Making sense through order

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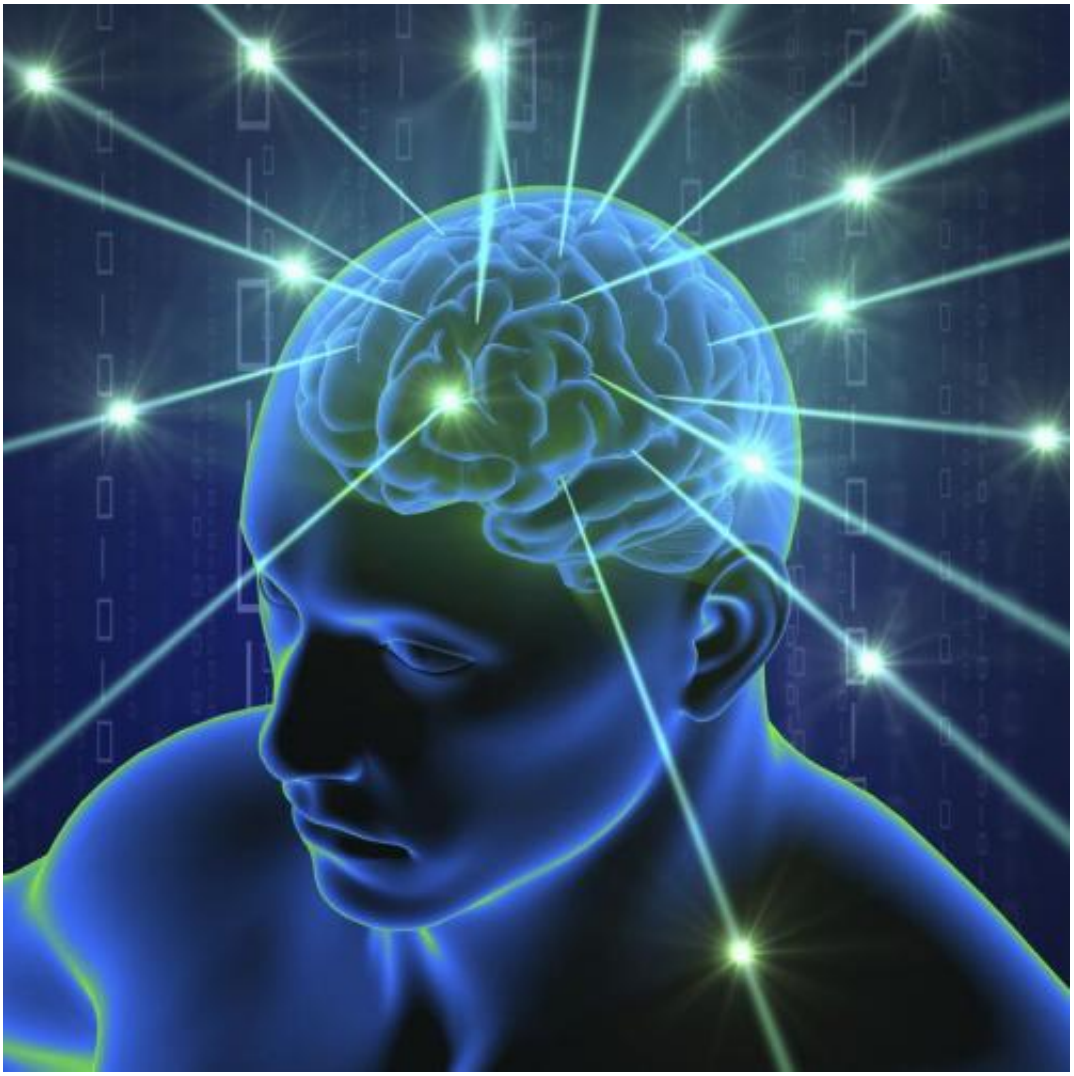

Credit: Rice University

Cognitive scientists at the University of Rochester say they have an

alternative to the standard explanation for why order matters when the human mind processes information. Instead of ignoring the order in which people receive information, they embrace it.

"Most researchers have treated the order in which the information is shown as a nuisance that can bias the interpretation of data," said Ting Qian, lead author and a former graduate student in brain and cognitive sciences at the University of Rochester. But as Qian's co-author and thesis advisor, Professor Richard Aslin explained, "We see it as a part of the natural statistics of the real world, and therefore a signal—or cue—that can be the basis of rational decisions."

In a paper published in the journal *Proceedings of the National Academy of Sciences*, Qian and Aslin have explained that our tendency to detect patterns in data is built into our cognitive processes, even when it's at the risk of overestimating the importance of such patterns.

When a coin is flipped, it rarely alternates between heads and tails over a large number of flips. Instead, there will be multiples of one, then the other.

"If we get an unusually high multiple—maybe five or six heads—someone could easily assume it's an unfair coin," said Aslin. "But if the coin is normal, and if the person waits long enough, the number of heads and tails would pretty much even out."

Qian and Aslin explain that even when patterns do not lead to correct conclusions—as , as in the case of assuming a standard coin has been modified in a way to come up heads more times than not—the patterns provide information that point to possibilities that might not have been considered otherwise.

For example, if there were several coins being flipped, and an observer

knew that one of the coins was biased, an unusually large number of consecutive heads might be a cue that the one coin is unfair.

"If we could wait forever in any given situation, we'd have all the information we need to reach a fair conclusion," said Aslin. "But in the real world, we need to make decisions more quickly. And that involves working with bundles of data that convey, what looks like, consistent information—such as a coin coming up heads four straight times."

In their work, the two researchers began by replicating the classic "hot hand" in basketball study conducted by Amos Tversky and Thomas Gilovich (1985) to see how people interpreted players' performances based on their shooting statistics. Qian and Aslin showed 100 subjects six different sequences of data presented in bundles—3 hits, 3 misses, 3 hits, 3 misses—and asked them whether the performances could be classified as "streak shooting." Qian and Aslin's results were in agreement with the original study. While the data showed players making about 50 percent of their shots during a game, 90 percent of the subjects perceived streak shooting, even though the streaks were too small to support the notion that any player had a "hot hand."

Tversky and colleagues interpreted the perception of streak shooting under these circumstances as irrational because the overall evidence indicates the shooters have a roughly 50 percent success rate, and the short bundles of made and missed shots are typical of what is found in situations with two recurring possibilities. In contrast, Qian and Aslin argued that the tendency to see streaks is an inevitable result of the brain's programming to use order as a cue to hidden structures in sequential data.

"We proposed that this perception of streaks is not because of a failure to understand what probability is," said Aslin. "It's actually due to the natural tendency of the human mind to seek patterns."

Sometimes the streaks are real, of course.

When deciding which players to use at the end of a close game, a coach may consider a player's consecutive hits or misses. "If a player has missed four straight attempts, it may lead the coach to ask whether the player has an injury," said Qian. "That's a possibility that might not have occurred to the coach, if not for the pattern of several consecutive misses."

Qian and Aslin developed a rational computational model to explain how people infer such hidden structures in sequential data, which they refer to as "bundles." They call it the Hibachi grill process (HGP) mixture model, named for a popular Japanese-style dining experience. Imagine a restaurant at which one entrée is the primary offering at each table and customers are seated based on their meal preferences. The owner is trying to maximize customer satisfaction and staff efficiency by having customers sit at the tables of their preferred dishes. The HGP mixture model extends the metaphor to include the assumption that restaurant customers typically arrive as groups of friends who have similar tastes and would want to sit at the same table. The model uses mathematical computations in an attempt to identify those hidden groups of friends from a stream of customers by relying on the stimulus order—that is, the order in which the customers enter the restaurant. The additional feature—that different groups of friends may share the same table—gives the model its name - a resemblance to the typical seating arrangement in many Hibachi grill restaurants in the US.

However, Qian and Aslin said, the HGP mixture model is a description of the mathematical underpinnings involving cognitive processes, and does not necessarily reflect on the "rationality" of the conclusions drawn from data.

It is unclear whether people should discover bundles from order in every

situation. The Ebola crisis offers a real-world scenario. "If, for example, a person heard about three consecutive patients at a medical clinic who were diagnosed with the Ebola virus, he or she might suspect a community-wide epidemic," said Aslin. But, it's possible that the information conveyed by the patient order was not meaningful. It may be that the three patients were from the same household and contracted the disease because they were living together.

Qian and Aslin said that the HGP model reveals not what the world really is, but what our mind interprets it to be, assuming a crucial role for the order of information.

Provided by University of Rochester