Perception of onset asynchronies: Acoustic piano versus synthesized complex versus pure tones

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In studies on piano performance, simultaneous notes in the score are almost never played simultaneously by pianists. Melody leads are typically of the order of 30 ms (Palmer, 1989, 1996; Repp, 1996; Goebl, 2001). Here, we investigate the perception of such asynchronies. Previous psychoacoustic studies have found that asynchronies as small as 2 ms can be detected between steady-state synthesized pure and complex tones (Zera & Green, 1993). The temporal order of two sound events can be perceived for asynchronies greater than about 20 ms (Hirsh, 1959; Rosen & Howell, 1987).

The complex onset behaviors of real musical sounds such as piano tones suggest that thresholds for detection of asynchrony between such tones will be higher than for steady-state sounds. Our experiments investigated this hypothesis by comparing real and synthesized sounds within the same randomly ordered sequence of trials. We are also interested in the question of why asynchronies are introduced by performers. Rasch (1978) and Palmer (1996) have suggested that the aim of this strategy is to increase the salience of the tone. Since melody leads are more common than lags, this raises the question of which strategy is more audible. Does anticipation of an event make it more or less prominent (salient)? Moreover, does this depend on the type of tone?

Each experiment consisted of 88 trials: 4 tone types x 2 interval sizes x 11 asynchronies. Tone types were pure, harmonic complex with 16 partials (-6 dB per octave), MIDI-synthesized piano, and recorded from a computer-monitored grand piano. The pair of tones in each trial spanned an interval of an octave or a major seventh. Asynchronies varied from -50 ms to 50 ms, in 10 ms steps. The tone duration ranged from 300 to 400 ms so that the overlap of the two tones were constant at 350 ms. Musically trained and untrained listeners were asked to judge these stimuli on two separate occasions, each with a two-alternative forced choice paradigm. In the Experiment 1, they indicated which tone was more prominent. In Experiment 2, they indicated which sounded earlier.

Preliminary analysis of Experiment 1 firstly confirmed the finding and theory of Bregman and Pinker (1978) that asynchrony encourages harmonic segregation. There was no effect of order, regardless of the tone type: a delayed attack was considered to have the same prominence as an early attack. This casts doubt on the frequently encountered tacit assumption in the music (and especially piano) performance literature that the first onset is perceived as more salient. In Experiment 2, listeners only consistently reported the correct order of the two onsets for asynchronies of greater than about 30 ms–again, regardless of whether the higher or the lower tone began first. Identification of order improved as the sounds became the more artificial: the threshold was around 20 ms at pure tones, and 30 ms for real piano tones.

These preliminary experiments suggest that the detection of asynchrony is more difficult in real instrument sounds than in steady-state or artificial stimuli.

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