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Probabilistic distortions of temporal judgments with isochronous sequences

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Abstract

Isochronous stimuli create an expectation about the timing of future stimuli. This expectation is simply the probability of occurrence of stimuli with certain properties at particular time-points. The aim for the current study is to evaluate how such probabilities could influence temporal judgments about the perceived timing of stimuli. We hypothesize that probability of occurrence could influence perception by anticipating or delaying when the stimuli are perceived (i.e., by changing perceptual latency stimuli are perceived earlier or later).

Each trial comprises a sequence of short (20 ms) audio stimuli of different lengths (either 3, 4, 5 or 6 stimuli per sequence). In two conditions, stimuli were either presented blocked for each length or interleaved. While the initial stimuli are presented with the same inter-stimulus-interval (700 ms), the final stimulus of the sequence is presented at 15 levels of anisochrony (±200, ±150, ±100, ±80, ±60, ±40, ±20, 0 ms). Participants reported whether the last stimulus appeared ‘early’ or ‘late’. The proportion of ‘late’ responses for each asynchrony of the last stimulus forms a psychometric function. The shape of the function is indicative of the performance: a higher slope suggests better performance in discriminating the timing of stimuli. The 50% point indicates at what asynchrony the last stimulus is perceived to be isochronous. Distortions of the psychometric function from a cumulative Gaussian shape could be related to a change in perceptual latency for only some of the stimulus asynchronies.

Results indicate a slight change in the slope of the function with different sequence lengths, which indicates that anisochrony detection improves with longer sequences. Furthermore, sequences presented in blocks lead to an additional small increase in performance, which is evident as a decrease in the number of errors especially for large asynchronies. Most notably, however, a distortion in the shape of the psychometric function becomes apparent by comparing blocked and interleaved presentations of the sequence lengths. The difference between the two conditions is evident for stimuli presented slightly earlier than expected (20 ms) and for the ones presented later (between 20 and 60 ms), but not for stimuli presented isochronously for which responses are around chance level. Stimuli presented early are reported late more often with interleaved presentation than with blocked stimuli. Stimuli presented late are reported early more often with interleaved presentation. This pattern of responses is evident as a ‘N-

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shaped’ perturbation in the psychometric function with sequences of three stimuli presented interleaved with other stimuli, leading to a tendency to a reversal in temporal judgments for small anisochronies.

These effects can be explained by appealing to the probability of stimuli appearing at different levels of anisochrony and noting that the probability changes with interleaved and blocked presentation. For example, one could observe that the sixth stimulus in a sequence is equally likely to appear at any anisochrony. On the other hand, due to the presence of 4, 5, and 6 sequences in an interleaved block of stimuli, the stimulus appearing at the third place is probably more isochronous than anisochronous. The only anisochronous stimuli at the third place are for sequences of 3 stimuli, which are relatively infrequent. When such anisochronous stimuli eventually appear, they are perceptually distorted towards the expected isochronous time-point. In addition, the presence of a prior entry effect (a speed-up of processing) for stimuli appearing after the expected time-point leads to the perception of stimuli presented later than expected to be perceived slightly early. These observations lead to the characterization of a probabilistic model of perception of the timing of stimuli in isochronous sequences.

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