A startling acoustic stimulus suggests advance preparation of intentional bimanual pattern switches

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INTRODUCTION

- In-phase (IP) and anti-phase (AP) represent intrinsic modes of coordination (Fig. 1) and the former is more stable [1,2] and less attentionally demanding [3,4] than the latter.
- Intentionally switching from IP to AP (more stable to less stable) in response to an imperative cue requires more time than the reverse transition [5,6].
- It is unknown whether these behavioural findings result from advance preparation of the pattern switch or are strictly due to the intrinsic dynamics of the relative coordination patterns.
- Advance motor preparation can be investigated using a loud (>120 dB) startling acoustic stimulus (SAS) in place of the imperative stimulus during a reaction time (RT) task. If the known movement is sufficiently prepared in advance, the unexpected presentation of the SAS can involuntarily trigger the prepared action at shortened response latencies [7,8].

RESEARCH QUESTION: ***Are the motor commands associated with an intentional bimanual pattern switch prepared in advance?***

METHODS

- Participants (n=11) performed cyclical bimanual flexion-extension movements about the elbow joint.
- All trials began in either IP or AP (30 trials each and randomly ordered) and each trial lasted 18 s. During the first half of each trial, real-time visual feedback of the participant`s movements was displayed and cycling frequency was paced at 1.5 Hz using a visual metronome (Fig. 2).
- When signaled by an auditory switch cue (80 dB, 1 kHz) participants were required to intentionally switch into the opposite coordination mode as quickly as possible and maintain the new pattern for the remainder of the trial. In 50% of trials, the 80 dB switch cue was replaced with a SAS (120 dB, white noise).
- SAS trials were separated based on the presence/absence of a short latency (30-120 ms) EMG burst in the sternocleidomastoid (SCM) muscle (i.e., startle indicator) in order to investigate the effect of the SAS on motor preparation [9].
- Our dependent variables of interest were switch onset (i.e., RT) and switching time. Switch onset was the interval between the auditory switch cue to the start of the intentional switch. Switching time was defined as the time that elapsed between the moment at which relative phase first diverged from its previous mode and the achievement of the new mode of coordination. The criterion for achieving this pattern was set at 35° for at least two consecutive cycles (Fig. 3).

RESULTS, DISCUSSION, & CONCLUSIONS

- Switch onset (Fig. 4) was significantly faster ($P < .001$, $\eta^2_p = .94$) following the SAS compared to the control tone.
- Switching time (Fig. 5) was significantly faster ($P = .006$, $\eta^2_p = .55$) when switching from AP to IP compared to IP to AP. Switching time was also significantly faster ($P = .009$, $\eta^2_p = .51$) following the SAS compared to the control tone.
- Interestingly, the unexpected presentation of the SAS affected both switch onset and switching time (i.e., significantly reduced both). Switch direction however, only affected switching time (i.e., IP to AP > AP to IP), which is consistent with past research [5,6].
- A faster switching time due to the SAS may reflect a disruption in the intrinsic dynamics of the ongoing coordination pattern; thus, allowing participants to adopt the new pattern at a faster rate.
- These findings suggest that, independent of switch direction, participants may be able to prepare the motor commands associated with an intentional bimanual switch in advance of the imperative switch cue.

FIGURES

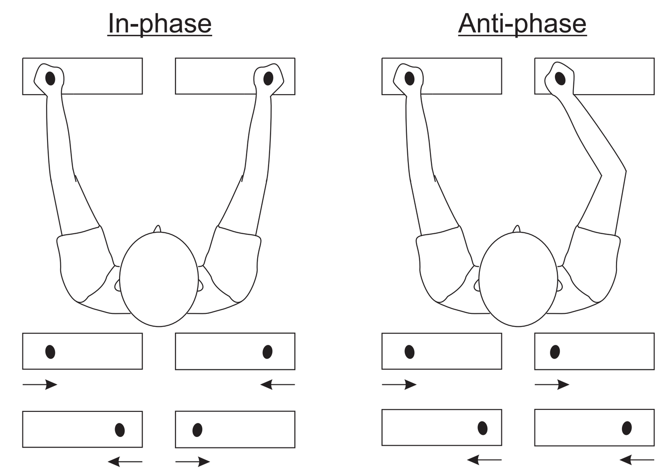

Fig. 1. A schematic representation of the required movements to perform in-phase (left) and anti-phase (right) modes of coordination.

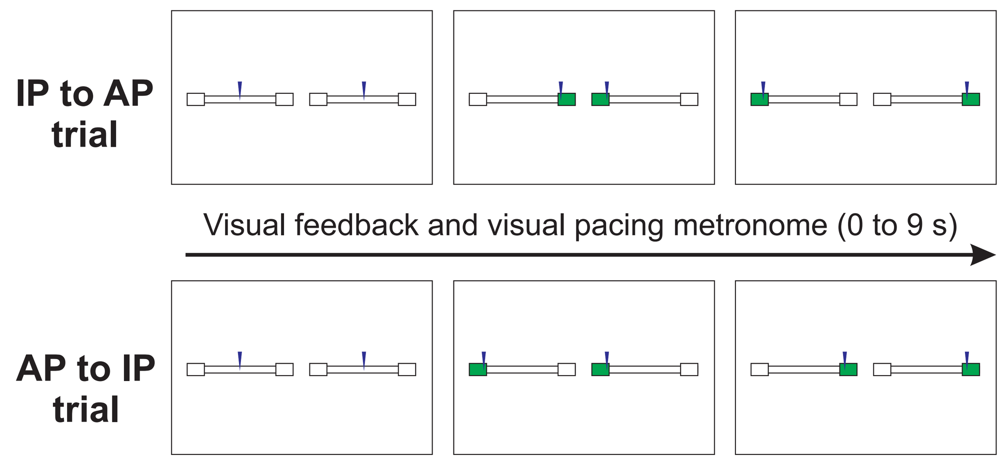

Fig. 2. An illustration depicting how visual feedback was provided to the participants as well as the visual metronome that paced the movements at 1.5 Hz.

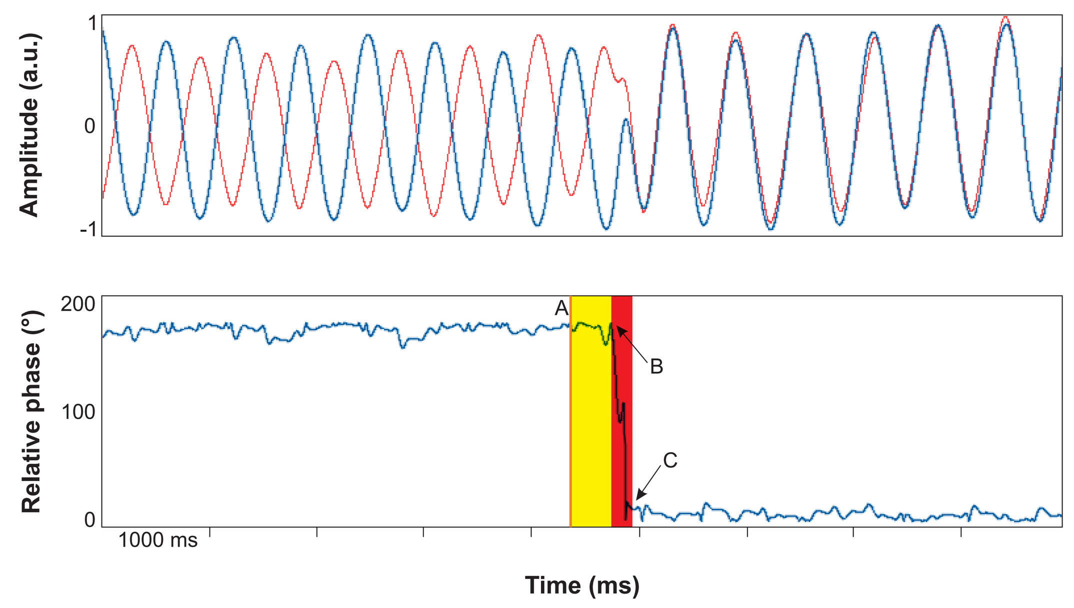

Fig. 3. Determination of the switch onset and switching time were completed using the interactive displays of the individual displacement trajectories (upper panel; red and blue traces represent left and right hand, respectively) and the relative phase estimation (lower panel). The presentation of the imperative switch cue is indicated by the orange line (A). The arrows (B and C) denote the onset and termination of the switching process. Switch onset (yellow window) was the difference between B and A and switching time (red window) was the difference between C and B.

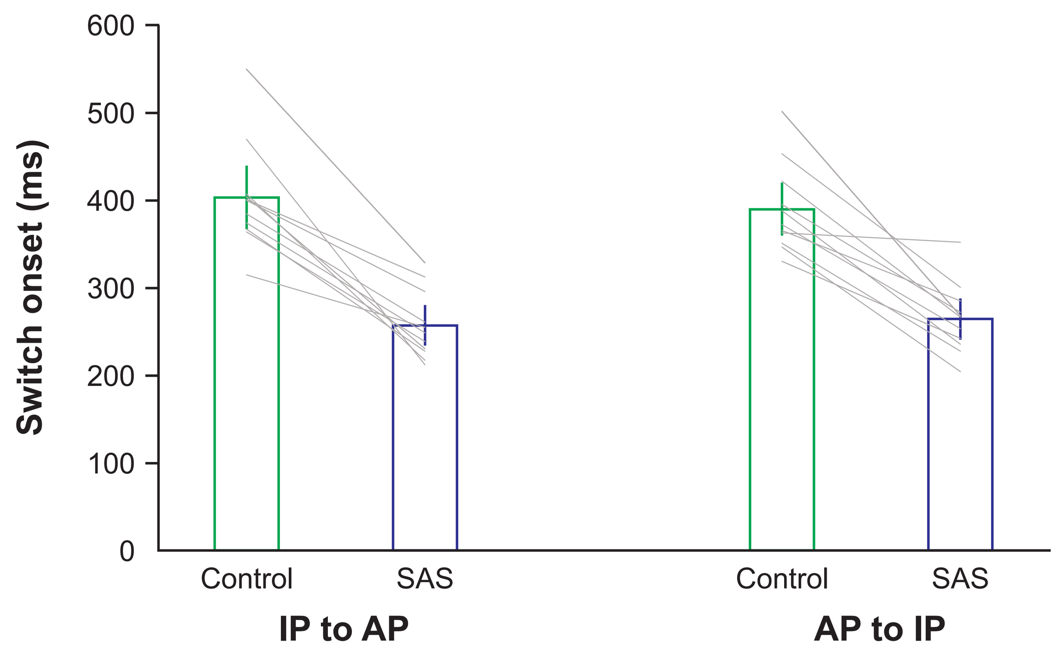

Fig. 4. Mean switch onset times for IP to AP and AP to IP trials for both the control and SAS tones. The grey lines represent means of each participant and error bars denote 95% confidence interval.

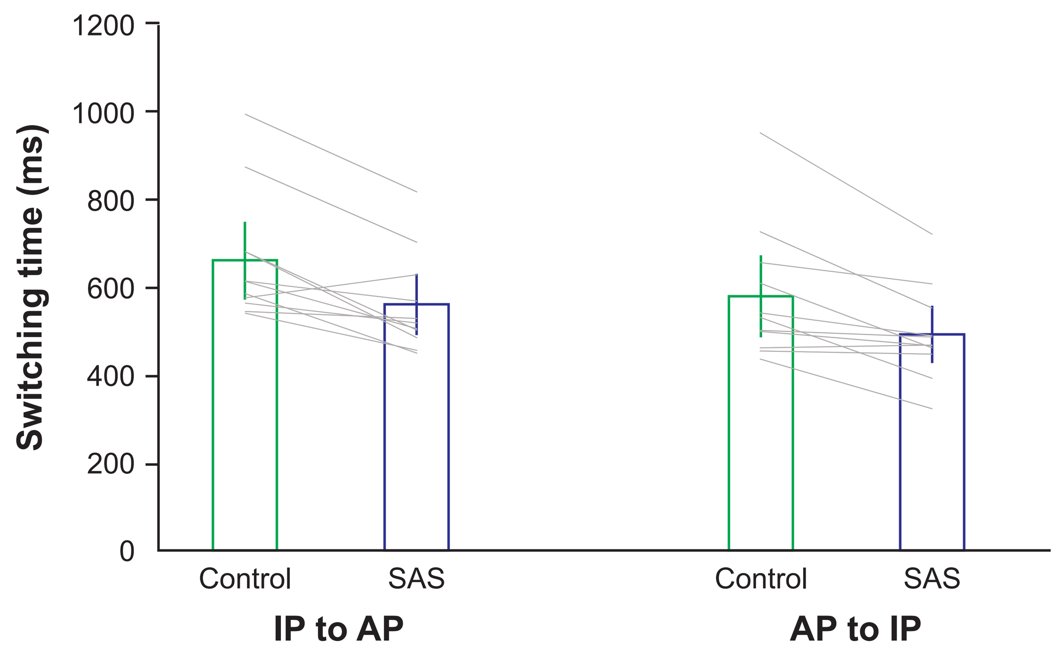

Fig. 5. Mean switching times for IP to AP and AP to IP trials for both the control and SAS tones. The grey lines represent means of each participant and error bars denote 95% confidence interval.

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