by denying the distinction between the perceivable and the imperceivable. Nevertheless, such a denial would amount to the adoption of an uncharitable stance towards the debate (insofar as Kivy, DeBellis, and Bátori are committed to our ability to at least roughly distinguish between the perceivable and the imperceivable). As with the case of explanations and interpretations, I will simply assume that we can identify uncontroversial perceivable entities (e.g., elephants and tables) and uncontroversial imperceivable entities (e.g., electrons and quarks).

My response to the first problem from fundamental explanations is to simply accept that music theoretic explanations are not analogous to fundamental physical explanations, but to deny that this is in any way problematic. It seems likely that our fundamental physical theories will continue to refer to imperceivable entities, and music theory cannot, in this discussion, do so (assuming [i.]). Nevertheless, most actual scientific explanations are not fundamental explanations. Thus, it would seem that this first problem accuses music theory of producing explanations that resemble those produced by physical geology rather than those produced by fundamental physics. But this accusation is merely a restatement of my thesis, and poses no challenge to anything that I have claimed. The only way that such an accusation could pose a challenge would be if it were accompanied by the claim that an explanation is a scientific explanation just in case it is a fundamental physical explanation. While this would preclude my analogy, it would do so at the cost of denying the scientific status of

most of what we take to be science (not just explanations from the social sciences but most of what is found in physics, chemistry, and biology). I take this to be a reductio against arguments employing this additional claim.

The second problem from fundamental explanations presents a more serious challenge to my claim. If all scientific explanations are reducible to fundamental explanations, but music theoretic explanations are not reducible to fundamental explanations, then the analogy between music theoretic explanations and scientific explanations breaks down. Against this challenge, I offer the following observation: while I will grant that music theoretic explanations are unlikely to eventually be reduced to the explanations of fundamental physics, it is not obvious that such a reduction can be accomplished for many sciences. For much of the 20th century, philosophers were hopeful that Nagelian semantic reduction could be carried out, but there is much less certainty today (Cat 2013). Those who deny the analogy between music theoretic explanations and scientific explanations on the grounds that the latter are reducible to the explanations of fundamental physics accept a burden to demonstrate that such a reduction between scientific explanations can actually be carried out. It is by no means evident that this can be demonstrated.

There is, of course, an uncontroversial *ontological* reductionist picture in which the entities that populate our scientific theories reduce to those of fundamental physics; the entities of all of our scientific theories are, quite plausibly, made out of physical stuff. This ontological reductionist picture need not involve claims of type physicalism or supervenience, but merely token physicalism (Stoljar 2009). On a reductionist picture of this sort, music theoretic entities are reducible to the entities of fundamental physics; musical works, considered as sounds that are perceived, are made of physical stuff, and trained auditors who perceive the works are also made of physical stuff. Thus, there is a sense of reduction in which music theoretic entities are reducible to those of fundamental physics, and there is another sense of reduction in which music theoretic explanations are plausibly not reducible to fundamental physical explanations. Neither sense of reduction presents a problem, however; for neither the ontological reducibility nor the lack of Nagelian semantic reducibility of music theory threatens the analogy between explanations from music theory and

explanations from the sciences.

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