ABSTRACT

1. Background

Various theories in music perception and cognition, from classical gestalt theory to more recent experimental work and data-driven modeling, have contributed to our understanding of chunking in musical experience (see Godøy 2008 for a summary). But our own research on music-related body motion has singled out intermittency in motor control, i.e. a basically discontinuous and point-by-point control scheme, as an essential factor in chunking. Classical motor control theories with claims of so-called closed loop continuous feedback have in recent years been challenged by models suggesting intermittent control, manifest in so-called open loop and preprogrammed motor commands, because continuous feedback loops are thought to be too slow for many highly demanding tasks (Loram et al. 2011, 2014). Various findings in human motor control, i.e. the so-called psychological refractory period, principles of posture-based motion control, of action hierarchies, of goal-directed behavior, etc., and our own research on music-related body motion, seem to converge in suggesting the existence of intermittent motor control for chunking at the short-term timescale of very approximately 0.5 seconds duration, all in all suggesting that there are what could be called quantal elements in musical experience (Godøy 2013).

Our interest in chunking stems from several years of research and reflections on what Pierre Schaeffer called sonic objects (Schaeffer 1966), i.e. holistically perceived fragments of musical sound in the approximately 0.5 to 5 seconds range, and which we with Schaeffer regard as one of the most essential elements of musical experience (Godøy 2006). However, this also leads to questions of what are the criteria for the constitution of such sonic objects, and of how they are perceived in musical contexts. It seems that various features in the auditory signal (e.g. shifts between sound and silence, contrasts in pitch registers, contrasts in timbre, or the occurrence of repeated patterns, etc.) may be fairly robust cues for chunking, but in many cases, these cues may be less salient (e.g. be weak, competing, masked, or even temporarily absent), requiring the use of other perceptual schemas. Adopting a so-called motor theory perspective (Galantucci, Fowler, and Turvey 2006) on music perception in general and chunking in particular, we believe images of sound-producing body motion may be effective in chunking continuous streams of sound into somehow meaningful units in musical experience (Godøy 2001, 2003, 2013, 2014).

The basic tenet here is that schemas of sound-producing body motion are projected onto whatever musical sound it is that we are hearing. This in turn means recognizing a number of constraints of body motion and motor control, something that suggests an unequal distribution of attention and effort in musical experience. Although the underlying neurocognitive processes of our organism may very well be continuous (Spivey 2008), the main argument for intermittency is that control takes time, and that continuous feedback is just not feasible (Loram et al. 2011, 2014). The various constraints of motor control also fit well with the idea of action gestalts as optimal for our organism (Klapp and Jagacinski 2011).

This means that we need a novel theory of chunking based on the idea of intermittency in motor control. Such a theory should also be capable of accommodating the (seemingly paradoxical) coexistence of continuity and discontinuity in musical experience, something we shall argue is possible by recognizing intermittent motor control of chunks, yet recognizing that chunks unfold continuously in time, and furthermore, that the concatenation of several chunks in succession may give rise to subjective sensations of continuity in musical experience.

2. Aims

The aim of the presentation is to demonstrate a novel model of intermittent motor control in musical performance and its consequences for chunking in music perception, based on convergent findings in several domains and our own research on music-related body motion, in particular our findings on coarticulation in music-related body motion, i.e. the fusion and the contextual smearing of otherwise distinct motion and sound events into holistically perceived chunks. The main claims of the model are as follows:

• That chunking is based on a confluence of production constraints
• That anticipatory cognition is manifest in sound-producing (and also sound-accompanying) body motion
• That we have fusion by coarticulation in musical performance
• That we need a more rigorous analysis and differentiation of timescales involved in the perception and production of music, and notably so, of both sound and corresponding body motion.

This last point means that we in particular need to differentiate the features of the sub-0.5 seconds timescale, what could be called the delta timescale, and which typically includes the psychological refractory period, as well as coarticulation and thresholds for so-called phase-transitions, meaning the fusion of singular events into superordinate events (or conversely, the fission of superordinate events into singular events), all dependent on the rate (the speed or temporal distance) and duration of events (Godøy 2014).

Furthermore, the model should establish chunking in music as conditioned by goal-directed behavior, similar to goal-directed body motion in various everyday contexts, and as focused on certain salient postures (Rosenbaum et al. 2007). We could say that chunking is focused on what we call key-postures, meaning salient shapes and positions of the effectors (fingers, hands, vocal tract, etc.), and that there is continuous, coarticulated motion between these key-postures. Furthermore, we think these key-postures are found at salient moments in time, typically at downbeats or other accented points in the
music, at what we call goal-points. In music, we think of these key-postures at goal-points as surrounded by prefixes (trajectories to the key-postures) and suffixes (trajectories from the key-postures), with overlap of suffixes and prefixes in sequences of chunks producing the effect of continuous motion. The basic tenet here is that all motion takes time, i.e. that instantaneous displacement of the effectors is impossible, and hence, that there will always be contextual smearing of motion leading to coarticulation within any chunk (Godøy 2013, 2014, in press).

Also, we think we can detect these goal-points and key-postures in motion capture data of musicians’ sound-producing body motion, as points associated with maximal acceleration and velocity reversals (Godøy 2013, 2014), points in time that we in turn understand as the basis for intermittent control.

3. Main Contribution

The main contribution of the presentation is a novel theory of chunking in music based on constraints of human motor cognition, in particular on the need for anticipatory motor control, its manifestation in intermittent control, and the associated coarticulation and contextual smearing of motion and sound within any chunk. This will all come together in a conceptual model that will include:

1. Intermittent motor control, focused on key-postures at goal-points
2. Continuity, coherence, fusion, integration, etc. within any chunk because of continuous motion trajectories with coarticulation

One attractive feature of this model is that the duality of discontinuity and continuity is built into the model: the within chunk coherence is due to a single discontinuous impulse, i.e. to the intermittent, so-called serial ballistic (Loram et al. 2014), control impulse, focused on one goal-point. The evidence for this model so far is in various other cognitive science research on human motor control, as well as the interpretation of our own empirical findings:

- Motion capture data on sound-producing motion trajectory shapes and their corresponding velocity and acceleration features suggest the existence of goal-points
- Motion capture data clearly indicate the coarticulatory shaping of sound-producing motion trajectories.

4. Implications

One consequence of recognizing intermittent motor control is to modify our basic understanding of chunking in music so that we see chunking as just as much dependent on intermittent motor control schemas as on purely acoustic features. Specifically, such an understanding of chunking may:

- Account for chunking difficult to induce by purely signal-driven schemes
- In focusing on goal-points, shift our attention towards chunk centroids from chunk boundaries, i.e. boundaries are seen as secondary to centroids, and this model may also accommodate/tolerate fuzzy boundaries.
- Account for the internal coherence and cohesion within the chunk as the result of one singular and intermittent control impulse

But clearly, we also need to:

- Develop experimental methods for more systematic studies of intermittency in practice
- EMG measurements to indicate temporal distribution of effort in sound-producing body motion
- Computational models (i.e. so-called reverse engineering) of intermittent control in sound-producing body motion

5. Keywords

Intermittency, motor control, action gestalts, coarticulation, contextual cohesion

REFERENCES


