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EXPLAINING MUSICAL IMAGINATION

(*Draft version, comments welcome!*)

Contemporary psychology of music approaches musical imagination in terms of either cognitive system's specific (voluntary, involuntary or anticipatory) behavior or capacity. Musical imagination-as-behaviour allows us, for example, to consciously experience the phenomenon of "musical earworms" (e.g., Beaman & Williams, 2010). However, we do not have to be conscious of the workings of musical imagination-as-capacity (e.g., to form mental representations of music). It would be - however - quite reasonable to assume that this capacity is the result of the existence and activities between more basic sub-capacities organized together in such a way that they result in experiential manifestations of musical imagination. The study of imagination-as-capacity has, in fact, a long-standing philosophical tradition (Schlutz, 2009). Various philosophers proposed that a distinct role of imagination-as-capacity in cognitive processing is to organize, identify or interpret sensory information in order to represent and understand environment. In this sense, imagination is a *constructive* process that enables the creation and continuous update of the subjective experiences, providing the basis for interpretation of upcoming information.[1] Such view on imagination is also received in cognitive musicology. For instance, Hargreaves (2012) argues that musical imagination is the cognitive basis of musical perception and production. The big question, however, is how (on what basis) does musical imagination work? Currently there seems to be no agreement on how to integrate different theoretical and empirical data within an unified and *complete* explanation of the phenomenon in question. One the one hand, for example, we can assume that musical imagination relies on some specific kind of information-processing. On the other, however, in order to specify what kinds of

[1] It was Aristotle, who provided as first systematic philosophical assessment of what Greeks called phantasia as an independent capacity in the epistemological process. Aristotle understood it as a capacity to produce mental images. Simultaneously, phantasia was responsible for transformation of aisthesis data and making them available in the form of representations (phantasmata) to dianoia for further processing.

information[2] are processed on various levels, we need to have a clear idea of the activities and (mental) entities that underlie their processing in a first place. The big challenge is thus to answer the question of how to connect those various levels of analysis without reducing the importance of any of them. I hypothesize that the most useful conceptual tool to capture those particular issues is the mechanistic model of explanation. To put it in yet another way: the capacity of musical imagination as a explanandum phenomenon should be primarily specified in terms of mechanisms (understood as a set of entities and activities organized in such a way that exhibits a phenomenon; Craver, 2007; Bechtel, 2008). To do so, we need to account for the *mechanism schema* of musical imagination. Such schema is a form of abstract description of mechanism that can be filled with description of know component parts and activities. It thus identifies what is necessary and relevant for the occurrence of a particular phenomenon in question. The complete explanation of musical imagination thus requires an idea how to fit partial (psychological and neuroscientific) data that we have about musical imagination into its bigger picture of how it works. This picture must be hierarchically and causally structured. Only after specifying that one can link it with the recent proposals on how this phenomenon *manifests* itself.

Accordingly, the descriptive aim of the following paper is to identify (at least some) multileveled mechanisms that underlie the capacity of musical imagination. The normative aim, discussed in the remainder of this paper, is to illustrate the way in which future complete explanations of musical capacities (like that of musical imagination) are to be achieved only if multileveled mechanistic explanations are consistent and equipped with explanatory pluralism (Dale et al., 2009; Miłkowski 2013) in cognitive science. We currently have incomplete and partial explanations of musical imagination. For instance, research in psychology of music is often rather carelessly referring to neuroscientific data, by suggesting that the latter (in some unspecified way) underlies the workings of cognitive capacity (e.g., Aganti et al., 2013; Boso et al., 2006). The received view here is that psychology is concerned with functional analyses of given phenomena (Cummins, 2000), while neuroscientific explanations are focused on identifying neural mechanisms. Accordingly, functional analyses and mechanistic neuroscientific explanations remain distinct and autonomous from each other (Craver, 2007). In such case, it is

[2] The causally specified information-processing of these mechanisms, however, does not have to be necessary limited by the boundaries of human skulls (Clark & Chalmers, 1998) or refer to modular conceptions of the musical mind (Peretz & Coltheart, 2003; Matyja & Schiavio, 2012). Nor does it have to be leading to theoretical reductionism, either brain-centered (Pearce & Rohrmeier, 2012) or embodied (Núñez, 2011).

unclear for instance how neuroscientists' focus on the activations of particular neural pathways during imagined and actual music perception (e.g., Zatorre & Halpern, 1999;; D'Ausilio et al., 2006; Brown & Palmer, 2012, 2013; Pecenka et al., 2013), including motor cortices (Brodsky et al., 2003; Lotze, 2013) relates to psychological or cultural theories concerning the phenomenon of musical imagination. In cognitive science, one proposition to overcome this particular obstacle is to attempt to reduce and thus replace one level of description (e.g., psychological) with lower-level one (neuroscientific). Such reductionism, I believe, does not lead to scientific progress, nor expands our understanding of the phenomena in question. In that sense, although we have some idea about the ways in which musical imagination manifests itself, and the theories interpreting these data, we still have little idea about what musical imagination exactly *is*. The first step towards the answer to this philosophically interesting question is to specify what is relevant to the explanation of this phenomenon (Craver, 2007; Bechtel, 2008; Illari & Williamson, 2012). What is more, mechanistic account importantly captures the interrelations between different levels of explanation (offered by various disciplines) and thus currently serves as a best explanatory tool available.

The plan for this paper is as follows. Firstly, I briefly introduce some (1) requirements for mechanistic explanation of musical imagination. Secondly, I turn to (2) mechanistic levels of description of musical imagination. I then illustrate the idea of multilevel mechanistic explanation with a case study (3) of the lowest (bottom/neural) level of musical imagination. I conclude with a (4) plea for explanatory pluralism in cognitive science, as compatible with mechanistic explanation.

1. Towards a mechanistic explanation of musical imagination.

Mechanistic explanation typically proceeds in three steps. Firstly, one needs to identify the phenomenon to be explained (explanandum phenomenon). Secondly, the research focus is on the decomposition of the phenomenon into the entities and activities that are *relevant* to the explanation of this phenomenon and. Thirdly, mechanistic explanation gives an account organization of entities and activities by which they produce the phenomenon (Illari & Williamson, 2012). Mechanistic explanation requires three further clarifications (namely: ontic, descriptive and epistemic adequacy (Machamer et al., 2000). As for the ontic account, mechanists see the functions (of given mechanism) in terms of activities by virtue of which entities contribute to the overall performance of a mechanism. Accordingly, entities and activities are ontological interdependent correlatives. The ontologically adequate description of a given mechanisms includes both entities contributing to the occurrence of a given phenomenon, as well as the activities that allow for this occurrence. For the mechanism to be adequately described, it needs to account for the causal relations between different levels (from the lowest – see the case study below – to the highest) of explanation. As for the epistemic adequacy, mechanistic explanations show *how possibly*, *how plausibly* or *how actually* things work. To illustrate how mechanistic explanation works, consider how scientists build models. They usually start with a given hypothesis of something works. On the basis of this hypothesis, they build a model. By a "model" I hereafter understand not an actually functioning system, but rather an account of the components and operations that are necessary for the occurrence of studied phenomenon – they build mechanism sketches (Piccinni & Craver, 2011). Mechanism sketch thus enables one to indicate gaps that need to be filled in order to provide a full mechanism schema. As such, it can be instantiated as prediction, explanation or experimental design. If novel data comes in place, the sketch may be revised or abandoned, presenting a rather liberal research practice. Mechanisms sketches, once confirmed, may in turn lead to the provision of a mechanism schema, being a truncated abstract description of a mechanism that can be filled with accounts on known component parts and activities. Given the level of abstraction, why then should empirically minded researchers be interested? One reason for the importance of recent contentions that different scientific disciplines share many methodological concerns, including causal explanations, causal inferences and modeling. Secondly, deliberations on explanatory mechanisms are, as it were, rather far from hot-tea and armchair philosophical discussions. Quite notably, current theoretical efforts are put into practice (Eliasmith, 2014). Mechanism, moreover, requires its explanatory models to be fairly realistic and complete, since their aim is to serve as a basis for possible empirical modeling. Mechanistic explanation is thus of great importance to understand what is common among scientific disciplines (Illari & Williamson, 2010).

2. Levels of mechanistic explanation of musical imagination.

One may distinguish three levels of analysis and explanation in research on musical imagination: neural/*bottom*, the embodied/*isolated* and situated/*contextual* level. The contextual level seems to be, so far, the one less accounted for. The first, bottom level - discussed below - is perhaps the broadest one – it can be further divided into molecular, single neuron and neural patterns levels. Explanation here draws upon neurochemical (e.g., Chanda & Levitin, 2013) and neurobiological (Gruhn & Rauscher, 2002; Boso et al., 2006; Homann, 2010; Aganti et al., 2013) data concerning imagination. From the single-neuron and neural patterns perspectives, the fMRI studies concern, for instance, differences and similarities during imaginary and actual perception (Zatorre & Halpern, 1993; Zatorre et al., 1996; D'Ausilio et al., 2006; Brown & Palmer, 2012, 2013; Pecenka et al., 2013). Of importance to the second, isolated level (discussed below), a lot of data is focused upon the motor cortices manifestations of musical imagination (e.g., during the silent reading musical notes and performed rehearsal tasks practices in skilled musicians (e.g., Brodsky & Henik, 2003; Lotze, 2013). However, as we will see below, researchers either avoid drawing conclusions concerning motor-layer of musical imagination mechanism. The main heuristics used in such studies are localization and decomposition (Bechtel & Richardson, 1993). The localization here, quite simply, refers to the identification of the component parts (e.g., brain areas activated during given manifestation of musical imagination). This scientific strategy is however often fallible (Weisberg, 2008; Carp, 2012). From a mechanistic explanation perspective, the treatment of localization may be either concerned with functional or structural investigation of these components. Importantly, researchers at not required to commit to the modularity of musical mind, although it often currently does (Matyja & Schiavio, 2013 for discussions). Note, however, that operations that the identified parts perform are different for the phenomena manifested as an activity of the whole (embodied) mechanism underlying musical imagination. The parts, individually, do not realize the workings of mechanism (Bechtel, 2009). Musical imagination thus occurs due to performance of all of its underlying mechanisms.

The second, embodied/*isolated* level however is, at least partially, concerned with drawing broader and often wild conclusions for the empirical data available. As already mentioned above, empirical researchers often refer to the observations of the workings of motor cortices. For instance, Kind (2013) devoted a lot of her attention to examine so-called "simulationist account of imagination" (e.g., Goldman, 2006), which is often ascribed to human Mirror Neuron System (MNS; Overy & Molnar Szakacs, 2006; Matyja & Schiavio, 2013; Schiavio et al., 2014). The links between the faculty of imagination and emotional processing (Van Leeuwen, 2011, 2014; Juslin & Västfjäll, 2008) however remain yet not sufficiently scrutinized. The main explanatory heuristic used in these analyses is Inference to the Best Explanation (IBE, for discussions see: Okasha, 2000). The idea behind IBE is that given hypothesis H that, for instance, J causes R (e.g., my observation of The Black Crowes guitarist Rich Robinson performing live *causes* my musical empathy subsumed by the activation of my MNS) should be inferred from the available evidence M (e.g., the laboratory experimental data concerning the activation of MNS during the observation of musicians performing; see: Badino et al., 2013). However, the fact that MNS research is currently under advanced critique (Kilner et al., 2003; Hickok, 2014) suggests that one should be, at least, cautious about them (Shapiro, 2011:111; for a mechanistic explanation of MNS, see: Herschbach, 2011). From the mechanistic perspective, the idea behind the isolated level is to examine how given mechanism (organism) works as itself, isolated from its environment and without implicating lower-level structures and functions. It is thus consistent with laboratory studies, that include, for instance, stimulation and recording recording spike trains from an isolated neuron or studying a human subject's responses to computer-generated stimuli are examples of this strategy (Wright & Bechtel, 2007: 62).

Finally, embedded/*contextual* level. As argued by numerous researchers (e.g., Matyja & Schiavio, 2013; Maes et al., 2014) working in the embodied (music) cognition paradigm, our musical interactions are not only subjects to bodily-environmental interactions, but are also situated within the historical and cultural constraints (e.g., Clarke, 2005; Leman, 2008). In his recent paper, although pushing for the need of computational modeling, Castelfranchi (2014) makes a case on incorporating these factors into our multileveled explanations. These intuitions are (at least) consistent with mechanistic explanations. For instance Bechtel (2009) underlines the high risk of underestimating the *significance* of environmental structures, therefore pointing to a critical importance of experimentation in organisms' natural environments, including the tool use. The ways in which musical imagination (e.g., Jorgensen, 2014 for relations between education and musical imagination) is situated within the broader environmental context are debated by philosophers of music (e.g. Cook, 1990). There is a recent interest in phenomenological accounts (Jansen, 2005; 2009; 2013) to imagination suggesting the need of incorporating those aspects into (embodied) cognitive science.

The future of this the research on the embedded level of musical imagination is thus in our hands. However, any deliberations on this particular level of should be done with careful identification and examination of the bottom and isolated levels. It is of crucial importance to draw accurate causal links between all of those levels. Otherwise, we are back to the *one church, many tribes* type of disunification of the research.

3. Case study: bottom level of musical imagination.

All of the abovementioned levels are further diversified. Take the bottom/neural level for instance. I suggested above that, drawing upon current empirical data, one may distinguish at least three contributing sub-levels, including: single neuron level, neural patterns level as well as functional level. The key question, often missing in those data, is what (if anything) links those levels? Cognitive neuroscience of music often omits this troublesome question. One way would be to try to reduce those data to the lowest level explanation available (i.e., say, that the key to understand the information-processing on the neural level lies in understanding the neurochemical or electrical processes occurring between neurons). This however, simply put, leaves us with following question; how does it relate to our understanding of the higher-levels? This reflects interesting debates on the relations (if any) between neuroscientific evidence and psychological theories, and the challenge of how to integrate them (Piccinini & Craver, 2011). I the following section I aim to underline the inter-level gaps in current neuroscientific research.

Consider the neurobiological mechanism of long-term potentiation (LPT), recently suggested to occur at all synapses in the mammalian brains (Malenka & Bear, 2004). This mechanisms is a means of strengthening synapses (Hebb, 1949), wherein it is assumed that the changing of strength of synapses between neurons in the *hippocampus* occurs during the formation of new memories. Craver & Darden (2001: 119), summarizing the workings of the mechanism at molecular levels, point to the relations between hierarchical *levels* of the workings of LPT mechanisms. At this point they propose two ways of integrating LPT as a component of a broader mechanism. The first strategy involves “looking up” a level and denoting a functional role for this particular item of analysis within a *functional* role of the higher-level mechanism that one initially aims to explain. The second means of integrating LTP mechanism within the higher-level mechanism involves showing that the activities (or properties) of a mechanism may be explicated in terms of lower-level mechanisms (Craver, 2001). Both looking up and looking down are crucial for contextualizing integrating multilevel mechanisms, as well as identifying what current neuroscientific explanations lack. However, as Craver & Darden (2001) illustrate this fact by discussing the *componency* constraints on given mechanism description (being the questions of what entities should be counted in and which of their activities should we be limited to describing, while we aim for an explanation). These constraints include metabolic requirements, computational resources, temperature limits or rates of protein synthesis along with other facts concerning carbon-based life on earth.

Another mechanistic constraint mentioned by Craver & Darden (2001) is the *spatiality constraint*, concerning - quite obviously - the spatial organization of a given mechanism. Although we currently possess research techniques (Stevenson & Kording, 2011) enabling us to measure the electrophysiological responses of a single neuron (e.g., using microelectrode system), most of research in cognitive neuroscience of music seems to tackle the activations of neural patterns in the brain (e.g., Meister et al., 2004; Bunzeck et al., 2005; Addis & Schacter, 2011; Vlek et al., 2011; Mullally & Maguire, 2013; Brown & Palmer, 2013). However, lots of fMRI studies lack valuable account of *how* the neurons within the activated regions of the brain work with each other. Neurobiologists, for instance, refer “compartmentalization” as the process of individuating a particular stage of the neuron cells’ work and the activities capable of linking them. Finally, the *temporal* constraints including the rate, order, duration and the frequency of the activities in which the components of a mechanism engage. Accordingly, is not enough to say that a given mechanism realizes some phenomenon, it is important to answer on what basis does it happen.

In psychology of music, the hippocampus is seen as a place for relating novel musical pieces to the previously heard ones. Hippocampus is also assumed to be responsible for the detection of temporal novelties in the auditory domain in a (Herdener et al., 2010), as well as differentiating on this basis between various styles of music and auditory motifs (e.g., Burunat et al., 2014). However, a complete explanation of its workings requires tracking (and describing) its activity with respect to componency, spatiality and temporal constraints. Yet, how can we integrate different levels of mechanistic description into a unified view of musical imagination?

4. Towards the explanatory pluralism in cognitive science of music.

Cognitive science is defined by its interdisciplinarity. Nevertheless, it is not obvious how to integrate its particular achievements into a sort of grand unified theory (for recent discussions see: Kiverstein & Clark, 2009; Shapiro, 2011; Pezzullo et al., 2011; Boccignone & Cordeschi, 2012; Castelfranchi, 2013; Soliman et al., 2013). Accordingly, although the bonding powers of musical interactions are often embraced (e.g., DeNora, 2004) we currently seem to lack clear ideas on how to unify and integrate the achievements of particular research subdisciplines scrutinizing the wonders of music itself. The latter disunification may be caused by the lack of consensus on how to define what music and musical objects in a first place (Schiavio, 2012). This, in turn, cashes out recent proposals to integrate different levels of analyses in cognitive science on the basis of shared understandings of explanatory concepts (e.g., Estany & Martinez, 2014). Recall, for instance, recent debates on what the concept of musical affordances may or may not denote (Menin & Schiavio, 2012; Windsor & de Bézenac, 2012). Note that particular disciplines of research draw upon different levels of analyses (e.g., neural, embodied, and situated) while analyzing the same or similar music-related phenomena. Theoretical disunification thus presents us with a danger of unnecessary duplication of research efforts, while reaching to conclusions that appear interdisciplinary incompatible. Another danger for cognitive science (of music) is connected with unnecessary greedy (Dennett, 1995) theoretical reductionism, wherein different theories either excluded or take effort to gain primacy. However, no scientific theory (restricted to a single level of explanation or particular discipline; be that brain, body or culture-related ones) can give a full account on the experiential richness of our musical interactions. Music just does not work in that way on us. Neither does musical imagination. The key thus lies in discovering its underlying mechanisms and identifying the plethora of connections between them.

5. Conclusions.

One of the important factors of mechanistic explanation is that it is open for changes (for instance due to new empirical data) up to the point, where one mechanistic model may be abandoned for another more detailed one. However, even the provisional mechanistic model (like in the case study sketch discussed in this paper) of a given phenomena serves the purpose of underlining the gaps in our knowledge. In this short paper, I have suggested that researchers interested in explaining musical imagination should pay attention to the possible links between different levels of analysis, rather than focusing on providing solely partial evidence. In fact, it was suggested, any complete explanation of mechanistic imagination should proceed in lines of non-reductive explanatory pluralism. Accordingly, the big challenge is to show how we can unify the current state of knowledge, rather than seek "one theory to rule them all" in a reductivist manner. Multileveled mechanistic explanations serve as valuable conceptual tool for these challenge, as long as we remember that, also in scientific explanatory models, *united we stand, divided we fall.*

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