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Visual working memory

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Working memory plays a central role in cognitive psychology. To understand the nature of the representations contained in working memory is fundamental to our understanding of what we usually mean by thinking. Executive processes, attention, consciousness and intelligence, all are they in some way associated with working memory. The basic purpose of the project was to investigate what and how much are represented in visual working memory. Three objectives were specified in the original project plan. The first objective was to examine how limited our visual working memory really is and what factors contribute to its limits. The second objective was to identify the different sorts of representations we have in visual working memory. Can we represent the whole object or only part (the so-called binding problem)? Can we represent three-dimensional objects or just a two-dimensional sketch? The third objective was to examine the effects of presentation time and if visual working memory can be likened to an update and rewrite process. The project focused primarily on objectives one and two and to a lesser extent on objective three, but the project was extended with neurophysiological indicators in the form of event-related potentials (ERP).

Our previous finding that visual working memory is more limited than previously thought for items that have continuous dimensions was controversial (about one object for stimuli with continuous dimensions compared with just under three objects for stimuli with discrete dimensions, such as red-square) and it was therefore important to replicate these results (Olsson & Poom, 2005). We have successfully replicated the results in our lab in Uppsala, Max Planck Institute for Human Development, Berlin, and at the Vrije Universiteit, Amsterdam. Further support for our conclusion in Olsson and Poom (2005) that different processes are involved when stimuli can be categorized (discrete stimuli) and when they can not be categorized (continuous stimuli) were found in Diamantopoulou et al. (2011) where the increase in memory capacity for stimuli that were easy to categorize corresponded to an increase in contralateral slow ERP waves, an effect related to memory processes. Diamantopoulou et al. also found that the capacity estimates for stimuli that were easy to categorize and stimuli that were difficult to categorize were not correlated, which further supports the conclusion that different processes are involved for the two stimulus types. A second important result is related to the question whether the visual working memory can represent whole objects or only parts. The results in Poom and Olsson (2009) show that the representation in visual working memory can retain binding of parts of objects, but the capacity is very limited, and that there is a facilitation effect of position (i.e., if an object is presented in the same position in the testing phase as in the memory phase) for discrete objects, but not for continuous objects. The results are also important in the sense that no storage hypothesis put forward in the literature can fully explain the results. A third important result is from
Poom and Olsson (2011), where we for the first time in the literature of visual working memory provide evidence that pure visual information is stored in multiple special purpose stores.

The two most important studies in the project are Poom and Olsson (2009) and Poom and Olsson (2011), because they question the validity of proposed models and hypotheses about how object binding works, and indicates a more nuanced and distributed memory structure in visual working memory than previously thought. In our first study (Olsson & Poom, 2005), we could not know for sure if participants represented entire objects or only parts of them. By using an experimental design based on Wheeler and Treisman (2002), we tested predictions from three binding models. The results showed that none of the models gives a good explanation of how object binding works in visual working memory. It may be the case that on certain trials binding was maintained for all object types whereas it failed on other trials, or that features may at the same time be stored both separately and bound as objects. Only new experiments and models can give clear answers on how and when features are bound together into objects, and how and when they are not.

It has previously been suggested that visual memory for objects is different from memory for simple features such as spatial frequency, but no empirical studies have been able to verify this hypothesis. The second important study in this project demonstrates for the first time the existence of separate memory systems for simple objects (eccentricity of ellipses) and simple features of objects (spatial frequency). By measuring response times and accuracy of memory representations, we could demonstrate a dissociation between these dimensions, which gives strong support for the existence of separate memory stores for features and objects. The precision of object memory is, contrary to feature memory, selective for object orientation. When objects are presented in orthogonal orientations, precision is reduced. The response times for spatial frequency discrimination are longer when patterns are orthogonal and successively presented at the same position. However, no influence of orientation on response times was obtained when they were shown at different positions. The response times for object discrimination is immune to orientation difference, irrespectively of position condition.

The most important new questions generated by the project relate to the binding problem and the organization of visual working memory. Current models of binding in visual working memory, and which memory systems that are involved, must be updated and new experimental paradigms that integrate psychophysical and neurophysiological insights with visual working memory research must be developed.

References:

Publikationer:
