Marc LEMAN, *Music and Schema Theory. Cognitive Foundations of Systematic Musicology*. Heidelberg: Springer-Verlag, 1995 (Springer Series in Information Sciences volume 31).

The author, Marc Leman, one of the active members of the IPEM (*Institute for Psychoacoustics and Electronic Music* at the University of Ghent in Belgium), is at the same time one of the two editors of the *Journal of New Music Research*, formerly known as *Interface*. Quite recently - volume 23, numbers 1 (March 1994) and 2 (June 1994) to be precise - the topic discussed concerned the theme of auditory models in music research. The list of authors - Leslie S. Smith, Neil P. McAngus Todd, Piero Cosi, Giovanni De Poli, Giampaolo Lauzzana, Guy J. Brown, Martin Cooke, Bernice Laden and Richard Parncutt - and the quality of the papers are sufficient evidence to conclude that a new domain of research is emerging within the field of musicology. As any philosopher and sociologist of the sciences knows, one of the most important characteristics an emerging discipline should acquire, is a series of foundational works. What we have here in front of us, is what deserves to be called the first of such a series.

The last sentence of the previous paragraph is sufficient reason for a review in a philosophy journal. But there is little difficulty in finding additional arguments. On the general level, it is common knowledge that the link(s) between philosophy and music are numerous, although at the same time philosophers seem reluctant to defend their views in published writings, Theodor Adorno probably being the most notable exception. Unfortunately, a lot of nonsense is written instead: philosophers often seem to join forces with mathematicians to uphold the Pythagorean-Platonic fiction of the musical phenomenon. Often we are supposed to hear numbers (whatever that is supposed to mean, but then the harmony of the spheres is mentioned) rather than sounds. What a relief when a musicologist-philosopher takes as a starting point the actual sounds that beat against our ear drums. What he is offering us is nothing less than a "naturalized" musicology. In addition, the last chapters of the book, especially chapter 12, *Epistemological Foundations*, are explicitly philosophical, so the reader (and this reviewer) does not need to guess as to what are the author's intentions.

The most distinctive feature of this book is its simultaneous mix of boldness and modesty. On the one hand, it claims that "the present study

[therefore] entails both a break and continuation with the tradition of systematic musicology." (p.191) It constitutes a break "because the qualitative and descriptive character of the phenomenological and Gestalt psychologically based paradigm is now replaced by a quantitative (computational), empirical and model based (computer based) approach." (idem) These are grand words indeed. But, on the other hand, when it comes down to the actual models themselves, the author is extremely modest in making it absolutely clear that a lot of work remains to be done, "not the task of one individual but, perhaps, of a community of systematic musicologists." (p.195) To be sure, I am not claiming that there is anything schizophrenic about the book. Quite the contrary: here is a grand proposal for new foundations supported by first-class empirical work. It almost looks like having the cake and eating it.

What is most impressive about the book, is chapter 10, *Evaluation of the Tone Center Recognition Model*. To explain why, let me draw a parallel. Usually in the field of Artificial Intelligence (AI), if a machine manages to put a pyramid on top of a cube in a reduced, totally artificial world, consisting mainly of pyramids, cubes and spheres, then we are deeply impressed (at least, we were at the time). So, what I expected here at best, was a program capable of recognizing elementary pieces, so elementary that they would not even have crossed Czerny's mind on a bad day. But not so: Leman's system has to analyze Bartok's *Through the Keys* (from *Microcosmos*), excerpts from *Brahm's Sextet no. 2*, and from *Chopin's Prélude no. 20*. Here we have a direct confrontation with the "real" thing. And the results are good to very good to excellent. This, on its own, justifies the importance of this book.

Although this is perhaps not the best of all places to discuss Leman's model in detail - I kindly leave this task to the musicologists, AI-specialists and neuro-scientists - let me nevertheless present some of the essentials. The key words are listed in the opening sentence of the *Introduction*: "This book is about schema theory, about how memory structures self-organize and how they use contextual information to guide perception." (p.1) The basic idea is to "mimic" the actual listening process: sounds reach the ear, are transformed into neuronal activity, are recognized and are interpreted. So we start with perception, we need contextual information to guide the perception, we want to have a brain that learns to recognize patterns in perceptual data so the brain has in some way or other to self-organize the structures that represent these patterns

in memory. Why we want the brain to self-organize is to solve the homunculus (or should one say, musiculus?) problem: where does tonal structure come from?

If one starts to think about the finer details of this process, it is extremely difficult to avoid, what I could like to call, *the musicologist's fallacy*: no matter how complex the actual processes taking place in the human ear, we can simplify the whole thing to tones with a specific height, toneness and dynamics and to treat these as independent properties existing prior to hearing and waiting just there to be heard. What Leman shows in chapter 2, *Tone Semantics*, and 3, *Pitch as an Emerging Concept*, is why it is necessary not to committ the fallacy. From a philosophical point of view, the examples he uses are quite interesting: perceptual illusions are not limited to the eye, the ear can be deceived just as easily as was shown by R. Shepard in his now famous experiments. The conclusion Marc Leman arrives at is that "pitch is now generally regarded as a concept that emerges from auditory information processing. Attributes, such as height, toneness and dynamics, are considered emergent properties of an underlying level." (p.31)

Starting from chapter 4, *Defining the Framework*, the (computer) model itself is presented in full detail, or rather the models. For Marc Leman wants to make clear that at the present moment we have no firm reasons to claim that this or that model is the "real" one (if any). However, what they all should have in common is one part that deals with the perception based on the findings in the previous two chapters, and another part that recognizes and interprets these perceived sounds.

Thus, in chapter 5, *Auditory Models of Pitch Perception*, the reader gets three computer models for pitch perception: SAM (Simple Auditory Model), TAM (Terhardt Auditory Model) and VAM (Van Immerseel and Martens Auditory Model). What comes out of these models forms the basis for the cognition part of the process.

In chapter 6, *Schema and Learning*, the process of self-organisation is introduced. Two types are discussed: (i) the SOM, the Self-Organisation Map, is a type of neuronal netwerk, also known as a Kohonen-map and, (ii), the TCAD, the Tone Center Attractor Dynamics. (i) and (ii) are not alternatives, but are complementary. SOM "constructs" the emergent properties that will act as (stable) attractors for TCAD. However, here they are treated separately. In chapters 7, *Learning Images-out-of-Time*, and 8, *Learning Images-in-Time*, S/T/VAM is connected to SOM - yes,

the models are indeed labeled SAMSOM, TAMSOM and VAMSOM - and the resulting model is set to work. I will not present the full details. Let me just mention that it is quite impressive to see the high degree of matching between the computer-model results and the psychological data (correlations run as high as 0.98). Chapter 9, *Schema and Control*, presents the full details of TCAD.

All of this then leads up to chapter 10 that I mentioned in the beginning of this review as the most impressive part of this book. I wrote that the results are good, but there is more to it: a few times, Leman has been forced, usually for practical reasons in terms of computer power and the like, to simplify matters somewhat, as he explicitly states. Nevertheless, these "mutilated" models still do an excellent job. So, it seems that Nature has been as kind to Leman as it has been to Newton. Although the latter was even more lucky: reduce earth and sun to points, introduce a mysterious force you don't quite understand, and, lo and behold, you still get things basically right!

Finally, chapter 11, *Rhythm and Timbre Imagery*, discusses some extensions pointing in the direction of a full-scale model that, who knows, in some distant or near future, might actually enjoy (or be extremely bored by) Beethoven's *Pastorale*.

The remaining two chapters, 12, *Epistemological Foundations*, and 13, *Cognitive Foundations of Cognitive Musicology*, are, as said above, explicitly philosophical. Marc Leman is not willing to make any concessions. He clearly formulates his position in terms of contrasting pairs. In summary, these are:

(i) continuity, not atomism: the basic material one had to deal with consists of the continuous flow of input sounds; it is a mistake to assume that one will find out there to be discrete already labeled bits, waiting to be discovered;

(ii) monism, not Cartesian dualism: there are no free-floating mental concepts on the one hand and the "raw" material on the other hand; they form an integrated whole;

(iii) complex system dynamics, not computational formalism: no comment needed, I presume;

(iv) naturalism, not representational realism: no comment needed;

(v) methodological ecologism, not methodological solipsism: in the author's own words, "the interaction with the world should be implemented because this is the starting point of all knowledge at higher levels.

Rather than being solipsist for methodological reasons, the non-symbolist is ecologist for methodological reasons. The model of a cognitive process is therefore also a model of the environment in which this cognitive process operates." (pp.183-184);
(vi) materialism, not cognitivism: the latter term is to be understood in the sense of formal systems and logics, that "float free in the air".

One of the nice consequences of his position is that, notwithstanding the focus on the neuro-physiological functioning of the brain, there is an explicit element of cultural dependency. In several places, Leman is explicit in denying any universal claim about his results, in the sense that all human beings should process sounds in precisely the same way. Cultural standards play an important part, e.g., in the learning process that is an essential component of his model(s).

At the same time, he remains modest about the whole undertaking. The difficult and hard problem of expressive meaning formation remains outside of the scope of the work presented here. However, he believes - as a decent naturalized musicologist should do - that models of this type are necessary ingredients of any non-trivial answer. Of course, the toughest philosophical problem of all is just around the corner: a decent theory of the meaning of meaning. Here, philosophers could and should join in. Indeed, it is definitely not the task of one individual, perhaps not even of a community of systematic musicologists, but of an interdisciplinary team including philosophers.

To counterbalance all this grandiose philosophical talk, let me mention, in between, two minor corrections that might confuse the non-mathematical reader: (i) to the definition on page 5 of the Γ-function should be added that a and b are relatively prime, otherwise $\Gamma(2/3) = \Gamma(4/6)$, but then $\Gamma(2*3) = \Gamma(4*6)$, which is false, as $\Gamma(6) = 4$ en $\Gamma(24) = 6$; (ii) the definition of $\theta(t,c)$ on page 25 entails that $\theta(1,1) = 0$, hence $\cos\theta(1,1) = 1$ and not -1; to obtain one of the maximum values of the function L(t,c) a possible choice is, e.g., $t = 1$ and $c = c_{max}/2 + 1$.

Finally, in conclusion, this reviewer cannot resist to formulate a personal remark. As a philosopher of mathematics, I strongly defend a program of naturalizing mathematics. Probably best known is, of course, Philip Kitcher's *The Nature of Mathematical Knowledge* (Oxford: Oxford University Press, 1983), but equally important in my mind are Brian Rotman's *Signifying Nothing. The Semiotics of Zero* (Stanford: Stanford University Press, 1993, reprint of 1987) and *Ad Infinitum. The Ghost in*

Turing's Machine. Taking God Out of Mathematics and Putting the Body Back In (Stanford: Stanford University Press, 1993). It is not hard to imagine the kind of resistance provoked by an undertaking of this kind. On a quite superficial level, mathematical proofs do have a strange likeness to musical scores. And, according to Marc Leman, many musicologists start with scores, not with sounds; just as mathematicians start with proofs, not with (mathematical) signs. Perhaps it is time that mathematicians, musicologists and philosophers join forces once again. In the past this holy alliance created the Platonic heavens where the perfect circle, full harmony and the essential transparency of the corrupt daily world are immediately given to those few able to see. Now it seems that an unholy alliance is in the making. But then it will be plain to see for all.

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