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Exploring the influence of temporal discontinuities in narrative text using eye tracking

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ABSTRACT

One prominent question in the field of language comprehension concerns the dynamics of constructing and updating mental models while reading narratives, especially with respect to dealing with sudden event boundaries that often occur after encountering temporal changes. The present study investigated the influence of introducing temporal discontinuities of different length within short stories using eye tracking. It compared participants' reading times and several eye-movement parameters associated with reading narratives in which either a short or long time shift was presented. The obtained results indicated longer reading times for stories containing a long time shift, which were also characterized by a larger number of fixations. Processing the encountered temporal discontinuities and the text presented prior to the temporal adverbial phrase was more demanding than processing the remaining part of the text. Furthermore, this effect was more pronounced for stories containing a long time shift than those incorporating a short time shift.

1. Introduction

Numerous modern theories of language comprehension suggest that readers construct mental or situational models of the presented text during reading (Graesser et al., 1997; Johnson-Laird, 1983; Van Dijk and Kintsch, 1983; Zwaan et al., 1995; Zwaan and Radvansky, 1998). These situational models, i.e., representations of presented events, combine the pure, objective information written in the text with the readers' interpretations that typically include additional background information. During reading, the formulated situational or event model is maintained in working memory and used for guiding the perception of incoming information (Zacks et al., 2009, 2007). According to one influential model, the so-called event-indexing model (Zwaan et al., 1995), these integrated situational representations are built around events defined on five basic dimensions: time, space, entity, causation and intentionality (Zwaan, 2008).

With respect to the temporal dimension, numerous studies have shown the relevance of temporal consistency and duration for text understanding. Their findings indicate that factors such as the presentation of violations in the

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expected order of events, temporal inconsistencies, or longer temporal discontinuities within the text increase the readers' processing load, impair their understanding and lead to difficulties in integration as reflected in an increased N400 component (Ditman et al., 2008; Rinck et al., 2003, 2001; Zwaan, 1996; Zwaan et al., 1995). Furthermore, some findings have indicated that encountering temporal discontinuities within the text may impair the accessibility of information presented before the temporal shift that is visible in, e.g., increased latency of responding to comprehension questions regarding the presented materials (Zwaan, 1996; Zwaan et al., 2000). However, other studies have indicated that the influence of encountered larger time shifts on information availability may depend on the study methodology, namely the choice of a dependent variable. Specifically, it has been demonstrated that temporal changes may influence the recognition of presented items, but not anaphor comprehension itself (Weingartner and Myers, 2013). Nevertheless, numerous findings indicate that reading and understanding a story in which an event takes place after a longer temporal discontinuity (e.g., *a week later*) is more demanding, takes longer, and may result in reduced accessibility when compared to a story where the critical event is continuous with previous events or presented after a shorter temporal discontinuity (e.g., *a moment later*). Overall, these findings suggest that readers track and integrate temporal information during text reading, and use temporal discontinuities as event boundaries (Speer and Zacks, 2005; Speer et al., 2007; Zwaan, 1996).

The present study used eye tracking in order to further investigate the influence of introducing temporal shifts of different length within narrative texts. Eye tracking was chosen as a method that provides valuable insights into the flow of visual attention by measuring the spatial and temporal features of eye movements. In the present study, the stories containing a long or short temporal discontinuity (*few weeks later* vs. *few moments later*) were first compared with respect to the readers' understanding, reading times and the number of fixations, i.e., maintaining the visual gaze on a certain location. In line with previous studies, we expected the stories containing longer temporal shifts to be associated with higher processing costs that would be reflected in longer reading times and a larger overall number of fixations. Additionally, the present study assessed the processing of information presented prior to the time shift that has previously been explored with inconsistent results (Zwaan, 1996; but see Weingartner and Myers, 2013). Since the majority of previous studies investigated this issue indirectly, by focusing on anaphoric references to information presented prior to the temporal shift that are themselves encountered after the temporal adverbial phrase, the present study attempted to study this issue by directly focusing on the text presented prior to the time shift. We expected the processing of longer temporal discontinuities within a story to be more demanding and decrease the availability of information presented prior to the time shift. Since the stories used in the present study were fairly simple, we did not expect such decreased availability to be visible in participants' diminished recall of presented information, so we focused on a somewhat indirect measure of the number of regressions to the first part of the text. In addition, the participants were expected to spend more time processing the temporal adverbial phrase designating a longer time shift that would prompt their regressions, or returns to the earlier parts of the text. Finally, the participants were expected to return more often to the text presented prior to the introduced time shift and process it with more scrutiny within stories containing a long time shift when compared to the stories incorporating a short time shift.

2. Methods

2.1. Participants

36 paid volunteers (32 females, age 22 ± 2 years), with normal or corrected-to-normal vision, participated in the study. All participants were undergraduates at the University of Zagreb. Each participant gave an informed written consent before taking part in the experiment.

2.2. Apparatus

Eye movement data were recorded using a stationary eye tracking system with a temporal resolution of 500 Hz and a spatial resolution of 0.25°–0.50° (SMI iView Hi-Speed system, SensoMotoric Instruments G.m.b.H.). The distance between the eyes and the monitor was 50 cm. Prior to every recording, the gaze of each participant was calibrated with a 13-point calibration algorithm. The gaze direction was calculated as a vector between corneal reflection (which is stable, i.e., it depends only on head movements) and pupil position (i.e., the calculated centre of the pupil). Microsaccades were automatically grouped in a fixation. The fixations were detected automatically using the "Event Detected Method" that is built into the eye tracking device. Blinks were corrected automatically.

2.3. Materials

Eleven short stories depicting everyday events were constructed for the experiment. Each story consisted of seven sentences of comparable length. Within the fifth sentence of each story a temporal discontinuity was introduced. Two different versions of each story were constructed, one containing a temporal adverbial phrase designating a short temporal shift (*a few moments later*), and one containing a temporal adverbial phrase designating a longer time shift (*a few weeks later*). All other