Abstract

The process of integrating the features of a visually sensed stimulus is known as visual feature binding. Feature binding enables an organism to identify and differentiate many types of stimuli. This early and quick process is not only integral to the perception of objects, but continues to be important as the visual representations are retained in memory for future manipulations.

The primary motive of the present research was to study the differential effect of simultaneous and sequential modes of presentation on feature binding. As the effect of the simultaneous mode of presentation was confounded with location information in previous studies, it was decided to manipulate locations orthogonally with respect to mode of presentation in the experiments undertaken in this research.

Using a swap detection task to test color-shape binding, five behavioral experiments, and one experiment using functional magnetic resonance imaging, were carried out. The two independent variables were mode of presentation [simultaneous vs. sequential] and locations [unchanged vs. random]. Both independent variables were fully crossed, leading to four experimental conditions. Change detection accuracy was calculated as d primes and functional magnetic resonance imaging was used to assess neural correlates in each experimental condition. Statistical analyses were carried out using null hypothesis testing, supported by the Bayesian approach.

Results clearly show that locations are a factor in simultaneous presentation, with binding performance being better in the unchanged locations condition as compared to the random locations condition. In sequential mode of presentation, performance was not different in unchanged and random locations conditions. Analogously, the interaction effect obtained in fMRI results was also significant, with the lowest activation observed in the simultaneous presentation condition with unchanged locations, whereas the activation in the other three conditions was at a similar level. This interaction was significant in the bilateral parietal areas, the left precentral gyrus, and the right fusiform area.

Conjunction analyses assessed activation at the different levels of the two independent variables. It showed the parietal regions and anterior insula to be associated with simultaneous presentation as well as unchanged locations, confirming that whenever stimuli are presented simultaneously, participants encode them as a pattern according to spatial relationships. The largest brain activation in terms of extent and intensity was observed when locations were random, involving the occipital, frontal, and parietal cortices. Sequential presentation was also associated with activation in many working memory related areas in the fronto-parietal network, and uniquely in the inferior temporal gyrus, suggesting a role for object identification and memory in the response to sequential presentation.

Overall, behavioral as well as fMRI data in this research establish locations as a factor in the effect of simultaneous presentation in feature binding. They also indicate that sequential presentation uses a temporal code and leads to intensive use of brain resources associated with object based attention and working memory.