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Spatiotemporal continuity alters long-term memory representation of objects

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Kahneman, Triesman, and Gibbs' (1992) influential object-file theory was motivated to explain how we could recognize an object as a persisting token over a sequence of encounters, captured famously by the saying, "it's a bird, it's a plane, it's Superman!" The point is that the *same* object can *appear* different to an observer over multiple encounters, requiring appearance-independent

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mechanisms for tracking identity. In the subsequent years of research on object-file theory, one important issue has been underappreciated and underresearched. If an object can look different to an observer over multiple encounters—if it can look at once like a bird, a plane, and Superman—how are these encounters integrated into a long-term memory of that object? In other words, how does variability in perception from encounter to encounter influence long-term memory?

We sought to address this issue by investigating long-term memory for objects encountered along spatiotemporally continuous paths (that should be bound into one object file) compared with objects seen along spatiotemporally discontinuous paths (and thus bound into independent object files). To manipulate spatiotemporal continuity, we utilized a common apparent motion paradigm, wherein an object could be seen either in a single apparent motion stream or in two different apparent motion streams (see Figure 1a; also see Yi et al., 2008, and Chun & Cavanagh, 1997, upon which these methods were closely modelled). In each trial, a participant saw a single object repeated twice, but either along a spatiotemporally continuous or discontinuous path. The cover task was to report whether the object was an "indoor" or "outdoor" object. In an unexpected

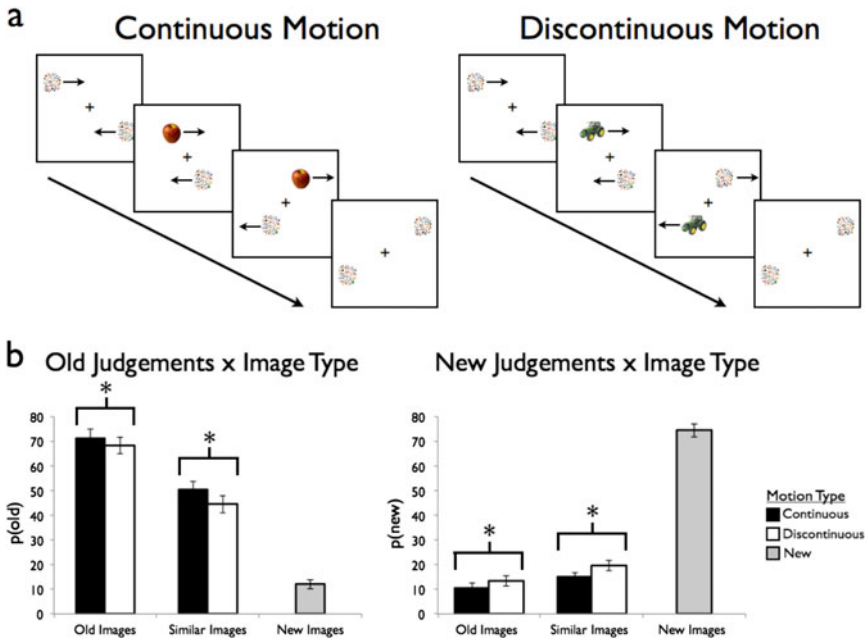


Figure 1. (a). Illustration of both continuous and discontinuous motion patterns used during encoding. Participants reported whether the object was an "indoor" or "outdoor" object. (b). Results plotted as probability of old and probability of new judgements across image type. See text for more details. *$p < .01$. To view this figure in colour, please see the online issue of the Journal.

segment of the experiment, we then tested memories for these objects using standard approaches. Participants viewed objects that were present in the previous task (old images), objects similar but not identical to ones in the previous task (similar images), and completely new objects that were not in the previous task (new images). They were instructed to make a judgement about whether each presented image was old, similar, or new.

Results are shown in Figure 1b. Given that new images in the retrieval phase were not encountered during encoding, there is no continuous versus discontinuous distinction for these images. Additionally, similar judgements are not shown because there was no main effect in this category. As shown, we found a significant effect of motion continuity. This effect can be summarized as a bias to report objects as old when they were seen under spatiotemporally continuous motion. There were no significant differences across motion type for similar judgements. During encoding, we found no differences in performance relative to motion type for classifying objects as "indoor" or "outdoor", suggesting that the main effect observed at retrieval cannot be explained in terms of smooth pursuit eye movements, and a control experiment further demonstrated that differences were unlikely to be caused by differences in eye movements during the second frame in a sequence.

These results suggest that token identity ascribed to objects when perceiving them influences the construction of long-term feature-based memories. Specifically, in spatiotemporally continuous streams objects are encoded into a single object file, whereas objects encountered in discontinuous streams are encoded as independent object files. Binding multiple encounters of an object into a single object file may lead to the creation of more tolerant long-term representations.

These results also establish a link between an important and extensively studied aspect of online visual perception and cognition with visual long-term memory, as well as a basic paradigm for investigating these connections. Such paradigms are needed to more closely relate research in long-term memory with research on object recognition, where the central question concerns the mechanisms that build abstract, tolerant, but explicit representations over encounters (Cox, Meier, Oertelt, & DiCarli, 2005). Though tolerance and explicitness bear obvious resemblance to pattern-completion and pattern-separation computations in long-term memory (Yassa & Stark, 2011), they have rarely been connected directly in extant research.

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What does that picture sound like to you? Oculomotor evidence for phonological competition in visual search

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Consider an experiment wherein, on each trial, you are shown a picture of some object (e.g., a hammer) as a visual search target, and then must find an image of a hammer against a background of other depicted objects. For obvious reasons, such studies of attentional guidance in visual search have primarily focused on the visual features of objects (e.g., Wolfe, 2007; Wolfe, Cave, & Franzel, 1989). However, several studies have shown that other, nonvisual object features can influence attentional guidance and interference from distractors. These include conceptual and semantic factors (Dahan & Tanenhaus, 2005; Huettig & Altmann, 2005), specificity of target descriptions in categorical search (Schmidt & Zelinsky, 2009), and phonological similarity (Gorges, Oppermann, Jescheniak, & Schriefers, 2013; Meyer, Belke, Telling, & Humphreys, 2007). In the present study, we further examined the phonological dimension, testing whether distractor object names may be implicitly activated during visual search, as indicated by potential interference from distractors whose names partially overlapped with

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