

Forschungsberichte

Eric F. Clarke

What is conveyed by the Expressive Aspect of Musical Performance?

Introduction

The aim of this paper is to try to demonstrate that there is a continuity between aesthetic approaches to the concept of musical expression, and certain perceptual and cognitive issues that arise out of empirical studies of musical performance. In this respect the title of the conference to which this paper contributed is particularly apt: "Cognitive structures and aesthetic experience" encapsulates very succinctly the linkage around which this paper revolves, and points to a relationship that has not been seriously tackled by the great majority of work in the psychology of music. I will start by making a number of points of a general kind which form a background to the more narrowly focussed ideas on musical performance expression which follow.

First, there is the relationship between aesthetics and cognition. The separation implied by the need to join these two words together is a feature of the overwhelming majority of research in the psychology of music, and is defended by a rationale that is both attractive and problematic. It is a widely expressed opinion that the psychology of music is best tackled by initially dispensing with aesthetic issues (which are often portrayed as being fascinating and profound, but an unnecessary luxury) and concentrating on "basic" perceptual and cognitive issues. Once having fully understood these fundamental processes, on which aesthetic matters are built, the psychology of music may turn its attention to the rarified and complex realm of aesthetics. The attractive feature of this approach is the promise that the undeniably complex nature of musical experience can be broken down into a coherent series of stages of enquiry, commencing with relatively uncontroversial and value-free basic perceptual and cognitive processes, and climb-

ing a ladder of increasing complexity until the highest level of musical and aesthetic issues has once again been reached.

A prominent example of this position is Lerdahl & Jackendoff's "A Generative Theory of Tonal Music" (1983), in which this particular kind of reductionism is spelled out and put into practice with admirable clarity. But, as I have pointed out elsewhere (Clarke, to appear), it is significant that the approach breaks down on the lynch-pin of the musical idiom with which they are concerned – the cadence. Without going into the details of the matter, in the development of their pitch reduction methodology they are obliged to treat the cadence as an undecomposable *sign* so as to avoid being led by their own system into a situation where different types of cadences cannot be distinguished, and the tonal function of even the most straightforward cadence is not adequately conveyed. The significance of this is that their recognition of the sign-like nature of the cadence undoes the bottom-up, simple-to-complex logic of their system by introducing a complex entity (the cadential sign) as a basic element. Unless one regards tonality as a nature system that can be accounted for in purely acoustical terms (which Lerdahl and Jackendoff do not) then, since sign functions are inherently systematic, this is also a recognition of the systematic and culture-bound nature of even the basic units of tonality, and hence the penetration of cultural *values* down to the most detailed level of the system. In essence this is no more than a recognition of the social and cultural character of human mental functions – a proposal that would hardly be denied when stated so directly, but which is all too easily lost from sight in the construction and development of cognitive theories. If we are really interested in *music* psychology, then an aesthetic element must be retained, since it is this which distinguishes musical from simply auditory issue.

The second general point that I want to raise is concerned with the approach to perception and cognition developed by James Gibson (e.g. Gibson, 1966). Gibson's ideas about psychology are significantly different from those of the information processing tradition which has come to dominate the psychology of music, and while I have no intention of trying to deal with these in anything approaching a comprehensive manner, certain aspects of his thinking are important for a consideration of expression in musical performance.

Gibson's psychology is characterised by a concentration on the mechanisms of perception, which has led some critics of Gibson to claim that he rejected or ignored the significance of cognitive processes. It has been argued, however (e.g. Reed, 1987), and is apparent in Gibson's own writing, particularly on language and art, that Gibson was trying to resist and push back the progressive invasion of perceptual issues by modern cognitive psychology, so as to map out the respective domains of perception and cognition, and to clarify the boundary between the two in order to understand both of them better. In this interpretation, Gibson's aim was not to supplant a cognitive approach to psychological issues with a purely perceptual one, but rather to restore a balance between the two. Connected with this aim was Gibson's insistence on the need to acknowledge the *active* nature of perception: cognitive psychology tends to portray the perceiver as a static and meditative organism, with a reflective style of thinking and perceiving which is heavily influenced by the computational metaphor that is currently so dominant. But perceivers are active in two senses: first, they are active explorers of their environment and hence pick up rich, dynamic information from it that is simply not available to a stationary subject; and second, perception is linked to action, which is either the consequence of perceptual information, or the source of that information. Essentially this view strikes at the subject/object dualism of the majority of cognitive psychology, and emphasises the dialectical relationship of organism and environment, and an environment described with reference to an organism. The clearest expression of this is in Gibson's concept of *affordance*, which can be somewhat simplistically defined as the possibilities or "use-value" offered by an object to a perceiver (or discovered by a perceiver in an object) in a particular context. To give a concrete example, a stick *affords* use as fuel to a person who wants to light a fire, and it also *affords* use as a defensive weapon to someone who wants to ward off an aggressive dog. Neither of these two uses is the "real" use for the object, and the other an idiosyncratic alternative: affordance is a truly dialectical concept since it arises out of the needs or requirements of an organism in a particular context and a particular time as they meet the possibilities offered by an object. The object really is both fuel and a weapon.

The second aspect of Gibson's thinking which is important is his in-

sistence on the need to consider what *is conveyed* by perceptual information, rather than the detail of the information itself. This is a consequence of his rejection of the idea that we experience sensations first, which are then organised into more coherent percepts, and his emphasis upon the primacy of perceptual events. Gibson's view of perception is that events are what we pick up from our environment most directly and immediately, and our ability to experience the sensations that they comprise (which is very limited) is the result of an analytical effort that *follows* the initial perception of the event. This has interesting though problematic implications for our understanding of music perception, since it begs the question of the nature of musical events. The acoustical information of music specifies a number of different kinds of event, ranging from quite concrete events such as the recording medium and recording environment from which the acoustical source originates, or the instrumental source of a sound (e.g. the acoustical information for a flute), through to rather abstract kinds of musical events of a structural kind, such as a melodic unit, a key or a metre. It seems to be a rather promising approach to ask what information is necessary to specify a key or a metre, since it focusses on the central relationship in music between the concrete musical "surface" and these more abstract musical events which are the stuff of our musical experience. In the study of performance expression in particular, it suggests that the central question to ask from a perceptual point of view should be "What events are conveyed to the listener by the information in a performance, and how are they conveyed?"

The final point about Gibson that I want to make concerns the distinction between direct and indirect, or mediated, perception. As the preceding discussion of the relationship between information and events implies, Gibson regarded perceptual events as being directly specified in the information reaching a perceiver's sensory systems, the process of perception being the pick-up of this rich source of knowledge about the environment. This is known as the theory of direct information pick-up, or as the theory of direct perception. While Gibson argued strongly for the application of this idea to the whole range of perceptual contexts, he also recognized that where the system and artifacts of human culture are concerned, perception cannot be regarded as having this entirely unmediated quality, but must be seen as a process whose basis is direct, but which is rendered indirect or

mediated by the codification of culture. The most obvious example of this is language: a direct perception approach can provide an interesting account of the way a listener picks up phonemes from the acoustical information projected by a speaker (see e.g. Fowler, 1986), but it cannot account for our understanding of the meaning of an utterance in a particular language, since that depends upon knowledge of a conventional code which cannot be directly specified in the perceptual information itself. The same considerations can be assumed to apply to music: it is perfectly possible to develop a direct perception approach to our pick-up of the basic building blocks of musical structure, such as the identification of the instrumental and directional source of sounds, or the coherence of identifiable lines in a complex texture, but a listener or performer's understanding of the most crucial aspects of a musical structure depends on an awareness of systematic frameworks, such as tonality and metre for western tonal music, which are culturally specific and contain a conventional or arbitrary component. The problem that this raises for a Gibsonian approach is that it implies a rather sharp divide between "nature" and "culture", corresponding to direct and indirect perception mechanisms. Not only is it somewhat uncomfortable to have to explain different aspects of a phenomenon with such fundamentally different approaches, but the divide also raises a number of tricky questions about coordination and communication between the two, and the extent to which a clear line of demarcation can be drawn. Informal observation argues against a separation of this kind, since knowing about the formal conventions of a musical style can help a listener to make perceptual sense of the immediate flow of events in a manner that suggests an extensive interpenetration of direct and indirect processes.

The third general point I want to address concerns music performance and the reasons for studying it. There are two separate issues here: the first is that musical performance is interesting to study in its own right, not least because of the close relationship between the high level of physical skill that it requires and the sophisticated cognitive processes that it embodies. In the last decade, a significant body of literature has built up around the study of music performance, taking a number of different perspectives which include motor programming (Shaffer, 1981; 1982), communication (Sloboda, 1983), rehearsal strategies (Gruson, 1988), generative theory (Clarke,

1988; Todd, 1985), tempo stability (Clynes & Walker, 1982), and coordination ensembles (Rasch, 1988). In all these studies, musical performances themselves are the object of enquiry and, particularly within the framework of motor programming, offer a fascinating context within which to investigate the relationship between symbolic representations (the knowledge that a performer has of a piece) and their concrete manifestations in action (the performance itself). Expressed in these terms, music performance can be seen as a striking embodiment of the interdependence of action and perception that Gibson emphasised, nowhere more so than in musical improvisation (e.g. Clarke, 1987; Pressing, 1987; Reinholdsson, 1987).

Musical performance can, however, also be used as an environment within which to study the cognition of a whole range of musical structures, by regarding expressive performance effects as the signs of a variety of structural forces (e.g. Clarke and Baker-Short, 1986; Sloboda, 1983; Todd, 1985). In the studies referred to above, the performance data (particularly timing data) are used to infer the properties of underlying representations, of either a motor or a more generally cognitive variety. In the second kind of enquiry, the performance data are regarded as *symptomatic* of the organisation of other parameters of musical structure rather than the primary focus of study in their own right – as signs rather than objects. This may appear a rather roundabout way of investigating these other parameters of musical structure, but the approach offers one solution to a significant problem in studying music perception and cognition, namely the “hidden” nature of musical percepts. Empirical investigation requires concrete data of some kind, but the majority of experimental methods used to study music perception are crude in relation to the supposed subtlety and sophistication of the mental processes that go on during playing, composing and listening. Music performance offers an overt behaviour of an exceptionally sophisticated and subtle kind which can offer a window into this largely hidden domain. Indeed, in the light of the intimate relationship between perception, cognition and action discussed above, musical performance can be thought of as a particularly concrete kind of *musical thinking*, the properties of which can be rather directly studied.

My final general point concerns the different uses of the word “expression”. The two senses in which this word is commonly used are, on the one

hand, to refer to what a piece of music expresses or means, and on the other hand to refer to a rather more specific and detailed attribute of music, namely the expressive features of a performance that a player uses to convey a particular aspect of the music and his/her interpretation of it. The first use of the word is one that is primarily associated with aesthetic issues (e.g. as explored by Cooke, 1959), with everyday assessments of the *extent* to which a particular piece or style is expressive (e.g. “*Verklärte Nacht* is an expressive piece”; “I don’t find serial music very expressive”), and with statements about what a piece means to someone (e.g. “Mahler’s third symphony expresses optimism about the hope of resurrection”). It is a property of musical experience which has not been tackled empirically to any great extent (though see Gabriellson, 1973 and Imberty, 1975).

By contrast, the second and more concrete sense of the word, which is used to indicate those aspects of a performance which are not directly specified in the score and which appear to be intentionally, though not necessarily consciously, introduced by the performer, has been more thoroughly studied. My intention in this paper is to show that while it is legitimate to distinguish between the two senses of the word expression, there is nonetheless no real discontinuity between them, an investigation of the apparently more technical use of the word leading directly into aesthetic issues. It is therefore to empirical research into performance expression that I now turn.

Expression in Musical Performance: Production

Partly as a result of developments in microcomputers and digital music technology, there has been a considerable amount of research in the past decade into detailed aspects of musical performance following a long gap since the pioneering work of Seashore (1938). The vast majority of this work has adopted the perspective of production, with an emphasis on timing patterns (e.g. Clarke, 1982; 1985; Clynes & Walker, 1982; Gabriellson, 1987; Sloboda 1983), motor programming (Shaffer, 1981; 1982; 1984), and the kinds of process that transform an abstract representation of a piece into an expressive performance (e.g. Clarke, 1988; Sloboda, 1982; Sund-

berg, 1988; Todd, 1985). A primary goal for this research has been to demonstrate and investigate the relationship between musical structure and performance expression, with an emphasis on attempts to describe this relationship in terms of generative rules.

The essential framework within which this work is conceived is as follows. A structural representation of the music to be played is built up in the mind of the performer in one of a number of ways: either by reading musical notation concurrently with the performance, or by a process of memorisation prior to the performance, or (in the case of improvisation) by inventing a representation during the performance itself. However it is arrived at, and with the corresponding differences in scope that these different strategies entail, the structural representation serves as the source for a motor program which controls the movements required to produce the performance. The representation also serves as the basis for a range of expressive transformations (in dynamics, timing, articulation, timbre etc.) which are applied to the expressively neutral representation that a score embodies. This separation between an expressively neutral representation of the music and its expressive counterpart is more of a conceptual convenience than a psychological reality, since there is evidence (e.g. Clarke & Baker-Short, 1986; Seashore, 1938) that performers are unable to play entirely without expression. Nonetheless it serves to clarify the way in which the same source of information is the basis for both the timed movements that a correct performance of the piece demands, as well as the interpretative treatment that a given performer chooses.

Thus, for example, Shaffer & Todd (1987) describe data from piano performances of a Chopin *étude* which can be closely modelled by a simple parabolic timing function that takes a structural description of the hierarchical grouping structure of the music as its input. The implication of this result is that a performer makes use of timing, and presumably the other parameters of expression, to convey to an audience the structural outlines of the music at a number of levels. Whether this is consciously intended by the performer is uncertain and need not concern us here: it is sufficient to show that structure and expression have a close correspondence.

While it is important to demonstrate in precise empirical terms that expression is used to convey structure, the idea is not particularly startling

– particularly not to anyone who has had instrumental tuition to a reasonably high standard. Once the basic technical mastery of an instrument has been achieved, the primary function of tuition is to refine the interpretation of a piece based on a consideration of its structure and the best way to project it. But the problem is not quite as simple as it has so far been made to appear. Apart from certain unusual situations (such as playing musical dictation exercises for students to transcribe), performers do not use expressive devices to convey the most obvious aspects of musical structure, since those features *are* obvious and need no further emphasis. In many circumstances, a performer may be attempting to bring out characteristics or ambiguities in the music that would otherwise go unnoticed, and this may involve subtly *contradicting* some features of the music’s basic structural framework. A performer who dynamically intensifies the strong beat of every bar in a performance would be regarded as intensitive and *inexpressive*. This is not a licence to distort the musical structure with expressive deviations in an arbitrary way, since coherence and comprehensibility are still a requirement, but an element of unpredictability and playfulness is expected of a performer, particularly by sophisticated concert audiences. Just where acceptable freedom stops and waywardness starts is partly a matter of subjective taste, as the different reactions to idiosyncratic performers such as Glenn Gould illustrate.

This re-creative element in performance is increasingly important as audiences become more expert in their knowledge of the musical style concerned. This is particularly true of musical idioms such as traditional jazz, or the fiddle music of Ireland, where a comparatively small repertoire of different pieces of music in a primarily oral tradition are continually reinterpreted in performance. Traditional jazz, for example, is based around a core repertoire of “standards”, which are well-known to performers and audiences alike. The aim is for performers continually to find new features of the music to exploit, expressed through new styles of performance. The jazz singer Billie Holiday is a striking example of this: very little of the music she sang was newly written, but she was able to find highly original, and in some cases radically different, ways of performing the standards that made up her repertoire. To analyse the expressive characteristics of her performances in the hope of finding some simple correspondence with the

phrase structure, metre or melodic contour of the music would be misguided, since the kind of audience to which Billie Holliday habitually performed was by and large extremely familiar with the material she sang. The expertise of the audience ensures that there is no need to project the basic structure of the music expressively, since it is already known (the habit of jazz audiences applauding at the *beginning* of a tune, as soon as they recognise it, is an indication of this knowledge), and that what is expected is a re-working of the material. No systematic research exists on this, but listening to Billie Holliday's recordings of jazz standards provides powerful though informal evidence for the remarkable originality of her performance style, and for the dramatic way in which she chooses to treat the timing, pitch and vocal quality of the music.

Expression in Musical Performance: Perception

All that has been suggested so far about the production of performance expression and the purpose to which it is put assumes a considerable amount about the kinds of detailed features that a listener will detect. There has, however, been comparatively little systematic research on this perceptual issue. What little there is (e.g. Clarke, to appear; Clarke & Baker-Short, 1986; Sloboda, 1983) suggests that listeners are sensitive to changes in timing of as little as 20–30 msec., but that this is dependent on the structural context in which the changes occur. When tonal and atonal tunes with identical rhythmic properties and matched for melodic contour are compared, it seems that listeners find it harder to spot a small timing change in the tonal tunes than in the atonal, but easier to be sure that an expressively neutral tonal tune has no timing changes in it than for an atonal one. One interpretation of this result is that the effect of familiar tonal structure is to provide listeners with such a strong perceptual framework that small deviations from the neutral “norm” are assimilated to it and thus pass unnoticed, in much the same way that Gestalt psychologists observed that perceivers failed to notice small imperfections in strongly structured stimuli. By contrast, the atonal tunes are less perceptually compelling, and allow listeners to pick up surface disruptions more easily. For the same reason, listeners

are more successful in identifying the neutral tonal tunes than their atonal counterparts, because the combination of tonal structure and normative expressive treatment forms a more unified perceptual combination. .

A different study (Clarke & Baker-Short, 1986) examined the relationship between structure and expression with an experimental method which required that subjects try to imitate tunes that they heard. Keyboard players heard short tonal melodies with different patterns of expressive timing, and were required to play them back on a keyboard, imitating all aspects of the tune. Three versions of two different tunes were used, one being entirely without expression (“deadpan”), one having a pattern of expressive timing that was related to the phrase structure of the tune, and the third having a pattern of timing unrelated to the structure of the tune. The results showed two primary effects: first, as already mentioned, reproductions of the inexpressive versions showed small but definite expressive timing patterns. Second, subjects’ attempts to reproduce those tunes with timing patterns unrelated to the musical structure were far more variable than their structurally coherent counterparts. The result is, of course, a consequence of both perceptual and production factors, but it strongly supports the generative model of performance expression that was outlined earlier, and suggests that an arbitrary relationship between structure and expression may be both perceptually and productively unstable.

Sloboda (1983) has also considered the communicative function of performance expression using a combination of production and perception. In his study, pianists of various levels of expertise played two versions of a tune that differed only in the placement of the bar lines, one version starting on a strong beat, the other on a weak beat. The performances were recorded on audio tape, and data from the piano keyboard analysed. These data showed systematic differences in the timing, dynamic and articulation data from the two versions of the tune, the distinction between the two being clearer for the more expert pianists. Sloboda subsequently played the audio recordings of all the performances of the two tunes to a panel of listeners who were asked to indicate which of the two metrical versions each tune appeared to be. The task is a difficult one, since the only cues for a listener to pick up are subtle changes in the expressive features. Nonetheless, Sloboda found that the two versions of the tune could be reliably distinguished,

though only for the more expert performers, who appeared to be both more consistent and more didactic in their use of expression. It is interesting that the most clearly differentiated performances came from a professional pianist who was experienced in carrying out music examinations, a component of which is to play simple tunes to listeners for the purpose of melodic dictation. Detailed analysis of the relationship between the performance data and the listeners' judgements in the study showed that timing differences between the two versions of the tune seemed to be less effective than dynamics or articulation as a communicator of metrical orientation. As has been argued elsewhere (Clarke, 1985), this may be because timing changes are rather indeterminate in their structural meaning, by contrast with the relatively unambiguous emphasising function of dynamic intensification, or the separating function of staccato articulation.

There is an enormous amount more to be discovered about the perception of expression in musical performance: we know nothing about the way in which listeners distinguish between expressive deviations and errors, about the more qualitative aspects of the influence of structural context on the interpretation of expressive transformations, or about the affective impact of these properties. Nonetheless, the progress that has been made in the area can at least help us to present reasonably systematically an outline of the processes that seem to be involved and some of the questions that still remain to be tackled:

1. In order that anything at all is conveyed to a listener by means of performance expression, a *change* of some sort, or departure from a normative course of events, must be picked up. There is clear evidence that the ability to detect such a change is affected by the structural context in which it takes place, and it seems certain that it will be further affected by a number of other factors, such as the consistency with which such changes occur, and thus their predictability.
2. Having noticed a change, the *meaning* that is attributed to it depends once again on the immediate structural context, and on a variety of *beliefs* about the performer and the context in which the performance and listening take place. If the listener has little confidence in the musical or technical capacities of the performer, this may well affect his/her assessment of the intentional or accidental nature of what has occurred. A

child's performance would represent a rather extreme case of this, where, because of external knowledge about the nature of the performer, one may be rather less disposed to try to make sense of inconsistent information than if one was told that the performer was a "crazy genius".

3. Depending on the kind of structural and situational factors described above, various characteristics can be conveyed:
 - a) Structural features of the music.
 - b) The expertise of the performer.
 - c) Performance style: the repertoire of expressive features, and the way they are organised differentiates different historical performance practices from one another, and hence conveys various ideological associations that have become linked with these styles.
 - d) The performer's state of mind, either real or adopted: "expressive" information may be an important source of information about the anxiety level of a performer, and it can also be used by a performer to convey an adopted or fictional state of mind (such as may be required in an operatic role, or in *Lieder*), or to persuade an audience of a particular affective quality in the music.

This collection of observations brings me back to the point from which this paper started – namely the links between cognitive and aesthetics issues, and the continuity between the two meanings of the word expression. The features that can be conveyed by performance expression encompass a diverse mixture of components that appear to differ in their cognitive and aesthetic content. The truth is that no real division between these can be drawn, since musical meaning, which lies at the root of both aesthetics and understanding, is a function of both musical structure and the wider social and semiotic context within which all musical activity takes place. The involvement of cognitive processes in aesthetic experience is generally taken for granted, but it is equally the case (and far less often recognised) that in all but the most artificial laboratory environment, music cognition is aesthetic in character. The heterogeneous elements that go to make up the notion of expression in both its senses are hard to accommodate within a single term that conveys the complex interpenetration of individual and social, structural and affective, local and global elements.

Summary

This paper is concerned with the relationship between different meanings of the word expression, and the different kinds of approach to expression that have been adopted. Following a discussion of a number of theoretical issues concerned with the relationship between aesthetics and cognition, the application of a Gibsonian view of perception to music, and the reasons for studying music performance, the results of a number of empirical studies of both the production and perception of expression in musical performance are summarised. These are used to provide an outline of the kinds of question to be addressed in considering the communicative function of expression, and demonstrate the essential continuity between the aesthetic and cognitive components of this process.

References

- E.F. Clarke, 1982, *Timing in the performance of Erik Satie's "Vexations"*. Acta Psychologica 50, 1–19.
- E.F. Clarke, 1985, *Structure and expression in rhythmic performance*. In: Howell, Cross & West (Eds): Musical Structure and Cognition. London: Academic Press.
- E.F. Clarke, 1987, *The role of improvisation in aural training*. In: M. Henson (Ed): Proceedings of the RAMP Conference on Aural Training. Music Department, Huddersfield Polytechnic.
- E.F. Clarke, 1988, *Generative principles in music performance*. In: J. Sloboda (Ed): Generative Processes in Music. Oxford: The Clarendon Press.
- E.F. Clarke (to appear), *The perception of expressive timing in music*. To appear in Psychological Research, 1989.
- E.F. Clarke & Baker-Short, C., 1987, *The imitation of perceived rubato: a preliminary study*. Psychology of Music 15, 58–75.
- M. Clynes & J. Walker, 1982, *Neurobiologic functions of rhythm, time and pulse in music*. In: M. Clynes (Ed): Music, Mind and Brain: The Neuropsychology of Music. New York: Plenum.
- M. Clynes & J. Walker, 1986, *Music as time's measure*. Music Perception, 4, 85–120.
- D. Cooke, 1959, *The Language of Music*. London: Oxford University Press.
- C.A. Fowler, 1986, *An event approach to the study of speech perception from a direct-perspective*. Journal of Phonetics, 14, 3–28.
- A. Gabrielsson, 1973, *Adjective ratings and dimension analyses of auditory rhythm patterns*. Scandinavian Journal of Psychology, vol. 14, p. 244–260
- A. Gabrielsson, 1987, *Once again: the theme from Mozart's piano sonata in A Major (K. 331)*. In: A. Gabrielsson (Ed): Action and Perception in Rhythm and Music. Publications issued by the Royal Swedish Academy of Music no 55, Stockholm.
- J.J. Gibson, 1966, *The Senses considered as Perceptual Systems*. Boston: Houghton Mifflin.
- L. Gruson, 1988, *Rehearsal skill and musical competence: does practice make perfect?* In: J. Sloboda (Ed): Generative Processes in Music. Oxford: The Clarendon Press.
- M. Imberty, 1975, *Perspectives nouvelles de la sémantique musicale expérimentale*. Musique en Jeu. vol. 17, p. 87–109.
- F. Lerdahl & R. Jackendoff, 1983, *A Generative Theory of Tonal Music*. Cambridge, MA: MIT Press.

- J. Pressing, 1987, *The micro- and macrostructural design of improvised music*. *Music Perception*, 5, 133–173
- R.A. Rasch, 1988, *Timing and synchronization in ensemble performance*. In: J. Sloboda (Ed): *Generative Processes in Music*. Oxford: The Clarendon Press.
- E.S. Reed, 1987, *James Gibson's ecological approach to cognition*. In: A. Costall & A. Still (Eds): *Cognitive Psychology in Question*. Brighton: Harvester Press.
- P. Reinholdsson, 1987, *Approaching jazz performances empirically: some reflections on methods and problems*. In: A. Gabriellson (Ed): *Action and Perception in Rhythm and Music*. Publications issued by the Royal Swedish Academy of Music no 55, Stockholm.
- C. Seashore, 1938, *Psychology of Music*. New York: Dover Books.
- L.H. Shaffer, 1981, *Performances of Chopin, Bach and Bartok: studies in motor programming*. *Cognitive Psychology* 13, 326–376.
- L.H. Shaffer, 1982, *Rhythm and timing in skill*. *Psychological Review*, vol. 83 no. 5, p. 109–122.
- L.H. Shaffer, 1984, *Timing in solo and duet piano performances*. *Quarterly Journal of Experimental Psychology* 36 A, 577–595.
- L.H. Shaffer & N.P. Todd, 1987, *The interpretive component in musical performance*, In: A. Gabriellson (Ed): *Action and perception in rhythm and music*. Publications issued by the Royal Swedish Academy of Music no 55, Stockholm.
- J.A. Sloboda, 1982, *Music Performance*. In: D. Deutsch (Ed): *The Psychology of Music*. New York: Academic Press.
- J.A. Sloboda, 1983, *The communication of musical metre in piano performance*. *Quarterly Journal of Experimental Psychology* 35 A, 377–396.
- J. Sundberg, 1988, *Computer synthesis of music performance*. In: J. Sloboda (Ed): *Generative Processes in Music*. Oxford: The Clarendon Press.
- N.P. Todd, 1985, *A model of expressive timing in tonal music*. *Music Perception* 3, 33–58.