Eye tracking:  
A comprehensive guide to methods and measures

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OXFORD UNIVERSITY PRESS • OXFORD 2010
Why we Wrote this Book

This book is written by and for researchers who are still in that part of their careers where they are actively using the eye-tracker as a tool; those who have to deal with the technology, the signals, the filters, the algorithms, the experimental design, the programming of stimulus presentation, instructions to participants, working the varying tools for data analysis, and of course, worrying about all the different things that must not go wrong!

A central theme of the book concerns the wide range of fields eye tracking covers. Suppose an educational psychologist wishes to use eye tracking to evaluate a new software package designed to support learning to read. She may have an excellent idea as a starting point, and some understanding of the kind of results eye tracking could provide to tackle her research question, but unless she and the group around her are also adept in computer science, it is unlikely she will know how the eye movement data she collects is generated: How raw data samples are converted into fixations and saccades using event detection algorithms, how the different representations of eye movement data are calculated, and how all the measures of eye movements relate to these processes. All this is important because subtleties involved in working with eye-tracking data can have large consequences for the final results, and thus whether our educational psychologist can confidently conclude that her software package is effective or not in supporting the development of reading skills.

This is not to say that hard-core computer science skills are the crux of good eye-tracking research, for this is certainly not the case. One can equally envisage a situation where an expert in programming and the manipulation of data plans and executes an eye-tracking study poorly, simply because she is not trained in the principles of experimental design, and the associated literature on the visual system and oculomotor control.

There are many contrasts between the diverging schools of thought which use eye tracking; practices and preferences vary, but certainly experts in different fields do not draw on each other's strengths enough. We felt there was a need to pinpoint the relative merits of adopting methods based in one field alone, whilst highlighting that the lack of synergy between different disciplines can lead to sub-optimal research practices, and new advancements being overlooked.

Besides technical details and theory, however, the heart of this book revolves around practicality. At the Humanities Laboratory at Lund University we have been teaching eye-tracking methodology regularly since 2000. We commonly see newcomers to the technique run aground when encountering just the sort of issues raised above, but beginners struggle with problems which are even more practical in nature. Hands-on advice for how to actually use eye-trackers is very limited. Setting up the eye camera and performing a good calibration routine is just as important as the design of the study and how data is handled, for if the recording is poor your options are limited from the outset.

There are fundamental methodological skills which underpin using eye-trackers, but at the other end of the spectrum there is also the vast choice of measures available to the eye-tracking researcher. For the present text to be complete, therefore, we felt a requirement should also be to draw together eye-tracking measures, as well as methods, into an understandable structure. So, starting around 2005, we began producing a taxonomy of all eye-movement methods and measures used by researchers, examining how the measures are related to each other, what type of data quality they rely on, and previous data processing they require. Our classification work thus consisted of searching the method sections from thousands of journal papers, book chapters, PhD theses and conference proceedings. Every measure and method we found was catalogued and put into a growing system. Some of the measures were extremely elusive, as they are known by different names, not only between research fields, but even within, and often the precise implementations are missing in the
published texts. At first, we were very unclear how to classify measures. Some varieties of taxonomic structures that we rejected can be found on p. 463. We ended up with a classification structure where the operational definitions are at the centre.

Users of eye-trackers often lack proficient training because there is little or no teaching community to rely on. As a result people are often self-taught, or depend on second-hand knowledge which may be out of date or even incorrect. When they participate in our eye-tracking methodology courses, we find that many new users are very focused on their research questions, but are surprised how much time they need to invest in order to master eye tracking properly. Often people attending have just purchased an eye-tracker to compliment their research, or for use in their company to tackle ergonomic and marketing-related questions. Our aim for this book is to make learning to use eye-trackers a much easier process for these readers. If you have a solid background in experimental psychology, computer science, or mathematics you will often find it straightforward to embrace the technologies and workflows surrounding eye tracking. But whatever your background, you should be able to achieve the same level of knowledge and understanding from this book as you would from training on eye tracking in-house in a fully competent laboratory.

More specifically, this book has been written to be a support when:

1. Evaluating or acquiring a commercial eye-tracker,
2. Planning an experiment where eye tracking is used as a tool,
3. About to record eye-movement data,
4. Planning how to process and interpret the recorded data, before carrying out statistical tests on it,
5. Reading or reviewing eye-movement research.

In our efforts to classify eye-tracking methods and measures, combined with useful practical hints and tips, we hope to provide the reader with the first comprehensive textbook on methodology for new users of eye tracking, but which also caters for the advanced researcher. Previous versions of this book have been used in eye-tracking education in Lund. Also, colleagues of ours in Potsdam, Tübingen, and Helsinki have used earlier manuscripts of the book when teaching and training masters and PhD level students in eye tracking. Lastly, although not the target audience, manufacturers have already shown a great interest in the book at the manuscript stage, which we hope may lead to even better eye-trackers in the future.

**How to submit suggestions**

Please send comments and suggestions to etbook@humlab.lu.se.
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