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Reflections on ... Phase Shifting Under Different Visual Conditions

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Introduction

When two limbs are moved out of time (i.e. opposing muscle activation at each limb) in rhythmic oscillatory movements, there is a tendency at high frequencies for the movements to synchronise in the temporal domain, resulting in bilateral homologous muscle activation known as a 'phase shift' (Kelso, 1984). In an effort to determine the degree with which perception influences this phase shifting behaviour (Mechsner et al., 2001), a mirror can be placed between the hands of participants, parallel to their mid-sagittal plane such that the reflected hand appeared in the place of the occluded hand. This paradigm can be used to create a conflict between vision (of moving with mirror symmetry) and action (attempting to move with mirror asymmetry), with the goal of manipulating the frequency at which a phase shift occurs. Additionally, as there may be differences in the degree of attentional and intentional control (Bestelmeyer & Carey, 2004) shown between the dominant and non-dominant hand, the orientation of the mirror (i.e. which hand was reflected) was also examined.

It was hypothesised that:

- Seeing both hands move in symmetry (with the mirror) would induce symmetrical movement (i.e. a phase shift) at an earlier than normal frequency.
- This phase shift would occur at an even lower frequency when viewing the reflection of the dominant hand.

Participants

Eighteen volunteers from the University of Aberdeen took part in this study. Participants, 6 of whom were male, were aged between 20 and 32 years (mean = 23.9 ± 3.5) with normal or corrected to normal vision. All participants were dextral (right handed), as measured by a modified version of the Waterloo Handedness Questionnaire, with 16 also showing right eye dominance.

References

Altschuler, E.E., Wisdom, S.B., Stone, L., Foster, C., Galasko, D., Llewellyn, D.D.E., & Ramachandran, V.S. (1999). Rehabilitation of hemiparesis after stroke with a mirror. *Lancet*, 353, 2035-2036.

Bestelmeyer, P.E.G., & Carey, D.P. (2004). Processing biases toward the preferred hand: valid and invalid cueing of left versus right-hand movements. *Neuropsychologia*, 42, 1162-1167.

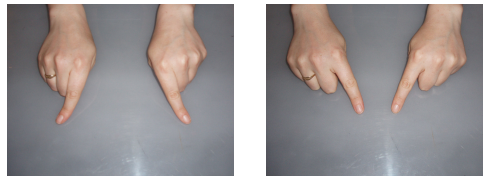
Kelso, J.A., (1984). Phase transitions and critical behavior in human bimanual coordination. *American Journal of Physiology – Regulatory, Integrative and Comparative Psychology*, 246, 1000-1004.

Mechsner, F., Kerzel, D., Knoblich, G., & Prinz, W. (2001). Perceptual basis of bimanual coordination. *Nature*, 414, 69-73.

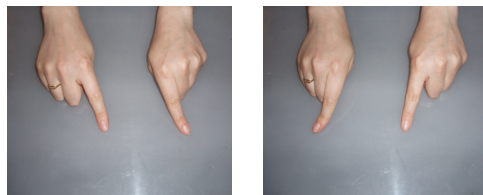
Method

Participants performed rhythmic oscillations, to the beat of a monotonically increasing frequency metronome (1hz – 6hz in 22 seconds) of both index fingers in 2 patterns:

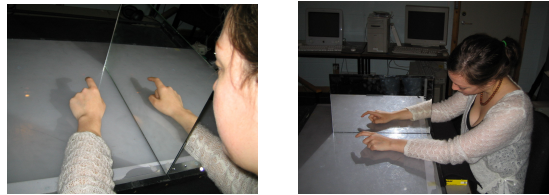
In-phase (symmetrical)



Anti-phase (asymmetrical)



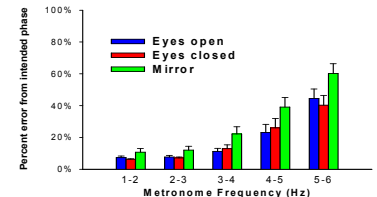
This task was performed with the eyes open (full view of both hands), eyes closed or with the mirror dividing the hands such that the reflected hand appeared in the place of the occluded hand.



The in-phase trials always preceded the anti-phase trials to provide an active visual binding between the view in the mirror and the proprioceptive feedback from the occluded hand – making the participant feel as if the reflected hand was the occluded hand. As the position of the mirror had to be rotated 180° to allow comparisons between which hand was reflected, the conditions without the mirror required participants to orient their gaze toward either the left or right limb. Position of the fingers were recorded on a 60Hz MacReflex system, relative phase was calculated and the data was binned into metronome frequency by percentage error from intended phase, on which a series of 2 by 2 ANOVA's were performed.

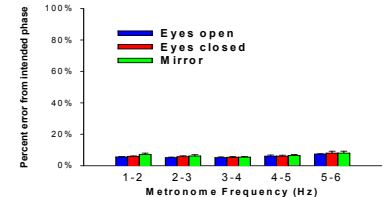
Results

When moving anti-phase



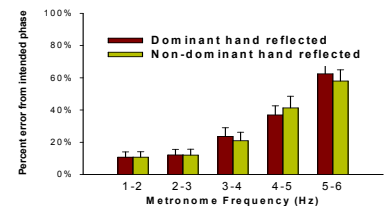
Statistical analyses of the measures of percentage error from intended phase when attempting performance of the anti-phase pattern, showed a significant main effect of both visual condition ($F(1,23)=14.56, p<0.001$) and frequency ($F(1,25)=39.4, p<0.001$), and more importantly an interaction between the 2 variables ($F(3,53)=6.47, p<0.001$).

When moving in-phase



When attempting in phase oscillations there was no significant main effect of either visual condition ($F(2,26)=1.9, NS$) or frequency ($F(1,20)=2.9, NS$). Additionally, there was no significant interaction between visual condition and frequency ($F(2,32)=0.89, NS$).

When moving anti-phase



Comparisons across hand in the mirror condition yielded a significant main effect of frequency ($F(2,33)=48.17, p<0.001$), but no main effect of hand ($F(1,17)=0.03, NS$). No interaction was found between visual condition and hand ($F(2,40)=0.71, NS$).

Conclusion

As the oscillation frequencies increased, phase shifting behaviour was observed when moving out of phase, and at lower frequencies in the conditions where the mirror was present compared to conditions without the mirror (full view of the hands and with the eyes closed). These increased levels of motor irradiation from one limb to the other did not differ as a function of hand. This study shows that having non-contingent false visual feedback can alter the pattern of phase shifting behaviour. As mirrors used in the way described above have been utilised in hemiparesis rehabilitation (Altschuler et al., 1999), it remains possible that any rehabilitation effects may be due to motor overflow similar to that which is seen in this study.