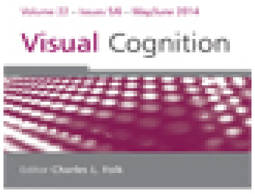

Visual Cognition

ISSN: 1350-6285 (Print) 1464-0716 (Online) Journal homepage: http://www.tandfonline.com/loi/pvis20

Visual long-term memory has weaker fidelity than working memory

M. W. Schurgin & J. I. Flombaum

VISUAL COGNITION, 2015
http://dx.doi.org/10.1080/13506285.2015.1093243

Routledge
Taylor & Francis Group

Visual long-term memory has weaker fidelity than working memory

M. W. Schurgin and J. I. Flombaum

Department of Psychological and Brain Sciences, Johns Hopkins University, Baltimore, MD, USA

ABSTRACT
Recent research suggests that visual long-term memory (VLTM) and visual working memory (VWM) possess similar resolution for feature memory. We investigated resolution in more holistic terms, exploiting a two alternative forced choice (2AFC) procedure and injecting noise into stimuli. Participants were exposed to two real-world objects per trial in a VWM experiment. One object was tested after a short delay. The other object (from each trial) was tested in a later session. We observed better performance for VWM, and the two systems were affected by noise in distinct ways. These results have broad implications for theories of visual memory.

ARTICLE HISTORY Received 14 July 2014; Accepted 25 August 2015

KEYWORDS Memory; Long-term memory; Working memory; Object recognition

Although visual working memory (VWM) and visual long-term memory (VLTM) are thought to be distinct systems (Broadbent, 1957; Jonides et al., 2008), they also clearly interact with and depend on one another in a variety of ways. Indeed, working memory maintenance appears to be a critical step for long-term encoding (Ranganath, Cohen, & Brozinsky, 2005). An important set of questions concerning how they interact pertains to the nature of the representations they employ, their contents, formats, and resolution. Under the assumption that they traffic in the same representational contents and formats, recent research has investigated the resolutions of the two systems in terms of colour. If an object is seen in a particular colour, how precisely can that colour be recalled on the basis of working memory, and on the basis of long-term memory? Using a delayed estimation procedure, Brady, Konkle, Gill, Oliva, and Alvarez (2013) found equivalent precision for the two systems.

A limitation of this research, however, is that VLTM and VWM representations could possess a similar resolution for any given feature, such as

CONTACT M. W. Schurgin maschurgin@jhu.edu

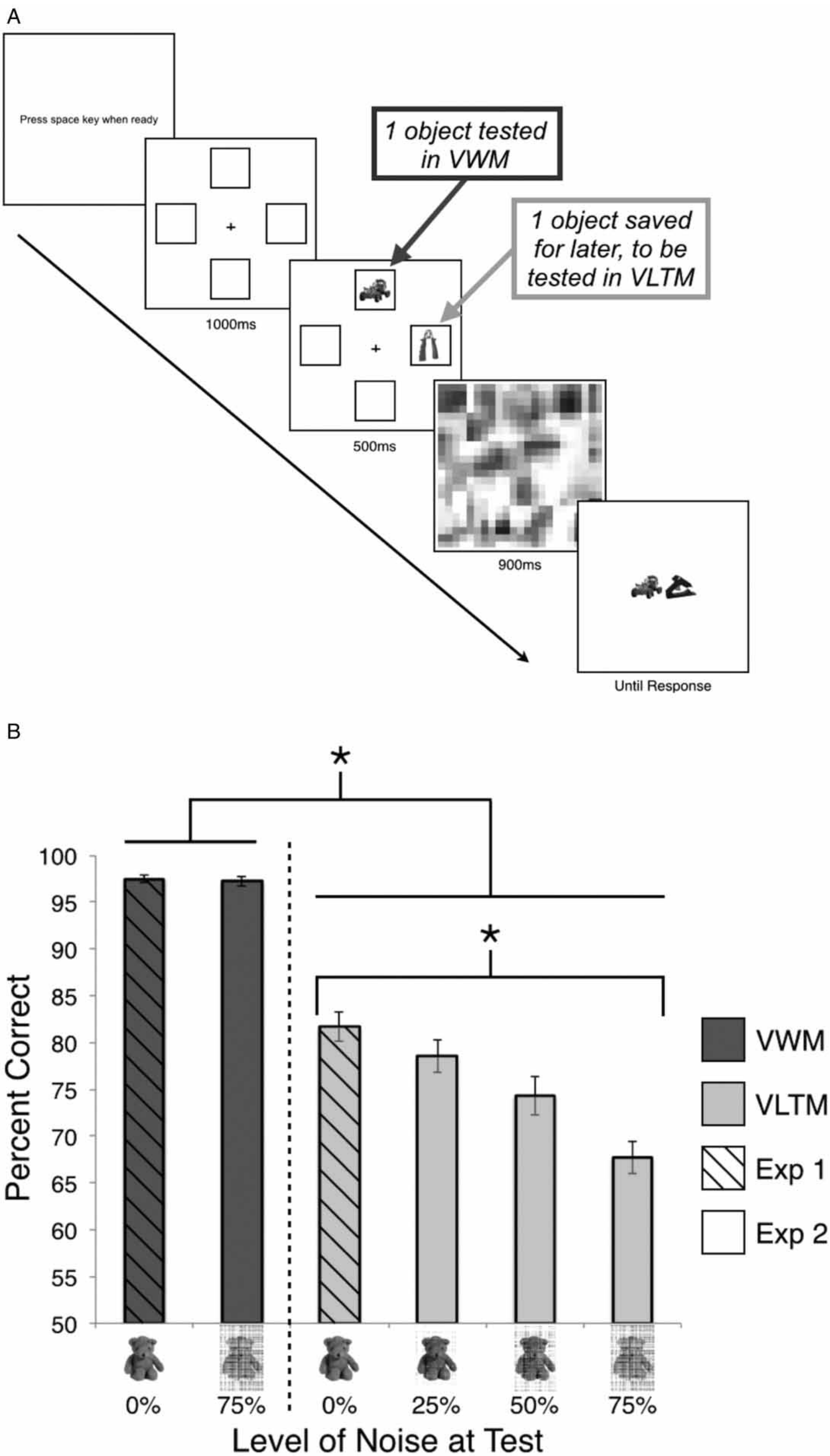

Figure 1. (A) Illustration of visual working memory paradigm. (B) Results of Experiments 1 and 2. Error bars represent ± SEM. *$p < .01$.

colour, while differing along others, and more importantly, in terms of how they encode objects as a whole. We therefore sought to investigate the resolutions of these systems in more holistic terms, by adding image noise to stimuli rather than probing precision along a single dimension.

The design of the study was as follows. In each trial of the experiment, participants briefly saw two real-world objects in one of four possible locations. The display was masked, and the task was to maintain the two pictures in VWM. At test, participants faced a two alternative forced (2AFC) judgment involving a randomly selected object from the encoding display and a new object, with the task of identifying the old object (Figure 1A). After 180 trials of this task participants faced a surprise VLTM test; on each trial, the previously untested object from each of the encoding displays was paired with a new object, and participants reported the one that was "old" (that is, the one that had appeared at some point in the encoding phase) In this way, each of the two objects from each encoding display was tested for recognition, one in VWM and one in VLTM, and they were tested in exactly the same way. Performance was considerably and significantly worse in the VLTM recognition test.

In a second experiment with the same design we injected noise into the test stimuli during the test encounters by randomly scrambling a percentage of the pixels (25–75%) in the images. We expected that less scrambled images would be recognized more easily, allowing us to measure whole-object representational resolution. Results are shown in Figure 1B. The resolution of the two systems was clearly different. We found that VWM performance was significantly better than VLTM performance. Indeed, VWM performance was unaffected by noise (with comparable performance between 0% and 75%), whereas increasing noise in VLTM led to a linear decrease in performance. Additional experiments showed that these results were not caused by ceiling effects, or by discarding untested items following VWM testing.

These results are inconsistent with the hypothesis that an integrated visual memory system traffics in representations with a shared constraint on resolution (Brady et al., 2013). More generally, these results suggest that VLTM and VWM may traffic in different *kinds* of representations in terms of their content and format. Our noise manipulation demonstrates operationally different whole-object resolution, but the causes of poor effective resolution remain an open question. VLTM and VWM may utilize different representations because they are designed to solve different kinds of problems. VLTM in particular needs to contend with greater variability in object appearance—the classic problem of object recognition. Poor resolution in the system may thus be a consequence of representational formats that support tolerant, invariant recognition despite variable viewing conditions.

References

Brady, T. F., Konkle, T., Gill, J., Oliva, A., & Alvarez, G. A. (2013). Visual long-term memory has the same limit on fidelity as visual working memory. *Psychological Science*, *24*(6), 981–990. doi:10.1177/0956797612465439

Broadbent, D. E. (1957). A mechanical model for human attention and immediate memory. *Psychological Review*, *64*(3), 205. doi:10.1037/h0047313

Jonides, J., Lewis, R. L., Nee, D. E., Lustig, C. A., Berman, M. G., & Moore, K. S. (2008). The mind and brain of short-term memory. *Annual Review of Psychology*, *59*, 193–224. doi:10.1146/annurev.psych.59.103006.093615

Ranganath, C., Cohen, M. X., & Brozinsky, C. J. (2005). Working memory maintenance contributes to long-term memory formation: Neural and behavioral evidence. *Journal of Cognitive Neuroscience*, *17*(7), 994–1010. doi:10.1162/0898929054475118