Understanding Motor Coordination with Unimodal and Bimodal Stimuli: Vision and/or Audition?

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1. Introduction

Daily life evolves around the perception of multimodal stimuli in our environment and developing coordinated action. Recent findings by Varlet et al. (2012) demonstrated better coordination with bimodal compared to unimodal conditions using auditory and visual stimuli with varying continuity (discrete or continuous). This improvement in coordination was due to the integration of auditory and visual information, something that is required in every day life activities. The role of spatio-temporal integration in coordination is also an important aspect for understanding multisensory coordination.

Recent findings by Armstrong et al. (in press) assessed coordination with two continuous stimuli: one containing spatio-temporal information (oscillating square) and the other containing only temporal information (fading square), in a pendulum based task. The results revealed that the supplementation of spatial information to the temporal stimulus significantly improved coordination, confirming the reliance on spatio-temporal integration in coordination with continuous visual stimuli. The following experiment builds on this research and used 8 conditions (4 unimodal and 4 bimodal) to assess the reliance on spatio-temporal integration in coordination with different auditory and visual stimuli in unimodal and multimodal conditions.

2. Methods

Thirteen participants sat in a height adjustable chair and swung a hand held pendulum in a darkened room, through the frontal plane by pronating and supinating their forearm while wearing noise cancelling headphones. A cover blocked their view of the pendulum and any forearm movement. The participants’ preferred frequency and ±20% of the preferred frequency were used in the experiment.

The visual stimuli consisted of a red square that oscillated in a sinusoidal fashion on screen (VP) and a stationary square that continuously faded from a yellow to red colour in a sinusoidal fashion (VC). The auditory stimuli consisted of a frequency-modulated tone that was continuously modulated from 400 Hz to 800 Hz in a sinusoidal fashion (AC) and the same tone that panned from the left to right ear of the headphones with 800 Hz always heard on the left and 400 Hz heard on the right (AP). The participants were asked to synchronise their pendulum swing with eight different conditions shown in Figure 1. The bimodal stimuli were always in-phase with each other and were presented at exactly the same time.

In order to assess the degree of coordination between the participants and the stimulus, continuous relative phase (CRP) was assessed. CRP was calculated using a Hilbert Transform and scaled between 0° and 180°. Data was recorded at 100 Hz using a Measurement Computing data acquisition device (Measurement Computing, USB-1608FS). The experiment was created in Matlab using the Psychophysics Toolbox extensions (Brainard, 1997; Kleiner M, Brainard D, 2007; Pelli, 1997).

3 Results and Discussion

The main findings from the experiment relate to the ACVP and APVP bimodal conditions. These two conditions displayed an audio-visual integration similar to that of Varlet et al. (2012), producing the lowest coordination values for all of the conditions. Both of these conditions also produced the lowest standard deviation of CRP. As expected, the results from the visual unimodal conditions confirmed the findings from Armstrong et al. (in press) showing that VP was significantly lower than VC.

Another key finding relates to the integration of spatio-temporal information. From the bimodal data shown in Figure 1 it appears that in order to produce a good level of coordination a spatio-temporal visual stimulus was vital. This may relate to a form of visual dominance in the bimodal conditions since coordination in the ACVC and APVC conditions were close to the VC level of CRP. This could indicate that the addition of any audio condition to VC did not improve coordination and may have negatively affected the coordination.

Figure 1. CRP Results for the 8 conditions.

References


