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# Contents

# 1

# Introduction

From the moment we wake up to the moment we end our day, we use interfaces built out of the written word. Textual information remains now, as it has for centuries, the cornerstone of human information acquisition. The wide adoption of smartphones, tablets, e-readers and personal computers has shifted the bulk of this reading from inflexible paper to digital content. The amount of information we acquire through reading digitally has grown rapidly over the last 15 years, and continues to grow. At the same time, literacy rates in the United States are staggeringly low: 130 million U.S. adults ages 16 to 74 (54% of the population) read below a sixth-grade level (Rothwell, 2020). Alarmingly, as of a 2022 report by the National Center for Education Statistics, young children's reading scores have experienced the largest decline since 1990 (U.S. Department of Education, 2022). Furthermore, dyslexia – the most common language-based learning disability – affects 15–20% of the population and represents 80–90% of all those with learning disabilities (International Dyslexia Association, 2022; The Yale Center for Dyslexia & Creativity, 2022). Readability research, as we describe here, takes a fundamentally individual approach to what each reader needs. Each reader, even readers who may not struggle, have their

own individual needs. Meanwhile, adapting the written word to the individual reader has never been easier, and the goal of maximizing individual reading efficacy is increasingly attainable.

**Readability** encapsulates the properties of a document which determine the ease and success with which individual readers decipher, process, and determine meaning from the text. These include (1) content, (2) document-level aspects, and (3) format features. These format features, which include all typographic elements, can have profound impacts on individual readers' speed and comprehension. Readability is discrete from legibility, which refers, in print or handwriting, to the property of being clear enough to read. In traditional printing, a single legible aesthetically pleasing layout was all that was possible, but digital displays now allow the potential of individuation, changing how text appears for each reader. Digital flexibility allows readability interventions to increase accessibility and efficacy. Here, we argue that this opportunity can be addressed with interdisciplinary methods spanning Human-Computer Interaction (HCI), design, user research, psychophysics, neuroscience, and data science.

**This monograph is about *Format Readability* – the visual and typographic features of the text**, which include font choice, size, spacing, and related attributes. We focus on format readability, rather than content and document factors, although we acknowledge and discuss their importance. We begin by discussing reading itself before turning to the readers. We then talk about reading materials for research, how those materials can be shown to readers, the research tools used to study readability, the experimental paradigms used in this research, and how the resulting data can be analyzed. We conclude by inviting researchers to ask their own questions in readability, using our review as a starting point for conducting readability studies and designing reading interfaces.

**The time is now.** To date, writers, publishers, and designers have been in control of the reading experience. However, digital reading provides a paradigm shift, through the multitude of device types, screen qualities, digital interfaces, and software settings available to readers. Depending on the technology, the readers – literate or nearly literate children or adults – can now control font size, screen polarity, spacing,

font choice, and other formatting choices. Amazon's Kindle, Apple's iBooks, Microsoft's Immersive Reader, Adobe's Liquid Mode, and modern web browsers all provide some of these controls, occasionally branded as accessibility features. Recent studies indicate that it is possible to dramatically improve reading for each individual – to make it much easier for struggling readers to read and for good readers to read even more efficiently by changing and, more significantly, personalizing the appearance of the text. The power of personalization and individuation has been shown with young (Crowley and Jordan, 2019a,b; Day *et al.*, 2022; Sheppard *et al.*, 2022a,b) and adult readers (Ball *et al.*, 2021; Cai *et al.*, 2022; Wallace *et al.*, 2020a, 2022a,b; Watson and Wallace, 2021), and suggests that every reader, at every level, can realize benefits if we can determine what they, individually, need and give it to them.

**No one discipline or field has all the tools or answers**, and readability work is inherently interdisciplinary. The authors of this monograph include vision scientists, technology experts, educators, designers, typographers, and data scientists; together, we represent voices from academia, the tech industry, and non-profit institutions, driven by common goals to improve the reading interfaces of today. This monograph is intended as a practical foundational resource for anyone interested in pushing readability research forward, including HCI researchers, practitioners, educators, tech companies, type designers, policymakers, and engineers. Our review cannot cover every topic we touch upon in full detail so we extensively reference related literature, to provide a starting point for our reader to build on. Different sections of this review may be individually useful to different readers from different backgrounds. Taken as a whole, if read from front to back, our review should be accessible to the budding HCI researcher, with prior exposure to cognitive science, computer science, or related disciplines, but without assuming specific knowledge about the psychology of reading, typography, or the latest technological advances, all of which we introduce here.

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