The Development and Assessment of the Semantic Fields Model of Visual Salience.

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Signed Statement

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Acknowledgments

Seven years is a long time to do anything in life, and certainly it is more than enough time to finish a Ph.D. thesis. It might go some way to helping the reader understand why this process has taken so long, if I mention that I have had as many supervisors as I have spent years completing this research.

In the beginning I worked with Dr Lynn Ward, Professor Ted Nettelbeck and Dr Brett Bryan. Both Lynn and Ted were from the School of Psychology and Brett was working with Geography department. Much of my first year was spent learning how to write computer programs. As an undergraduate, I had my first experience with computers' four years prior to this date, and it took until second year for me to worked up the confidence to submit an assignment that was not hand written. So, I had a fair way to catch up to improve my skill levels in this area. I thank Lynn, Ted and Brett for indulging me in this pursuit, as it has become a skill that I now use in my day to day work life and this thesis has relied heavily on these skills.

Brett is a good programmer and Geographical Information Systems expert. In my honors year we had developed a pupillometer using a video camera, and so the next logical step was to create the eye-tracker. Unfortunately, as was to become a recurring theme during my Ph.D., people have a life of their own to live, and the world does not revolve around me. At the end of my first year of candidature, Brett was offered a job at the CSIRO[1] and was unable to continue supervising me in this project. While I wish him all the best for this change in direction, it did stifle my plans to develop the eye-tracker and the Ph.D. thesis needed to be re-thought.

After taking a year off to work and plan a new Ph.D. project, I developed an interest in human behavior in Web based environments. Professor Michael Lee volunteered to supervise me in this new project, and Ted was kind enough to stay on as my secondary supervisor. The

[1] Australia's Commonwealth Scientific and Industrial Research Organisation.

approach of my research changed under Michael's supervision. Instead of developing an eye-tracker, Michael simply bought one. My research could now focus on the task of modeling users' behavior whilst engaged in Web tasks. After a year spent working with Michael, the University of California managed to enticed him away from Adelaide, and again I found myself without a supervisor. I also wish him all the best with his future pursuits.

Fortunately for me, Michael was replaced in the Psychology department by Dr Simon Dennis who was kind enough to take on the role as my principal supervisor. Simon really has been the driving force behind my academic development, and I will always be indebted to him for the friendship, guidance, and patience he has shown towards me. During the next two years in Adelaide, Simon helped develop my skills as both a programmer and a research scientist. However, as my story has already revealed, talented people are always in demand. Ohio State University offered Simon an Associate Professorship in 2007, and again I was without a primary supervisor in Adelaide. That said, Simon has continued to be my mentor in this research project as an external supervisor, and I thank him for sticking by me.

At the end of 2007, both Dr Dan Navarro and Professor John Dunn were kind enough to step into the roles of principal- and co-supervisors, respectively. I wish to thank them both for the support they have offered me over the last couple of years.

Many thanks go to Dr Peter Kwantes, who co-authored the third paper presented in this thesis with Simon and myself. Also many thanks go to the Defence Research & Development Canada (grant number – W7711-067985), who funded the research presented in the third paper. Furthermore, there have been numerous reviewers who have helped improve the four papers presented in this dissertation. I wish to extend my sincere appreciation for their helpful comments and suggestions, which have greatly improved the work present here.

So, seven years and as many supervisors on, I find myself at the end of this journey with a few others to thank. First, I would like to thank my wife Tegwen who is the most patient and understanding person I know. Next, my parents Barbara and Peter, who are both owed many

thanks for their constant encouragement and support. Finally, thank you to all my friends and colleagues who have had continued to encourage and motivate me towards the completion of this work.

Dedication

To those that I love most, Tegs, Mum, Dad, Chris and Del.

Summary

The present thesis describes the development and assessment of the Semantic Fields Model of visual salience. The Semantic Fields model provides estimates of visual salience in relation to goal-oriented Web site search tasks. The development and assessment of this model is reported over seven studies that are presented in two journal articles and two peer-reviewed conference papers.

In Paper 1 (N=50), pupil dilation is validated as a measure of cognitive load for use in later studies. While it has been found previously that a participant's pupil dilation will be larger during more complex tasks, these experiments have not generally been conducted under the environmental condition of light radiated from a computer monitor. The findings of this experiment indicate that computer monitor radiance in our experimental setting did not interfere with the ability to discriminate successfully between task-related pupil dilation.

Paper 2 (N=49) introduces the Semantic Fields model for estimating the visual salience of different areas displayed on a Web page. Latent Semantic Analysis and the Touchstone Applied Science Associates (TASA) corpus were used to calculate Semantic Field values for any (x, y) coordinate point on a Web page based on the structure of that Web page. These Semantic Field values were then used to estimate eye-tracking data that was collected from participants' goal-oriented search tasks on a total of 1842 Web pages. Semantic Field values were found to predict the participants' eye-tracking data.

In Paper 3 (N=100), four studies are present in which improvements are made to the semantic component of the Semantic Fields model. Estimates of textual similarity generated from six semantic models were compared to human ratings of paragraph similarity on two datasets. Results suggest that when single paragraphs are compared, simple non-reductive models (word overlap and vector space) can provide better similarity estimates than more complex models (Latent Semantic Analysis, Topic Model, Sparse Non-negative Matrix

Factorization, and the Constructed Semantics Model). Various methods of corpus creation were explored to facilitate the semantic models' similarity estimates. Removing numeric and single characters, and also truncating document length improved performance. Automated construction of smaller Wikipedia-based corpora proved to be very effective even improving upon the performance of corpora that had been chosen for the domain. Model performance was further improved by augmenting corpora with dataset stimulus paragraphs.

In Paper 4 (N=49), ten models are compared in their ability to predict eye-tracking data that was collected from participants' goal-oriented search tasks on a total of 1809 Web pages. Forming the basis of six of these models, three semantic models and two corpus types are compared as semantic components for the Semantic Fields model. Latent Semantic Analysis, Sparse Non-Negative Matrix Factorization, vector space, and word overlap were used to generate similarity comparisons of goal and Web page text in the semantic component of the Semantic Fields model. Vector space was consistently the best performing semantic model in this study. Two types of corpora or knowledge-bases were used to inform the semantic models, the well known TASA corpus and other corpora that were constructed from the Wikipedia encyclopedia. In all cases the Wikipedia corpora out performed the TASA corpora. The non-corpus based Semantic Fields model that incorporated word overlap performed more poorly at these tasks. Three display-based models were also included as a point of comparison to evaluate the effectiveness of the Semantic Fields models. In all cases the corpus-based Semantic Fields models outperformed the solely display-based models when predicting the participants' eye-tracking data. Both final destination pages and pupil data (dilation) indicated that participants' were actively performing goal-oriented search tasks.

Based on this research, it is concluded that the Semantic Fields model provided useful estimates of visual salience during participants' goal-oriented search of Web sites.