

# REPORT DOCUMENTATION PAGE

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13. ABSTRACT (Maximum 200 words)  <b>Specific Aims:</b> During human scene perception, visual acuity is highest at fixation and drops off precipitously and continuously with increasing visual eccentricity. The highest quality visual information is acquired from the region of the scene projecting to the fovea, a region of the retina corresponding to about the central 2° of the viewed scene. The human visual-cognitive system takes advantage of the fovea by reorienting fixation over the viewed scene an average of three times each second via saccadic eye movements. The aim of the current project was to investigate the influence of semantic factors on human gaze control during the free viewing of complex, natural scenes, focusing on the extent to which initial fixations are controlled by semantic properties of the scene.				
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### Statement of Problem Studied

During human scene perception, visual acuity is highest at fixation and drops off precipitously and continuously with increasing visual eccentricity. The highest quality visual information is acquired from the region of the scene projecting to the fovea, a region of the retina corresponding to about the central 2° of the viewed scene. The human visual-cognitive system takes advantage of the fovea by reorienting fixation over the viewed scene an average of three times each second via saccadic eye movements. The aim of the current project was to investigate the influence of semantic factors on human gaze control during the free viewing of complex, natural scenes, focusing on the extent to which initial fixations are controlled by semantic properties of the scene.

### Summary of Important Results

- Each time the eyes are spatially reoriented via a saccadic eye movement, the image falling on the retina changes. How visually specific are the representations that are retained across saccades during active scene perception? Answering this question is critical for understanding the degree to which semantic factors can and do influence gaze control. Using a saccade contingent display-change paradigm in which pictures of complex real-world scenes are globally changed in real time during eye movements, project research demonstrated that contrary to prior theory, visual representations generated across saccades and retained in memory over time are relatively rich and detailed. Project research established many of the factors that determine the nature of this representation, including attention, fixation position, and semantic relevance. These representations are generated incidentally rather than intentionally.
  - Hollingworth, A., & Henderson, J. M. (in press). Sustained change blindness to incremental scene rotation: A dissociation between explicit change detection and visual memory. *Perception & Psychophysics*.
  - Castelhana, M. S., & Henderson, J. M. (in press). Detailed visual memory for objects in scenes following intentional and incidental learning tasks. *Visual Cognition*.
  - Henderson, J. M., & Hollingworth, A. (2003). Eye movements, visual memory, and scene representation. In M. Peterson and G. Rhodes (Eds.), *Perception of faces, objects, and scenes: Analytic and holistic processes*. Oxford University Press.
  - Henderson, J. M., & Hollingworth, A. (2003). Global transsaccadic change blindness during scene perception. *Psychological Science*, 14, 493-497.
  - Henderson, J. M., & Hollingworth, A. (2003). Eye movements and visual memory: Detecting changes to saccade targets in scenes. *Perception & Psychophysics*, 65, 58-71.
  - Hollingworth, A., & Henderson, J. M. (2003). Testing a conceptual locus for the inconsistent object change detection advantage in real-world scenes. *Memory & Cognition*, 31, 930-940.
  - Hollingworth, A., & Henderson, J. M. (2002). Accurate visual memory for previously attended objects in natural scenes. *Journal of Experimental Psychology: Human Perception and Performance*, 28, 113-136.
  - Hollingworth, A., Williams, C. C., & Henderson, J. M. (2001). To see and remember: Visually specific information is retained in memory from previously attended objects in natural scenes. *Psychonomic Bulletin & Review*, 8, 761-768.
- The nature of the internal memory representation generated over multiple fixations is critical in determining the degree to which semantic factors can play a role in eye guidance during subsequent scene perception; if the memory representation is sparse, then the information missing from the representation logically cannot drive eye movements. The research in Point 1 above established that relatively rich memory representations are in fact generated and retained. Project research also directly investigated the effects of memory and semantic factors on gaze control. Eye movements were monitored during semantic interpretation and memory comparison tasks; project research established the strong role of semantic factors on gaze control and began to investigate the interplay between image features and semantic knowledge.

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- Henderson, J. M., & Ferreira, F. (in press). Scene perception for psycholinguists. In J. M. Henderson & F. Ferreira (Eds.). *The interface of language, vision, and action: Eye movements and the visual world*. New York: Psychology Press.
- Ferreira, F., & Henderson, J. M. (in press). Introduction to the interface of language, vision, and action. In J. M. Henderson & F. Ferreira (Eds.). *The interface of language, vision, and action: Eye movements and the visual world*. New York: Psychology Press.
- Gajewski, D., & Henderson, J. M. (in press). Minimal use of working memory in a scene comparison task. *Visual Cognition*.
- Henderson, J. M. (2003). Human gaze control during real-world scene perception. *Trends in Cognitive Sciences*, 7, 498-504.
- Henderson, J. M., Williams, C. C., Castelhana, M. S., & Falk, R. J. (2003). Eye movements and picture processing during recognition. *Perception & Psychophysics*, 65, 725-734.
- Oliva, A., Torralba, A., Castelhana, M. S., & Henderson, J. M. (2003). Top down control of visual attention in object detection. *IEEE Proceedings of the International Conference on Image Processing, Vol I*, 253-256.
- Henderson, J. M., Falk, R. J., Minut, S., Dyer, F. C., & Mahadevan, S. (2001). Gaze control for face learning and recognition by humans and machines. In T. Shipley and P. Kellman (Eds.), *From fragments to objects: Segmentation and grouping in vision* (pp.463-481). New York: Elsevier.

### **Publications and Reports**

The project has to date resulted in 13 published and in-press journal articles, 1 edited volume, 3 book chapters, and 23 presentations at national and international conferences and invited colloquia. Additional journal papers, conference presentations, and book chapters currently in the planning stages or in preparation will also result from experiments planned and data collected during the project.

### **Journal Publications**

- Hollingworth, A., & Henderson, J. M. (in press). Sustained change blindness to incremental scene rotation: A dissociation between explicit change detection and visual memory. *Perception & Psychophysics*.
- Castelhana, M. S., & Henderson, J. M. (in press). Detailed visual memory for objects in scenes following intentional and incidental learning tasks. *Visual Cognition*.
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- Hollingworth, A., Schrock, G., & Henderson, J. M. (2001). Change detection in the flicker paradigm: The role of fixation position within the scene. *Memory & Cognition*, 29, 296-304.

**Edited Volumes and Book Chapters**

- Henderson, J. M., & Ferreira, F. (Eds.). (in press). *The interface of language, vision, and action: Eye movements and the visual world*. New York: Psychology Press.
- Ferreira, F., & Henderson, J. M. (in press). Introduction to the interface of language, vision, and action. In J. M. Henderson & F. Ferreira (Eds.). *The interface of language, vision, and action: Eye movements and the visual world*. New York: Psychology Press.
- Henderson, J. M., & Ferreira, F. (in press). Scene perception for psycholinguists. In J. M. Henderson & F. Ferreira (Eds.). *The interface of language, vision, and action: Eye movements and the visual world*. New York: Psychology Press.
- Henderson, J. M., & Hollingworth, A. (2003). Eye movements, visual memory, and scene representation. In M. Peterson and G. Rhodes (Eds.), *Perception of faces, objects, and scenes: Analytic and holistic processes*. Oxford University Press.

**National and International Conference Presentations and Invited Talks**

- Henderson, J. M. (2003, August). A cure for change blindness. Keynote Address, 12th European Conference on Eye Movements, Dundee, Scotland.
- Henderson, J. M. (2003, August). Invited chair for session on vision and language, 2003 Architectures and Mechanisms of Language Processing Conference, Glasgow, Scotland.
- Henderson, J. M. (2003, November). Introduction to The Visual Cognition of Real-World Scenes. Invited Symposium, Annual Meeting of the Psychonomic Society, Vancouver, BC, Canada.
- Henderson, J. M. (2003, November). Cognitive Influences on Gaze Control during Scene Viewing. Talk presented at the Annual Meeting of the Psychonomic Society, Vancouver, BC, Canada.
- Williams, C. C., Zacks, R. T., & Henderson, J. M. (2003, November). Incidental memory in visual search: Age differences in visual memory for targets but not distractors. Poster presented at the Annual Meeting of the Psychonomic Society, Vancouver, BC, Canada.
- Pearson, A., Henderson, J. M., & Schyns, P., & Gosselin, F. (2003, November). Task dependent eye movements during face perception. Poster presented at the Annual Meeting of the Psychonomic Society, Vancouver, BC, Canada.
- Mack, M., Castelhana, M. S., Henderson, J. M., & Oliva, A. (2003, November). What the visual system “sees”: The relationship between fixation positions and image properties during a search task in real-world scenes. Object Perception, Attention, and Memory (OPAM) Conference, Vancouver, BC, Canada.
- Pearson, A., Henderson, J. M., Schyns, P. (2003, June). Task dependent eye movements in face perception. NSF/IGERT Conference, Carnegie Mellon University, Pittsburgh, PA.
- Gajewski, D., & Henderson, J. M. (2003, June). NSF/IGERT Conference, Carnegie Mellon University, Pittsburgh, PA.
- Oliva, A., Torralba, A., Castelhana, M. S., Henderson, J. M. (2003, May). Top-down control of visual attention in real world scenes. Talk presented at the Annual Vision Sciences Society Meeting, Sarasota, FL.

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- Gajewski, D. A., & Henderson, J. M. (2003, May). Eye movements are cheaper than memory: Evidence from a scene comparison task. Talk presented at the Annual Vision Sciences Society Meeting, Sarasota, FL.
- Williams, C. C., Henderson, J. M., & Zacks, R. T. (2003, May). Incidental memory in visual search: Both targets and rejected distractors leave a lingering trace. Talk presented at the Annual Vision Sciences Society Meeting, Sarasota, FL.
- Castelhana, M. S., & Henderson, J. M. (2003, May). Flashing scenes and moving windows: An effect of initial scene gist on eye movements. Talk presented at the Annual Vision Sciences Society Meeting, Sarasota, FL.
- Wieth, M., Castelhana, M. S., & Henderson, J. M. (2003, May). I see what you see: Gaze perception during scene viewing. Poster presented at the Annual Vision Sciences Society Meeting, Sarasota, FL.
- Henderson, J. M. (July, 2002). A cure for change blindness. University of Glasgow, Glasgow, Scotland.
- Hollingworth, A., & Henderson, J. M. (2002, March). Sustained insensitivity to incremental scene rotation: A dissociation between explicit change detection and visual memory. Vision Sciences Society Meeting, Sarasota, FL.
- Castelhana, M. S., & Henderson, J. M. (2002, November). Early extraction of scene gist facilitates eye movement guidance during visual search. Annual Meeting of the Psychonomic Society, Kansas City, MO.
- Gajewski, D. A., & Henderson, J. M. (2002, November). Minimal memory in a scene comparison task. Annual Meeting of the Psychonomic Society, Kansas City, MO.
- Henderson, J. M., Castelhana, M. S., Oliva, A., & Minut, S. (submitted). Take it from the top: The role of visual saliency in human gaze control. Vision Sciences Society Meeting, Sarasota, FL.
- Castelhana, M. S., Falk, R. J., & Henderson, J. M. (2001, May). *Idiosyncratic characteristics of eye movements*. Presented at the Annual Meeting of the Midwestern Psychological Association, Chicago, IL.
- Castelhana, M. S., & Henderson, J. M. (2001, November). *Eye movements, viewing task, and scene memory*. Presented at the Annual Meeting of the Psychonomic Society, Orlando, FL.
- Falk, R. J., & Henderson, J. M. (2001, May). Eye movements in the study of holistic processing of faces. Annual Meeting of the Midwestern Psychological Association, Chicago, IL.
- Henderson, J. M. (April, 2001). A cure for change blindness. Presented in the RUCCS colloquium series and the Human and Computer Vision talk series, Rutgers University Center for Cognitive Science, New Brunswick, NJ.

**Scientific Personnel and Degrees Earned While Employed on Project**

Benjamin Swetts, M.Sc. (continuing on for Ph.D.)  
Monica Castelhana, M.Sc. (continuing on for Ph.D.)  
Daniel Gajewski, M.Sc. (still in progress)

**Scientific Personnel and Degrees Earned While Working on (but not Employed by) Project**

Andrew Hollingworth, Ph.D. (now assistant professor, University of Iowa)  
Carrick Williams, Ph.D. (now post-doctoral fellow, University of Massachusetts)  
Aaron Pearson, M.Sc. (still in progress)