When errors improve performance: Model describes how experiences influence our perception

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During estimation processes we unconsciously make use of recent experiences. Scientists from Ludwig-Maximilians-Universität (LMU) in Munich and the Bernstein Center Munich asked test subjects to estimate distances in a virtual reality environment. The results revealed that estimates tended to approach the mean of all previously experienced distances. For the first time, scientists were able to accurately predict the experimental findings using a mathematical model. The model combines two well-known laws of psychophysics with a theorem from probability theory. The study could be of fundamental relevance to research on perception.

Why do we perceive identical distances as long in one situation and short in another? It all depends on the distances that we have covered in the immediate past. This might seem a trivial conclusion, but it gives an important insight into how the brain processes signals of different intensities or even abstract elements such as numbers. Dr. Stefan Glasauer (LMU Munich), project leader at the Bernstein Center Munich, and PhD student Frederike Petzschner have investigated this effect both experimentally and theoretically. Test subjects were first asked to perform certain displacements in virtual reality and then to reproduce these displacements as accurately as possible. As in previous studies, the results showed a bias towards the mean of all previously experienced displacements.

The scientists can now provide a general explanation for this phenomenon. With the help of a mathematical model, they can calculate how previous stimuli affect the current estimate. “The influence of prior experience most probably follows a general principle, and is likely to hold true for the estimation of quantities or sound levels also,” says Glasauer. Test subjects whose distance estimates were strongly influenced by prior experience also placed greater weight on prior experience when asked to assess angular displacements. In both cases, they were learning without having received any information about the success or failure of their previous performance. Conventional learning methods, however, presuppose such feedback mechanisms.

Whether or not a fundamental principle determines the perception of stimulus strengths, such as sound levels, brightness, or even distances, has been a controversial issue. Two important laws of psychophysics, the so-called Weber-Fechner law, published 150 years ago, and the 50-year-old Stevens' power law, seemed to contradict each other. The Munich scientists have now shown that the two laws are in fact compatible, at least for certain cases. By combining the Weber-Fechner law with Bayes' Theorem (1763), a procedure from probability theory that allows evidence to be weighted, they were able to transform it into Stevens' power law. Glasauer is therefore confident that “we have contributed to solving a problem that perception researchers have been studying for more than 50 years now.” Next, the researchers want to analyze historical data and determine whether the model also applies to different stimulus modalities, such as sound levels and brightness.

More information: Petzschner F, Glasauer S (2011): Iterative Bayesian estimation as an explanation for range and regression effects - A study on human path integration; *J Neurosci* 2011, 31(47): 17220-17229

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