Visual perception of summary statistics not following mathematical rules

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Cognitive psychologists of the Higher School of Economics have experimentally demonstrated that people are capable of estimating the mean size of visible objects and their approximate number simultaneously, showing for the first time that these two cognitive processes are independent of each other and do not follow the rules of mathematical statistics. The results of this experiment, published in *PLOS ONE*, can inform new approaches to statistical data visualisation and statistical education.

In the last fifteen years, research in the field of ensemble statistics has been gaining popularity. Scientists use the term ensemble (or summary) statistics to describe the instant and fairly accurate perception by most people of summary characteristics of a set of objects. For example, by looking at multiple objects for just half a second, a person can estimate their average summaries such as mean size or motion speed, as well as their total number, with a relatively low margin of error. But how exactly do people process visual ensembles and what principles and laws of perception may be involved?

The idea that the visual perception system can compute statistical data was borrowed from mathematical statistics. It intuitively implies that there should be a cognitive module—internal statistician—responsible for such computations. Scientists of the HSE Laboratory for Cognitive Research conducted a series of experiments to examine the relationship between the perceptions of the mean size and number of objects.

In three separate experiments, the participants were given half a second to look at a set of circles of different diameters and then asked to estimate either the mean size or the number of circles. In half of all cases, the participants were informed in advance which parameter they would be asked to estimate and could focus on it, while in the other half they did not know what their task would be and had to divide attention between the two problems. "We had assumed that a single module in the visual perception system is responsible for estimating both the mean size and number of objects; if this were true, then having to divide attention between two different tasks would have decreased the accuracy of responses," explained Igor Utochkin, head of the HSE Laboratory for Cognitive Research and the paper co-author.

However, the researchers did not find either any decrease in the accuracy of estimations, or any correlation between the two types of problems. These findings suggest that perception relies on two independent processes for visual estimation of the mean size and number of objects.

According to the paper authors Igor Utochkin and Konstantin Vostrikov, ensemble statistics, as opposed to mathematical statistics, does not need information on the number of objects to estimate their mean size.

Findings from research of ensemble perception can be used for better visualisation of statistical information and for statistical education. In particular, visualising a mean object can facilitate student understanding of the fundamental concept of the mean; other visual properties of ensembles can be used to explain other fundamental statistical concepts, such as distribution, variance, mean comparison, correlation, regression, etc.

More information: Igor S. Utochkin et al, The numerosity and mean size of multiple objects are perceived independently and in parallel,

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