Eye Movements and Pupil Dilation During Event Perception

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1 Introduction

Human observers segment ongoing activities into events that are reliable across observers [Newtson and Engquist 1976]. Segments can be small (”fine”) or large (”coarse”) with clusters of fine-grained segments relating hierarchically to coarse segments. Segmentation behaviour occurs even without instruction indicated by neural activity in the Medial Temporal complex (MT+)and Frontal Eye Field (FEF). Similar activation is observed during active segmentation [Zacks et al. 2001]. These two brain regions are known to be active during the processing of visual motion (MT+) and guiding saccadic eye movements (FEF). This, along with behavioural evidence [Zacks 2004], indicates that visual motion may play an important role in identifying events.

The intention of this study was to use eye-tracking to identify if eye movements and other ocular events (such as pupil dilation) are related to event boundaries.

2 Methodology

19 subjects (aged 18-34, 6 males) performed three stages of segmentation: passive, active coarse, and active fine. Their eye movements were recorded using an Eyelink II (SR Research Inc.) eye tracker recording at 500Hz. Subjects first watched (without specific instruction i.e. passive segmentation) three videos depicting an actor or a group of actors involved in a goal-directed activity. The subjects were then split into two groups and performed either the coarse or fine segmentation task on all three videos. The subjects were instructed to press a button to mark off the behaviour of the person or people into the largest (coarse) or smallest (fine) units that seemed meaningful. The process was then repeated at the other level of segmentation.

3 Results

The event boundaries identified during the coarse and fine segmentation task were superimposed onto the data from the passive viewing condition. This allows the identification of changes in viewing behaviour at event boundaries during non-segmentation viewing (see [Zacks et al. 2001]). All event boundaries at a particular granularity were then aligned to create an average pattern of ocular activity around a passive event boundary.

No significant relationship was found between passive event boundaries and blink frequency/duration, fixation frequency/duration, saccade amplitude/frequency/duration, or average X or Y gaze position. However, two significant effects were found:

There was a significant decrease in saccade frequency 260ms prior to a fine event boundary followed by a sudden increase 140ms after the boundary. This increase can be interpreted as visual search confirming neuroimaging evidence that eye movements may be related to fine event boundaries [Zacks et al. 2001]. No effect was observed for coarse boundaries.

Prior to all event boundaries (from 740ms for coarse boundaries and 1000ms for fine) pupil area was significantly larger than the mean. Immediately following the event boundary (0-120ms, coarse; 0-400ms, fine) pupil area returns to the mean before slowly increasing again. This indicates that subjects are experiencing a high degree of cognitive load prior to all event boundaries [Hess and Polt 1964]. This disappears after the boundary. Given the increased recognition for event boundaries previously observed [Newtson and Engquist 1976], this high cognitive load could be attributed to encoding of the event in memory.

4 Conclusion

This eye-tracking evidence confirms neuroimaging and behavioural evidence that changes in eye movements may be involved in the perception of fine event boundaries. The results also indicate that the end of all event segments are accompanied by a sudden decrease in cognitive load (indexed as pupil contraction). Taken in combination this evidence can be interpreted as indicating that fine event segments represent clear units of cognitive activity beginning with visual search and ending with encoding of the event in memory.

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ETRA 2006, San Diego, California, 27–29 March 2006.
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