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Experience as cognition: musical sense-making and the 'in-time/outside-of-time' dichotomy

ABSTRACT: Musical sense-making relies on two distinctive strategies: tracking the moment-to-moment history of the actual unfolding and recollecting actual and previous sounding events in a kind of synoptic overview. Both positions are not opposed but complement each other. The aim of this contribution, therefore, is to provide a comprehensive framework that provides both conceptual and operational tools for coping with the sounds. Five major possibilities are proposed in this regard: (i) the concepts of perspective and resolution, which refer to the distance the listener takes with respect to the sounding music and the fine-grainedness of his/her discriminative abilities; (ii) the continuous/discrete dichotomy which conceives of the music as one continuous flow as against a division in separate and distinct elements; (iii) the in time/outside-of-time distinction, with the former proceeding in real time and the latter proceeding outside of the time of unfolding; (iv) the deictic approach to musical sense-making, which conceives of an act of mental pointing to the music, and (v) the levels of processing, which span a continuum between primitive sensory reactivity to actual sounding stimuli and high-level symbolic processing.

KEYWORDS: experience, sense-making, coping behaviour, continuous-discrete, in-time/outside of time, deixis and mental pointing, real-time listening

Introduction

Music is a temporal and sounding art. Musicology as a discipline, however, has a long tradition of structural or goal-state analysis (Laske, 1977) with the celebration of the score as its major analytical tool and with a strong adherence to traditional positivist thinking in musicology (see Kerman, 1980, 1985 for a critical stance). This analytical approach has been fruitful to some extent. Yet it has left somewhat unexplained the lived experience of music in a real-time listening situation. Music, in fact, cannot be sufficiently explained in a detached and disembodied way. What is needed also is an approach to musical understanding that revolves around the conception of 'music as heard' and 'music as apprehended', as stressed already by some phenomenological approaches in the 1980s (Lochhead, 1986; Clifton, 1983). Music, in this view, is something that has existential structure and meaning in the sense that our involvement with music is experienced rather than being merely reasoned and interpreted (Reybrouck, 2014, 2017a, 2017b). Or put differently, our experience is *drastic* rather than *gnostic,* to use Jankélévitch's terms (Jankélévitch, 2003; see also Abbate, 2004). Such an experiential approach is not without consequences as it questions to some extent the undisputed status of the score, the role of many theoretical notions about music and the analytical methods to study the music as a sounding phenomenon. What is argued for, however, is not a renouncement of traditional methods of analysis but a broadening of their scope with the aim to go beyond a disembodied cognitivist approach for coping with sounds. As such, there is need of an expanded conception of musical sense-making that holds a dynamic tension between sensory experience and cognitive economy. Music, in that view, is not to be considered as a static structure that can be conceptualized outside of the time of actual unfolding, but should be characterized by a dynamic unfolding in real time. Hence the metaphor of the *river analogy* in which the sounding music is equated with a mountain river that flows, wandering back and forth across the landscape. Sometimes it simply goes downstream, at other times it branches off, following a trajectory that twists and turns, with exciting parts as waterfalls and rapids, and dull slow parts without any challenge. Listeners, in this analogy, can be compared to persons who are seated in a rubber raft to navigate a mountain river. They do not choose the direction they go in, as the river does it. But it is possible to make a choice by paddling and steering the raft towards a desired course, depending on the nature of the current, the rapids and the strength of the rafter. The analogy is fruitful and reveals at least two major points: the conception of music as a temporal and sounding flux, and the way how listeners cope with the sounds. It stresses the dynamic and constructivist approach to musical sense-making, not in a disembodied way but as a moment-by-moment interaction with the music as it unfolds over time.

Terminological preliminaries

In order to smooth the transition from a disembodied and detached description of music to understanding the lived musical experience, there is need of an operational approach that provides a descriptive and explanatory terminology together with a theoretical framework and empirical findings to validate its claims. There are four major steps which may be helpful here: (i) the introduction of the concept of music user, (ii) the process of dealing with music, (iii) conceiving of this process in terms of coping behavior and interactions with the sounds, and (iv) going beyond a rather narrow concept of music analysis.

The concept of *music user* is a generic term that includes all agents who deal with music in some way or another, both at the level of perception, action and mental processing of the sounds (Laske, 1977; Reybrouck, 2005). By analogy with the concept of language user, which entails the use of language both at a productive-generative (speaking, writing, ...) and a receptive-acceptive level (listening, reading, ...), it is an umbrella terms that embraces listeners, performers, composers, improvisors, conductors, music theorists and others.

The counterpart of this concept is the process of *dealing with music*, which, as a generic term, embraces the activities of all conceivable music users. There is, however, an operational description of this open-ended process by describing it in ecological terms as 'coping behavior' and 'interactions with the sounds' (Reybrouck, 2012, 2015a). The ecological approach goes back to Haeckel's definition of ecology as the science of the relations between an organism and its environment and the way it interacts with this environment (Haeckel, 1988 [1866], p. 286). Crucial in this approach is the reciprocity of organism and environment, as mapped out in depth by Gibson (1966, 1979, 1982) who claimed that the way observers make sense of the external perceptual flux is not gratuitous but ecologically constrained. Observers, in this view, do not rely merely on their senses, which function solely to arouse sensations, but they fall back on perceptual systems to pick up information in the environment which is already structured and ordered. Hence the major role of key concepts such as 'attunement', 'reciprocity' and 'resonance' with the environment. They make it possible to discriminate, to recognize and to identify things and events in a rather direct way by developing a selective attitude towards the environment and to readjust following upon selection.

It is not difficult to translate this to the realm of music and to conceive of the music user as an organism and of music as a sounding environment. Such an approach has the advantage of the breadth of scope – it is not constrained by canonical and normative descriptions of music – by conceiving of music as part of the broader sonic world or sonic universe (Cogan, 1984; Cogan & Escot, 1976; Reybrouck, 1998). As such, it describes those mechanisms that are at our disposal for coping with sounds in general (Reybrouck, 2015a). Music users, in this view, interact with their sonic environment, and to the extent that this environment can be challenging, both in an advantageous or threatening manner, it is possible to conceive of these interactions as *coping behavior*. Coping skills, further, are to be considered as combining 'coping style' and 'coping strategies'. The former is a mixture of attributional style (the way how stress is perceived, the locus of control and the optimistic or pessimistic outlook of finding a solution) and personality characteristics (risk tolerance, sense of self-efficacy and introversion or extraversion); the latter reflect the available repertoire of responses to stressful situations which can be used in a successful way (Sahler & Carr, 2009). Coping responses are most typically brought to bear when people are confronting stress and have been defined as 'constantly changing cognitive and behavioral efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the resources of the person.' (Lazarus & Folkman, 1984, p. 141). They involve those behaviors that are helpful in maintaining the needed adaptations to prevent, avoid or control the problems and cognitive responses that are needed to deal with emotional distress and provide the ability to survive in an environment and to steer clear of external perturbations. Coping responses, further, can be mild or demanding, but as a rule, they go beyond a gratuitous and neutral estimation and valuation of the environment. The latter, then, is to be considered as a source of stimuli and affordances that may invite an observer to deal with them both at a physical or epistemic level of interaction. Translated to music, this means that music should be considered as an environment that triggers music users to adapt themselves to the solicitations of a subset of the sonic world. It is arguable, in this view, to conceive of a broader conception of *music analysis* as a way to investigate the sonorous flux by exploring its constituent parts as well as the functions and affordances they offer to the music user. Such an approach should be broader than the traditional concept of music analysis, by relying on a generic approach that goes beyond the descriptive vocabulary that is commonly used to describe the common practice music of the canonical repertoire of Western art music. A valuable approach to music analysis, therefore, should embrace both the music as a structure as well as the mental processes of the analyzer, which means that it should include both action verbs that describe the interactions with the sounds as well as substantives and adjectives that take a more distanced stance towards the sounding structure. The concept of 'analysis' seems to have a primary role in this context. Stemming from the Greek word ἀνατέμνω, which means literally 'to cut up', it refers to the possibility to examine in detail the constitution or structure of something by 'dissolving,' 'dissecting,' or 'distilling' in order to put apart the ingredients of a larger structure. This can be done either at a macroscopic or microscopic scale, somewhat analogous to description of a visual object with the naked eye or by means of a microscope. Translated to the domain of music, this should mean that the music user can direct the focus of attention either to discrete particulars or to a more synoptic overview. Traditional concepts of musical description, such as note, motif, phrase, period, section, movement and musical work, show a gradual transition from a narrow focus on individual and discrete elements to more encompassing larger structures. The most common used terms to describe musical forms, such as sonata form, rondo, ABA, etc., moreover, hold a rather broad perspective and should be considered as macroscopic forms. Minute analysis of a single sound or even a subpart of a sound, as done, e.g., by spectrographic analysis, on the other hand, should be considered as microscopic analyses. They resolve the unitary character of a single sound event into many constitutive elements that are not commonly picked up by the naked ear. Hence the major role of the concept of 'resolution' as the number of elements that are used to display something. The concept is used commonly in the computer and media industry to refer to the number of picture elements that can be displayed by a screen (e.g. pixels, dpi or dots per inch, ...), but it is possible to apply it also to the field of music, both in terms of audio reproduction (high-resolution versus low-resolution sample rate) or listening strategies. Listening to music with high resolution should then mean that the music user has a high rate of attentional focal points; listening with low resolution should mean that he/she groups together several minute particulars to greater and more encompassing units (see Reybrouck, 2016a). An example is depicted in Figure 1, which shows the transition from a highly compressed (upper pane) to a more detailed visual waveform representation (middle pane) to a microscopic high-resolution representation (lower pane) of a smaller excerpt of the same music.

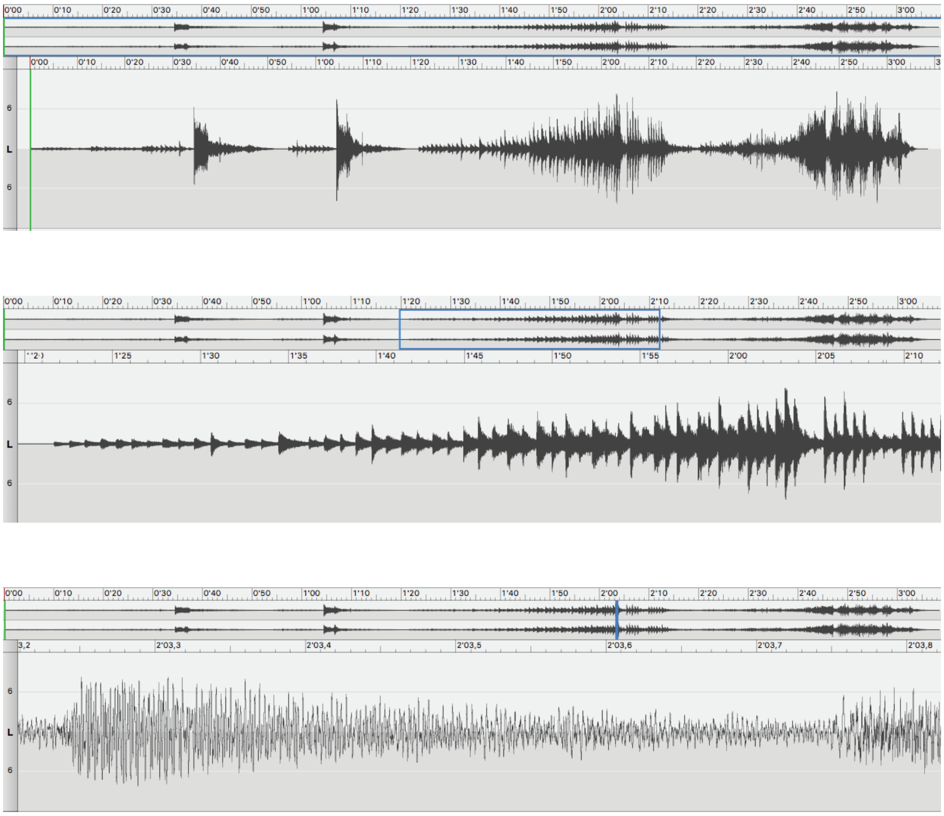

Figure 1. Example of different levels of resolution. The example depicts the first three minutes of the first movement of Bartók's Sonata for 2 Pianos and Percussion (Assai Lento – Allegro Molto). The upper pane shows a waveform representation of the whole three minutes excerpt, the middle pane zooms in to depict only one minute with much more temporal resolution, and the lower pane zooms in still further to show the high-resolution representation of only 1 second of the music.

It is thus possible to decompose a larger structure into smaller and constitutive elements. This holds not only for the dissection of physical objects but also for mental structures or representations which can be dissolved in more primitive constituents. The concept of analysis, however, is only one of the cognitive operations we can perform on the content of consciousness. It reminds us of the conception of Leibniz in his *Dissertatio de Arte Combinatoria,* in which he argued for the dissection of a larger whole in smaller parts and on which arithmetic and algebraic operations could be performed (Leibniz, 1974). His main contribution was the introduction of an algebraic model of thinking which states that through analysis we can find the prime factors of human thinking in order to conclude synthetically on new possibilities. Such an *algebra of thoughts* uses essentially the basic operations of analyzing and combining, somewhat analogous to Aristotle's distinction between *lytic* and *thetic operations*, embracing both the operations of segmenting and grouping. Both approaches, further, are not opposed to each other but are complementary to some extent. It is possible, in fact, to navigate between a focal and a more encompassing view, depending on the perspective taken, with a distinction between broad-band types of representations as against moment-to-moment overviews (Godøy, 1997). Much depends here on the attentional strategies of the music user, which are dependent both on his/her dispositional constitution (e.g., personality traits) and his/her individual learning history as well as on the intrinsic characteristics of the music. Music users, as a rule, do not listen in an unmotivated way, but rely on mechanisms of sense-making that reflect their personal engagement with the sonic world.

Real-time listening and the epistemological approach

Dealing with music in a real-time listening situation entails a process-like approach to musical sense-making.This can be qualified as *analysis-by-ear*, as advocated already in the phenomenological approaches of the 1980s (Lochhead, 1986; Clifton, 1983), which argued for a dynamic and constructivist approach to music knowledge acquisition (Reybrouck, 2014, 2017a, 2017b; Reybrouck & Eerola, 2017). Central in this approach is the *knowledge-by-acquaintance*, as stressed already by pragmatic philosophers such as Dewey and James (see below). Musical sense-making, in this view, can be considered in epistemological terms as a process of knowledge construction that is the result of interactions with the sounds. These interactions can be manifest, as in the case of playing a musical instrument, but they can be internalized as well. The former can be studied from the point of view of physical interactions in general, which have both a motor and a sensory aspect, in the sense that performing actions on an object may have an effect on this object, which can be felt and fed back through the senses. This is the case for instance while hitting a ball, or tearing a sheet of paper to pieces. Gardening, sculpting or drawing are other examples that clearly show the results of a multiplicity of actions that are directed at obtaining a specific goal. This is even more the case with physical-musical interactions, such as pressing a key on a piano keyboard or plucking a stringed instrument. It is quite easy to perform such an action. Playing at a skilled level of performance, however, needs a combination of precision, speed and force and the only way to learn this is to rely on minute sensory feedback. Or put in other terms: there is a continuous *action-perception coupling* which is responsible for a learning curve with regard to the interactions between a musician and a sound-producing device. Such repeatedly executed sensorimotor routines can lead to formation of *internalized sensorimotor schemes*, allowing the music user to perform motor programs at a virtual level of mental imagery, also called 'ideomotor simulation' (Reybrouck, 2001b; Prinz & Chater, 2005). Such internalized actions are not necessary perceptually bound and make it possible to conceptualize music at a reproductive, expressive or perceptive level, mapping directly on the motor domain, either in the domain of implied, expressive gestures or in other forms of simulated movement (Kühl, 2007), which have been coined 'the private dancer' (Brandt, 2004) and 'the inner walk' (Benzon, 2001) as a kind of dancing in our head.

It is a small step from 'internalized actions' to 'epistemic interactions, ' which can be considered as processes of knowledge construction by means of activities such as exploring, observing, measuring, labeling, comparing, etc. (Reybrouck, 2016a, 2016b). This can be done in a detached way, without reliance on actually perceived sounding elements. This is not the case, however, in a real-time listening situation, which has always access to the sensational level of listening and which entails both perceptual immediacy as well as a more disembodied and detached way of performing mental operations on virtual and symbolic replicas of the sounds. Comparing a musical motif, for example, involves the perception of this sounding event (actual) with what has sounded before (virtual), and the same holds true for anticipations with respect to what could possibly sound next. There is, as such, a tension between the actual and the virtual, between the role of sensory stimulation which makes the listener a first-hand witness of the music as it sounds in real time and the mental operations which take a more distanced stance towards the sounding music and which go beyond a mere immersion in the sound by dealing with the music also outside of the time of actual unfolding (Reybrouck, 2017b). This tension, however, does not harm. The complementarity of in-time and outside-of-time processing can even enhance the richness and fulness of the first-hand experience by adding additional representational tools, which can be the outcome of previous interactions with the sounds, both at a physical level of interactions as well as on the level of internalized actions schemes. It brings us to the transition from actual to virtual or simulated actions, as advocated already in the theoretical claims of the *Kharkov School* in Russian psychology in the 1930s. Central in this approach was the crucial role they attributed to the role of activity in the formation of mental acts (see Haenen, 2001 for an overview). Gal'perin, in particular, has stressed the role of human activity as the basis for the development of semiotic means. In what has become known as the *formation of mental actions*, he sketched the development from action to thought with a gradual transition from overt actions to mental actions at an internalized level of performing (Gal'perin, 1992). Applied to music this means that even listening can be tied to action, be it at an internalized level. The listener, in that case, takes more distance with regard to the sounding music and substitutes epistemic actions for physical ones, operating at an internal level of imagery by carrying out operations on mental replicas of the sounds. But even in instrumental play, where the performer carries out actions and interactions on sound-producing devices, it is possible to go beyond these physical actions by focusing on actual sounding moments (relying on sensory feedback) and by comparing them with previous or future ones. As such, listeners and/or performer work both in time and outside of the time of the actual temporal window.

Going beyond dichotomies

The tension between epistemic and physical actions and interactions challenges to some extent the opposition between detached and disembodied approaches to music and embodied and experiential ones (see Reybrouck, forthcoming). It is possible, in fact, to rely on distinct listening strategies for coping with the sounds, with as critical distinction the width of the temporal window of focal attention. There are, as such, four major distinctions, which can be labeled as (i) the focal/synoptic, (ii) the continuous/discrete, (iii) the sensory/symbolic and (iv) the in-time/outside-of-time dichotomy.

The *focal/synoptic* dichotomy refers to the distinction between step-by-step processing as against taking a global overview. It is exemplified most typically by the distinction between a hiker who has posited himself on a panoramic viewpoint to look at a group of rafters that is paddling down a wild mountain river as against the experience of the rafters in the boat who are tackling gushing rapids and spectacular whitewater. The experience of the rafters is likely to provoke more adrenaline rushes through their body and full consumption of the actual sensory experience. This is not the case for the hiker who may enjoy also the beauty of the scenery but in a more detached way. In distinction to the rafters, however, he has a broader overview. Or put in other terms, he has a synoptic overview by taking distance in order to broaden the focus but at the cost of losing the richness and fulness of the actual experience. The analogy with music listening is obvious in the sense that listeners can focus on the actual sounding moment, as in real-time listening, as well as recollect the actual moments in memory and conceive of them in a kind of synoptic overview.

The *continuous/discrete* dichotomy stems from the domain of signal processing and is related to the distinction between analog and digital. The term discrete, in this context, refers to things that are distinct and separate from each other and which can be referred to in terms of an all-or-none character. The digits 0 and 1 as used in computer programming are typical examples, but the same holds true for all other numbers and letters of a language, and even words or other separate things which are distinguishable from each other and which have unit character. Hence the commonly used combination of the terms discrete-digital, which may even be assigned a symbolic meaning as well. The transition between discrete and continuous, however, is fluent in the sense that raising the number of discrete things in a succession can smoothen the discrete character of these things. This is obvious in the visual domain with as typical example the case of spatial resolution. In a low-resolution picture, the individual pixels are visible as separate things; in a higher resolution this discretization of the picture disappears. Raising the number of dots or pixels per surface area in a photograph makes it much sharper with smoother transitions between the discrete parts. The same holds true also for the temporal domain, where a fast succession gives the successive elements a continuous character. This can be shown at a microscopic level of listening, were the frequencies of pitches are summarized as one tone with a definite pitch. But even at a larger scale of processing it is possible to group separate sounding elements together to form greater chunks. A distinction should be made here, however, between the music as a sounding stimulus and the way it is perceived by the listener. The music, as a sounding flux, is always continuous; the symbolic notation, as displayed in score notation is discrete. Converting score notation to spectrographic or waveform depiction, however, shows clearly that the discretization is in the head of the listener rather than in the music, where transitions between individual elements are smooth rather than discontinuous. Yet the discretization has benefits as to the economy of processing. It is, in fact, much easier to follow a score than to navigate through the continuous flow of sounding signals. This is illustrated in Figure 2, which depicts the first measures of Mozart's Piano Sonata No. 11.

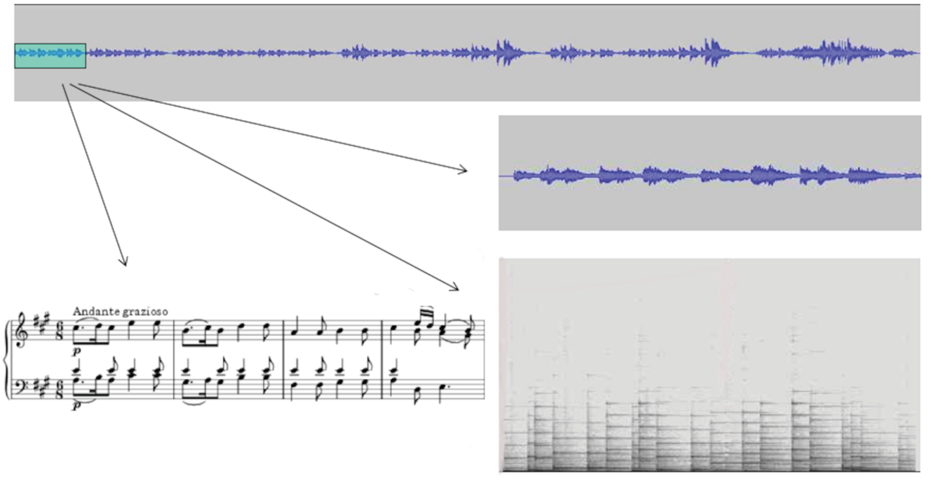

Figure 2. Discrete and continuous depiction of the first measures of the first movement of Mozart's Piano Sonata No. 11 in A major, KV 331 both as score notation (left, lower pane) and waveform (right, middle pane) and spectrogram notation (right, lower pane).

The score notation depicts discrete symbols, which are clearly separated from each other and which are easy to follow. The waveform depiction, on the other hand, is continuous in its unfolding with no visible separation between the constituting parts. The spectrogram is somewhat easier to follow as it both depicts the continuity of the unfolding as well as the discrete character, due to the common onset of much of the overtones of individual sounding elements. The spectrogram and the waveform depiction, moreover, resemble the original sound source, in the sense that they reflect all the particularities and specifics of the actual temporal unfolding. As such they are analog-continuous rather than discrete-digital.

The *sensory-symbolic* distinction is related to the digital-discrete/analog-continuous dichotomy in the sense that the sensory experience is continuous and perceptually bound while the symbolic representation takes a more distanced stance towards the sounding music. Assigning a symbolic label to sounding events is, in fact, a 'logogenic approach' to music cognition, which is conducive to verbal expression that can be put into words (Tagg, 2013). It relies on a language-like or propositional system, which describes music in general terms by stripping away all the particularities and idiosyncrasies which characterize the actual sounding. Such symbolic labels can be used also outside of the time of actual unfolding, which means that they are more detached from the music as it sounds. Contrary to the sensory impressions which are picked up in a bottom-up way, they can be assigned to particular delimitations of the sounding music in a top-down manner. What matters in this distinction is the tension between the richness and fulness of the sensory experience as against the abstractness of the symbolic denotation. The former has the advantage of first-hand witnessing and immersion in the sound; the latter has the advantage of cognitive economy, by reducing the sensory richness to just one single symbol.

The *in-time/outside-of-time* dichotomy, finally, is related also to the sensory/symbolic dichotomy. Discrete-digital signals reduce the sensory richness by abstracting and stripping away in favor of symbolic representations that are detached from the actual perceptual bounding. As such they can be addressed also outside of the time of unfolding, which makes them apt for mental computations. The distinction, which has been coined originally by Xenakis (1965, 1992) shows the dynamic tension between the sensorial aspect of capturing sound, which is characterized by consumption of time, and which taps the moment-to-moment history of the successive acts of focal attention and the epistemic interactions with the sound that operate also outside of the time of actual unfolding. They allow the simultaneous representation of the sounding music, allowing the listener to go beyond the narrow temporal window of actual now moments and to recollect past events or to anticipate upcoming events. As such they transcend the inexorable character of the arrow of time, making it possible to deal with music in terms of mental computations.

Theoretical grounding

Conceiving of musical sense-making in terms of 'ongoing knowledge construction' stresses the role of music-as-perceived rather than music-as-conceived. Though both approaches do not exclude each other, the primacy of the sensory character of music as a sounding art should not be questioned. It makes sense, therefore, to explore and examine the theoretical groundings for the study of real-time epistemic interactions with the music. There are basically four domains of study which should be considered in this regard: (i) a process-like description of music, (ii) the real-time description of having an experience, (iii) the dynamics of representations, and (iv) the deictic framework and the use of indexical devices.

The *processual approach* to music, first, takes as a starting point the dynamic character of music as a temporal art. Contrary to a sculpture or a painting which do not change over time, and which thus can be assigned a static or lasting character, music is to be considered as the concatenation of now moments which proceed in an inexorable way. There is, moreover, a continuous shift in ontological status, with now moments being actual and real, while past moments are virtual but definitive (the past cannot be changed) and future moments are virtual but undefined (the future is open to lots of possibilities). Dealing with music, therefore, is time-consuming, as it entails the sequential concatenation of now moments, proceeding in a unidirectional way from earlier to later. This is the 'arrow of time' which gives it its inexorable character, and which means that it is not possible to invert the flowing of time. Every now moment that actually happens, gets a definite and irreversible character with a compulsory tension to the next moment. This is in a nutshell the core assumption of real-time processing of a temporal event. It is possible, however, to take distance with respect to this temporal flux and to navigate mentally in a kind of virtual space, recollecting past moments in memory and anticipating possible future events. This is the domain of epistemic interactions with the sounds which take more distance with respect to the sounding music. It makes it possible to replace the arithmetic notion of counting and serial ordering (the string-and-knot approach) with the algebraic conceptions of reversibility and plasticity of mental operations. The latter make it possible to return to the starting point (inverse operation) or to obtain the same goal by different ways (associativity) (Piaget, 1968). As such, there seem to be two major aspects in the processual approach: the actual now moments and the broader relational network that places these moments in relation with what precedes and what comes thereafter. The now moments are related to Piaget's conception of 'concrete operations', as they deal with concrete sensory material; the relational network takes more distance and implies a whole set of 'formal operations' that operate at a more symbolic level of representation (see Reybrouck, 2016c for a more in depth elaboration).

Figure 3 shows an example of these claims. It depicts the first 75 seconds of Mahler's *Abschied* (*Das Lied von der Erde*) and combines the linear unfolding of the sonorous articulation and the simultaneity of the global overview. The upper pane shows a spectrogram which renders a kind of microscopic depiction of the sonorous unfolding. The visual character of the spectrogram makes it possible to select at will some concrete elements with or without unit character, which can receive some semantic weight and which can be represented also at a symbolic level of representation outside of the actual time of sounding. As such, they can be dragged and moved around in a kind of symbolic work space (middle pane). Making sense of them, however, needs a kind of structuring and re-enactment so as to put them again in the right order with elements on the left side occurring earlier than those on the right side. The elements can be contingent, but can be at a distance from each other as well. Besides the process of seriation (putting in the right order), it is possible also to apply a process of classification and to compare the elements and to decide whether they can be subsumed under the same class or not. There are, of course, many transitions from mere equality over similarity or analogy to qualitative difference.

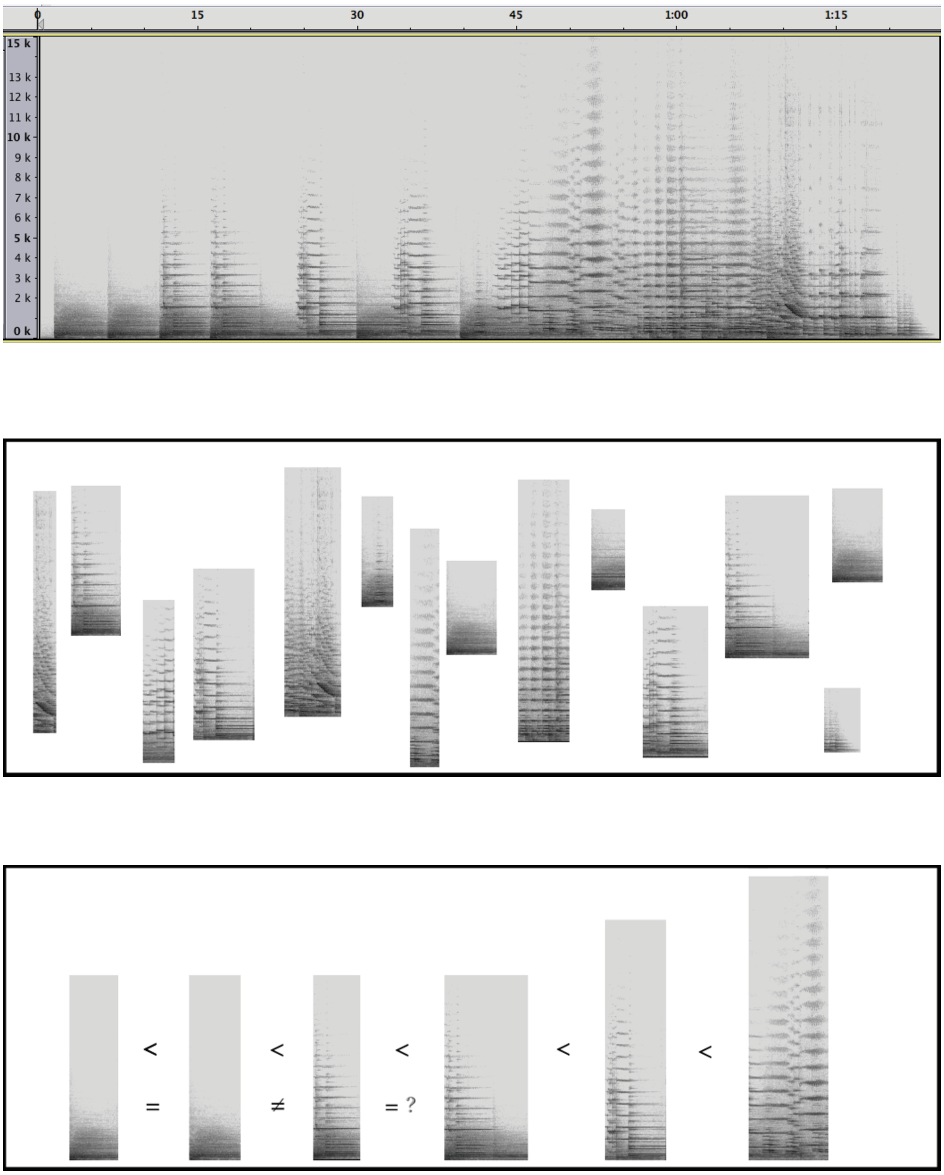

Figure 3. Example of concrete and formal operations. The upper pane depicts the beginning of Mahler's *Abschied* as a spectrogram. The middle pane acts as a kind of work space in which selected areas of the upper pane can be dragged and moved around in a kind of symbolic play. The lower pane illustrates the operations of seriation which puts the elements in the right order ('<' means 'earlier than').

The concept of *now moment* has been discussed already in depth in the philosophies of time which have dealt extensively with the actual moment of sensation and the perceptual flux and its corollary in the 'stream of consciousness' (see Reybrouck, 2001b for an overview). An important conceptual tool in this regard is the concept of 'temporal window' which restricts the width of the actual now moments through which we can keep step with the actual unfolding of a sensory flux. Such now moments, which are perceived during a short time of focal attention have been called the *specious present* by James and the *psychical present* by Stern (James, 1890; Stern, 1897; see also Dainton, 2000, 2010; Kelly, 2005; Roeckelein, 2000; Varela, 1999 for discussion). According to James the basic units of lived presence comprise a span of attention that is opened on experience as a window, not as a knife-edge but as a duration block that comprises the present, past and future. Such practically organized present can be defined as a moment in time that sharply divides past from future, but which is clearly distinct from both. It has been described by James can as a saddle-back with a certain breadth of its own in which we sit perched and from which we can look in two directions in time (James, 1890, p. 609). It is possible, further, to extend this temporal window by recollecting previous moments in memory and by anticipating future moment in imagery, which brings us to the phenomenological description of time, as elaborated by Husserl. Every now moment, in his approach, retains the just-elapsed phase of consciousness with the present consciousness. There is, so to say, a retential continuum that stretches back over the past experience. The latter, however, is only intentionally contained in the present. It continuously slips away and disappears from view with increasing clarity and impinging force. Yet it is renewed at each moment and is simultaneously filled with new content. This leads to an intentional unification of consciousness over time with an interlocking of primal impressions (the now moments), a tacit awareness of just-elapsed phases of experience (retentions) and an open and forward-looking horizon (protentions) (Husserl, 1928, 2001, see also Varela, 1999 and Thompson, 2007, p. 322). In what he coined as the *phenomenological constitution of time*, Husserl combined phenomenological and real or objective time in the sense that there is a sequential succession of primal data of objective time—as a succession of now moments—, which are continuously receding with a shift from actual perception to retential memory. Actual sounds, then, become memory traces at each new time-moment and memory traces of these memory traces and so on. It is a relational framework that goes beyond the mere description of temporal order by combining a causal-transitive and simultaneous way of processing of the sounds, offering an experience of time that deals with actual and virtual time simultaneously.

Husserl's approach has a lot of operational power by stressing the role of relational consciousness. By bringing together now moments, their retentions and protentions, it brings perception in relation with memory and anticipation, thus opening a lot of areas of investigation for the study of musical time. A first broadening of this, as applied to music, has been proposed already by Schütz in what he called the dimensions of the inner experience of time (Schütz, 1971, 1976). Recalling Bergson's 'tensions of consciousness' and James' 'stream of consciousness', he conceived of inner life as a stream of connected experiences with the now moment as the time of immediate experience, the past as a set of complete but indirect experiences which are available through memory, and the future which is available through anticipation. It led him to make a distinction between reproduction, retention, the actual now moment, protention and anticipation (See Figure 4).

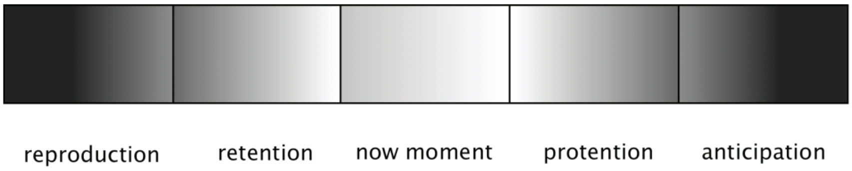

Figure 4. Schematic depiction of Schütz' inner dimensions of time.

The totality of our experience of time thus embraces perception, memory and anticipation, which, together, constitute an uninterrupted stream of consciousness. There is, however, a difference in ontological status between the constituent parts: retention is an experience in which the actual experience is still retained; reproduction is not contiguous with the actual experience but is more remote; protention, similarly is an expectation with respect to the immediate future; and anticipation is directed also to a more distant future (see Reybrouck, 2004 for an overview). This whole construction has a lot of operational power, as illustrated in Figure 5.

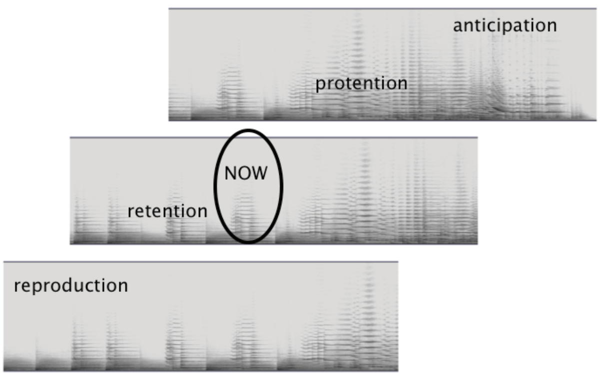

Figure 5. Graphic depiction of the inner dimensions of time. The middle pane displays the level of actuality with the now moment being selected through a temporal window of focal attention. The lower pane provides the level of reproduction and the upper pane the level of anticipation. It is possible to resize the scope of each window in order to provide a smaller or more global overview.

Besides James' and Husserl's elaborations on the concept of now moment and its temporal extensions, there is another theoretical approach which may be of interest for the processual approach to dealing with music, namely Langacker's distinction between 'sequential' and 'summary scanning' and the related distinction between processual predication and episodic nominalization (Langacker, 1987). The processual predication can be conceived as the successions of multiple focal points, following the temporal evolution of a situation. It involves a continuous series of states that represent different phases of a process, thus occupying a continuous series of points in conceived time. Episodic nominalizations, on the contrary, refer to just a single instance of the process. They can be considered as a thing or event that can be characterized as a bounded region in some domain (Langacker, 1987, pp. 191 and 244). Processual predication, further, makes it possible to grasp the sonorous unfolding as it unfolds in time as a path of becoming and as a kind of continuous transformation. The mechanism behind this process is *sequential scanning*, which involves the successive transformations of one configuration into another. It is the mode of processing that defines what it means to follow the evolution of a situation through time, and where the component states are processed in series rather than in parallel, and without being coexistent are simultaneously available. *Summary scanning*, on the contrary, is basically additive with the processing of the constituting components proceeding in parallel. It means that all the facets of a complex scene are simultaneously available through their coactivation, which is the mode of processing things, and atemporal relations (Langacker, 1987, p. 248).

The *real-time processing* of music, second, goes back to the concept of having an experience, as elaborated already in the theoretical writings of pragmatic philosophers as Dewey and James. Revolving around the distinction between 'percept' and 'concept' they have stressed the importance of the richness and fulness of the sensory experience. Their insights, moreover, have influenced deeply some recent contributions in cognitive neuroscience, in particular the domain of neuroaesthetics and the whole field of dynamic systems theory (see below). Dewey, in particular, has stressed the role of having an experience proper, which is characterized by a kind of heightened vitality, by active and alert commerce with the world, and by the richness and fulness of the sensory experience (Dewey, 1925; 1934). Such sensory experience, further, is not to be put apart from the artistic experience, which is continuous with the natural experience. The difference is only in degree, not in quality. There is no lowering of value by stressing the primacy of sensory experience; it only stresses the richness of full perception, which proceeds in time rather than outside of the time of unfolding.

A somewhat similar approach has been advocated by James in his original epistemology, which is known as 'radical empiricism'. It stresses the tension between concept and percept and argues for knowledge-by-acquaintance as that knowledge that we have of a thing by its presentation to the senses. It further argues that the significance of a concept consists always in its relation to perceptual particulars. Conceptual knowledge can be self-sufficient, but the full value of such knowledge is only reached by combining it with perceptual reality. As he states it: we only extend our view by inserting our percepts into our conceptual map, but the map remains superficial through the abstractness and false through the discreteness of its elements. Conceptual knowledge, therefore, is inadequate to the fulness of reality (James, 1976 [1912], p. 245).

A third theoretical area of study is the *dynamics of representation*. It revolves around the focus of attention which can take a step-by-step processing versus a synoptic overview, as explained already above. What matters in this distinction is the opposition between a focal time window on the one hand and an overview of the overall structure on the other hand. There are, or course, multiple ways between, which together constitute the dynamics of representation, which have been operationalized by Godøy in terms of 'perspective' and 'resolution' (Godøy, 1997). Starting from the analogy of scanning the sonorous articulation, it is possible to break the continuous image of the sound into a grid of acoustic pixels, as used in the field of spatial resolution with spatial quantization through the process of pixelization, sampling or scanning. There may be, further, 'high-speed' or 'broad-band' types of representations as concentrated graphical overviews that show longer stretches of temporal unfolding at a glance, or slower or more sequential types of representations that can be considered as 'frame by frame' overviews. There is, as such, a multiplicity of temporal representations with each velocity of representation providing a different kind of perspective and knowledge of the musical substance. It is thus possible to conceive of musical representations at different velocities in terms of resolution and perspective, which can be considered as morphological dimensions of the music, on condition that we are ready to apply these visual terms to the temporal dimension of sounding music (Godøy, 1997, p. 66). The proposal is appealing as it calls forth the tension between low-resolution representation which reduces the musical structure to more synoptic or simultaneous overviews and high-resolution representations which are more focused on narrower temporal windows. The former is basically time-indifferent, where the latter depends critically on the passage of time, but what mostly matters in this distinction is the difference between a dynamic and symbolic approach to musical information processing (Cariani, 1997, 2001; Pattee, 1979; see also Reybrouck, 2016b, 2016c). The dynamic approach is related to analog, rate-dependent processes and styles of modeling as commonly used in physics, the latter is more related to orderly, rule-governed successions of discrete functional states which allow mental computations to be done on them and which are thought to be largely autonomous and not dependent on the underlying microdynamics. The choice between these levels of representation, however, is not totally free, as there are different levels of granularity or resolution, which are dependent on the working of our nervous system. This system, in fact, cannot work at any particular level of resolution, but selects a scope of attention, so that no more knowledge is processed than what goes into this scope. The nervous system seems to be built specifically to deal with processes of generalizations and their opposite processes of instantiations, in the sense that too much diversified information calls forth processes of generalization to cope with it in a more economical way. As such, it is possible to conceive of swarms of information which can be nested within more encompassing swarms with multiple granularities of nestedness. The construction of such swarms has a great power of interpretation, but at the cost of high-resolution knowledge. This means that the more generalized the knowledge is, the more details seem to disappear within these generalized entities. Resolution, in fact, can be understood as the degree or the ability to depict details. It is often waived in order to manage the larger picture and to broaden the scope of attention, though it is even possible to decompose an event to form parallel high-resolution schemata which can be unified in a lower-resolution schema (Meystel, 1998, and Reybrouck, 2001a for an overview).

The *deictic framework*, finally, is closely related to the concept of focal attention and the real-time processing of music. It goes back to the original work of Bühler, who made a distinction between 'pointing words' or deictics such as 'I/you,' 'this/that'or 'here/there' and 'naming words' (Bühler, 1934, 1982, see also Kita, 2003, for an overview). He conceived of deixis as the field of pointing rather than the symbolic field of meaning, relying on deictic expressions that refer to gestural analogies for showing direction and place, allowing to take an indexical approach to sense-making (Hanks, 2005). Such expressions refer to a context where a *zero point* or *origo* is fixed by the person who is doing an utterance (I), the place of utterance (here) and the time of utterance (now). Deictic terms, accordingly, are words that pick out or point to something in relation to the participants in a referential exchange. They are related to the notion of indexicality (Nunberg, 1993, West, 2011) and the notion of pointing and its correlates (Kita, 2003). As such they provide a source of reference by picking up or pointing to something in relation to the actual situation of utterance, which involves both the place and time of the utterance. They thus locate individual elements in context rather than simply tagging them and have to be defined with reference to the event of utterance, the participants and their relations to the position and time of utterance (Fillmore, 1982).

Deictic terms can be used either as a direct demonstration with the index finger—hence the term indexical— or as derivate forms of pointing such as using the same word anaphorically (e.g. 'this') or pointing in imagination to something that is perceived. The index finger, in that case, is replaced by other more covert deictic means. It is possible, finally, to extend the concept of pointing still further by distinguishing three possibilities: (i) pointing as selection, which means that some width of the temporal window is the subject of focal attention, (ii) pointing as a physical gesture, which can keep track with the sounding music or at least some parts of it, and (iii) pointing as predication which means that there is a transition from sensory perception to a kind of propositional thinking, by assigning conceptual labels to the attended and selected temporal windows (Reybrouck, 2009a, 2009b, 2015b, 2017b).

Applied to music, this should mean that the allocation of attention is apprehended in a real-time listening situation, which implies the physical presence of the sounding music. This holds a 'dynamic-vectorial' approach to the music, in the sense that the objects of attention are selected and pointed at in a dynamic and ongoing way and this in a unidirectional way (from the listener to the music), hence the term 'vectorial'. Listening, then, calls forth ongoing epistemic interactions with the sounds, which can even be hypostasized as virtual agents, so that it is possible to conceive of a kind of overlap of focal attention of the parties of a referential exchange (in this case the music and the listener) (Diessel, 2006; Grassmann & Tomassello, 2009; Seemann, 2011). Both the music and the listener can then be considered as the *origo* or anchoring point of such referential exchange with something that happens in an actual here and now. Listening, in this view, can be systematized in terms of personal, spatial and temporal deixis. These are the *socio-spatio-temporal axes*, namely 'I' (the listener or the music), 'here' and 'now,' which together provide an operational description of space/time moments and their relation to the actual position and time of utterance. The primacy of the visual aspect is obvious in the deictic approach, as evidenced by the tendency to use a pointing gesture to accompany the uttering of the word 'here' for indicating the exact location where something is happening (see also, Johnson, 2007, p. 251). It is tempting, therefore, to try to apply this also to the domain of music.

Empirical evidence

The theoretical claims, mentioned above, refer mostly to older seminal writings. These insights, however, are still valuable and inspiring for new research, which can now rely on research methodologies and measurement techniques which were not yet available at the time of these 'founding fathers.' There are mainly two areas of research which are worthy of further empirical investigation: a dynamic description of the sounding articulation—this is the sounding music as it actually unfolds in real time— and a minute description of the sound tracking process by the listener as well as a search for its underlying mechanisms. This latter involves a description of the levels of processing as well as the assessment techniques.

The *sonorous articulation* is the starting point for dealing with music. Without sound there is no music, and music is only music when it sounds. There may be ontological discussions about the 'work concept' of music, as a fictional object that exists in an ideal world as a fixed, fully formed and endured object, apart from any physical and any single performance of that score (see Elliott, 1995, p. 26 for a critical discussion). Yet the very idea of dealing with music in an experiential way implies the presence of sensory stimuli which can evoke reactions—both physical, cognitive and emotional—in an ongoing and continuous way. To the extent that the aim of research is to uncover any causal links between the music and the reactions it can evoke, there is need of a fine-grained time-locking between the music and the listener's responses. What is needed, therefore, is a dynamic rendering of the music as it unfolds in real time, or put in mathematical terms: a depiction of the sounding music as a function of time. There are currently already some representational formats, such as the *waveform* and *spectrogram* representation—either in the time domain (waveform) or frequency domain (spectrogram) —which deliver a continuous representation of the music as it sounds, and which make it possible to conceive of music in 'morphological terms,' combining genuinely a discrete and continuous depiction of the sound.

The spectrogram or sonogram, in particular, has proved to meet some of these requirements (Helmuth, 1996) but the description of sound as a function of time is likely to be more fruitful (Dannenberg et al., 1997), as exemplified, e.g., in Cogan's conceptions of *spectral morphology* (Cogan, 1984; Cogan & Escott, 1976) with sonic morphologies which resemble one another, which may be transformations of each other, or which may even oppose each other. Besides, there have been somewhat related elaborations in the field of *spectromorphology* (Smalley, 1997) and *acousmatic morphology* (Desantos, 1997). Such a morphological way of thinking is challenging as it provides a description of typical patterns of unfolding. This is exemplified in Figure 6, which depicts a fragment of the song of a nightingale. The waveform (upper pane) has a better time resolution, allowing to clearly distinguish discrete events with their typical onset and offset time. The spectrogram (lower pane) on the other hand has a frequency resolution, which makes it possible to compare the contents of distinct events with others more easily.

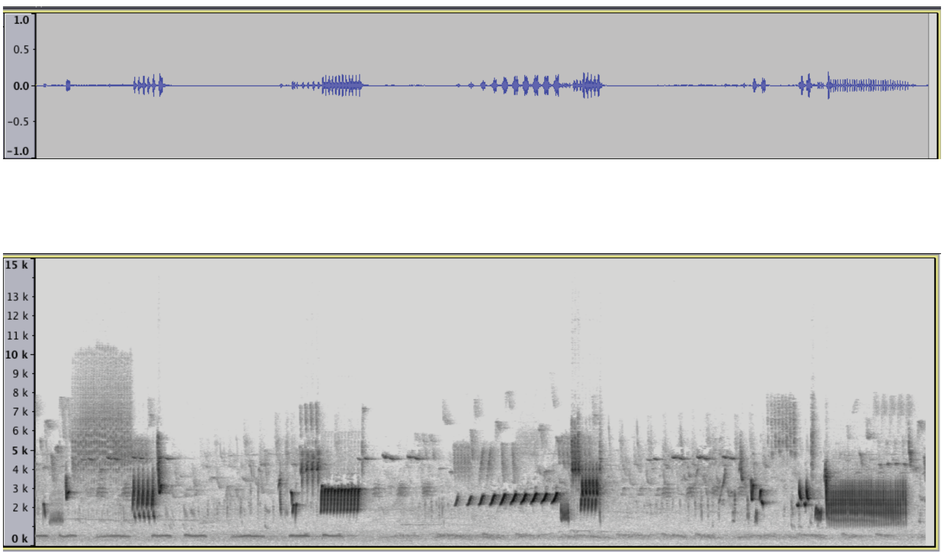

Figure 6. Graphic depiction of a waveform (upper part) and a spectrogram (lower part) depiction of the song of a nightingale. The waveform has the better resolution in the time domain, the spectrogram has a better resolution in the frequency domain.

Yet, there is still much to be debated in this domain as there is the whole domain of *morphodynamics* and the morphological way in general to delimit morphological lexicons, which consist basically of elements that are defined as being dependent upon the interplay between stability and change in order to deliver the fundamental perceptual effects of invariance and discretization (Thom, 1980; Petitot, 1989; and Dufourt, 1989; McAdams, 1989; and Reybrouck, 2016c for musical applications). Such discretizations, further, make it possible to carry out syntactic and epistemic operations on them in an attempt to knit them together in a relational network, thus considering a transition from the perception of discrete particulars to an organized structure, as an understandable form that may manifest an internal connectedness, logic and coherence.

Starting from such a dynamic representation of the sounding music, it is possible to time-lock the reactions by the listeners in a continuing way. A distinction should be made, however, between levels of processing with a gradual transition from low-level sensory reactions to higher-level cognitive/emotional responses. Both levels involve each other, but the search for linear causal relations between them has been difficult and unconvincing up to now. There is, in fact, no 'pharmaceutical model' that explains the effects of music in terms of structural features of the sounds (Sloboda 2005, p. 319).

The low-level responses are more causally linked and more temporally locked to the proximal stimuli. They have been studied in the context of *psychophysics* and to some extent also of *psychobiology* where some linearity between the sensory input and the corresponding reactions by the listeners can be shown (Reybrouck, 2008, 2013). There are, in fact, triggering forces in the physical features of the sound that can modulate perceptual reactions in a quasi-causal way (Reybrouck & Eerola 2017). The higher-level responses, on the contrary, have more degrees of freedom as there is a lot of subjectivity and dispositional variance in the way how individual music users make sense of the collection of sound/time phenomena that together constitute the sounding music. The effects of music, in that case, are not only triggered by human physiology, but are mediated also by the listener's choices and mental states. It makes sense, therefore, to conceive of musical sense-making in interactional and enactive terms as a kind of active perceptual exploration with a lot of freedom for each individual listener.

There are several methods to assess the listener's responses and ways of sense-making with a major distinction between *direct* and *indirect* measurement techniques, which can be either *invasive* or *non-invasive*, which means that they do (invasive) or do not (non-invasive) intrude the body. Inserting a needle, a catheter, or a deep electrode in the brain are examples of invasive measurement techniques. Using surface electrodes or external devices that do not intrude the body are non-invasive. Direct measurements, further, are directed mostly at measuring psychoacoustic reactions and autonomous reactions of the nervous system and their physiological correlates, such as heart rate, blood pressure, skin conductance, respiration rate, hormone release (e.g. oxytocin, prolactin, testosterone, cortisol, etc.), brain activation patters, and muscular tension. Some of these measurements are very fast and quasi-instantaneously, while others need more time before the effects are visible. Such temporal delay, however, is a critical aspect when the aim is to monitor the reactions to the sounds in a continuous and ongoing way in an attempt to track the listener's reactions while the music unfolds in real time (see Schubert, 2001, 2004 for a first description) in the sense that they may hamper a high-resolution temporal description of processing by the listener. Indirect measurement, on the other hand, embraces behavioral assessments in real time of task-related behaviors in a clinical testing situation, such as pressing a button at focal points in time, or reaction time measurements.

Other possibilities are ways of reporting, such as filling in a questionnaire. The limitations of the latter is that they occur mostly out of the time of musical unfolding and they provide only a post hoc description of listener's experiences.

There are, as such, multiple ways of measurement. Much depends here on the aim of the research. The whole domain of psychobiology, however, is very promising in this regard, as it aims at uncovering a mapping between percepts, experience and thought. By looking for a kind of lawful coordination between sounding stimuli and responses of the music users, it studies the mind-brain relationship and the particular ways in which mental processes are encoded and represented. Its major claims are that the nervous system provides the immediate, necessary and sufficient mechanisms for the embodiment of all mental processes and that mental processes are reducible to the function, arrangement, and interaction of neurons as the constituent building blocks of the nervous system (Uttal, 1973, 1998). This is, in a nutshell, the basic *axiom of psychobiological equivalence* which claims an equivalence of maintained information from the neural to the psychological state. The approach has been criticized somewhat for being reductionistic (Schiavio et al., 2017, and see Reybrouck, forthcoming, for an overview) by reducing musical sense-making to the restrictions of the skull and brain. It has been argued accordingly that the whole body should be included in the process of sense-making and that music cognition should be extended to embrace the brain, the body, and even the environment, in the sense that objects within the environment can even function as part of the mind (Clark, 2011; Clark & Chalmers, 1988). The use of a notebook or a smartphone to aid our biological memory is a typical example of such extension. The question can be raised in this regard, whether such external memory is constitutive of our mind or whether it is only an external aid. It is one of the basic claims of what is considered nowadays as 'extended cognition' or 'extended mind'. The latter—the 'extended mind' hypothesis— is a radical position which has received a lot of impetus in the context of the philosophy of mind, as exemplified in the recent literature around *4E Cognition* (Menary, 2010). The approach aims at a richer and more holistic model of music cognition, that revolves around the concept of embodiment and the phenomenological experiences of music. It argues for an engagement with music in the course of a lived experience by proposing 4E Cognition as an umbrella term for the terms embodied, embedded, extended and enacted. Cognition, in this view, involves the entire body of a living system (embodied); it is co-determined by physical, social and cultural aspects (embedded); it is offloaded into biological beings and nonbiological devices (extended); and it implies a mutual exchange between a living organism and its environment (enacted). The translation to the realm of music, however, is still mostly to be done (see Reybrouck, forthcoming).

Perspectives and future epistemologies

Music can be described in objective terms as a vibrational phenomenon that impinges on our body and our mind. There are, as such, two levels of description: the physical-acoustic description of the sounds and the physiological-affective-cognitive responses of the music user. Where musicology has taken traditionally a positivistic stance toward the analysis of music, there is currently a change of paradigm that celebrates the role of the music user and his/her way of sense-making while dealing with music in a real-time listening situation. This entails a lot of subjectivity on the part of the music user, which means that current research is confronted with divergent but complementary approaches towards the music as a sounding structure. What is needed is a phenomenological approach as applied to listening, revaluing the 'first-person description' of the lived experience together with 'third-person assessment tools' that may validate the veridicality of the subjective claims (Varela & Shear, 2002; Zahavi, 2005). It is an endeavor that brings together hard sciences and soft sciences and that conceives of experience as cognition with the aim to assess the kind of ongoing knowledge construction and epistemic interactions with the sounds. There are mainly three domains of research which may be helpful here: (i) second-order cybernetics, (ii) neuroscience and neurophenomenology and (iii) dynamical systems theory.

The first domain deals with the tension between the role of the knower as the designer of knowledge as against the actual object of observation. It has been mapped out already in the domain of *second-order cybernetics*, which introduced a kind of paradigm change in scientific discourse by going beyond the original focus of cybernetics as the science of communication and control, as conceived originally by Wiener. Arguing against the classical information processing paradigm which was unable to encompass the role of the observer, it conceives of the observer as a participant and part of the observed system with a major focus on the role of interaction, emphasizing the role of the knower and observer rather than the known things or events (Maturana & Varela 1980; von Foerster 1974, 1984; Luhmann 1990, 1995; Pask 1961a, b, 1992). By stressing the role of subjectivity and its influence on our reactions to the external environment, it must be considered through the first-person perspective and with active verbs.

The role of subjectivity has been elaborated also in the context of *phenomenology*, which has the aim to describe and analyze in detail the experiential dimension and to disclose the cognitive contribution of the knowing subject (Husserl, 2001, p. 170). It cannot be equated simply with introspection as its aim is not to deliver a subjective account of an experience, but to provide an objective account of a subjective experience, avoiding biased and subjective accounts (Gallagher & Zahavi, 2008, pp. 19 and 21). This phenomenological method, moreover, has been adopted recently in the domain of *neurophenomenology* in an attempt to raise it to the status of a scientific model, which is closer to experience than to theory (Thompson, 2007, p. 10). The term has been coined by Varela who claimed the essential complementarity of neurobiological and first-hand descriptions so that the phenomenological descriptions should help guide and shape the investigation of consciousness and that scientific investigation could sharpen the phenomenological observations (Varela, 1996, p. 343). Phenomenology, in this approach, is understood as a methodologically guided reflective examination of our experience, on condition that both the experimenters and the experimental subjects have received some level of training in the phenomenological method for studying consciousness and cognition. The claims, though challenging, are still a matter of debate, especially with respect to their practical implementation in clinical settings. Yet some experimental findings have been gathered already in an attempt to incorporate first-person description in neuroscience by relying on techniques that subjects use to increase the threshold of their awareness so as to provide more refined first-person descriptions of their experiences (Lutz et al., 2002; Jack & Roepstorff, 2003; Gallagher & Brøsted Sørensen, 2006; Lutz & Thompson, 2003; Le Van Quyen, 2010). Subjects, in this approach, are actively involved in the generation of stable experiential categories and are asked to describe them so as to guide the experimenter in the analysis and interpretation of the measured neuroscientific data. As a discipline, then, neurophenomenology should comprise a phenomenological account of the structure of experience, it should provide formal dynamical models for this description, and it should aim at realizations of these models in biological systems (Thompson, 2007, p. 329).

It is assumed further, that *dynamical systems theory* can be supposed to mediate between phenomenology and neuroscience as the phenomenological method is particularly relevant for combining first-person descriptions and the dynamical analysis of neural processes of subjects in experimental conditions. As a relatively new emerging field, it studies the way how complex systems evolve over time, starting from the assumption that the passage of time is continuous (Beer, 2000; Thelen, 1995; Thelen & Smith, 1994; Port & Van Gelder, 1998). A dynamical system, then is a differentiable system which means that the variables change also in a smooth and continuous way, so that the mathematical equations that describe and govern the changing state of a system take the form of differential equations (Thompson, 2007, p. 38). What matters in this description, is the description of the state of a system as a set of quantitative variables that change continually and its qualitative evolution over time, with conceptual tools such as ‘state space’ and ‘trajectories’ in this space which can be described by some set of equations. It thus considers a system’s characteristics as continuous temporal trajectories, which can converge or deflect, and can be applied to behaviors that unfold in real time to study the continuous and simultaneous evolvement of the nervous system, the body and the environment.

Arguing on these lines, it is possible to conceive of a future musical epistemology in terms of a dynamic definition of musical sense-making as a continuous and ongoing process of knowledge construction (Reybrouck, forthcoming). It is a research agenda that aims at bringing together semiotics, cognition, dynamic systems theory and neurobiology by introducing the first-person perspective and by focusing on the continuous measuring of real-time processing of the music as it sounds.

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