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Anti-phase synchronisation: Does 'error correction' really occur?

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ABSTRACT

Background

While there is a large amount of evidence about the way that people perform in-phase synchronisation, less is known about off-beat, or anti-phase synchrony. 'Error correction' is observed during in-phase tapping, and involves some adjustment of the rate of movement to compensate for the perceived asynchrony between stimulus and movement onset (e.g. Repp, 2005). There is evidence that behaviour during off-beat tapping is similar, with error correction calculated similarly, but using the midpoint of two stimuli to determine the asynchrony, rather than using the asynchrony between two perceived events (Repp, 2001). However, in calculating whether error correction occurs, averaging is normally performed over a large number of trials and participants, which may downplay the role of individual variability in response. It is also likely that using isochronous stimuli, with one perturbation in order to elicit error correction responses, is more likely to result in error correction of this kind than more ecologically valid stimuli (Repp, Keller & Jacoby, 2012), with variability at each interonset interval (IOI). Error correction is generally thought to be an automatic process (Repp, 2002), so we attempted to minimize the attention participants paid to the anisochrony in the stimuli, to see whether it could still occur.

Aims

By analysing off-beat synchronisation data with anisochronous stimuli we hoped to determine whether people really do perform 'error correction' in this situation. The possibility of purposeful error correction was minimized by using non-expert participants, and instructing them to tap at a regular pace (i.e. to ignore variability in the stimulus sequence).

Method

A sensorimotor synchronisation paradigm was used, with participants told to tap at a different time from sounds, but that they should try to maintain a regular beat, and tap once for each tone heard. This instruction should reduce the possibility of purposeful error correction. Stimuli were a sequence of anisochronous tones, organised similarly to Madison and Merker (2004), with each interval shortened or lengthened from an underlying isochronous beat of 600ms according to a binary sequence. The sequence of 96 taps changed level of anisochrony every 32 taps made, either becoming increasing isochronous, with anisochrony of 645ms/555ms, 622.5ms/577.5ms, 600ms, or becoming increasingly anisochronous, with anisochrony of 645ms/555ms, 667.5ms/532.5ms, 690ms/510ms.

Data from 34 non-musicians (scoring below 500 on the Ollen Musical Sophistication Index; Ollen, 1996) were analysed in several different ways, in order to determine how participant behaviour could be best described. Method 1 used averaging over the whole set of data, method 2 involved time series analysis on a small number of individual trials. Method 3 involved grouping participants according to potential ways of tapping, and multilevel linear modeling with an autocorrelation structure in order to assess how each group performed.

Results

Method 1 gave results that were inconsistent with true error correction, but did demonstrate that each tap made was affected by the previous stimulus interval heard. Method 2 demonstrated that different individuals required substantially time series models to best explain their behaviour throughout each trial, suggesting that there were some idiosyncrasies in behaviour. Method 3 first used maximum likelihood estimates to determine which model could best fit the data, either one involving error correction, with an associated constant (alpha) relating asynchrony to following intertap interval (ITI), or simply maintaining a regular asynchrony after each stimulus heard (which might approximate error correction behaviour). Approximately a third of the participants fell into the second category, tapping with the median trial asynchrony after each tap heard. Those with error correction as a better model further split into three distinct groups, with some having very low alpha values, suggesting that they maintained a regular tapping pace, others with higher alpha values, indicative of genuine 'error correction', as has been identified in previous work, and a third group with negative error correction constants. Having separated these four categories we modeled asynchronies for each group separately using multilinear level models including autocorrelation. The three groups appeared to have quite distinct forms of model, and the autocorrelation components in particular were quite different.

Conclusions

As we explore forms of synchronisation that are increasingly ecologically valid it is important to assess whether previous models of behaviour are still the best explanations for the data. Using several forms of analysis in the current experiment we were able to explore the data in far more depth than initially intended, and this revealed interesting variability in behaviour. As the current results suggest high interpersonal variability in this kind of study, we cannot generalise results to comment further on how people might perform in this kind of task. Maintaining a regular pulse would suggest that participants are likely to be using some oscillatory modeling of their own behaviour, and were capable of ignoring the stimuli. Error correction also suggests some kind of oscillatory tapping model, but with automatic error correction, that occurred despite the instruction to maintain a regular pulse. Maintaining a regular asynchrony would imply more of a 'stopwatch' form of timing, with each tap triggered at the same period after the stimulus is heard.

Finally, negative error correction is not generally reported in studies of this kind, and may suggest some attempt to resist a normal error correction response, as a consequence of the instruction to maintain a regular pulse. All four strategies were observed in our data set, suggesting some flexibility in these approaches.

Keywords

Synchronisation; off-beat; error correction

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