Epreuve orale Sélection Internationale ENS 2017
Sciences Cognitives / Discipline Secondaire

Veuillez lire l'article « spotlight » suivant pour en faire un rapide commentaire. Naturellement, vu le temps limité pour la préparation, nous ne nous attendons pas à un commentaire détaillé, mais plutôt à une réflexion personnelle prenant comme point de départ la question de recherche développée dans l'article. En particulier, vous pourrez vous appuyer sur les questions suivantes :

1) Quelle est la question de recherche sur la mémoire de travail visuelle mise en lumière dans cet article ? Pourquoi cette question est-elle pertinente pour comprendre la mémoire de travail visuelle hors du laboratoire ?

2) Quelle est la technique utilisée dans l'étude citée pour étudier les corrélats cérébraux de la mémoire de travail visuelle ?

3) Comment est-ce que les auteurs de l'article interprètent l'« avantage de stockage en mémoire » observé pour les objets réels par rapport aux objets artificiels ?

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Spotlight

Measuring Visual Memory in Its Native Format

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Knowing how memories are represented is crucial for understanding how the mind works. Brady *et al.* [1] explore an important and rarely considered aspect of visual working memory, which is the amount of information that can be stored when remembering meaningful objects, rather than the arbitrary colors and shapes that are typically used in such experiments [2].

For the most part, visual working memory research uses simple shapes, such as colored squares, precisely because there are few prelearned bindings of feature values for such stimuli; one colored square is almost as likely as another for most of us. These artificial stimuli give the researcher greater control over the amount of information to be stored, since the visual system of the participant will be limited in its ability to chunk or compress the information.

However, asking the visual system to perceive and remember such sterile stimuli cuts off the great majority of perceptual capabilities that are employed when we perceive the natural world. From birth, the visual system encounters an incredibly rich set of statistical regularities with each glance. These regularities are gradually incorporated into the visual pipeline throughout childhood, and are connected with a broad network of semantic attributes. Thus, the fully developed visual system provides a rapid and highly accurate interface between patterns of light on the retinal surface, and the meaning of those patterns in terms of what objects are present and in what context.

Therefore, it is clearly important that we use natural stimuli to study the full capabilities of the visual system. There is a thread of such research dating back to the surprising findings that the average person can easily detect novel, target images in a rapidly presented stream of natural images [3]. Such a task is easy even when the presentation is faster than the average eye-fixation rate, with images blazing by so quickly that participants cannot even recognize the nontarget images in a follow-up test. Other work has suggested that we capitalize on regularities in the spatial statistics of visual scenes, to make rapid inferences about parameters such as naturalness, openness, and expansiveness [4]. Real-world objects are also highly effective as visual search targets [5] and natural images can capture attention [6]. These findings all suggest that perception of naturalistic information is extremely accurate and rapid, but what about memory for this information?

Complementing other recent attempts to measure memory for naturalistic information [7], Brady *et al.* compared visual working memory capacity for natural objects with that for colored squares using both behavioral and neural measures. The experiments asked participants to store several objects in memory for a short time and then tested them on the memory for one of the objects with a two-choice recognition test. In terms of behavior, when the display duration was short, there was no difference in capacity between the squares and natural objects, both measuring at about three items. However, as stimulus duration increased, there was a substantial improvement in capacity for the natural objects but not the squares. This increased capacity is likely to depend on the conceptual familiarity of the more complex natural objects, given that memory of unfamiliar complex objects exhibits dramatically smaller capacity [8].

To gain insight into the cause of this capacity advantage, Brady *et al.* next examined an electroencephalogram correlate of active memory maintenance, known as contralateral delay activity (CDA) [9]. The amplitude of this CDA was larger for the longer study condition, suggesting that when participants had additional study time, they could add extra items into memory. In a separate experiment, the CDA was larger for natural objects compared with simple objects and there was also a behavioral replication of the capacity advantage for natural objects.

Importantly, this latter difference was present when participants needed to remember five objects but not three, which is suggestive that the measured increase in memory capacity in the behavioral experiment is due to an increase in the quantity of objects stored, but not the quality of their storage. Additional experiments will be required to determine whether this is the case given evidence that even the representation of a single feature of an object can be stored with varying degrees of quality depending on expectations [10].

The CDA differences are critical because they indicate that this capacity advantage for natural objects is not due solely to the ability to exploit long-term memory, but also involves active working memory representations. The argument stems from the fact that the CDA is lateralized in parietal–occipital regions opposite to the side of the visual field containing the remembered objects. Given this topography, the CDA is unlikely to reflect long-term memory, which presumably would not exhibit stimulus-driven laterality. The lateralized CDA difference also argues against the possibility that participants constructed a narrative mnemonic to help them remember the natural objects, because the neural locus of linguistic processing would also not be determined by the physical location of the stimulus.

To explain this storage advantage, we theorize that conceptually meaningful information is represented in a higher dimensional space than simpler objects

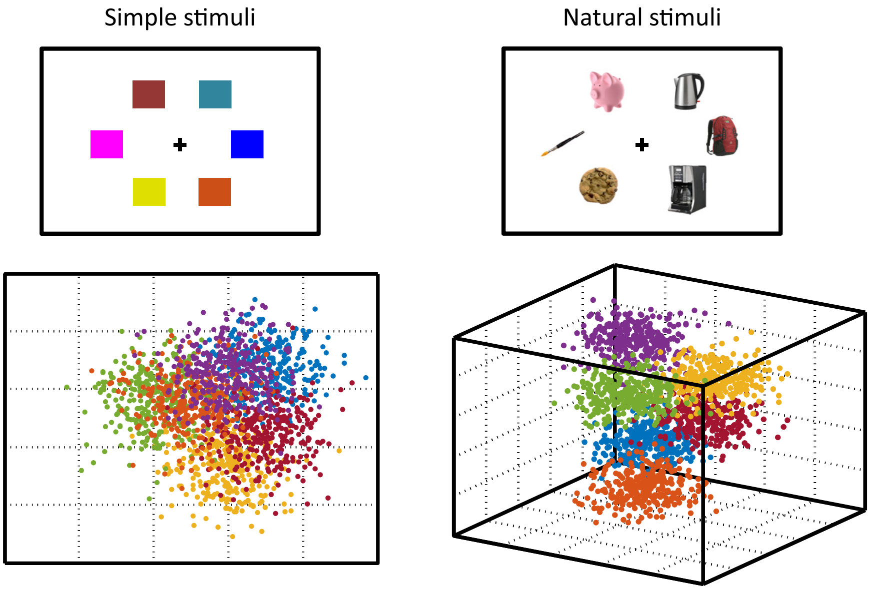

Figure 1. High-Dimensional Representations Allow Increased Capacity. One possible reason for the increased active memory capacity for natural objects is that those stimuli are represented with a higher dimensionality than simpler objects, which allows patterns of neural activity to be more distinct. In this illustration, each colored cluster corresponds to a hypothetical neural representation for one of six objects, with the assumption that information having conceptual meaning has access to a higher dimensional mental representation.

(Figure 1). This high-dimensional space would be based on a lifetime of visual experience, and would permit meaningful information to activate distinct representations that can be stored with less interference compared with relatively meaningless shapes. The key findings of Brady *et al.*, namely, that memory for multiple natural objects benefits from extra study time, that these differences exist only for large set sizes, and that this effect involves active storage, collectively provide valuable constraints on models of visual memory. Moreover, studying memory for natural stimuli has the potential to bridge the gap between theoretical models of memory storage in humans and the rapidly developing field of deep-learning networks for image comprehension. Such a bridge will be instrumental for the development of memory systems that will allow artificial intelligence to learn how to navigate and interact in the natural world. Such technology might even allow memory prostheses for individuals with brain damage or dementia.

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