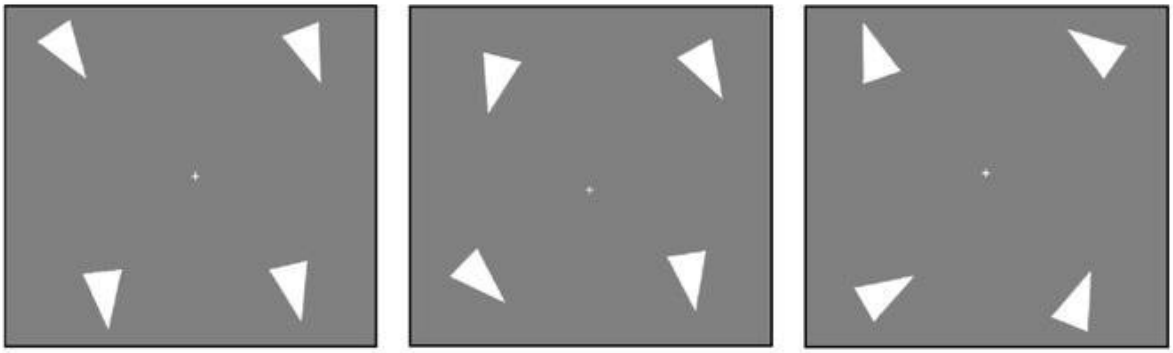
Visual working memory is hierarchically structured

July 23 2020



According to the hierarchical encoding framework, it will be easier to recall the items in the first picture, rather than in the third one, due to the lower range of triangle orientations. Credit: Utochkin, I. S., & Brady, T. F. (2020). Individual representations in visual working memory inherit ensemble properties. *Journal of Experimental Psychology*: Human Perception and Performance, 46(5), 458-473.

Researchers from HSE University and the University of California San Diego, Igor Utochkin and Timothy Brady, have found new evidence of hierarchical encoding of images in visual working memory. It turns out that the precision of remembering and recalling individual objects in a group is affected by ensemble representations—the mean and standard deviation of all objects in the group. The study has been published in

Journal of Experimental Psychology: Human Perception and Performance.

Visual working memory stores information about a limited number of perceived objects during a short period of time while we are involved in a task exploiting this information. For example, you will be using visual working memory if you are asked to memorize circles on the screen and then recall the size of one of them.

It is known that working memory capacity is limited: we are capable of remembering about three or four objects on average. Many theories assume that each object is memorized, stored and forgotten in working memory independently of the other objects. In contrast, proponents of the hierarchical encoding framework do not agree with this assumption. According to this framework, memory encodes not only the information on each item separately, but also the information on the group of objects together. This generalized representation about the group is coded in ensemble summary statistics. The visual system can calculate the mean and standard deviation of all features of the items present. For example, we can easily assess and memorize the average size of the apples on a tree, as well as how similar all the apples are to this average apple.

The researchers carried out a series of experiments that demonstrate a strong impact of ensemble statistics on individual items' memory. In one of the experiments, the participants were shown a group of four isosceles triangles with different apex orientations. The range of apex orientations varied: they were pointing in about the same direction, or in completely different ones. The higher the variability, the more difficult it is to calculate the mean orientation.

The participants were asked to memorize the triangle orientations and then recall one randomly chosen triangle. If the hierarchical encoding theories are correct, the variety of apex orientations in a group would

impact the quality (precision) of the ensemble statistics calculation (mean orientation of all triangles), and accordingly, the precision of an individual triangle.

The researchers found out that the precision of an individual orientation report depended on the variability of all orientations. Furthermore, there was a significant resemblance between how accurately participants could remember the orientations of the items in the display and how clustered the orientations to be remembered were.

"This says for a fact that even as we try to memorize items individually, our working memory also stores the summary of the whole group," commented Igor Utochkin, professor at the HSE School of Psychology. If precise information about a specific item isn't in memory, one uses the ensemble statistics to recall the approximate characteristics of the object. The more precise these statistics are, the more precise the response concerning that object is.

More information: Igor S. Utochkin et al, Individual representations in visual working memory inherit ensemble properties., *Journal of Experimental Psychology: Human Perception and Performance* (2020). DOI: 10.1037/xhp0000727

Provided by National Research University Higher School of Economics