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The supplementation of spatial information improves coordination

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HIGHLIGHTS

- Assessing the supplementation of spatial information with a temporal stimulus.
- We used a spatio-temporal (ST) and temporal (T) continuous visual stimulus.
- ST: produced significantly higher level of coordination in comparison to T.
- T: resilient and still produced good levels of coordination.

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ABSTRACT

Vision plays an important role in allowing the development of coordinated movements and often acts as the dominant perceptual modality for every day movements. This visual information is often presented in the spatio-temporal domain but the specific role of spatio-temporal information has not been specifically assessed in the literature. This experiment used two visual stimuli to assess the reliance on spatio-temporal integration and the effect of supplementing spatial information to a temporal stimulus on coordination. Participants manipulated a hand held pendulum at three frequencies in coordination with these stimuli. The results revealed that the supplementation of spatial information significantly improved coordination. Interestingly, the absence of spatial information still produced good levels of coordination indicating a resilience of motor coordination to adapt to changes in the environment.

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1. Introduction

The pioneering work by Gibson [5] on the perception of visual information reflects the key role of visual information in coordinated action. To date, extended research has focused on understanding how humans visually coordinate their actions using stimuli in the form of an oscillating object [6,11–13,18]. While these studies have identified important aspects of visual coordination and fundamental dynamics of coordination in terms of variability and stability, further research is required to assess the specific role of spatio-temporal information in coordination. Spatio-temporal information can play an important role in many motor skills, such as catching a ball. In order to catch the ball, accurate perception of both spatial and temporal information is required: moving your hand to the correct location and at the right time, respectively [10]. The importance of spatio-temporal information is evidenced in the previous example and this article aims to analyse the role of spatio-temporal information in a coordinated task by supplementing an oscillating temporal stimulus with spatial information.

Much has been revealed about how we coordinate with visual stimuli in the spatio-temporal domain over the last two decades [1,2,8,9,14,19]. For example, Bingham's work on the perceptually driven dynamical model for coordination [1] has led to research exploring what information is used for coordination with an oscillating visual stimulus. One such article by Hajnal et al. [6] highlighted how coordination can be negatively affected when information about the relative direction of movement is reduced by occluding the end points of an oscillating square. In other words, when the stimulus was supplemented with more information, i.e. the stimulus was not occluded, coordination improved. This concept of supplementing a stimulus with additional information is what the current article is investigating by supplementing a temporal stimulus with spatial information. While a spatio-temporal stimulus is commonly found in the literature as discussed above there is a lack of research utilising a visual stimulus exclusively represented in the temporal domain.

Few studies have assessed coordination with a continuous visual stimulus exclusively in the temporal domain. For example, Varlet

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et al. [15] examined how the nature of a visual stimulus, whether it is discrete or continuous, significantly effects coordination. The results from Varlet et al. [15] supported previous findings [3,7], revealing that coordination was superior and more stable with the continuous stimulus (fading square) compared to the discrete stimulus (flashing square). Based on these results, there appears to be a preference of the motor coordination system for continuous visual information perhaps due to a weakening of the perception-action coupling when discrete stimuli are present as less information is available. This continuous stimulus (fading square) exclusively contained temporal information. A similar stimulus will be used in this article.

The current article will essentially be building on the findings from Varlet et al. [15] by taking a deeper look at their temporal stimulus and assessing how the supplementation of spatial information to this temporal stimulus can affect coordination. The results are expected to confirm previous findings relating to coordination with a visual oscillating stimulus in the spatio-temporal domain and provide support for the evidence found from Varlet et al. [15].

2. Methodology

2.1. Participants

Twelve volunteers (8 females and 4 males) between the ages of 18 and 24 years (22.4 yrs ± 2.9) took part in the experiment. All participants were right handed, had normal or corrected to normal vision and no known history of a neuromuscular deficit that would affect their participation. Colour blindness was assessed using a series of five Ishihara pictures. Any participant with any form of colour blindness was removed from the experiment. No compensation was given to the participants for their involvement in the experiment. The procedure for the research received full ethical approval from the Dublin City University Research Ethics Committee (DCUREC/2011/038).

2.2. Experimental setup

Participants sat in a height adjustable chair with a forearm support and gripped an aluminium pendulum with their right hand. Fixed to a 14 cm long handle, the pendulum had a length of 49 cm and a weight of 53 g attached at the end. Its eigenfrequency was 0.90 Hz. Participants were prevented from viewing the pendulum's movements with a wooden cover and the arm of the participant was also concealed using a sliding panel. Participants swung the pendulum in a darkened room, through the sagittal plane by pronating and supinating their forearm while wearing noise cancelling headphones. The screen displayed the stimuli and was placed at eye level approximately 1 m from the participants. Data from the pendulum was recorded at 200 Hz using a National Instruments DAQ device (National Instruments, USB-6229) and stored for further analysis.

2.3. Stimuli

The stimuli consisted of two different oscillating visual signals presented on a screen with a white background. The spatio-temporal stimulus appeared as a green square (30 mm × 30 mm) oscillating horizontally across the screen in a sinusoidal fashion with an amplitude of 40 cm. The temporal stimulus was similar to the "Visual Continuous" stimulus used by Varlet et al. [15] and appeared as a stationary square (30 mm × 30 mm) in the centre of the screen that continuously faded in colour between a black and green colour in a sinusoidal fashion. The various stages of these stimuli are presented in Fig. 1. Both of these stimuli were created using Labview software (National instruments, Labview 10.0).

2.4. Procedure

Upon arrival participants were handed an information sheet about the experiment and were asked to sign an informed consent

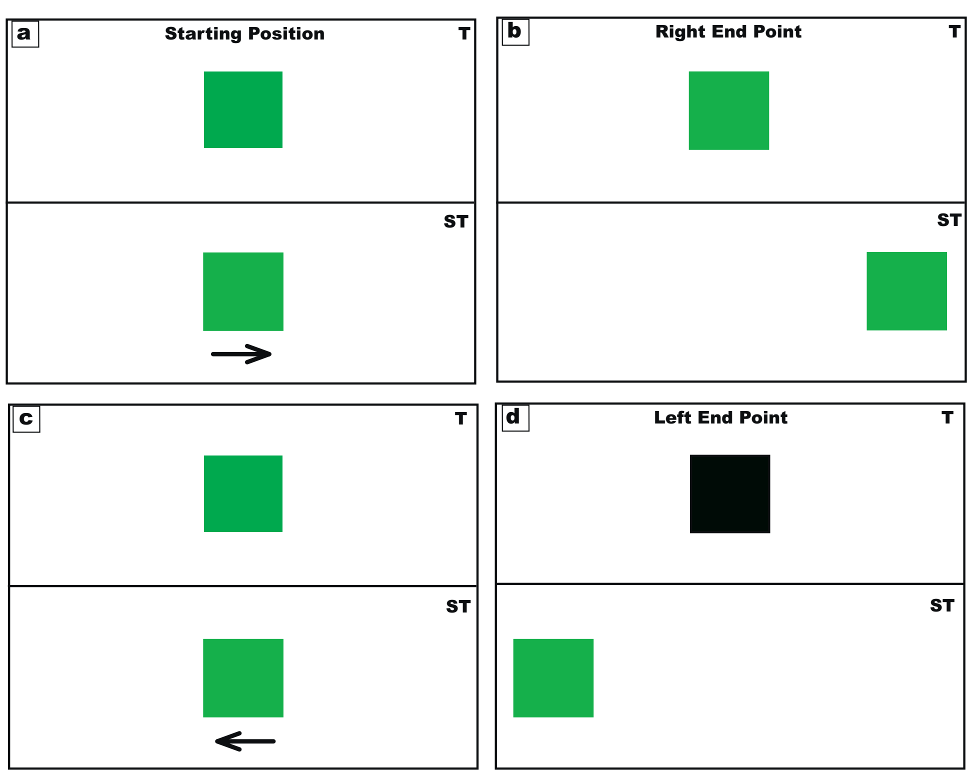

Fig. 1. Stages of the two stimuli. The top half of (a–d) displays the stages of the temporal stimulus (T) while the bottom half displays the spatio-temporal stimulus (ST). (a) shows the starting point of each stimulus, (b) the first end point of the stimuli, (c) the return to the starting/mid point and (d) the second end point of the stimuli.

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