Input-output trade-offs found in human information processing

August 16 2010

The most beautiful thing about humans, says Indiana University researcher S. Lee Hong, is that they are both ever-changing and sometimes prone to error. Yet humans are still extremely flexible and adaptable, managing the transition from one context to another almost seamlessly. His new study demonstrates how this adaptability boils down to a zero-sum game.

"There's a famous Einstein quote: 'God does not play dice.' Unfortunately, we all have to do so every day," said Hong, assistant professor in IU's School of Health, Physical Education and Recreation. "Humans are unpredictably variable organisms living in fundamentally unpredictable and uncertain environments. Humans are capable of adapting to different levels of uncertainty, which is quite well documented, but 'how' has been unknown up to this time."

Hong's study, published in *PLoS One*, involves information processing and found that human behavior is systematic, not random, demonstrating a trade-off between input and out. The study also points to limitations to information processing, Hong said.

Hong and his co-author, Melissa R. Beck, cognitive psychology professor at Louisiana State University, studied eye movement and response times to stimuli sequences that included varying levels of uncertainty or unpredictability. When the researchers increased the uncertainty in the environment by having images on a computer monitor appear in different locations in irregular intervals, the uncertainty of

study participants' scanning patterns decreased. When the "input," or the objects' appearances became more regular or predictable, the level of uncertainty of the study participants' "output," or scanning behavior increased.

Hong uses a desk as an example. If someone needs to find a note on a desk with little clutter, his search need not be thorough. He can effectively glance around the desk to find what he wants. If the desk is messy or contains many papers and other objects, his search will need to be more systematic to find what he is looking for to make sure he hasn't missed anything. If he ransacked the desk in a random fashion, it likely would take longer to find the note.

"These exchanges are pretty much equal and opposite, much like the laws of the conservation of momentum and energy," Hong said. "More importantly, it seems that the human organism is fundamentally in tune with patterns of uncertainty, evolved, maybe. It's definitely a question for the future."

The study involved 29 college students. They generated repeated responses to a continuous series of visual stimuli presented on a computer monitor. As soon as a target was detected, they pressed a keypad. The researchers manipulated where and when the targets would appear. The more uncertain the time and place of the stimulus, the more systematic the visual search strategy was. On the other hand, their response times became much more unpredictable. The most interesting finding, said Hong, was that the changes in uncertainty of the eye movements were a virtual mirror image of the changes in uncertainty in the response times.

"The results show that the subjects adapted their visual search behavior to adjust to the different levels of stimulus uncertainty," the authors wrote in their paper.

More information: Hong SL, Beck MR (2010) Uncertainty Compensation in Human Attention: Evidence from Response Times and Fixation Durations. PLoS ONE 5(7): e11461. doi:10.1371/journal.pone.0011461