

Real-world context increases capacity for remembering colors, shows study

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Real-world objects: a red jacket, blue tea kettle, green dog-shaped balloon, and orange-brown drawstring bag (top row); and scrambled versions of the objects in teal, olive, indigo, and purple, respectively (bottom row). Objects were given randomly assigned colors in the experiments. Credit: Y. Chung et al.

Human memory is fundamental to everything we do. From remembering the face of a new acquaintance to finding the cell phone that one just left on a table, one's "visual working memory"—the core cognitive system

that retains visual information in an active state for a short period of time—plays a vital role.

Prior work has found that visual working memory capacity is well correlated with other important cognitive abilities such as [academic performance](#), and with fluid intelligence, which includes general reasoning and [problem solving](#), so understanding its limits is integral to understanding how human cognition works.

In the past, theories have proposed that an individual's capacity for visual working memory is fixed, but a new Dartmouth-led study finds that more [visual information](#) can be retained when stimuli are meaningful, demonstrating that visual working memory capacity is flexible. The results are published in *Psychological Science*.

"Our findings broadly suggest that the capacity for visual working memory may be more continuous and flexible than we thought," says lead author Yong Hoon Chung, a Ph.D. student in cognitive neuroscience and member of the Perception, Attention, and Memory Laboratory at Dartmouth.

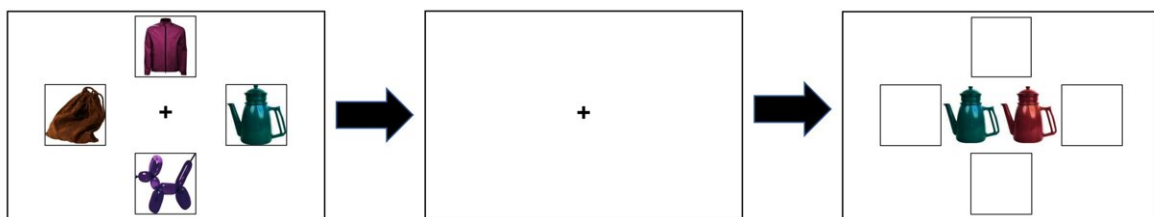
In one of the experiments, participants were presented with images of four different colored objects on a single computer screen and instructed to remember the colors as well as they could. They were shown recognizable objects in the "meaningful" condition, and scrambled versions of the objects in the "meaningless" condition.

Next, they were presented with a blank computer screen. Then, they viewed an image of one of the objects or scrambled versions of the objects in two different colors and were tasked to identify which color they just saw. Participants were never asked about the identity of the object, only the color. The task was "What color did you see?" not "Did you see a tea kettle?" Participants were then presented with hundreds of

objects as well as scrambled objects, both in random colors, and were tested on their color memory.

Through a series of five experiments, the researchers tested participants' capacity for remembering the colors of recognizable real-world objects such as that of a tea kettle versus that of an unrecognizable version of the object. The team used an algorithm developed by other researchers to convert the known object into a scrambled, abstract shape that is similar in visual complexity.

The original objects and scrambled objects were then assigned random colors from a 360-degree color wheel. The idea was that earlier visual processing of the brain would be similar across both intact and scrambled objects, yet scrambled objects would be unrecognizable by the observers. Thus, by scrambling the object, the meaningfulness of the stimuli would be removed.



In the "meaningful" condition task, participants were tested on their ability to remember the color of an object that they just saw. Credit: Y. Chung et al.

The researchers calculated how well participants were able to remember the colors of the stimuli in the meaningful versus meaningless conditions.

"Our results show that participants' memory for color was better when

they had a meaningful context," says Chung. "For example, people could remember the color blue better when it was part of a blue kettle than the scrambled blue shape of a jacket. When colors are seen as part of something meaningful, you are more likely to remember that color," says Chung.

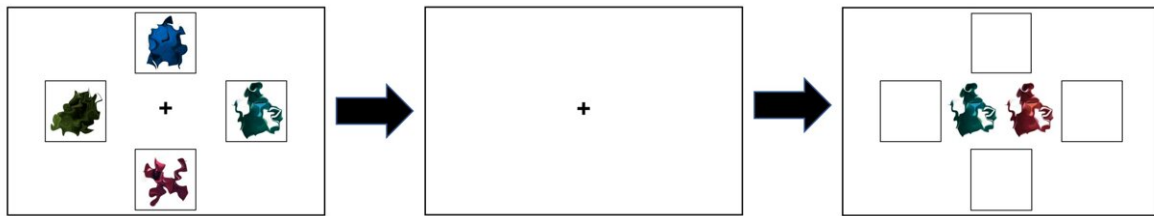
The other experiments in the study were similar and served as controls to test whether color memory would be better with recognizable objects, which proved true across the study. The controls included using upside-down stimuli instead of scrambled objects, or adding a verbal task on top of the visual task to rule out the prospect that color memory of the stimuli was due to verbalizing what was seen or adding a spatial cue at retrieval.

"Prior research has shown that space is one of the strongest cues that our visual working memory system uses, as it is kind of baked in to our [visual representations](#), so we were also interested in examining if the effect of meaningfulness would remain when participants could use spatial locations to retrieve the colors," says senior author Viola Störmer, an assistant professor of psychological and brain sciences, and principal investigator of the Perception, Attention, and Memory Laboratory at Dartmouth.

"What we found is that participants continued to remember the colors better when they were part of real-world objects and didn't only rely on the spatial locations of where the object was seen."

"Our study demonstrates that this higher-level semantic meaning, which draws on the long-term storage of general knowledge or in this case the recognition of an object, can help make a really low-level feature that's not meaningful by itself, like color, meaningful," says Störmer. "When relatively abstract information is combined with conceptual knowledge that people already have, this can enhance one's capacity to retain this

new information better."



In the "meaningless" condition task, participants were tested on their ability to remember the color of one of the scrambled object images that they just saw. Credit: Y.Chung et al.

"A lot of working memory measures are used as diagnostic tools in [clinical settings](#) to help identify deficits in memory, but they are based on the assumption that there is a fixed capacity for this type of [memory](#)," says Chung. "So, how we are testing in those fields might not necessarily be as accurate as we originally thought. It may be time to rethink the testing methodologies in order to obtain a more accurate measure of [human memory](#)," says Chung.

"Beyond the [clinical setting](#), our findings may also have implications for how artificial intelligence systems model and manipulate human behavior, as working [memory capacity](#) is known to be related to general capacity of human cognition."

The research builds on [Störmer's earlier co-authored works](#), which have found that the ability to remember real-world objects is stronger than remembering abstract objects.

The team plans to investigate the underlying mechanisms of [visual working memory](#) using electroencephalogram (EEG) and fMRI

technologies to better understand how the brain responds to the visual context of [colors](#).

More information: Yong Hoon Chung et al, No Fixed Limit for Storing Simple Visual Features: Realistic Objects Provide an Efficient Scaffold for Holding Features in Mind, *Psychological Science* (2023).
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