This is a post-print (author's final draft) of an article in the journal *Musicae Scientiae* (2010), pp. 187-202. [Original page numbers between square brackets].

Music cognition and real-time listening: denotation, cue abstraction, route description and cognitive maps

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ABSTRACT

This contribution is about music cognition in real-time listening. Starting from the distinction between knowledge-by-acquaintance as against conceptual knowledge, it argues for a definition of music listening as an ongoing process of sense-making that relies on epistemic interactions with the sounds. In order to provide a theoretical framework to assess this process of sense-making, it brings together conceptual and operational tools from the domains of deixis, cue abstraction, route-description and cognitive maps. Basically in this combined approach is the construction of knowledge through the 'extraction' and 'abstraction' of salient elements from the articulation of sounds through time. This articulation can be continuous or discrete, but is possible to deal with the sounding elements in a propositional way, relying on principles of cognitive economy rather than on the richness of full sensory experience.

INTRODUCTION: FROM ARTEFACT TO MUSICAL EXPERIENCE

This contribution is interdisciplinary in its claims. It concerns music listening and knowledge-construction as a real-time experience and argues for a processual and experiential approach to dealing with music (Reybrouck, 2005b). Rather than conceiving of music as an artefact, as something 'out there' to be analysed in a static way, it considers music to be a temporal art that is instantiated only when it sounds. Dealing with music, according to this view, entails an ongoing process of sense-making that relies on epistemic interactions with the sounds

(Reybrouck, 2004). These interactions can be exploratory to a great extent—in searching for new distinctions and observables, i.e. percepts and the distinctions between them—but they can trigger processes of recognition that activate patterns of schematic knowledge that are part of our cognitive structure as well. As such, there is a dynamic tension between ‘experience’ and ‘recognition’ with the former relying on a moment-to-moment scanning of [188] sensory particulars, and the latter relying on processes of abstraction and generalisation.

Musicology, as a discipline, did not really deal with this distinction. It was the merit of Irène Deliège to introduce the topic of real-time listening and the psychological organisation of listening behaviour by focussing on conceptual tools such as cue abstraction and mental representation of the music-as-listened-to. This article will elaborate on these topics by broadening the theoretical background and by providing some additional conceptual tools from pragmatic philosophy, linguistics, psychology and cartography. It aims at introducing an operational framework for the assessment of acts of focal attention and their embedding in a more encompassing cognitive structure. Central in this approach is the act of mental pointing—what does a listener select from the musical surface?—and the construction of a broader design of the musical work as a whole. To deal with these claims, it first explores some characteristics of real-time listening, stressing the role of knowledge-by-acquaintance, to proceed to the level of conceptual and symbolic knowledge which is much more economical, but at the expense of the richness of the full sensory experience. As such, it holds a dynamic tension between what Bühler (1965[10934]) has coined as the deictic—the field of pointing—and the symbolic field of knowledge (see also Reybrouck, 2009a, b).

There are several ways to deal with this dynamic tension: there is, first, the in-time/out-of-time distinction (Laske, 1977; Xenakis, 1992) that refers to the perceptual processing of music as it unfolds through time as against the reliance on memory and imagination that can proceed out of the time of the actual unfolding of the sounds that are perceived; second, there is James’s percept/concept dichotomy (1968 [1911])—see also Dewey (1958 [1934])—that stresses the role of knowledge-by-acquaintance as the kind of knowledge which we have of a thing by its presentation to the senses as against conceptual knowledge that strips off the full richness of sensory experience in favour of a more economical way of processing; and finally there is Langacker’s (1987) distinction between ‘processual predication’ and ‘episodic nominalisations’. The conceptualisation of the former involves the successive transformations of one configuration into another and defines what it means to follow the evolution of a

situation through time. It involves a continuous series of states representing different phases of the process as occupying a continuous series of points in conceived time. Processual predications thus involve ‘sequential’ rather than ‘summary’ scanning. Episodic nominalisations, on the other hand, are essentially additive and the processing of conceptual components proceeds more or less in parallel, which means that the facets of the complex scene are simultaneously available through their coactivation. This is the mode of processing of things and atemporal relations that is also called ‘summary scanning’ (Langacker, 1987, p. 248).

Common to these claims is the distinction between our understanding of the unfolding of sounding music as a kind of simultaneous snapshot as against a continuous process of acts of [189] focal attention that keep step with the sonorous articulation through time. The latter is ‘coperceptual’ and proceeds in time, while the former relies on memory and imagination and proceeds mostly out of time.

LISTENING AS AN ADAPTIVE BEHAVIOUR

Real-time listening entails an experiential approach. It involves the presentation to the senses of sounding stimuli that make up part of the sonic environment. This environment can be challenging to the extent that it invites the listener to establish new semiotic links with the sounding world. Listening, in this view, can be described in *ecological* and *ecosemiotic* terms, stressing the role of interaction with the sonic world (Reybrouck, 2005a, 2006). It is an approach which defines the listener as an ‘organism’ and the sounding music as the ‘environment’, and which goes back to the original definition of Haeckel who conceived of ecology as “*the science of the relations between the organisms and the environmental outer world*” (1988[1866], p. 286). The related field of *ecosemiotics* can be defined as the study of the semiotic interrelations between an organism and its environment (for a critical definition, see Kull, 1998). It means that a full description of perception cannot be given by analysing either an organism or its environment—organism-environment dualism—but that we need an approach which treats the ‘environment-as-perceived’. Perception, in this view, is not ‘organism-neutral’ but must be defined in terms of the mutualism of organism and environment (Ingold, 1992).

The same holds true for real-time listening. To make sense out of the sounding flux, the listener should rely on epistemic interactions with the sounds in order to acquire new knowledge or to activate pre-stored knowledge in his/her cognitive structure. This is a kind of semiotisation of the sounding world: it involves the construction of new distinctions and observables as well as the recognition of knowledge structures that are already acquired as the outcome of previous interactions with the sounds. Listeners, in this view, can show *adaptive behaviour* in their interactions with the music as environment (Reybrouck, 2001, 2005a), which means that they behave as organisms that change themselves in order to survive in their environment (Fleagle, 1999). This is a biological concept of adaptation but it is possible to translate it to the realm of cognition, as did Piaget (1967). Knowledge, in his view, can be defined as an adaptive function with the results of our cognitive efforts being helpful to ‘cope’ with the world of our experience. Starting from the biological drive to produce an optimal state of equilibrium between our cognitive structures and the environment, he introduced the concepts of *assimilation* of knowledge that fits our existing mental schemata which are ready to be matched by the elements of the environment, and *accommodation* which allows an organism to adapt its cognitive structure to cope with challenging environments and to achieve a new state of equilibrium.

Figure 1. Adaptive device with input, output and input-output coordinations (after Cariani, 1991).

Dealing with music, accordingly, can be considered as *adaptive behaviour*. Space limitations do not allow me to go into detail here (see Reybrouck, 2005a, 2006) but it can be stated in [190] general terms that music users are able to match their perceptual input against their knowledge and coordinate it with possible behavioural responses, somewhat analogous to the basic schema of a ‘perception-action loop’. This is the standard approach of cybernetic functioning which goes back to the classical schema of a ‘control system’ with its major moments of input, central processing, output and feedback. It allows us to conceive of listeners as devices that are made up of sensors, coordinative computations (input/output mappings) and effectors, somewhat analogous to the primitive functions of measurement, computation and control (Cariani, 1991, see figure 1). These functions can be considered in terms of their organismic counterparts, such as perceptions, actions and flexible perception-action coordinations, but, more importantly, each of them can be also a locus for adaptation. As such, listeners can be considered as *adaptive devices* that can change their semiotic links with the sonic world by altering each of these basic functions (Reybrouck, 2001, 2006—for a general discussion of adaptive devices, see Cariani, 1991, 2003; Pattee, 1985 and Rosen, 1978). Listeners, then, can arbitrarily choose what kinds of distinctions are to be made (perceptual categories, features and primitives), what kinds of actions are done on the environment (primitive action categories) and what kinds of coordinative mappings and mental computations are carried out between these sets.

CUE ABSTRACTION AND COGNITIVE ECONOMY

To the extent that an adaptive device is able to acquire new knowledge, it can be considered a *learning device*. Contemporary conceptions of learning devices have focussed mostly on the coordinative, cognitive adaptation, located in the computational part of the device, but it is possible, also, to broaden the possibility of adaptation and to include the perceptual and effector side as well. For the remainder of this contribution, the focus will be mainly on the [191] perceptual and computational part, starting from James’s distinction between percept and concept and the deictic approach to music cognition (Reybrouck, 2009a, b).

The percept/concept dichotomy, as advocated by James (1912 [1976]) in his doctrine of radical empiricism, states that the significance of concepts consists always in their relation to perceptual particulars. What really matters is the fullness of reality with which we become aware only in the perceptual flux. Conceptual knowledge is needed only to manage

information in a more economical way. As such, it is related to principles of *cognitive economy*, or as James (1912 [1976]) himself puts it:

We extend our view when we insert our percepts into our conceptual map. We learn about them, and of some of them we transfigure the value; but the map remains superficial through the abstractness, and false through the discreteness of its elements; and the whole operation, so far from making things appear more rational, becomes the source of quite gratuitous unintelligibilities. Conceptual knowledge is forever inadequate to the fullness of the reality to be known. Reality consists of existential particulars as well as of essences and universals and class-names, and of existential particulars we become aware only in the perceptual flux. The flux can never be superseded. (p. 245)

Most objects of our ordinary perception lack this kind of completeness, being short-circuited as soon as there is an act of identification and/or recognition. The full ‘perceptual realisation’ of just the individual thing we perceive is then replaced by the ‘identification’ of something that acts merely as an index of a specific and limited kind of conduct.

This brings us to the problem of sense-making in music listening which is both an ‘experiential’ and a ‘conceptual’ affair: consisting of sensory *realia* as well as their symbolic counterparts, it embraces both ‘perceptual immediacy’ and ‘conceptual abstraction’. The question, however, is how to deal with this distinction. A possible answer is the *deictic approach* to cognition (Bühler, 1965[1934]—see Reybrouck, 2009a, b for a musical analogy) which means that a listener is able to point mentally to some focal points in the temporal unfolding of the sounding music. Relying on acts of focal attention, as a means for ‘singling out’ those things that can be denoted as being meaningful, it holds a dynamic-vectorial approach to the world which is directive in nature, rather than relying on distancing and polarisation between the cogniser and the world, as in symbolic approaches to cognition. The deictic approach, therefore, is coperceptual and proceeds in real-time.

Singling out elements that are eligible for denotation—the denotata—, however, is only a first step in sense-making. There is, in fact, a good deal of freedom in the delimitation of these elements, both with respect to what they are, their features and their temporal extension. A distinction can be made here between the ‘extraction’ of salient elements and the ‘abstraction’ that follows upon this extraction. The former has as a starting point the full richness of

sensory experience, while the latter is characterised by the stripping of those characteristics that make the experience a particular one. It is possible, therefore, to conceive of a ‘salient [192] *specification*’ (Anderson, 1983). This brings us to the concept of *cue abstraction* as proposed by Deliège (2001):

A cue is a salient element that is prominent at the musical surface. This suggestion of key structures that play a foreground role in the musical work is undoubtedly an example of the idea of figure/ground discrimination applied to the perceptual organization of musical structures, an idea that again brings us close to Gestalt notions. But beyond its connections with the original structure, a cue generates different cognitive strategies by virtue of the very fact that it is “emergent”—a property that confers upon it, cognitively speaking, a clearer definition with respect to the rest of the musical environment.” (p. 237)

Such cues can be abstracted to play an active role in the listening process by attracting the listener’s attention, by functioning as a memory storage mechanism and by summarising the sequences from which they arose into a succinct representation. As such, they function as a sort of label, reducing the memory load that is required to internalise the whole structure. To quote Deliège (2001) again:

Musical time is thus progressively marked out, with the different cues that are abstracted during listening acting as waymarkers or milestones. This gives rise to the notion of a mental line that makes reference to a symbolic “musical space” in which the fundamental articulations of the mental schema of the work are drawn. In addition, a cue always acts in concert with the other main features of the model - the principles of similarity and difference - in the context of which a cue becomes a cornerstone in the process of musical categorization: its primary dynamic function in music cognition. The cue therefore provides us with a basic point of reference for the comparisons between musical structures that occur throughout the listening process. (p. 238)

Cues are thus salient elements or key structures that play a foreground role in the musical work. They define units in the perceptual field, based on the properties of objects and the relationships between them, and they can assist listeners to grasp the overall design of the musical structure. As such, the *cue abstraction* proposal aimed to develop an account more congruent with real-time perception that is not restricted to particular types of musical structures, and that can be adapted to any kind of repertoire (Deliège, 2001).

ROUTE DESCRIPTION AND DEICTIC SPACE

The selection of key elements is related to the concept of cognitive economy. By reducing the number of denotable things they allow the listener to grasp the design of a musical work by identifying fixed points and invariant foundations to build his/her organisation around (Deliège, 1992). The question, however, is how cue abstractions are organised in the case of real-time listening. A possible answer can be found in theories of discourse comprehension [193] that suggest that memory of discourse is achieved by focussing attention on a selection of ‘key elements’. As such it is possible to build a kind of mental schema which should be built up at the beginning of the listening process and to progress and evolve over the course of listening to the work (Deliège, 1987, 1989).

This mental schema can be handled in a kind of virtual simultaneity by relying on the concept of *deictic space*, which is set up mostly by summing up all possible denotata. To quote Klein (1982):

In its most general sense, a deictic space is nothing but a set of elements provided with some structure (an order or a topology); its subsets or some of them, are the possible denotata. (p. 163)

These denotata can be local ‘deictics’ or localities such as rooms, apartments, streets, cities, countries... But they need not be localities. They can be abstract places in a train of thought as well, allowing the concept of deictic space to be broadened to give it a more abstract definition. Deictic spaces, further, may differ in several of their characteristics, such as their elements or minimally discriminable units of perception, their subsets, the kind of structure that characterises them, the number of dimensions—one-dimensional (e.g. a train of thought), two-dimensional (e.g. a map) or three-dimensional (the space of visual perception)—and a kind of metric (most deictic spaces have a concept of distance) (Klein, 1982).

It is arguable to conceive of music also in terms of deictic space and to enhance the referential exchange between the listener and the music by working out *route descriptions* of different kinds. The idea is simply to describe how to go from a starting point to a destination, or as it is commonly called in deictic terms, to go ‘from here to there’ (Klein, 1982). Route-based techniques, then, allow the listener to navigate mentally through the music as a deictic space

and to perform a number of mental operations: to retrace or infer a route, to estimate the distance between the start and end nodes of the route or of the segments that make it up, and to estimate the direction between the start and end nodes of the route or between a number of locations along its length (Kitchin & Jacobson, 1997). To do so, the listener should have access to a kind of cognitive representation of the area in question, which is the outcome of the structuring of previous and actual experiences which can be used as a guiding tool for dealing with the sounding music. It is a procedure which is somewhat reminiscent of Tolman's method of *cognitive map* formation (1946), and which is sufficiently general for being applied to listening to music as well.

COGNITIVE MAPS

Cognitive maps are interpretative frameworks of the world. They are built up by the extraction of salient features or 'hallmarks' which are put together in some coherent way. As such, they reflect a process of mental structuring that leads to the creation of an overall mental [194] image or representation of the space and layout of a setting (Arthur & Passini, 1992). Maps mostly represent the world not directly and transparently, but provide versions of truth for human minds to apprehend. Minds, in turn, represent the world internally as 'cognitive maps' (Montello, 2002). Maps, in this view, are 'cognitive devices' as is apparent from the study of *cognitive cartography*, which encompasses the application of cognitive theories to understand maps and mappings and the application of maps to understand cognition (Montello, 2002; Robinson, 1952).

The utility of cognitive maps can best be exemplified through tasks that demonstrate the map in action, such as wayfinding in a complex environment. Two strategies are possible here: to use previous cognitive map knowledge to guide the actions or to use the cues in the environment in order to construct this knowledge (Kitchin & Jacobson, 1997).

The cognitive map of space is an example: it is a structure of information that is physically unobservable and which is held in the mind to represent spatial knowledge (Kuipers, 1978). It can be defined as the body of knowledge of a large-scale environment that is constructed by integrating observations gathered over time, in order to find routes and to determine the relative position of individual places (Downs & Stea, 1973). Two options are possible here, somewhat analogous to the distinction between *primary* and *secondary plans*. The primary

plan involves the localisation of a starting point and destination. Building up this plan may be done in advance or step-by-step (advance or stepwise planning) but it is a first condition to construct a route description successfully. The organising principle of the secondary plan is that of an 'imaginary journey' through the primary plan from starting point to destination. During this journey certain points are selected and marked, yielding a series of 'fixed points' that form the skeleton of the final description (Klein, 1982).

The selection of fixed points and their integration in a more encompassing cognitive map can be applied also to the realm of music. Deliège's notion of *mental line* is a typical example: it makes reference to a symbolic musical space in which the fundamental articulations of the mental schema of the work are drawn (Deliège 2001, p. 238). It is thus possible to conceive of cognitive maps for listeners with the listener being considered as a navigator who tries to find his/her way in a sounding environment. These maps may be differently structured for different listeners, but even if they are vague, incomplete, or even wrong in some respects, they may be very informative as to the way individual listeners structure their own routes and how their attention may be focussed on different points. As well as allowing a factual description of actual hearing strategies, they also provide operational tools for intervening in these strategies (Downs & Stea, 1973; Kitchin & Jacobson, 1997; Kuipers, 1978). It is known that fewer landmarks are selected by poor navigators and that a poor performance can be attributed to the inability to acquire enough information from the environment. Listening strategies, therefore, are related to the problem of acquisition of a cognitive map and its [195] application in the process of navigation. In order to make these claims operational, however, we should consider the cues the listener extracts from the sounding environment. It brings us to the concepts of 'places' and 'sensory snapshots'.

SENSORY SNAPSHOTS AND SPACE STRUCTURE DIAGRAMS

The construction of a cognitive map is related to the domain of data collection and analysis techniques. The map can be simple or complex, and the simplest way of constructing a cognitive map of an environment, *e.g.*, is to use the landscape's 'landmarks'. Common elements of the countryside (mountain, hill, rock, stone, valley, stream, island, lake, cottage, wood, field, grass, meadow, hedge, bush, path, cliff, coast, beach, dune, sea ...) and outdoor objects (mailboxes, traffic signs, trees) are typical examples, but every possible object of pointing can be useful here (objects, places, directions, actions, events ...). It is even possible

to conceive of them not merely in terms of ‘perceptual attributes’ but also in terms of ‘functional qualities’ and ‘action words’ (Mazet, 1991).

Translated to the realm of music, this should mean that the listener extracts cues from the sounding environment. Much can be taken here from the descriptive vocabulary of cognitive mapping research in 3D virtual environments (Rameshsharma & Mowat, 2001) and the problem of wayfinding in large-scale virtual environments. It is centred around the concept of place as *sensory snapshot* which is related to the place where we are when we experience a given sensory image rather than to a set of Cartesian coordinates (Pinette, 1994). To create a cognitive map, the representation should involve the capturing and organising of these sensory snapshots together with a spatial information gathering strategy. A possibility for doing this is the *Space Structure Diagram* which represents large-scale spaces using graphs (Rameshsharma & Mowat, 2001). In this conception of constructing virtual environments, space may be subdivided into functionally distinct regions, each of which is referred to as a *space-node*, and which allows transitory relationships between them. Transit-boundaries provide interfaces between two space-nodes, with the possibility to enter (entries) and to exit them (exits). *Views*, as an additional concept, are special points of views that reveal salient or landmarked sensory data which are of interest to the navigator within a given space-node. Together with the generation of exits and entries they make it possible to capture and organise the pictorial representations of the virtual environment and to create a cognitive web. The application of this strategy to the problem of navigating through the music, however, mostly still has to be done and is the subject of our ongoing research.

CONCLUSION AND PERSPECTIVES

As was stated in the beginning of this contribution, real-time listening can be conceived as a process of ongoing epistemic interactions with the sounds. It entails the construction of knowledge, both at a perceptual and conceptual level with a distinction between the [196] knowledge-by-acquaintance and the reliance on pre-established knowledge that is already stored in the cognitive structure of the listener. Starting from a conception of the music listener as an adaptive device, it is possible to conceive of adaptations at the perceptual and cognitive level of the interactions with the sounds. This means that a listener is able to learn to make new distinctions and observables by mentally pointing to them. The act of pointing, however, involves only a first level of sense-making: it encompasses the mere

‘extraction’ of salient elements with a focus on the perceptual character of the sounding stimuli. To the extent that the listener is able also to ‘abstract’ rather than to ‘extract’, there is a process of cognitive elaboration with a corresponding shift from a mere perceptual to a more propositional and computational level of processing (Reybrouck, 2004).

These claims have consequences for future research, both at a theoretical and empirical level. As to the former, it is possible to elaborate further on the in-time/out-of-time distinction, relying, *e.g.*, on Husserl’s phenomenological approach to perception (Husserl, 1964[1905-1910]) with a central focus on the perceptual experience, the indexicality of perception, the individuation of individual object of perception, the perception of processes and temporal events, the notion of temporal horizon and the specious present, and the distinction between experience and perceptual judgment (see Miller, 1984 for an overview, and Lewin, 1986 and Reybrouck, 2004 for a musical analogy). Much is to be expected further from bringing together Husserl’s phenomenological approach with Böhlers conceptual work on deixis and indexical elements (Böhler, 1965[1934]). The latter draw an explicit analogy between gestural and linguistic means for showing direction or place, with the meaning of deictical expressions depending crucially on when, where and by whom they are used. As such, each ordinary speech situation can be systematised in terms of personal, spatial and temporal deixis (the socio-spatio-temporal axes) (Filmore, 1972, 1982). Deictic expressions, further, refer to a deictic field of language whose zero point—the Origo—is fixed by the person who is speaking (the I), the place of utterance (the here) and the time of utterance (the now). The translation to the field of music is possible by conceiving of music as a deictic space that can be set up by summing up all possible denotata of local ‘deictics’ or localities.

This brings us to the need of empirical research with a major focus on two questions: (i) which elements does a listener extract from the sounding environment? and (ii) which are the cognitive elaborations which are done on these elements? In order to provide the operational means to assess this kind of sense-making, it is arguable to conceive of real-time map construction which allows the listener to point to the music both in a continuous and discrete way and to leave a lasting trace together with its temporal index. These traces can be focal points or temporal extensions and can be implemented by envisaging computer software that allows the listener to tap a key at points that are selected as possible denotata and that appear as markers on the screen. These markers—and what they refer to—, can function as local deictics that can be used to set up a deictic space.

[197] Such kind of processing is copereceptual and is proceeding in real-time. It is possible, however, to work on the traces out-of-time as well and to try to assess the processes of abstraction and relational consciousness (cue abstraction, similarity judgments, categorisation processes (see Cambouropoulos, 2001) that can be applied to them. This work, however, mostly still has to be done.

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