

Eye-Tracking

Eye-tracking is quickly becoming a valuable tool in applied linguistics research as it provides a real-time, direct measure of cognitive processing effort. This book provides a straightforward introduction to the technology and how it might be used in language research. With a strong focus on the practicalities of designing eye-tracking studies that achieve the standard of other well-established experimental techniques, it provides valuable information about building and designing studies, touching on common challenges and problems, as well as solutions. Importantly, the book looks at the use of eye-tracking in a wide variety of applied contexts including reading, listening and multimodal input, writing, testing, corpus linguistics, translation, stylistics and computer-mediated communication. Each chapter finishes with a simple checklist to help researchers use eye-tracking in a wide variety of language studies. Discussion is grounded in concrete examples, which will allow users coming to the technology for the first time to gain the knowledge and confidence to use it to produce high-quality research.

Kathy Conklin is an associate professor in psycholinguistics at the University of Nottingham. She has expertise in the use of eye-tracking to understand processing in a first and a second language.

Ana Pellicer-Sánchez is a senior lecturer in applied linguistics and TESOL at the UCL Institute of Education. Her research centres on the teaching and learning of vocabulary in a second and foreign language and makes use of eye-tracking.

Gareth Carrol is a lecturer in psycholinguistics and a researcher in figurative and formulaic language at the University of Birmingham. His work focuses on idioms and utilises psycholinguistic methods, principally eye-tracking, to investigate questions relating to processing, learning and use in first and second language speakers.

Cambridge University Press
978-1-108-41535-4 — Eye-Tracking
Kathy Conklin , Ana Pellicer-Sánchez , Gareth Carrol
Frontmatter
[More Information](#)

Eye-Tracking

A Guide for Applied Linguistics Research

KATHY CONKLIN

University of Nottingham

ANA PELLICER-SÁNCHEZ

UCL Institute of Education

GARETH CARROL

University of Birmingham



Cambridge University Press
978-1-108-41535-4 — Eye-Tracking
Kathy Conklin , Ana Pellicer-Sánchez , Gareth Carrol
Frontmatter
[More Information](#)

CAMBRIDGE UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom
One Liberty Plaza, 20th Floor, New York, NY 10006, USA
477 Williamstown Road, Port Melbourne, VIC 3207, Australia
314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India
79 Anson Road, #06–04/06, Singapore 079906

Cambridge University Press is part of the University of Cambridge.
It furthers the University's mission by disseminating knowledge in the pursuit of
education, learning, and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9781108415354
DOI: 10.1017/9781108233279

© Cambridge University Press 2018

This publication is in copyright. Subject to statutory exception
and to the provisions of relevant collective licensing agreements,
no reproduction of any part may take place without the written
permission of Cambridge University Press.

First published 2018

Printed in the United Kingdom by Clays, St Ives plc

A catalogue record for this publication is available from the British Library.

Library of Congress cataloging-in-publication Data

Names: Conklin, Kathryn author. | Pellicer-Sánchez, Ana author. | Carrol,
Gareth author.

Title: Eye-tracking : a guide for applied linguistics research / Kathryn
Conklin, University of Nottingham ; Ana Pellicer-Sánchez, UCL Institute of
Education; Gareth Carrol, University of Birmingham.

Description: Cambridge ; New York, NY: Cambridge University Press, 2018. |
Includes bibliographical references.

Identifiers: LCCN 2017043873 | ISBN 9781108415354

Subjects: LCSH: Applied linguistics – Research.

Classification: LCC P129 .C625 2018 | DDC 418.0072–dc23

LC record available at <https://lcn.loc.gov/2017043873>

ISBN 978-1-108-41535-4 Hardback

ISBN 978-1-108-40120-3 Paperback

Cambridge University Press has no responsibility for the persistence or accuracy of
URLs for external or third-party internet websites referred to in this publication
and does not guarantee that any content on such websites is, or will remain,
accurate or appropriate.

Contents

<i>List of Figures</i>	<i>page</i> ix
<i>List of Tables</i>	xi
<i>Preface</i>	xiii
1 Introduction to Eye-Tracking	1
1.1 What Is Eye-Tracking?	1
1.2 Why Use Eye-Tracking?	5
1.3 Basic Considerations When Doing Eye-Tracking	8
2 Choosing the Equipment	14
2.1 Introduction	14
2.2 Types of Eye-Trackers	14
2.3 Technical Specifications (Hardware Properties)	21
2.3.1 Monocular or Binocular Recording	21
2.3.2 Data Quality	21
2.4 Software Properties	26
2.5 Conclusions and Final Checklist	31
3 Practicalities of Eye-Tracking	33
3.1 Designing an Experiment	33
3.1.1 Choosing the Type of Experiment	33
3.1.2 Selecting and Controlling Stimulus Materials	36
3.1.3 Building and Testing the Experiment	47
3.1.4 Defining Regions of Interest	59
3.2 What Are the Different Eye-Tracking Measures?	64
3.2.1 Reading Measures	65
3.2.2 Measures in Visual Scene Perception and Visual Search	67
3.2.3 Selecting the Right Measures	69
3.3 Selecting Participants	70
3.3.1 How Many Participants Are Needed?	72
3.3.2 Considerations about the Participants	72
3.4 Setting Up an Eye-Tracker	73
3.4.1 Physical Set-Up of the Eye-Tracker and Participants	73
3.4.2 Calibrating the Eye-Tracker for Participants	75
3.5 Running Experiments	76
3.5.1 Monitoring Trials	76
3.5.2 Correcting for Eye-Drift	76
3.5.3 Saving Data	77
3.6 Conclusions and Final Checklist	77

CONTENTS

4	Researching Reading	80
4.1	Introduction	80
4.2	What Do We Know about Reading from Eye-Tracking?	87
4.2.1	What Do We Know about Word Recognition in Reading?	87
4.2.2	What Do We Know about Word Integration in Reading?	90
4.3	Words and Meaning	92
4.3.1	Contextualising an Example Study: Reading an Authentic Novel	92
4.3.2	Matching Second Language Participants	93
4.3.3	Using Authentic Materials	94
4.3.4	Data Analysis and Results	95
4.4	New Words	97
4.4.1	Contextualising an Example Study: Reading a Constructed Text	98
4.4.2	Matching Participants	98
4.4.3	Using Constructed Materials	99
4.4.4	Data Analysis and Results	101
4.5	Multi-Word Units	102
4.5.1	ROIs and Additional Variables for Multi-Word Units	102
4.5.2	Contextualising an Example Study: Using the Boundary Paradigm	103
4.5.3	Matching Participants and Controlling Materials	104
4.5.4	Data Analysis and Results	105
4.6	Sentences and Morpho-Syntax	106
4.6.1	Contextualising an Example Study: Counterbalanced Materials	106
4.6.2	Matching Participants from a Special Population	106
4.6.3	Matching and Controlling Materials	107
4.6.4	Data Analysis and Results	109
4.7	Conclusions and Final Checklist	109
5	Researching Listening and Multimodal Input	112
5.1	Introduction	112
5.1.1	Properties of the Stimuli and Real-World Knowledge Attract Visual Attention	115
5.1.2	The Goals of the Task Guide Visual Attention	117
5.1.3	Visual Attention Indicates Referential Decisions	119
5.1.4	Referential Decisions Can Tell Us about Parsing	121
5.2	What Has Been Studied?	122
5.2.1	Factors to Consider When Designing Visual Stimuli	126
5.2.2	Factors to Consider When Designing Audio Stimuli	128
5.3	Visual-World Paradigm with Objects and Scenes	128
5.3.1	Contextualising an Example Visual-World Study	129
5.3.2	Matching and Controlling Visual and Audio Input	130
5.3.3	Data Analysis and Results	131

Contents

5.4	Using Authentic Material	132
5.4.1	Contextualising an Example Video Study	133
5.4.2	Methodological Considerations for Video Stimuli	134
5.4.3	Data Analysis and Results	135
5.5	Conclusions and Final Checklist	137
6	Using Eye-Tracking in Other Contexts	139
6.1	Introduction	139
6.2	Eye-Tracking in Language Testing	140
6.2.1	What Can Be Measured?	141
6.2.2	Methodological Considerations	144
6.2.3	Example Study	152
6.3	Eye-Tracking in Writing Research	155
6.3.1	What Can Be Measured?	155
6.3.2	Methodological Considerations	157
6.3.3	Example Study	159
6.4	Eye-Tracking in Corpus Linguistics	161
6.4.1	What Can Be Measured?	161
6.4.2	Methodological Considerations	162
6.4.3	Example Study	164
6.5	Eye-Tracking in Translation Research	166
6.5.1	What Can Be Measured?	167
6.5.2	Methodological Considerations	170
6.5.3	Example Study	173
6.6	Eye-Tracking in Computer-Mediated Communication in Language Learning	175
6.6.1	What Can Be Measured?	175
6.6.2	Methodological Considerations	176
6.6.3	Example Study	180
6.7	Eye-Tracking in Literary Linguistics	181
6.7.1	What Can Be Measured?	181
6.7.2	Methodological Considerations	183
6.7.3	Example Study	185
6.8	Conclusions and Final Checklist	187
7	Working with the Data	189
7.1	Making a Start with the Data	189
7.1.1	Checking the Data	190
7.1.2	Cleaning the Data	191
7.1.3	Visualising the Data	192
7.2	Analysing Data	196
7.2.1	Exporting Data	196
7.2.2	Preparing the Data for Analysis	198
7.2.3	Approaches to Analysis	198
7.2.4	Types of Data and How to Analyse Them	199

CONTENTS

7.3	Presentation of Results	203
7.4	Conclusions and Final Checklist	204
8	Conclusions	206
8.1	All Language Research Can Benefit from Eye-Tracking	206
8.2	Eye-Tracking Results Are Easy to Interpret	207
8.3	Participants Don’t Always Do What You Want Them to Do	207
8.4	Let’s Track and See What Comes Out!	207
8.5	There Is a Magic Sample Size for All Eye-Tracking Studies	207
8.6	Eye-Tracking Is All about Heat Maps	208
8.7	Eye-Movement Analysis Can Be Done by Watching Gaze Videos in Real Time	208
8.8	The Dot on the Screen or Output Indicates Exactly Where a Person Looked and What They Saw	208
8.9	All Data Should Be Analysed	208
8.10	Anyone Can Do Eye-Tracking	209
	<i>References</i>	210
	<i>Index</i>	224

Figures

1.1	Examples of regressions due to different factors.	<i>page</i> 2
1.2	Hypothetical fixations for a skilled reader during silent reading.	4
1.3	Fixations used to assess cognitive effort to two matched words.	6
1.4	Examples of the visual-world paradigm presenting images and auditory stimulus.	8
2.1	SR Research EyeLink 1000 Plus with desktop mount being used with head support in its high-precision mode.	16
2.2	SMI iView X Hi-Speed tower-mounted eye-tracker.	17
2.3	Tobii Pro TX300 remote, desktop-mounted eye-tracker.	18
2.4	SR Research EyeLink II head-mounted eye-tracker.	19
2.5	SMI Eye-Tracking Glasses.	19
2.6	Tobii Pro TX300 system set-up with two screens.	20
2.7	Difference between accuracy and precision.	25
3.1	Example stimuli with single (left) and double (right) line spacing.	38
3.2	Counterbalancing in a video study with subtitles.	43
3.3	Structure of a typical eye-tracking experiment.	49
3.4	Hierarchical nested structure in an EyeLink experiment.	52
3.5	Sample layout for Block 3 – ‘Trial’ – and Block 4 – ‘Recording’ – within the overall EyeLink structure.	53
3.6	Sample data source in Experiment Builder.	55
3.7	Schematic of a sample layout in Tobii Pro Studio.	56
3.8	Schematic of the Application Window layout in Experiment Center.	58
3.9	Example ROIs on a video with subtitles.	62
3.10	Eye-tracking measures of interest in our reading example.	65
3.11	Example sentence with the ROI around ‘infect’, illustrative eye-movement pattern and list of eye-tracking measures.	68
4.1	Depiction of the decrease in visual acuity moving away from a fixation point.	81
4.2	Illustration of a line of text falling on the foveal, parafoveal and peripheral regions of the retina.	82
5.1	Examples of a visual-world paradigm task presented while participants hear linguistic input.	114
5.2	Two ways of representing eye-tracking data for visual ROIs.	120
5.3	Depiction of boundaries for visual ROIs.	121
5.4	Example of audio and visual stimuli to examine syntactic parsing choices.	122
5.5	Example of the visual-world paradigm manipulating the predictability of objects.	124
5.6	Depiction of two issues to consider for visual stimuli.	126
6.1	Example of stimuli for an eye-tracking study examining performance on an authentic reading test.	145

LIST OF FIGURES

6.2	Representation of stimuli for an eye-tracking study examining the processing of the text and questions in a reading test.	146
6.3	Representation of stimuli for an eye-tracking study exploring the processing of text and visual stimuli in a reading test.	147
6.4	Example of stimuli for an eye-tracking study exploring performance on a video-based listening test.	148
6.5	Representation of stimuli for an eye-tracking study examining performance on an online writing test.	150
6.6	Example of stimuli for an eye-tracking study examining performance on a speaking test.	151
6.7	Representation of stimuli for an eye-tracking study exploring performance on a reading test with incomplete sentences.	153
6.8	Example of output of a writing task showing the text produced and the pauses made.	160
6.9	Example of stimuli for an eye-tracking study exploring users’ engagement with the concordance tool from AntCont.	163
6.10	Example of stimuli for an eye-tracking study exploring the processing of a set of concordance lines.	165
6.11	Possible locations of the source (ST) and target (TT) texts in eye-tracking-supported written translation studies.	168
6.12	Example of stimuli for an eye-tracking study examining performance on a written translation task.	174
6.13	Example of stimuli for an eye-tracking study examining learners’ processing of their own messages at different time points in a synchronous computer-mediated communication (SCMC) task.	177
6.14	Example of stimuli for an eye-tracking study examining learners’ processing of messages in a synchronous computer-mediated communication (SCMC) task.	179
7.1	Eye-movement data where the calibration was vertically misaligned.	190
7.2	Example scan path data showing the fixation patterns for a specific trial.	194
7.3	Example heat map showing the relative number of looks to each picture in a visual-world study.	195
7.4	Early and late windows for analysing visual-world data.	197
7.5	Hypothetical plots for visual-world data showing looking patterns over time to a target image and distractor.	204

Tables

1.1	‘Global’ characteristics of fixations and saccades in reading and scene perception for skilled English readers.	<i>page 3</i>
2.1	Main technical specifications of some of the eye-tracking systems by SR Research, Tobii and SensoMotoric Instruments.	27
2.2	Software and operating systems supported by the three main types of eye-trackers discussed in this chapter.	29
3.1	Main stimulus types in applied linguistics eye-tracking studies.	35
3.2	Items counterbalanced in a Latin square arrangement.	43
3.3	Common trigger types and their availability in the three eye-tracking systems discussed in this chapter.	51
4.1	Factors that have been investigated with regard to their ability to influence processing when words are in foveal (<i>n</i>) and parafoveal view (<i>n+1</i>).	83
4.2	Summary of the ways in which Howard and colleagues (2017) showed that their typically developed participants and those with an autism spectrum disorder only varied on the factor of autism.	107
5.1	Illustration of the grammatical gender manipulation in Experiment 2 in Morales et al. (2016).	130
7.1	Stages of checking and cleaning data in eye-tracking studies.	193

Cambridge University Press
978-1-108-41535-4 — Eye-Tracking
Kathy Conklin , Ana Pellicer-Sánchez , Gareth Carrol
Frontmatter
[More Information](#)

Preface

The eyes provide a window into the mind.

Eye-tracking can in part make this statement a reality. More specifically, by tracking people's eye-movements, we can determine what they are attending to and for how long. By extension, we can make inferences about what they might be thinking about and how much cognitive effort they expend in doing so. We don't need to set an additional task (although we often do); we can simply ask participants to read a text, look at an image or watch a video as they normally would on a computer screen. Importantly, eye-tracking provides a rich moment-to-moment data source. Because of its advantages, it is an essential and well-established research tool in psychology and psycholinguistics, as well as in more applied fields like translation studies. Increasingly, it is being used more widely in a range of applied linguistics domains. While it might seem that eye-tracking is a magic potion that can make our studies more natural, authentic, less contrived, etc., it is simply a tool. Like all tools, it is only as good as the uses we put it to. Even with the best equipment and high-quality materials, with no training we are far more likely to build a rickety shack than a good, sturdy house. Without a clear understanding of the limitations of eye-tracking technology and a good foundation in experimental design and data analysis, eye-tracking technology will likely tell us very little. The goal of this book is to provide readers with a good foundation so that eye-tracking can become a useful and valuable research tool in applied linguistics research.

One aim of this book is to provide researchers with a good understanding of what eye-tracking is and what it can do given the current technical constraints of the equipment. Our focus is on the main eye-tracking systems that are used in language research: SR Research EyeLink, Tobii and SensoMotoric Instruments (SMI)¹ systems. We do not advocate the use of any one system over and above the others. We simply provide information about technical specifications and the dedicated software that the systems use to design experiments and analyse data. This should help readers gain an awareness of the kinds of studies that are appropriate and/or easier to carry out with particular systems.

The book is intended to be broad and inclusive, to make eye-tracking understandable, accessible and achievable for any language researcher coming to the technology for the first time. We expect the primary audience of the book to be applied linguists, and it covers a range of topics that will be of particular interest to them. However, the book can also be a resource for people in fields where eye-tracking is well established, but the researchers themselves are making a start with the technology. The sheer volume of language research making use of the technology will prove daunting for anyone starting out with it, no matter the field. Thus, in this book, we explain the basic assumptions of eye-tracking, which are

¹ Eye-tracking manufacturers and software developers are constantly updating to ensure that their methods are advanced and up-to-date, which means that the landscape is constantly shifting. After the book was written, Apple acquired SensoMotoric Instruments. This will likely pose challenges for SMI users, as the level of support and the pace of developments may change or even cease entirely.

PREFACE

often not fully spelled out. Understanding these is the first step in producing good research with the technology.

A predominant theme throughout the book is the methodological considerations we should take into account when designing studies. We try to relate all of our discussions to concrete examples. In Chapters 1, 4 and 5 we spell out methodological concerns largely in regard to existing research. This serves two purposes. First, it provides some sense of the existing eye-tracking literature. Second, it lays out some well-established means for dealing with a range of methodological concerns. In Chapter 6, we turn to more uncharted territory and provide a discussion of methodological considerations when using eye-tracking in very applied fields, which have generally been less explored. We have tried to describe a range of ‘test cases’ where we think eye-tracking could be fruitfully employed, as well as a few examples where it has already been used. Importantly, the focus in this chapter is on how we can meaningfully use eye-tracking with ‘authentic’ materials. A recurring topic is the trade-off between maintaining authenticity and modifying the experimental input in various ways so that we can acquire particular kinds of data.

In this book we walk people through eye-tracking from start to finish, and it can be read from cover to cover to gain a comprehensive overview of eye-tracking technology and its use in (applied) language research. However, the book is also written in such a way that it can be used as a resource for studying particular topics. Thus, if a reader already has some knowledge about eye-tracking in reading, he/she may not need to read Chapter 4 on reading research before diving into the discussion of eye-tracking reading tests in Chapter 6. Because we intend sections of the book to be somewhat self-contained, this means that there is some repetition in places. Similarly, in Chapters 2 and 7, where we talk about the different eye-tracking systems, readers may want to read them from start to finish if they want to learn more about the available systems – maybe because they are considering buying one. However, in many cases researchers may only have access to a particular eye-tracker. Thus, they may only want to read the sections that are specifically relevant to their system. Again, allowing the discussion to be, at the same time, inclusive and compartmentalised leads to a certain level of repetition.

This book would have been difficult to write without the help and support of manufacturers and colleagues. Thanks to people who have either read and commented on sections of the book, or helped with guidance on and demonstration of certain aspects of the system: Kurt Debono, William Schmidt, Sam Hutton, Marcus Johnson and Jiye Shen of SR Research; Ricardo Matos and Cecilia Lago Albright of Tobii; Meike Mischo and Stefanie Gehrke of SMI; and Richard Lilley of Tracksys Ltd. We would also like to thank our colleagues Steven Frisson and Bodo Winter (University of Birmingham) and Walter van Heuven (University of Nottingham) for their comments on different parts of the book and guidance on the use of some systems, as well as Dave Evans for his attentive proofreading.

Finally, we believe that we have produced a comprehensive overview of (1) the current state of eye-tracking technology for language research; (2) what measuring eye-movement behaviour can tell us in various domains; and (3) how we might extend it to more applied contexts. Our discussion is grounded in concrete examples to allow new users of the technology to gain the knowledge and confidence to use the ‘tool’ to produce high-quality research. We hope that you find it a good and helpful resource.