Cognition 136 (2015) 14–29

Contents lists available at ScienceDirect

Cognition

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

The role of relational triggers in event perception

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ARTICLE INFO

Article history:
Received 17 February 2014
Revised 5 November 2014
Accepted 17 November 2014

Keywords:
Event perception
Change detection
Film perception
Working memory
Spatial cognition

ABSTRACT

Research exploring visual attention has demonstrated that people are aware of only a small proportion of visual properties, and that people only track these properties over a subset of moments in time. This makes it critical to understand how our perceptual system leverages its limited capacity, such that properties are tracked across views only when they can support an understanding of meaningful events. In this paper, we propose that *relational triggers* induce between-view property comparisons when spatial relationships between objects appear inconsistent across views-moments that are particularly likely to mark the beginning of meaningful events. In these experiments, we activate relational triggers by violating heuristics that filmmakers use to create visuospatial continuity across views. We find that these violations increase change detection when they coincide with visual property changes, demonstrating that relational triggers induce a comparison of properties held in working memory. We also demonstrate that relational triggers increase the likelihood of event segmentation, and that change detection increases both in response to triggers and natural event boundaries. We propose that relational triggers are an effective heuristic cue that facilitates the comparison of properties when they are likely to be useful during event perception.

1. Introduction

Although perceptual experience appears to be continuous and rich, a wide variety of findings suggest that this richness arises from a surprisingly limited amount of concrete visual information. These limits can be documented when viewers fail to report events that fall outside of a narrow focus of visual attention (Mack & Rock, 1998; Simons & Chabris, 1999), when they fail to detect large visual changes in both unattended and attended objects (Levin & Simons, 1997; Rensink, O'Regan, & Clark, 1997; Scholl, 2000; Simons & Levin, 1998), and when they cannot perceive subsequent targets that follow initial targets (Chun & Potter, 1995; Dux, Asplund, & Marois, 2008). However, these limits to visual experience must be reconciled with viewers' clear ability to be aware of almost any visual property they choose to focus upon (Blackmore, 2002), to remember large numbers of objects (Standing, Conezio, & Haber, 1970), and ultimately to effectively understand dynamic visual events that extend over space and time (Magliano, Miller, & Zwaan, 2001; Zacks & Swallow, 2007; Zacks & Tversky, 2001). In part, this reconciliation depends upon processes that efficiently leverage limited visual information in the service of understanding important events.

The effective comprehension of events not only requires an ability to focus attention to informative properties, but also requires representing and tracking properties across space and time (Levin & Saylor, 2008). Research exploring event perception provides a principled basis for temporal selection by hypothesizing that relatively deep, rich encoding processes are limited to the beginnings of meaningful

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http://dx.doi.org/10.1016/j.cognition.2014.11.030

events (Swallow, Zacks, & Abrams, 2009; Zacks & Swallow, 2007). However, as we will review below, this work has yet to specify a full set of mechanisms that are needed to support this form of selective encoding. In this paper, we hypothesize a mechanism that relies upon a default encoding of spatial relationships, and induces a comparison of visual properties held in working memory when spatial relationships change. Using a change detection paradigm, we find that *relational triggers* cause between-view comparison of visual properties stored in working memory and induce event segmentation when spatial relationships appear fundamentally altered. Relational triggers are evidence of a perceptual mechanism that not only guides attention, but also elicits comparison and updating of working memory representations. Further, they are a principled mechanism for directing awareness during events.

In the pages that follow, we review previous research documenting limits to visual awareness, and we describe how research on event perception can shape visual selection for more efficient feature encoding. Then, we argue that a key basis for this form of event-based selection is a default encoding of space that is informed both by research in cognitive science and by longstanding real-world practice in visual story telling. Independently of psychological research, filmmakers have developed a simple set of spatial heuristics to combine disparate views that create seemingly continuous, understandable narratives. These heuristics are so prevalent in the film industry that film scholars have argued that "the framework for coherence is spatial" (Kraft, Cantor, & Gottdiener, 1991, p. 603). Not only does this practice highlight the importance of spatial information in visual event perception, but in the present set of experiments it has also inspired a new method for assessing how properties are encoded and compared as events unfold.

1.1. Visual awareness and event perception

Although our experience of an event is rich and compelling, research over the past 15 years has demonstrated that the perceptual basis of this experience is remarkably limited. Viewers can fail to detect unexpected objects, even when they are looking right at them, (e.g. inattention blindness; Mack & Rock, 1998), and they can miss changes ranging from the color of low-level singletons (Scholl, 2000) to replacement of a face-to-face conversational partner (e.g. change blindness; Rensink, O'Regan, & Clark, 1997; Simons & Levin, 1998; for review see: Simons & Rensink, 2005). These phenomena dramatically reveal a perceptual system that continuously monitors relatively few, specific visual properties. However, this limited form of on-line perceptual encoding must be reconciled with people's clear ability not only to remember a large amount of perceptual information (for example, a large number of pictures; Standing et al., 1970), but also with their ability to successfully extract the meaning of the complex visual events that surround them.

A partial explanation for the puzzle of visual awareness is that perceivers are efficient at representing only those properties that are helpful in understanding their surroundings. A number of studies have demonstrated that both subject and task factors can guide attention and awareness to specific sets of properties. Individuals demonstrate increased change detection for features relevant to their expertise (Werner & Thies, 2000) as well as when attention is cued to specific objects (Scholl, 2000) or individual dimensions such as orientation or color (Müller, Heller, & Ziegler, 1995). Another important piece to the puzzle is to recognize that change blindness implies not so much an absence of representation per se, but rather the failure to represent properties *and* effectively compare them between views (Angelone, Levin, & Simons, 2003; Beck & Levin, 2003; Simons, 2000; Simons, Chabris, Schnur, & Levin, 2002). As working memory has limited capacity and is constrained to retain information over limited periods of time, an efficient representational process is likely constrained to relatively few but informative moments (Levin & Saylor, 2008). A possible mechanism for intelligently selective representational tracking is described by theories of event perception, which imply that visual properties may be encoded and updated during disruptions to perceptual continuity, known as *event boundaries* (Magliano et al., 2001; Zacks, Speer, & Reynolds, 2009; Zacks & Tversky, 2001).

Models of event segmentation are particularly interesting because they imply the existence of broadly applicable circumstances where visual properties might receive additional encoding. According to Event Segmentation Theory (Reynolds, Zacks, & Braver, 2007; Zacks, Speer, Swallow, Braver, & Reynolds, 2007; Zacks & Swallow, 2007), new events occur when perceptual predictions fail to match observed events, producing an error signal that in turn induces encoding of visual information in anticipation of a new event. Many studies document the release of working memory representations following event boundaries (Glenberg, Meyer, & Lindem, 1987; Kurby & Zacks, 2012; Morrow, Bower, & Greenspan, 1989; Radvansky & Copeland, 2006; Swallow et al., 2011; Swallow et al., 2009; Zacks et al., 2007). However, the exact consequences of event boundaries for the on-line representation of visual properties are ambiguous. On the one hand, recent research suggests less detection of secondary task stimuli at event boundaries (Huff, Papenmeier, & Zacks, 2012), presumably due to a focusing of attention to event-relevant features and release of working memory for the previous event. Although secondary task stimuli by definition fall outside a primary attended channel, other phenomena such as the attentional blink suggest that some events that reach awareness can lessen detection even for subsequent stimuli within an attended channel (Chun & Potter, 1995). So, if new events are processed in a manner similar to target-detections in the attentional blink paradigm, attention will be drawn away from visual properties by the elaboration necessary to comprehend that new event. If this is the case, observers would be more prone to errors of awareness, such as change blindness or inattentional blindness, during event boundaries. On the other hand, there is also good reason to predict increased comparison of visual features following disruptions on event boundaries. Unpublished research in children suggests increased change detection on event boundaries (Saylor & Baldwin, 2004), and numerous other studies demonstrate increased encod-