Crossmodal Double Dissociations Between 'What' and 'Where'

Jason S. Chan and Fiona Newell

Department of Psychology, Trinity College Dublin, Ireland.
{jchan, fiona.newell} @tcd.ie

Abstract. Double dissociations are typically used to examine the modularity of the brain, and its effect on behaviour. This double dissociation method has typically been used within one modality. Tresch, Sinnamon & Seamon [1] found double dissociations in participants' ability to recognize the form or location of an object. We adapted the paradigm of Tresch et al. to become a crossmodal task. In Experiment 1, participants felt or saw random objects and determined whether the two objects presented within a modality were the same or different. We found that double dissociations of object recognition do not exist crossmodally. In Experiment 2, the same paradigm was utilized, but all stimuli were presented haptically. If the double dissociation effect exists, this would support the evidence from previous studies of crossmodal perceptual load. The implications will be discussed further.

1 Introduction

Double dissociation demonstrates the modularity of brain structures and their neural pathways [2]. Double dissociations occur when similar tasks produce different behavioural or neurological effects. It is generally believed that this is because different brain structures or neural pathways are involved.

Tresch, Sinnamon, and Seamon [1] used a double dissociation paradigm to examine participants' ability to visually recognize an object's form or location. They found that a form (or 'what') interference task disrupted the form (or 'what') primary task, but not the location (or 'where') primary task. See Figure 1 for an example of the typical results of a double dissociation. The 'where' interference task disrupted the 'where' primary task, but not the 'what' primary task. The results of this experiment can be explained by the neural architecture of the human brain. The magnocellular stream leading to the posterior parietal areas is responsible for location discrimination, while the parvocellular stream leads to temporal areas, and is responsible for colour and orientation discrimination. Since two independent streams are utilized to discriminate form and location, it is likely that processing in these streams does not interfere with one another.

A similar paradigm was used in this experiment. The purpose of this experiment was to examine if double dissociations can be achieved when the tasks are presented in the visual and haptic modality. If this is the case, then it could be that the visual and touch systems use the same neural pathways to identify or localise objects.

2 Experiment 1

2.1 Method

2.1.1 Participants

Six participants (5 female, 1 male) between the ages of 18 and 22 years (mean age = 19 years) took part in this study, and received course credit or were paid €10. The experiment lasted approximately one hour.

2.1.2 Apparatus and Materials

2.1.2.1 Stimuli

i) Haptic stimuli

Ten unique shapes composed of LEGO bricks were randomly assigned and fixed to four different locations on 20 cm plywood circles. These locations were top-left, top-right, bottom-left, bottom-right, and centre. Each pair of stimuli was either identical or they differed in their form or location, relative to their paired stimulus, resulting in a total of 80 stimuli. Each haptic stimulus was presented for a duration of 1,500 ms. Participants were instructed to remove their hands from the object when an auditory

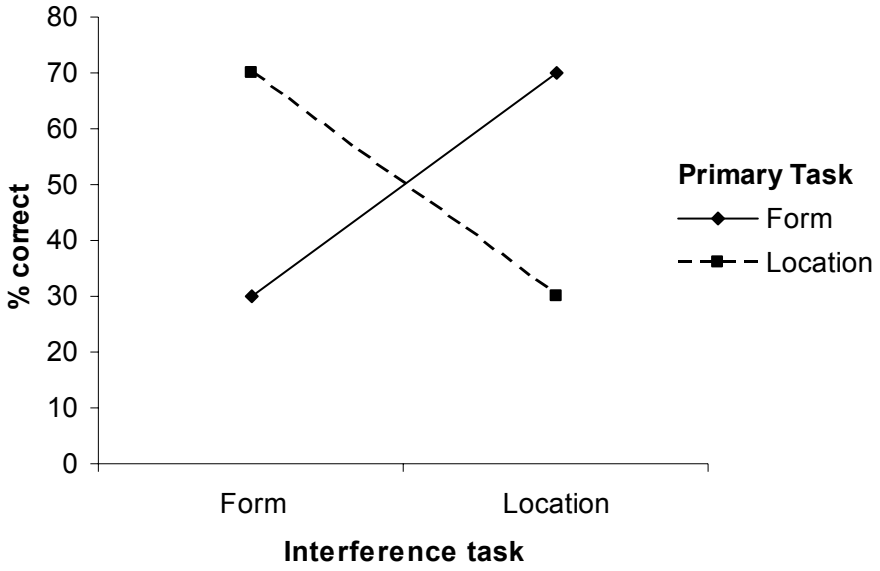

Fig. 1. An example of a typical double dissociation result. The form interference task only affects the form primary task, and not the location primary task. The location interference task only affects the location primary task, and not the form primary task.

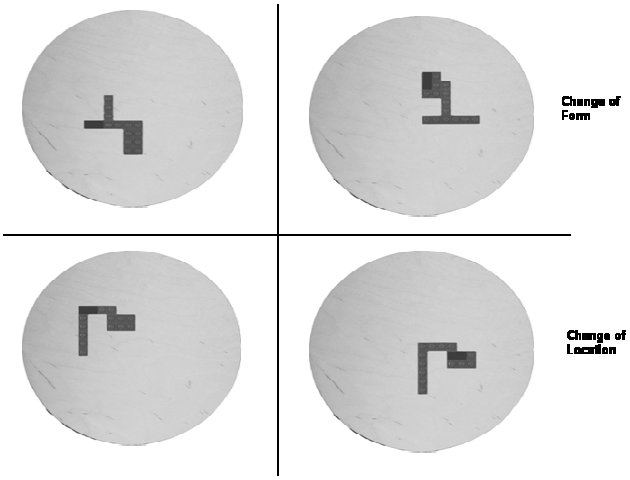

Fig. 2. These LEGO patterns were presented visually and haptically. The top two images demonstrate a change in form, while the bottom two images illustrate a change in location. Either type of change could occur with a trial.

click was presented. Furthermore, the experimenter simultaneously removed the haptic stimulus upon tone presentation.

ii) Visual stimuli

Digital pictures were taken of all LEGO patterns mounted on base plates. These digital pictures were presented at 20 cm on the computer screen, for a duration of 50 ms. This way we ensured that the same object stimuli were presented to both modalities during the experiment. See Figure 2 for an example of the stimuli used in this experiment.

2.1.3 Apparatus

The visual stimuli were presented on the computer monitor which was placed directly in front of the participant. The haptic stimuli were presented on the table directly in front of them, below the computer monitor. An occluder surrounded the haptic stimulus, so that the participant was unable to see the haptic stimulus.

2.1.4 Procedure

The experiment was a 2 X 2 X 2 design with Modality of the Primary Task (visual or haptic), primary task ('what' or 'where') and interference task ('what' and 'where') as conditions with two levels ('what' and 'where'). Different primary tasks were presented in different experimental blocks, such that in one block the participants were required to make judgements on either haptic or visual form (i.e. 'what' task) and in the other, the participants were required to compare the location of two stimuli ('where' task). Within each experimental block, both interference tasks were conducted. The nature of the interference task (i.e. 'what' or 'where') was randomly assigned to the trials within each block, and was always conducted in the modality other than that of the primary task

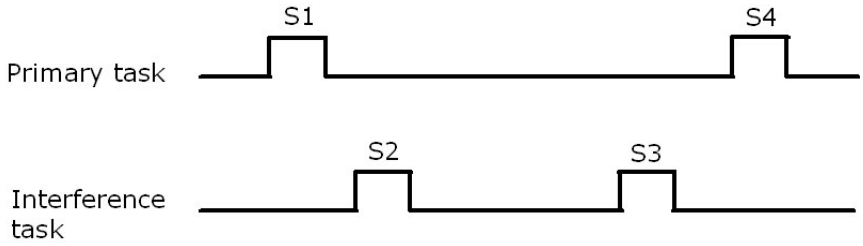

Fig. 3. This is a graphic illustration of the double dissociation paradigm used in Expt 1

The two different task conditions took place within each single trial (primary task and interference task). See Figure 3 for an illustration of the structure of a typical trial in this experiment. In each task condition, participants were presented with two LEGO patterns in succession, either visually or haptically. They were required to indicate whether these patterns were the same or different.

2.2 Results and Discussion

The results given here are from a preliminary 'what' primary task only. Further results will be provided at the conference proceedings. A two-way ANOVA with the factors of Modality (vision and haptic) and Interference Task (form and location) was conducted to examine the effect of the interference tasks on the primary task. There was no main effect of the Modality factor [$F(1,5) < 1$, *n.s.*]. There was a main effect of the Interference Task factor [$F(1,5) = 11.00$], $p = .045$] (see Figure 4). Participants had increased accuracy when the interference task was the same as the primary task. There was no interaction between the two factors [$F(1,5) < 1$, *n.s.*].

These results runs counter to our hypothesis. We were expecting that when the interference task and primary task were the same, performance would decrease. Participants were aware that in the primary task they were to simply identify if the form was the same. The attentional load may have been lower when the task was the same, than when the interference and primary task were different.

Previous double dissociation experiments have only utilized one modality. However, there is crossmodal evidence that the attentional mechanisms for each modality are separate [3,4,5]. In these experiments, performance decreased as the attentional load within a modality increased. However, when the task was divided between two modalities, performance remained the same as the attentional load increased. This suggests that there are independent streams of attention for each modality. In the next experiment, the interference task will remain in the same modality as the primary task. Thus we aim to replicate the findings of Tresch et al. (1993). These data will be presented at a later stage.

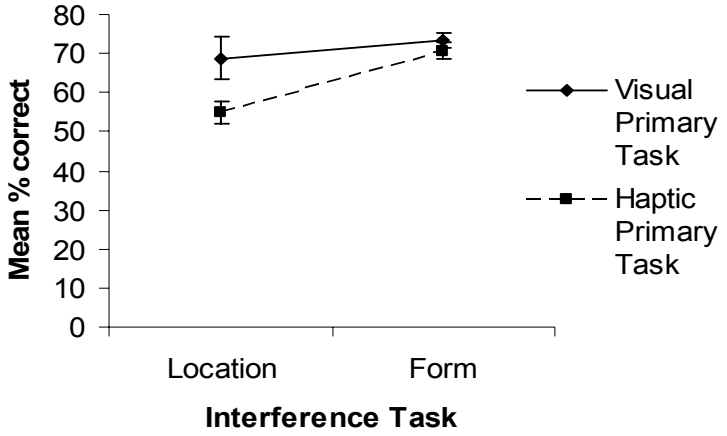

Fig. 4. The effect of the Interference Task factor on the primary form task. The interference task was always presented in the other modality. The error bars represent the standard error of the mean (SEM).

3 Conclusions

If a double dissociation effect occurs (as expected), it will demonstrate that the visual and haptic modalities use separate streams for recognizing objects. There has been little research on crossmodal object recognition [6,7], and there is no research pertaining to the neural correlates of crossmodal object recognition. This could be the first time that separate attentional streams are utilized in crossmodal object recognition. Further results and discussions will be presented at the conference.

References

1. Tresch, M. C., Sinnamon, H. M., & Seamon, J. G. (1993). Double dissociation of spatial and object visual memory: Evidence from selective interference in intact human subject. *Neuropsychologia, 31*(3), 211-219.
2. Van Orden, G. C., Pennington, B. F., & Stone, G. O. (2001). What do double dissociations prove? Cognitive Science, 25(1), 111-172.
3. Lavie, N. (1995). Perceptual load as a necessary condition for selective attention. Journal of Experimental Psychology: Human Perception and Performance, 21(3), 451-468.
4. Lavie, N., & Fox, E. (2000). The role of perceptual load in negative priming. Journal of Experimental Psychology: Human Perception and Performance, 26(3), 1038-1052.
5. Lavie, N., & Tsal, Y. (1994). Perceptual load as a major determinant of the locus of selection in visual attention. Perception & Psychophysics, 56(2), 183-197.
6. Newell, F. N., & Bülthoff, H. (2002). Categorical preception of familar objects. Cognition, 85, 113-143.
7. Newell, F. N., Ernst, M. O., Tjan, B. S., & Bülthoff, H. H. (2001). Viewpoint dependence in visual and haptic object recognition. Psychological Science, 12(1), 37-42.