

Introduction: The many faces of human cognition in musical research and practice

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The presentations at the *Symposium on Music and the Cognitive Sciences* covered a vast array of approaches and aims from disciplines such as music composition, musicology, music theory, music analysis, experimental psychology, neuropsychology, mathematics, and computer science. These different approaches are briefly described. A plethora of fundamental concerns were raised across these disciplines. Those discussed in this chapter include the perception and representation of musical attributes, patterns, and forms, the mental organization of musical material and form, the development and learning of musical skills, and musical universals. A number of problems in the cross-disciplinary dialogue are also noted and discussed, with emphasis being placed on the problems that the basic assumptions of each discipline pose when considering what is relevant in other disciplines.

KEY WORDS: Mental organization, mental representation, multi-disciplinary dialogue, music cognition, music perception, musical development, musical universals.

In this introductory chapter, I would like to examine some of the promises and problems of the diversity of approaches that confront the field of music cognition, with the aim of evaluating how we might best proceed as a community in the near and more distant future. I am especially concerned with how we might establish and widen the channels of communication among disciplines, rather than re-trenching ourselves in our various restricted domains. With this aim in mind, the near future is certain to continue the frustration felt by many, but a serious consideration of what is "relevant" in other domains of musical thought, aside from one's own, is bound to be important if we are to understand something of the diversity of musical experience and research.

The approaches and aims

At the base of all musical study is the product of the one who creates the music, be it noted, improvised, or passed on by oral tradition. Our culture being dominated by what Trevor Wishart (1985) calls the "class of scribes", participation by creators of music at the symposium was not so surprisingly limited to composers, though all of those present use electro-acoustic technology in their works and thus do not confine their activity to notation on the page. When they write, composers most often reflect on their own creative concerns and on how they organize their thought and work. Some explicitly examine the way issues in the cognitive

sciences have influenced their composing, and what their compositional approaches have to offer to cognitive study itself. But ultimately, their aim is to make music rather than words. That they consciously reflect and write on what they do should be considered a boon to the scientists interested in musical activity, since scientific studies on the processes and concerns of composition are extremely rare.

Musicology, music theory and analysis try, as a group of disciplines, to describe what forms music takes, to explain what the constituents are, and how and why these evolved, and even to evaluate critically the end results. Their concerns are perhaps much broader today than they were in the past. Many, like Jean-Jacques Nattiez (1987, p. 15), consider the *musical work* to be more than a notated text or ensemble of structures (configurations as he would prefer to call them). It also includes the processes that gave birth to the music (the acts of composition) and that manifest it in the world (the acts of performance and perception). The analytic endeavor often draws from formalization practices in other fields, such as linguistics, semiotics, mathematics, historical and epistemological research, biology, sociology, cognitive psychology, and so on. But their primary concern is most often considering and explicating the specifically musical in terms of the constituent elements of music. The particular interest of the work of theorists for more psychologically oriented researchers, is to have some reasonable formulations of the structure of music as a starting point for theory and experiment that aims at an understanding of how humans actually conceive, perform, and experience music.

Experimental psychologists seek to establish tendencies, constraints, and possibilities of the mental mechanisms that underly musical activity and experience. They try to find a way of describing musical structure and process in a way that reflects as much as possible the mental structures and processes by which music is created, reproduced, and understood. To do this, experimental method obliges the scientist to measure some kind of behavior that then allows one to infer the mental states and processes that underly it and to relate these to the original stimulating acoustic structure. The aim can be to use music as a means of understanding more about the human mind in general, or of using knowledge of the mind to explicate observable aspects of musical experience. The interest of psychological theory and data for other domains is that they can offer an empirical test of compositional or music theoretic hypotheses, and that theory based on empirical results can extend the base of the composer's, theorist's or music teacher's craft by advancing their *conscious understanding* of musicians' intuitions. This work also provides models and constraints for research in neuropsychology and for work in computer simulation.

Neuropsychology tries to elaborate the brain structures and functions underlying human activity. The musical neuropsychologist through a knowledge of neuroanatomy, neurophysiology, and clinical neurology seeks to determine which parts of the brain are involved in various aspects of musical activity and to understand the contribution of general and music-specific neural mechanisms to musical perception, thought, and production. Musical neuropsychology mostly proceeds with the methods of experimental psychology, testing both normal people and patients with various kinds of brain damage, in order to show how certain kinds of damage affect certain aspects of musical mental function.

The last domain that is represented in this volume is one where researchers try to formalize understanding of a physical, music theoretic, psychological or

neurological nature in mathematical formulae or computer programs using techniques developed in artificial intelligence or in other computational domains. The approach of some modelers is to achieve an output behavior similar to that of humans when exposed to music. This is a way of testing our understanding of the operation of mental and physiological mechanisms in musical activity. Some people try to go further in assuring that the way the program functions is also a simulation of the way the human information processing system works, even in the intermediate stages. The interest for other domains is the concrete nature of this research. One might claim that to be able to formalize one's knowledge is to truly understand the phenomenon in question, though this is surely open to debate.

Some fundamental questions

In spite of this diversity of approaches and issues, several fundamental concerns emerge in cognitive considerations of music, some of which are presented below. The selection cannot help but be subject to my own biases as an experimental psychologist that is in constant contact with composers of electroacoustic music.

Perception and Representation of Attributes, Patterns, and Forms

This area concerns the mental representation of sound attributes and relations, and of their ordering in systems of relations, and the representation of specific musical patterns and forms. What are we capable of learning and storing in memory, and of comparing across time? This is clearly one of the important questions concerning what is possible as musical form.

Another important question concerns the psychological reality of reductional representation, a hypothetical construct dear to all Schenkerian analysts and their descendants, not to mention many other schools of music theoretic thought. The notion of reduction of several events to a single abstract one at a higher level of representation has a certain intuitive appeal at some levels of musical elaboration. But the psychologist becomes a bit skeptical when claims are made to extend this to a whole piece. Of pressing interest is a program of research that puts this notion to the test in order to determine to what extent reductional representation is real, to what levels it extends, what its limits are and why.

The notion of associational structure, evoked in several papers, particularly with respect to the notion of "parallelism" of musical structure is badly in need of formalization, or at least clarification, in music theory, and of empirical testing in experimental psychology. It seems clear that such relations can strongly influence musical perception, particularly when striking or repeated events or patterns adopt the function of Signs (cf. Clarke, this volume). It also seems clear that hierarchical structure is not sufficient to explain the experience of musical form, but we do not have a clear agenda for how to proceed. Explorations in the degree of perceived relations among patterns or "indices" of musical segments, and their contribution to form cognition, is an appropriate and important first step (cf. I. Deliège, this volume).

The distinction between declarative and procedural knowledge raised by Krumhansl would seem to be an important one. As Dowling discusses, there are

aspects of musical knowledge representations and processing that may be more pertinently considered as procedural, many of which have to this point been conceived in declarative terms. This implies that they are less available to conscious verbal interrogation and may require the development of new methods of measure and experimentation. The shift of perspective necessary to digest this point of view is non-trivial. A lot of clarification is necessary in our thinking about what representations are good for in our explications of musical activity.

It is of capital importance to extend the few studies to date (and most notably work by Francès starting in the 1950's, cf. 1972/1988) that have made serious attempts to investigate musical dimensions and systems outside of pitch and rhythm as confined to the Western tonal/metric system. The reason for studying within these confines are surely justified, i.e., most of the Westerners that psychologists study have far greater experience within this system than outside of it. But for research in music cognition to claim an important place in the interaction with composers and theorists, the horizons need to be opened. Directions have been indicated for pitch research in non-Western cultures, in atonal and serial idioms, and to some extent with micro-tonal systems. Much work remains to be done both in theory and experimentation on the bases and possible future evolution of 20th century harmony. Similar efforts could be directed to rhythm research. At the top of the agenda should be work on timbre, and here the door is open for vital interaction between composers, theorists, and psychologists to determine the limits and possibilities of timbre as an essential form-bearing dimension in music. This has importance for the development both of orchestration and sound synthesis techniques.

Mental Organization of Musical Material and Form

It is encouraging to see an increasing concern with mental *process* in musical activity, after so many years of concern primarily centered on mental *structure* and representation. This brings into play the essential dimension of time and temporal experience. Two of the key notions that have been advanced which distinguish structure and process and, at the same time, show the way to their relationship, are abstract knowledge structure and event structure (Bharucha, 1984; Deutsch, 1984; McAdams, this volume), the latter being a representation that is accumulated through time in the process of listening, or generated through time in the process of performing. They depend both on already acquired knowledge as well as on processes of perceptual or motor organization. A concerted effort to more clearly define their respective natures and interdependencies will be important for our understanding of real-time music cognition. This also concerns the ability to draw together perceived materials widely separated in time, and to plan detailed temporal relations over long time periods in score-based or improvised performance.

One of the more elusive aspects of real-time musical experience is the generation, modulation, and resolution of expectation. This would have its counterparts in the conception of implication in composition and improvisation, in its realization and reinforcement in expressive performance, and in its perception and resolution in listening. Work on this problem at the level of music theory is included in the chapter by Narmour. A crucial psychological question concerns the relation between these music theoretical constructs and the theory of anticipatory mental

schemata, addressed in part here and elsewhere by Bharucha. This problem area is very closely related to that of the accumulation of event structures. One might imagine that partially accumulated event structures that match well-formed or familiar schemata would tend to create a sense of expectation, that is, to imply the eventual realization of the schema in question. Understanding the conditions and time course of the realization and its experience may be a direction that allows the experimental sciences to at last approach some of the more affective and aesthetic aspects of musical experience that, for many reasons, have been left to the side for the time being (cf. Clarke, Krumhansl, this volume, for other points of view on this last question).

Development and Learning of Musical Skills

Omnipresent in any discussion of development is the question of those aspects of mental structure and process which exist at birth (the "initial state", as some call it). The degree of innateness attributed to various perceptual and cognitive capacities often depends on the (tacit) philosophical stance of the researcher. A wide spectrum was seen in the few papers that addressed such issues at this symposium, but no experimental work was reported on neonate or infant perception and cognition that might indicate the nature of precursors to musical skills. In fact, such work is relatively rare and extremely difficult to do (but see Zenatti, 1975, 1981; Shuter-Dyson & Gabriel, 1981; Hargreaves, 1986; for reviews of issues in the development of musical abilities). The question is: what do we possess at birth that allows the development of musical skills and to what extent are they specific to music, if at all? Or do general mechanisms of learning exist that allow either the acquisition of domain-specific skills in music listening and production, or the acquisition of general cognitive skills that serve musical as well as other activities?

Developmental problems in general, which could do much to advance techniques of music education, have not been much treated. It would be fruitful to examine the process of development of musical skills, including possibilities and limits at different ages, for the activities of listening, performing, comprehending, analyzing, improvising, and composing. How do these various skills develop in conjunction with other perceptual and cognitive skills such as language, seeing, reading, reasoning, calculating, and imagining? Do they in some ways share common cognitive architectures?

Learning is also important at adult ages, as we are forever encountering new musical works, idioms, styles, and cultures. Learning concerns the storage and accommodation of information and knowledge with the purpose of modifying existing knowledge structures, perceptual strategies, and action strategies. The learnability (whether by conscious effort or by passive exposure) of various musical systems, patterns, and forms is of crucial importance for an understanding of contemporary musical experience where those listeners who are interested in the "art" music of their time are constantly struggling with novelty of sound and organization and, at times, with what Lerdahl (1988) has characterized as a divorce between compositional and listening grammars.

Musical Universals

Much debated at the symposium and extensively discussed in the chapter of

Dowling, is the question of universals in music. Some people seem to have a tendency to confuse questions of innateness with those of universals. But as Dowling points out, the *capacity to acquire* certain mental structures for music could be universal throughout the human species. What he raises is the question of the appropriate level of consideration when discussing universality of some perceptual or cognitive capacity. For example, it may be that octave equivalence is not an *a priori* universal property of human hearing, whereas humans universally have the *capacity to learn* this equivalence if exposed to an appropriate musical environment. It seems likely that consideration of universal capacities to represent, organize, and learn musical structures, may be a more fruitful approach to the question than trying to make claims for specific structures found in individual cultures.

This cursory overview certainly does not exhaust the many fundamental issues confronting students of music cognition. But I feel it includes some of the more urgent ones that should be considered from the many disciplines currently investigating music cognition.

The challenge of cross-disciplinary communication

When one comes from another discipline, it is sometimes difficult to achieve an understanding of what researchers in a certain domain are trying to accomplish and of what methodological limits are posed by their discipline. Clearly none of us can take everything into account in any given study, whether it be of a musicological, music theoretic, music analytic, psychological, neurological, or computational nature. It seems that disputes across disciplines are often based on misunderstandings of the vocabulary, methods, aims, and a certain vision of what is "relevant" for the other discipline. The problem of what is "relevant" seems varied and elusive. The many concerns and approaches are, I believe, fairly clearly stated in the chapters that compose this volume. I leave it to the reader to ferret out their basic assumptions and limits.

The challenge and the stakes are clear. If this symposium showed us one thing, it is that we have a long way to go to be able to communicate freely among the disciplines. As I stated at the beginning, for those with the desire to continue the dialogue, a certain amount of frustration is still in store, and patience is called for. The members of each discipline have a lot to learn about the others. We have several sets of vocabulary and explanatory concepts that are only partially overlapping. Adopting an autodidactic will is a first step to resolving the problem of inter-education. One hopes that the making and appreciation of music itself will benefit from the attempt. One hopes also that such coordinated effort will help establish the study of music as a viable, important, central domain of research in human cognition, rather than leave it in the margins as the larger scientific community has a tendency to do with anything associated with the arts and letters. I personally feel we have a critical mass of good will and genuine concern to carry on the ancient dialogue between music and science. The diversity of relevant approaches is a testament to the complexity of the problem. It is necessarily the affair of a multi-disciplinary community.

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