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Big sister Pitch's little brother Timbre comes of age

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The study of pitch perception and the processing of pitch structures and systems has largely dominated music psychology throughout its history. Other form-bearing auditory "dimensions" such as rhythm and timbre have been given only secondary and tertiary importance, respectively (McAdams, 1989). Timbre, that (until recently) ill-defined younger sibling of Pitch and Rhythm, has nonetheless increasingly captured the imaginations of composers, theorists, and scientists alike. What I will attempt in this brief presentation is to give a global view of some of the main directions the experimental and theoretical research is taking at present, as well as a few suggestions for important problems to address in the near future.

Among the main areas where research on timbre as a potential structuring force in music are making progress, I will discuss the study of auditory organisation processes (of which timbre, like all other auditory attributes, is a by-product), multidimensional analyses of the perceptual dimensions underlying timbre and their acoustic correlates, and the study of the perception of abstract relations among timbres. Other areas that are of interest , but which space does not allow me to discuss, include the recognition and memory of the timbre of sound sources and of sequences of timbres, as well as the perceptual interactions between pitch structures and timbral structures in music.

Auditory organization

Research on auditory organization processes has demonstrated that timbre is an auditory attribute resulting from the perceptual grouping of concurrent acoustic components (Bregman & Pinker, 1978). Therefore compositional control of the cues affecting grouping is an important consideration in the creation of timbral objects in sound synthesis and orchestration. Striking examples of this include the maximization of fusion cues such as parallel frequency motion, onset asynchrony and harmonicity in the composition of *Boléro* by Ravel. Capitalizing on the cues for fusion in the compositional structure allows the composer to use the orchestra as a kind of synthesis instrument with which he can build up a composite timbre with several instruments. Later in this century the "spectral school" of French composers continued in this tradition.

An important theoretical ground for explaining how auditory organization processes play a role in the control of dissonance have been laid by Wright & Bregman (1987). They propose a framework to explain how the perception of a timbral property such as roughness, which is one of the primary sensory components of musical dissonance, depends on the way simultaneously present sound events are organized by the perceptual system. If two overlapping events (that might otherwise create a dissonant harmonic interval when presented synchronously and in relative isolation) can be interpreted as belonging to independent sequential auditory streams, then their degree of perceived dissonance is lessened. It remains for these ideas to be tested experimentally (though see Bigand *et al*, this conference, for a beginning approach), but if they can be supported by experimental data, the implications for compositional practice and orchestration are far-reaching.

Some of the acoustic dimensions underlying timbre are important factors in the organization of the musical surface into melodic streams and segments, indicating that compositional control of timbre can also be a structuring force at this level (Deliège, 1987).

Multidimensional analysis

The timbre of a perceptually fused event has been shown to have a multidimensional character (Plomp, 1970; Miller & Carterette, 1975; Grey, 1977). This multidimensional analysis has even been extended to timbral blends (Kendall & Carterette, 1991). Current research in several laboratories has allowed us to define the acoustic dimensions and auditory processes that result in this complex perceptual representation (cf. Krimphoff *et al.*, 1994). This work may well provide the basis for the development of perceptually relevant control of sound synthesis or of computer-assisted orchestration algorithms. Multidimensional representations have also been shown to be sensitive to context effects only for certain kinds of timbral variation (see Donnadieu *et al.*, this conference) and future work

should be oriented toward understanding the importance of musical context on the perception of musical relations among timbres.

Perception of timbral relations

Recent work further suggests that relations among timbres may be perceived in their own right, giving rise to the possibility for composition of timbral melodies that can be recognized under various kinds of transformation such as transposition. Timbral intervals can thus be defined with respect to the relative positions of timbral objects in a multidimensional space that captures the mental representation of a set of timbres within a given context (McAdams & Cunibile, 1992). These early results were encouraging but need to be extended under more controlled conditions to verify the notion that listeners are truly capable of extracting and comparing relations between timbres as opposed to comparing the timbres themselves.

A number of limitations to this fine-grained structural use of timbre in ways analogous to pitch need to be pointed out. These have to do with the very close relation that timbre holds to the inference of the physical cause of a sound event, linking it inexorably to identification and thus to an absolute perception of the source rather than to the structural relation of the event it has produced to surrounding events. What melodic perception, and the very notion of transformation of musical materials, presume is a perception of abstract relations between the perceptual attributes of a sequence of sound events. If we tend to perceive timbre in a more absolute way, it may be difficult to use it in situations where perception of a musical development depends on the abstraction of relations. That timbre is perceived more absolutely in sequences than is pitch is suggested by the work of Krumhansl & Iverson (1992) which has shown that detection of change in the pitch of a note in a melody is affected by the stability of the surrounding pitch intervals while detection of change in a note's timbre is unaffected by such changes in the surrounding timbres.

Of course, one cannot rule out the possibility that this perceptual tendency is the result of acculturation. Given that the structures present in the music of most cultures do not appear to employ invariant transformations of timbral relations, as occurs with pitch configurations, it may be that children never learn to extract such relations quite simply by lack of exposure to them. It would be very interesting to do long-term developmental studies on the acquisition of these kinds of abilities. But that would imply the existence of an educational infrastructure that seems rather utopic given today's cultural context.

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