Trends in Cognitive Sciences

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Letter

Ensemble Coding and Two Conceptions of Perceptual Sparsity

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In their paper "What is the Bandwidth of Perceptual Experience" Cohen *et al.* contribute to a growing literature [1] on the implications of ensemble coding (also known as summary statistics) for accounts of the bandwidth of perception [2,3]. According to the sparse view, the bandwidth of perception is very narrow, and subjects have conscious access only to the handful of objects that get through the bottleneck of attention and/or working memory. Cohen *et al.* argue that ensemble coding research undermines the sparse view.

Although there is much in Cohen *et al.*'s account with which we agree, we suggest that the critical issues they raise are best appreciated in light of a distinction between two versions of the sparse view: what we call the 'phenomenal version' and the 'tracking version'. The phenomenal version claims that we visually experience only a handful of objects and their properties in detail at any point in time. This conception is suggested by talk of the 'bandwidth' of perceptual experience. The tracking version claims that we are able to track only the states of (and changes to) a handful of objects at any one point in time.

It is important to distinguish these two conceptions of sparsity, for evidence in favour of one form of sparsity is not automatically evidence in favour of the other. In principle, vision might generate a sparse phenomenology but nonetheless enable one to track a wide range of environmental changes through unconscious perception. Alternatively, vision might track the environment relatively poorly but nonetheless support a rich phenomenology because aspects of visual experience might be 'filled in' by top-down processing.

How does ensemble coding (EC) bear on the foregoing? We take Cohen *et al.* to have made a plausible case against tracking sparsity. Change-blindness and inattentional blindness paradigms show that we are poor at tracking changes to individual objects outside attention and/or working memory, but the EC evidence indicates that we are good at tracking changes to the 'gist' of our environment.

What about phenomenal sparsity? Although we are less certain about how to read Cohen *et al.* on this point, we take them to endorse a 'middle way': visual phenomenology is richer than the sparse view allows, but it is less rich than views according to which visual phenomenology can 'overflow' access [4]. On this view, EC contributes to the phenomenology of visual experience only by consciously representing the statistical properties of the scene. For example, one might have a visual experience of the mean emotional expression of a group of faces [3].

We have some sympathy for this interpretation, but it is important to note that there are at least two other ways of interpreting the data: a 'deflationary' interpretation and an 'overflow' interpretation.

According to the deflationary interpretation, EC has no impact on visual phenomenology at all, but is merely a matter of post-perceptual judgment (which are often held to be conscious but not phenomenal). Unlike the interpretation assumed by Cohen *et al.*, the deflationary interpretation has no implications for accounts of the richness of visual phenomenology, although it might explain why naïve subjects are prone to over-estimate the richness of their visual phenomenology. The deflationary interpretation can be motivated by doubts about whether summary statistics are represented in visual phenomenology. It is clear that there is a visual phenomenology associated with representing an individual's emotional expression, but it is much less obvious that there is a visual phenomenology associated with representing the mean emotional expression of a crowd.

According to the overflow interpretation of EC, we have detailed phenomenal representations of all (or at least many) of the objects that are sampled in ensemble perception. Some (albeit limited) motivation for this view comes from considering ensemble perception in the context of

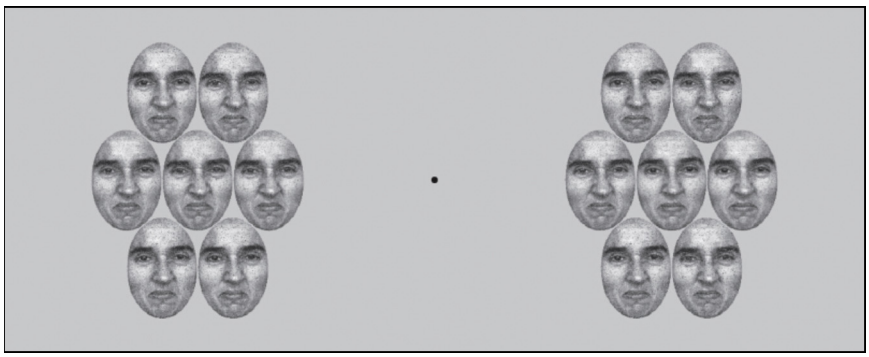

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Figure 1. Ensemble Coding in the Context of Visual Crowding. Fischer and Whitney [5] presented two groups of faces to the left and right of a fixation dot. In separate runs, subjects either judged which central face was more disgusted, or which set of faces was on average more disgusted. Only performance on the second task was above chance. It is unclear whether this is an example of the effects of unconscious information on performance, or whether it involves phenomenal consciousness in the absence of conscious access. Reprinted from [5] with permission from the American Physiological Society and kind approval of the authors.

perceptual crowding (Figure 1) [5,6]. The data shows that detailed representations of the central face contribute to the subjects' experience of the statistical properties of the whole display, and thus indirectly contribute to their visual phenomenology. Further, one might argue that the best account of why these representations inform the ensemble judgments that subjects make appeals to the fact that they are phenomenally conscious. Note, however, that this view is at odds with phenomenal sparsity.

The overflow interpretation might be dismissed on the grounds that it posits phenomenal states to which subjects lack cognitive access, but in our view such a response would be premature. Although cognitive access is currently our best source of evidence regarding visual phenomenology, we should not rule out the possibility that science will identify measures of consciousness that are relatively independent of cognitive access. Indeed, the recent development of no-report paradigms might be taken to push in this direction [7].

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