A startling acoustic stimulus reveals advance preparation of intentional bimanual switches

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Introduction

- Research has revealed that the human neuromotor system displays two intrinsic modes of bimanual coordination: In-phase and Anti-phase (see Figure 1).
- During in-phase coordination, the limbs are moved in a mirror symmetric manner and can be described as involving homologous muscle activation. During anti-phase coordination, the limbs are moved in the same direction and therefore can be said to involve non-homologous muscle activation.
- Research has shown that in-phase coordination can be performed more stably and accurately than anti-phase coordination (Swinnen, 2002).
- In tasks where participants are asked to intentionally switch between coordination modes following an imperative stimulus (i.e., reaction time [RT]), the time required to switch typically correlates with pattern stability (Figure 2).
- It is unknown whether these switching times occur due to advance preparation of the pattern switch or due to the intrinsic dynamics of the relative coordination patterns.
- Research has demonstrated that advance motor preparation can be investigated using a loud (>120 dB) startling acoustic stimulus in place of the imperative stimulus during a RT task. If the known movement (e.g., direction of a intentional bimanual switch) is sufficiently prepared in advance, the unexpected presentation of a SAS can involuntarily trigger the prepared action at shortened response latencies (Carlsen et al., 2012)

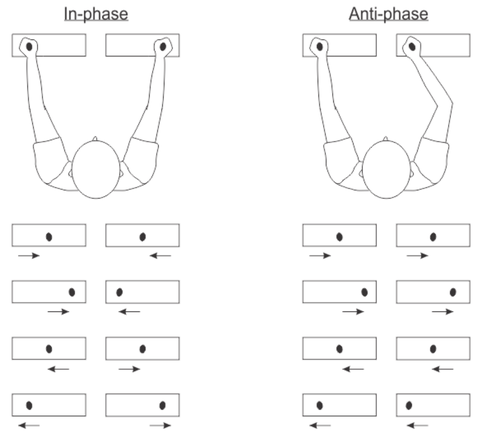

Figure 1.

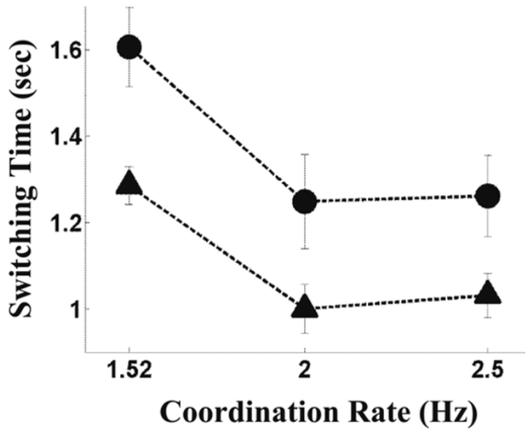

Figure 2.

Research questions

Do participants prepare the motor commands associated with an intentional bimanual pattern switch in advance?

Methods

- Participants (n = 6; M age = 23.5; SD = 3.73 years; 3 Males and 3 Females) performed cyclical bimanual extension-flexion movements about the elbow joint
- All trials lasted 18 s. and during the first half of all trials, participants' movements were paced at 1.5 Hz using a visual metronome
- Visual feedback of the participants' movements were also displayed for the first half of all trials
- Trials began in either in-phase or anti-phase (30 trials each and randomly ordered)
- When signaled by an auditory switch cue (80 dB, 1000 Hz), participants were required to voluntarily switch into the opposite coordination pattern as quickly as possible and maintain the new pattern for the rest of the trial
- In 50% of the trials, the 80 dB switch cue was replaced by a SAS (120 dB, white noise)
- SAS trials were separated based on the presence/absence of a short latency EMG burst in sternocleidomastoid (SCM) muscle (i.e., startle indicator) in order to investigate the effect of the SAS on motor preparation (Carlsen et al., 2011)
- Our dependent variable of interest was the time required to initiate the switch (i.e., RT). This was measured as the interval from the auditory switch cue to the start of the intentional switch.

Results

Time required to initiate switch

- Results indicated that switch onset (i.e., RT) was significantly faster (101 ms difference) following the SAS compared to the control tone (p = .003, η^2_p = .853). Importantly, secondary analysis of switch onset times between trials with a reflexive startle response (SCM+) and those without (SCM-) suggest this result is not simply a stimulus intensity effect as switch onset times were significantly faster (77 ms. difference) in trials with SCM activity compared to those without (p = .010, η^2_p = .766).

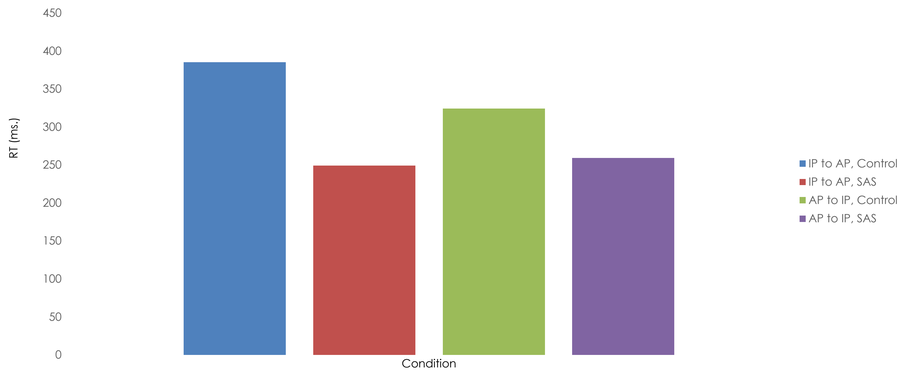

Figure 3. Mean reaction times (in ms.) for control and startle trials in both IP to AP and AP to IP conditions.

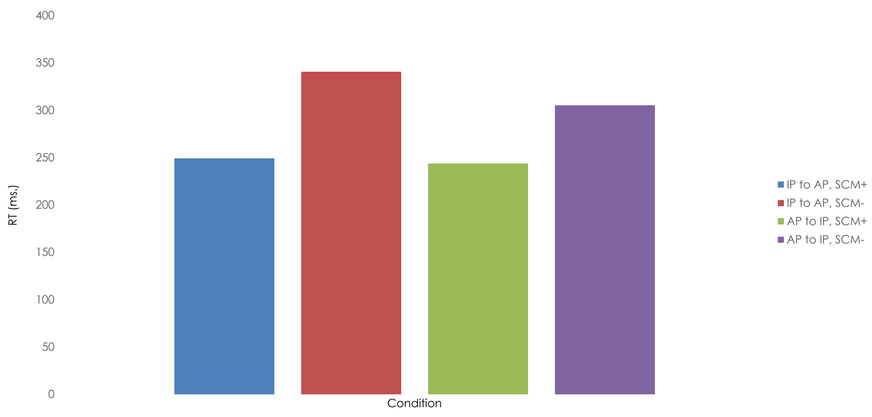

Figure 4. Mean reaction times (in ms.) for SCM+ and SCM- trials in both IP to AP and AP to IP conditions.

Discussion / Conclusions

- The preliminary results revealed that intentional switches, independent of switch direction were completed significantly faster on SAS trials compared to control trials
- As it is known that the unexpected presentation of a SAS involuntarily triggers a sufficiently prepared response (Carlsen et al., 2012), these findings suggest that participants were capable of pre-programming the motor commands associated with an intentional bimanual switch in advance of the imperative switch cue
- Our secondary analysis ruled out that the significant speeding effects caused by the SAS was the result of a stimulus intensity effect
- Contrary to past research (Swinnen, 2002), we did not find that intentionally switching from anti-phase to in-phase was significantly faster than switching in the reverse direction. However, the results show a trend in the expected direction.
- Data collection is still on-going

References

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