Cognitive Psychology 88 (2016) 1–21

Contents lists available at ScienceDirect

Cognitive Psychology

journal homepage: www.elsevier.com/locate/cogpsych

The dynamics of fidelity over the time course of long-term memory

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ARTICLE INFO

Article history:
Accepted 18 May 2016

Keywords:
Episodic memory
Prior knowledge and expectations
Remember-guess models
Bayesian mixture models

ABSTRACT

Bayesian models of cognition assume that prior knowledge about the world influences judgments. Recent approaches have suggested that the loss of fidelity from working to long-term (LT) memory is simply due to an increased rate of guessing (e.g. Brady, Konkle, Gill, Oliva, & Alvarez, 2013). That is, recall is the result of either remembering (with some noise) or guessing. This stands in contrast to Bayesian models of cognition while assume that prior knowledge about the world influences judgments, and that recall is a combination of expectations learned from the environment and noisy memory representations. Here, we evaluate the time course of fidelity in LT episodic memory, and the relative contribution of prior category knowledge and guessing, using a continuous recall paradigm. At an aggregate level, performance reflects a high rate of guessing. However, when aggregate data is partitioned by lag (i.e., the number of presentations from study to test), or is un-aggregated, performance appears to be more complex than just remembering with some noise and guessing. We implemented three models: the standard remember-guess model, a three-component remember-guess model, and a Bayesian mixture model and evaluated these models against the data. The results emphasize the importance of taking into account the influence of prior category knowledge on memory.

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http://dx.doi.org/10.1016/j.cogpsych.2016.05.003
0010-0285/

1. Introduction

An important question for memory is whether category knowledge biases performance, and whether an influence of category knowledge changes as a function of the fidelity of memory.

Recent work in visual working memory has suggested that when recalling stimulus features, observers either remember the episodic information with some noise or guess (Brady, Konkle, Gill, Oliva, & Alvarez, 2013; Zhang & Luck, 2008). Zhang and Luck found that fidelity is fixed once capacity of visual working memory is reached, but that the guessing rate changes. The resulting error distributions are well fit by a mixture of a Gaussian-like (remembering with some noise) and uniform distribution (guessing). They argued that observers remember continuous feature values and are not biased by categorization of those values. Importantly, a finding of category bias would suggest an intermediating step between remembering and random guessing. Such a bias was found by Bae and colleagues, establishing that category biases originate in perception and are reflected in visual working memory (Bae, Olkonnen, Allred, & Flombaum, 2015).

Several extensions to the original remember-guess model have been implemented to account for additional factors that influence visual short-term and working memory performance (e.g., Bays, Catalao, & Husain, 2009; Bays, Wu, & Husain, 2011; van den Berg, Shin, Chou, George, & Ma, 2012). For example, the variable-precision model (VP; van den Berg et al., 2012) postulates variability in the precision with which items are encoded in working memory. The resulting error distribution is a mixture of many von Mises distributions (as opposed to the one memory component in the remember-guess model), to account for residual noise in memory that the standard model cannot fit. Other proposed models incorporate task-based components, such as "misassociation" or "misbinding" parameters to extend the standard remember-guess model (Bays et al., 2009, 2011).

Although these models provide substantial revisions to the original, it is important to note that they are grounded in visual short-term and working memory. Relatively few studies have sought to apply the remember-guess framework to understanding long-term episodic memory. One such application by Brady et al. (2013) showed that there is a loss of fidelity from working into long-term (LT) memory. They argued that this decrease in fidelity is due to an increased rate of guessing, without addressing other factors that impact long-term memory.

The remember-guess model stands in direct contrast to a number of Bayesian cognitive models which assume that LT memory is an integration of expectations learned from the environment with noisy memory representations (e.g., Hemmer & Steyvers, 2009a, 2009b; Hemmer, Tauber, & Steyvers, 2015; Hemmer, Persaud, Kidd, & Piantidosi, 2015). These models are pervasive in cognition in general, and in specific domains including categorization (e.g., Huttenlocher, Hedges, & Vevea, 2000), generalization (e.g. Griffiths & Tenenbaum, 2006), semantic memory (Hemmer & Steyvers, 2009b; Steyvers, Griffiths, & Dennis, 2006), and episodic memory (Shiffrin & Steyvers, 1997; Steyvers & Griffiths, 2008).

Bayesian models of cognition propose a tradeoff between the fidelity of memory content and the influence of prior expectations. When the fidelity of the episodic trace is high, for example, as in visual short-term memory, there is minimal noise and potentially little influence of prior expectations. As fidelity decreases in working and LT memory, whether as a function of time or errors in retrieval, the influence of prior expectations would increase.

At an aggregate level, however, the error distributions resemble a combination of precise and imprecise memory, which might appear only to be remembered content and guessing, effectively masking underlying stages between the two. Prior expectation is a potential factor that might compensate for decreasing memory fidelity at the stage between precise memory and random guessing. In point of fact, Donkin, Nosofksy, Gold, and Shiffrin (2014) showed model-based evidence from visual short-term memory positing three discrete states of memory: One, a state based on perceptual memory and high precision, two, due to memory decay from perception, a state with intermediate precision based on verbal labeling, and three, guessing. Here, we seek to compare the performance of models that have been employed to characterize long-term memory, namely the remember-guess model (Brady et al., 2013) and Bayesian models of long-term memory (e.g., Hemmer & Steyvers, 2009a, 2009b; Persaud & Hemmer, 2014).