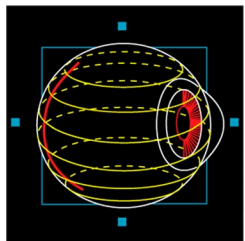


**VSS 2005**

# **The Effect of Edge Filtering on Inattentional Blindness**

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# ABSTRACT

Neisser & Becklen<sup>1</sup> identified inattentional blindness, the *inability* of observers to maintain awareness of events in more than one of two superimposed scenes. The ability of the brain to make use of such multiplexed visual information and avoid confusion is central to the utility of many augmented vision devices, such as see-through head-mounted displays and head up displays. We are developing a number of such devices as aids for people with vision impairments. The constraints imposed by visual or perceptual phenomena such as binocular or perceptual rivalry and inattentional blindness may limit the utility of these devices. It is possible that specific aspects of the display format might affect these phenomena. Specifically, if the two scenes are easier to separate they may not rival to the same degree.

In this study we investigated the effect of edge filtering on inattentional blindness and the ability to follow superimposed/multiplexed scenes. We closely reproduced parts of the original Neisser & Becklen experiment, and then treated one or both of the video scenes with edge filtering to create a cartoon-like image. The special bipolar edge filtering produced white and black contours at each luminance edge, facilitating clear uninterrupted visibility of the edge-filtered scene over bright and dark sections of the other scene.

36 normally-sighted young adults viewed superimposed videos that included 6 trials with unexpected events, while attending scenes that did not have the events. Edge filtering was applied to the attended scene in two of the trials and to the unattended scene in two trials. We found no evidence that edge filtering affected the detection of unexpected events. Filtering the attended scene reduced performance of the attended task slightly, while filtering the *unattended* scene did not significantly affect performance of the attended task, as measured by response time to actions in the attended scene. We were able to see a small priming effect, with later unexpected events detected more easily after the first had been detected.

# MOTIVATION: Vision multiplexing and Inattentional Blindness

- Many of the vision aids we are developing are based on the simultaneous (“multiplexed”) presentation of more than one view to one or both eyes;<sup>2</sup> e.g., spectacles to aid people with peripheral vision loss (tunnel vision, Fig. 1).<sup>3</sup>
- When playing close attention to the action in one scene, a person can be unaware of otherwise obvious events in an overlapping scene (“inattentional blindness”).<sup>1</sup>
- Inattentional blindness may affect a person’s ability to benefit from multiplexed information.
- We investigated the effect of using a cartoon-like representation<sup>4</sup> for one scene in an inattentional blindness experiment.



Fig. 1: a) Spectacles for peripheral vision loss, with a video screen in one lens that displays an edge-filtered, wide-angle, minified view. b) View through the spectacles, c) expanded view of the imbedded see-through display. The visual fields of many people with tunnel vision are narrower than the 16°-wide display screen.



## METHODS: Games and unexpected events

- As in Neisser & Becklen<sup>1</sup>, we used two games: a ballgame and a hand-slapping game.
- Three scenes which included unexpected events were taped for each game (Fig. 2).
- Four takes of each game without unexpected events were also taped, to vary the action in the attended scenes.

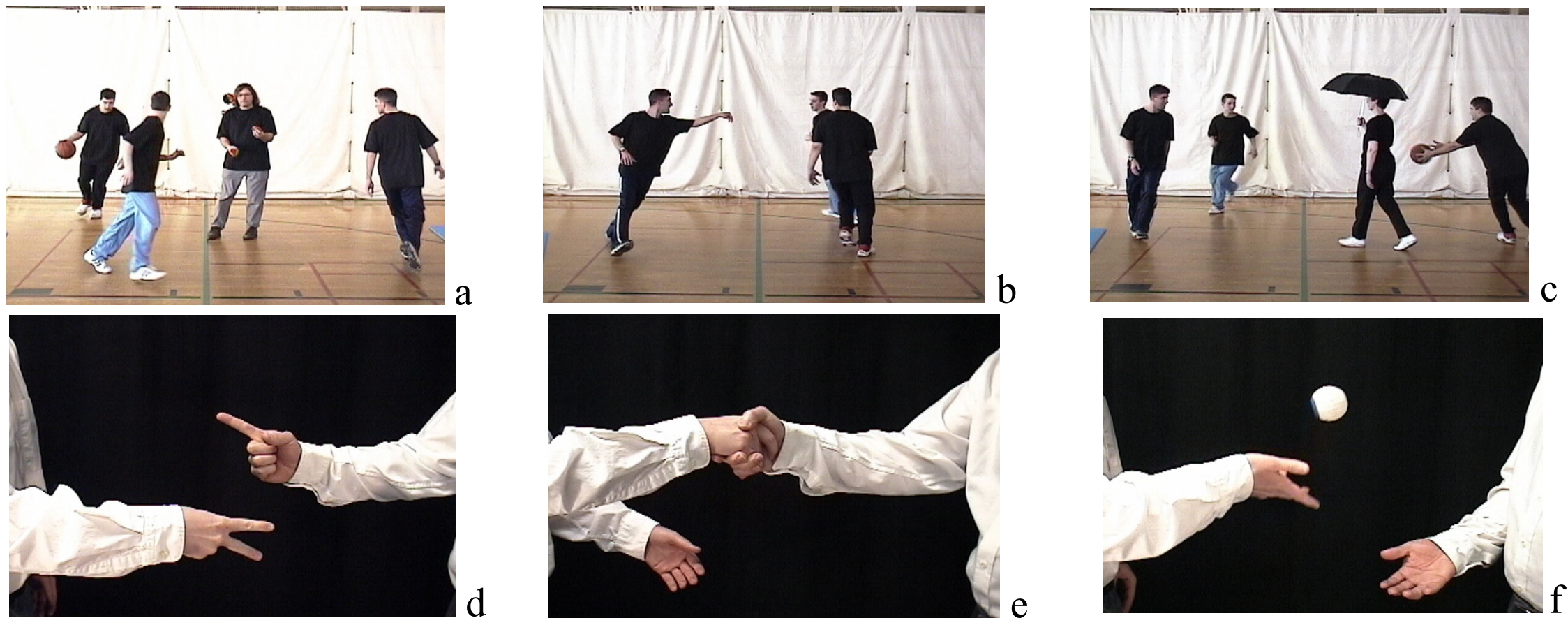


Fig. 2: Unexpected Event Scenes. a) Juggler; b) Lost ball; c) Umbrella woman; d) Choose-up; e) Handshake; f) Toss

## METHODS: Presentations and Treatments

- Hypothesis: Reducing one of the scenes of a superimposed pair to a cartoon-like line drawing<sup>4</sup> would reduce inattention blindness.
- A “presentation” was a superimposed combination of a scene from each game.
  - ◆ Some unattended scenes included unexpected events.
- Presentations with all four possible pairings of full or cartooned treatment were tested (Fig. 3).

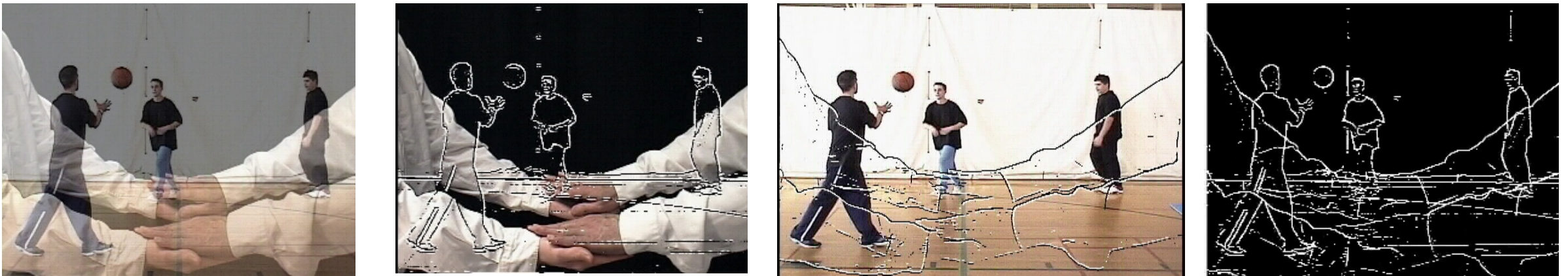


Fig. 3: a) Full video over full video presentation. b) Ballgame with bipolar edges and full-color handgame: The novel use of bipolar edges that transition between full white and black ensured that the edges were visible against any full-color video background. c) Cartooned handgame and full-color ballgame. d) Cartoon-over-cartoon presentation.

# METHODS: Experiment Design and Balancing

- 36 young adult subjects were used to achieve balance across order and pairings of treatment and unexpected events.
- Each subject viewed up to 26 trials:
  - ◆ Trials 1-4 were practice, illustrating the games, treatments, and tasks.
  - ◆ **Trials 5-12 were the critical (scored) trials:**
    - Each game was attended in half of the trials.
    - **Each of the unexpected events was included once.**
    - 2 trials had no unexpected events.
    - **Each of the treatment combinations was used once per attended/unattended pairing.**
    - Cartoon/cartoon was always used without unexpected events.
    - A digram-balanced Latin square design was used for order effects.
    - A different attended-game take was used in each trial.
  - ◆ Optional trials 13-26 were replays used to check that earlier responses were scored correctly.



## METHODS: Trials

- One video presentation per trial.
  - ◆ The subject clicked a mouse at each ball toss or hand slap attempt in the attended game
- After each of trials 1-12 the experimenter asked the same questions:
  - ◆ How difficult was that?
  - ◆ Were there any particularly hard parts?
  - ◆ Was there anything worth noting in the background video that was distracting or interfered with following the game?
- After trial 12 the experimenter described each unexpected event (UE) and asked if it had been seen before.
  - ◆ Two events not shown were described to detect cheating.
- Any UE not noticed was replayed in trials 13-26, without the click task.
  - ◆ As each UE was detected, the subject was asked if it was seen before but not thought worthy of mentioning.

## METHODS: Data Collection and Scoring

- The experimenter was masked to the content of each trial.
- All mouse clicks were recorded.
- All multiple choice responses and any comments were logged.
- To maintain unexpectedness, when a subject detected events the experimenter initially reacted with surprise, then resignation, explaining that the experiment was still in pilot phase and apparently some videos from another experiment were mixed in.
- During later analysis, mouse clicks were classified as hits, misses, or false alarms
  - ◆ Based upon a  $\pm 0.5$ s window around the subject's average response time to events in a trial.
  - ◆ **Hit rate** (percentage of correct hits out of 30 attended events in a trial) and **average response time** of correct hits were calculated.
- **Unexpected events were scored as **detected** if the subject identified them in trials 5-12 or later indicated that the event had definitely been seen.**



## RESULTS: Hit Accuracy and Response Time

	Hits	Misses	False Alarms
<b>Ballgame</b>	95.2%	4.8%	5.2%
<b>Handgame</b>	98.2%	1.8%	3.0%

Table 1: Hit rate was high, with handgame significantly higher than ballgame hit rates. ( $p < 0.001$ ).

Unexpected event scene did not significantly affect hit accuracy ( $p = 0.38$ ), nor did it affect response times ( $p = 0.65$ ). Filtering did not have a significant effect on hit accuracy ( $p = 0.76$ ).

		Unattended Scene	
		Full color	Edge filtered
Attended Scene	Edge filtered	532 ( $\pm 84$ )	522 ( $\pm 96$ )
	Full color	500 ( $\pm 97$ )	496 ( $\pm 100$ )

Table 2: Response time (ms) to the attended task degraded slightly if the attended task was filtered ( $p < 0.001$ ). Filtering the unattended task had no significant effect on the attended task ( $p = 0.37$ ).

# RESULTS: Noticing Events

Attended:	Full	Full	Edge	Total
Unattended:	Full	Edge	Full	
Juggler	10	7	10	27
Lost ball	3	2	2	7
Umbrella	8	8	3	19
Choose-up	9	10	9	28
Handshake	4	3	4	11
Ball toss	10	10	11	31
<b>Total</b>	44	40	39	123

Table 3: Frequency of detections by cartooning treatment vs. unexpected event scene. Each pairing was shown to 12 of the 36 subjects. **Event scene was highly significant ( $p < 0.001$ ), but treatment was not ( $p = 0.67$ ).** Unexpected events were detected in 123 (57%) of 216 presentations.

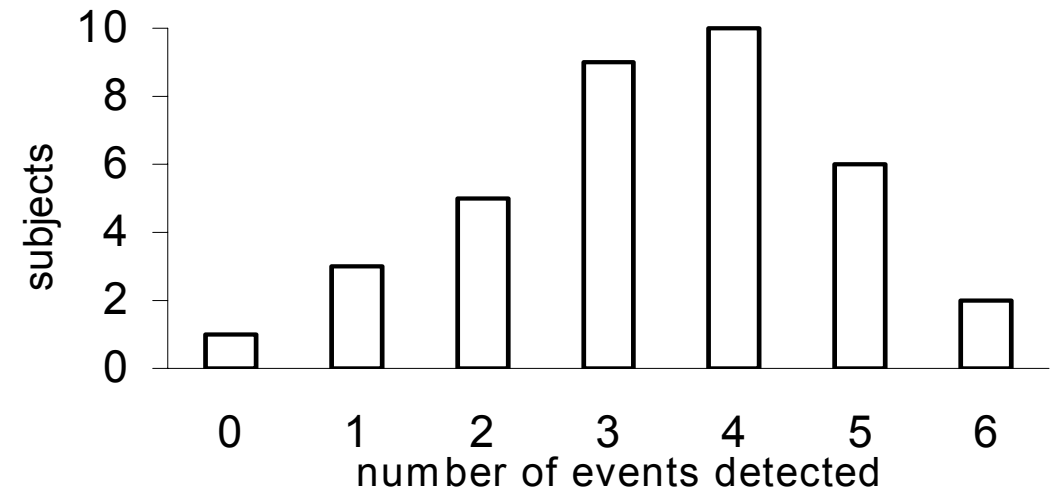


Fig. 4: Number of subjects who detected a given number of unexpected events. Only 2 out of 36 subjects detected all 6 events.

Power analysis indicated that we had a 24% chance of detecting a 10% effect of treatment on detection rate, a 70% chance of detecting a 20% difference, and 97% chance of detecting a 30% difference.

## RESULTS: Was there priming?

- The 35 subjects who detected at least one unexpected event used a total of 75 trials to detect the first event. The likelihood of success per trial was 0.46.
- Out of 141 opportunities after the first unexpected event was detected by subjects, 88 events were detected. The likelihood of success per trial was then 0.62.
- The difference in detection rates is significant<sup>5</sup> ( $p = 0.015$ ), suggesting that it became easier for a subject to detect events after one had been noticed (priming, Fig. 6).

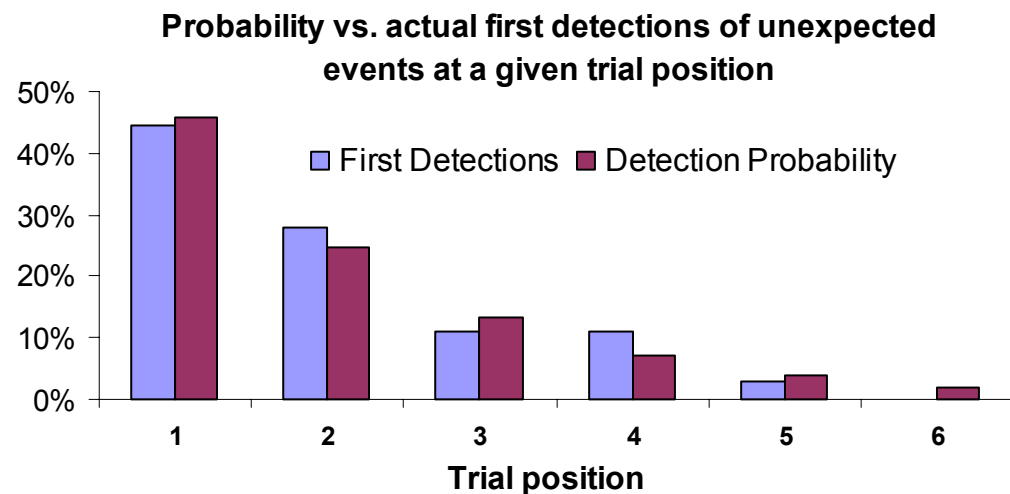


Fig. 5: The number of times the first detection of an unexpected event occurred at a given trial position closely tracked the residual probability.

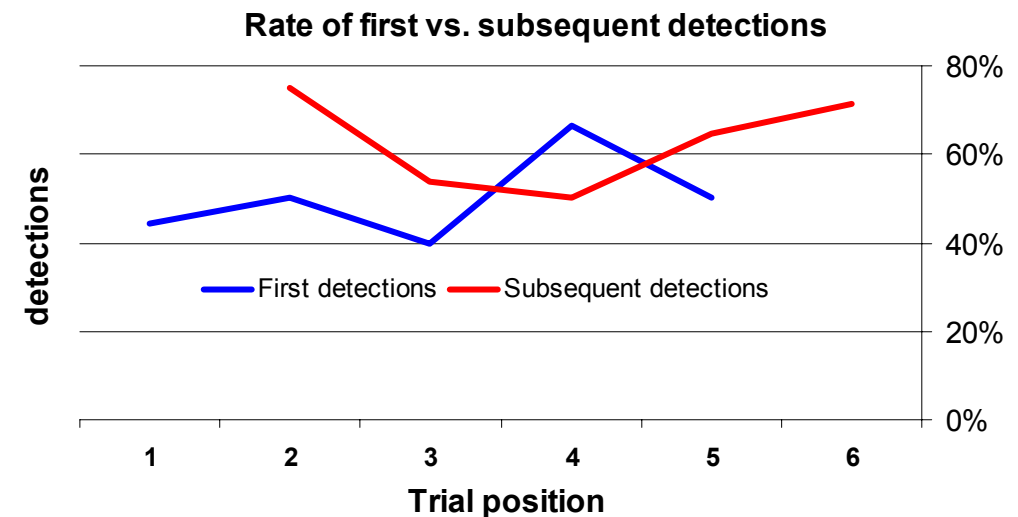


Fig. 6: Detection rates were higher after a first detection.

- We did not find an effect of first detection on hit rates or response times.

## DISCUSSION

- Edge filtering the minified view in our augmented-vision device is an aid to feature detection and orientation, so we are pleased that filtering one view did not degrade performance of a superimposed full-color view.
- The apparent inability of edge filtering to mitigate inattention blindness was disappointing.
- We plan to include people with tunnel vision in a future study.
- Differences in detectability of unexpected events may guide efforts to develop effective scanning techniques and training for users of our low-vision aids.
- Our augmented-vision aids present the **same** scene at different scales. The contextual relationship of the two views may improve detectability of events. We plan to investigate that possibility.
- The use of bipolar edges improved visibility, but our present see-through aid can not impose black edges; the video image is strictly additive. A purely-video “see through” device would afford that advantage.



# ACKNOWLEDGEMENTS

Supported in part by NIH grant EY 12890 and DOD grant W81XWH-04-1-0892. We thank Prof. U. Neisser for providing videotaped examples from his experiments, E. M. Fine for design advice, M. A. Garcia-Pérez for help with analyses, B. Peli and A. J. Mandel for help with application development, J. Barabas for videography, the Levinthal-Sidman JCC for use of the basketball court, the ball players recruited from the JCC staff, the handgame players from our group at Schepens, and C. Simmons for juggling.

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