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Learning to Read in a Digital World

EDITED BY
Mirit Barzillai, Jenny Thomson, Sascha Schroeder and Paul van den Broek

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Volume 17

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Introduction

With digital texts ubiquitous in both homes and classrooms, understanding their influence on the way children read is of the utmost importance for researchers, educators, media designers, policy makers, and parents. The aim of this edited volume is to examine how advances in technology are influencing children’s reading skills and development across a variety of environments and populations.

Investigations into children’s interactions with texts in digital contexts vary along many dimensions, including how reading in digital environments is defined, whether reading processes are considered fundamentally different across digital and print media, and conceptualizations of how reader skills develop in digital environments. These in turn influence which aspects of reader and text-specific factors are studied. Thus, it is worthwhile to consider some of these dimensions before embarking on a survey of the results.

1. What is reading in digital environments?

One central dimension along which researchers differ concerns the definitions of ‘reading in digital environments’. For some researchers, reading in a digital environment refers to the reading of single texts – one might say, ‘traditional’ texts – on a digital display, as opposed to in paper format. The main questions these researchers focus on concerns how the physical and perceptual features of the display and the affordances allowed by the device influence the processing of the presented information and the experience of the reader. Other researchers consider reading in a digital environment as the processing of written language, in any form (long/short, formal/informal, etc.), in the highly interactive environment provided by the internet. In such an environment, knowledge is processed and constructed in interaction with the information sources by the reader, and often even co-constructed with others. Studies stemming from this view often consider how various elements of digital texts interact with reader skill to influence performance. These different conceptualizations of reading in digital environments can be thought of as endpoints on a spectrum. Between these endpoints are conceptualizations of reading in digital environments such as the reading of multiple texts in traditional formats, non-interactive activities as reading for entertainment or for information-gathering on the internet, and so on.
2. How do reading processes in digital environments compare to those in traditional paper environments?

A second dimension along which researchers vary concerns the relation between reading processes in traditional print contexts and those involved in reading in a digital environment. The central issue underlying this dimension is whether one considers the cognitive processes involved in reading essentially the same in these two contexts (and all intermediate contexts as outlined under the preceding point) or considers the reading processes to be fundamentally different across these situations. The former view emphasizes continuity in the processes: reading draws on a set of processes that are involved in all reading situations, although the relative weight of particular processes may differ across reading situations. The latter view emphasizes the discontinuity of reading processes in the different reading environments: reading in a digital context draws (in part) on unique processes that are not required when reading printed or written text. The question here is whether research on reading in digital environments requires a paradigm shift in theoretical models of reading and experimental measures or whether the same models and methods used in the study of reading in traditional environments can be adapted for and extended to reading in digital settings. Two observations are important in this context. First, the position of a particular study or researcher on the first dimension (what is reading in digital environments?) is likely to influence the position on the dimension of continuity/discontinuity. In the context of single text reading in a digital environment, the view of continuity in cognitive processes is more likely than in the context of interactive, co-constructive internet explorations, which are more likely to conjure up views of discontinuity. Second, the distinction between continuity and discontinuity of processing may depend on the granularity of description of the processing. When considered at a global level, processes may be more similar than when considered at a level of detail in which particulars of the source of information are included. For example, inference making is likely to be essential for creating an understanding of text in any context, but the specifics of the component processes of such inference making – and the relative weight of these component processes – may vary depending on whether one investigates reading of a written text, perusal of information on the internet, consultation of Wikipedia, and so on.

3. How does one conceptualize ‘development’ in the context of reading in digital environments?

Investigations into the development of reading skills in digital environments vary in their definition of what exactly it is that develops or what aspects are open to influence from education and practice. With regard to development, one may focus
on the complexity of processing of information in digital environments and, hence, emphasize the need for mature levels of information processing (e.g., executive functions, working memory) that are typically associated with age-related, maturational factors. Conversely, one may focus on the impact of familiarity with digital environments and successful integration of information and, hence, emphasize the need for experience with these environments. Analogously, educational practices may focus on either practicing the fundamental processes in increasing complexity regardless of whether the environment is analog or digital, or on specific exposure to and practice with the unique requirements of digital environments. Of course, most researchers and educators adhere to a mixture of both views of development and both views of the role of education and experience but, even so, they are likely to differ considerably in the relative weight given to each side of these dimensions.

Thus, how researchers conceptualize digital environments and reading development in these environments will determine which aspects of the reader (e.g. skills, emotions, goals) and the text are studied. Throughout the volume, individual chapters differ in their positions on these dimensions and the foci of their research. Yet, the dimensional framework points at areas of potential investigation that have thus far not received much research attention. This is amplified by the fact mentioned above that the position of researchers and studies on the dimensions tend to be correlated.

The book is divided into three themes that cover aspects of learning to read in a digital age, on both a theoretical and practical level. The chapters draw on the expertise of scientists and researchers across countries and disciplines, and review what is currently known about the influence of technology on reading, about how it is studied, and about new insights and research directions based on recent work.

**Theme I: Foundations**

The book opens with two chapters that address basic questions related to the use of digital texts in various contexts (family, school, etc.). The first (Deszcz-Tryhubczak & Huysmans, Chapter 1) includes a summary of children’s and adolescents’ multimedia use for different purposes (studying, socializing, etc.) across different EU countries. In the second chapter (Walker et al., Chapter 2) important design properties of digital texts are identified and differences between these and traditional, paper-based texts are discussed.

**Theme II: Cognitive and emotional aspects of digital reading across development**

Cognitive processes crucial for traditional print reading are well known and extensively studied. Technology and the internet, however, change the balance of cognitive processes needed for efficient digital reading. The chapters in this section...
review and outline the cognitive processes and emotional/motivational aspects related to the specific demands of the digital media across different age groups and populations. The cognitive processes discussed in the third chapter (Wylie et al., Chapter 3) include executive control, attention, and memory. In Chapter 4, Salmeron and colleagues focuses on the new sets of skills critical for successfully reading digital texts such as search and navigation skills, integration of multiple pieces of information, and critical evaluation of information. In Chapter 5, Ben Yehuda and colleagues discuss individual differences in digital reading with respect to populations of children with learning difficulties. The role of emotions in digital reading is examined in Chapter 6 in which Kaakinen and colleagues address how text design may induce emotional reactions and explore how factors such as readers’ attitudes and motivations influence the way they approach and construct meaning from digital texts.

Theme III: Education, instruction, and assessment

The final section of the book focuses on the impact of digital technology on education, primarily – but not exclusively – during formal schooling in childhood/young adulthood. Our understanding of how digital technology may alter existing models of learning to read remains underspecified. Teachers of reading are increasingly incorporating digital technologies and multimodal practices in their classrooms and must face the challenge of reaching their print-based literacy goals while integrating new literacy skills related to digital technologies. In Chapter 7, Mifsud and Petrova examine the influence of digital technologies on early literacy education by exploring how digital technologies generate both unique challenges and opportunities. As children take on more agency in their own reading, digital technology poses new affordances and challenges in terms of text comprehension and reading strategies. This is the focus of Chapter 8, in which Baturay and colleagues discuss current multimodal conceptualizations of reading comprehension in mid-childhood and beyond. Finally, taking an international perspective, Støle, Mangen, Frønes and Thomson (Chapter 9) focus on the transition of formal assessments to a digital platform and the dilemmas this process poses.

In the final chapter we discuss the implications of digital reading for educators, parents, and practitioners and suggest further research directions. We hope that this volume provides a valuable resource for the host of parents and professionals devoted to understanding children’s reading and promoting their optimal development in digital and print environments. We wish to gratefully acknowledge the networking support by the COST Action IS1404 E-READ as well as the publication support of the GO Foundation.

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CHAPTER 1

Reading and digital media
European perspectives

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The on-going discussion between parents, educators, politicians and academics on the consequences of screen reading as compared to reading from paper is filled with controversy. This chapter aims at providing a factual context for these debates. We first focus on early studies concerning children’s use of media. We then summarise available data on children’s digital media use and media preferences based on national and cross-national surveys conducted in Europe since 2010, including reading in a family context. We also look at evidence related to digital reading in public and school libraries. We conclude by discussing limitations in the available methodologies and possible new approaches to be taken to enhance our understanding of the ways in which reading is changing.

1. Reading and digital media: Utopian and dystopian perspectives

Discussions on the presence of new media in our lives have usually developed within a field of tension between utopian enthusiasm and elevated hopes about the potential of new technologies and the dystopian rhetoric of fear about the moral and intellectual degradation of society in general, and children and youth in particular. The debate is not new; similar dichotomous approaches accompanied, for example, the widespread introduction of TV into family life. In *The Disappearance of Childhood*, Neil Postman (1982) argued that TV was likely to erode the distinction between childhood and adulthood as the use of the new medium required neither special prior knowledge nor fostered the development of new skills. Andrew Keen (2007), in *The Cult of the Amateur*, deplored the degrading effects of a Web 2.0, favouring user-generated content over “our most valued cultural institutions” like newspapers and the music business, leading to the “destr[uction] of our economy, our culture, and our values”. Without restrictive measures, Keen
writes, children will be continuously tempted to spend more time online at the expense of more valuable and important activities. While Keen is right about new media’s power of attraction, he paints a very black-and-white picture when he states that “parents must man the front lines in the battle to protect children from the evils lurking on the Web 2.0” (Keen, 2007, p. 202).

These variations on technological determinism – the conviction that technologies and media have a determining influence on society and affect our lives and culture in uniform ways (Itō, Horst, Bittanti, Boyd, Herr-Stephenson, Lange, Pascoe & Robinson, 2009; Boyd, 2014) – have also emerged in public debates about the effects of the increasingly pronounced use of electronic media and digital devices on the processes and habits of reading. At one extreme, the statistics indicating the decline of literary culture seem to be the most frequently publicised results of studies and surveys concerned with assessing reading in the electronic age. The emphasis on falling literacy standards – such as shorter attention spans or lower reading speed and comprehension level (Greenfield, 2015; Goleman, 2013) – understandably causes anxiety about the digital natives’ academic achievement, job performance, professional competitiveness and general prospects for the future (Sorbring, 2014). On the other hand, while young media users have become “produsers” (producers + users) and “prosumers” (producers and consumers) (Lemish, 2015), the overly optimistic depictions of “technologically empowered ‘cyberkids’” (Itō et al., 2009, p. 14) capable of critically interpreting media contents, are equally misleading. The general public in fact often remains uninformed about the complex and uneven impact of screen reading on, for example, reducing the gender and socioeconomic gaps among young people (Livingstone et al., 2005). Both approaches also fail to acknowledge convergent media environments and diverse sociocultural contexts of media appropriation (Hasebrink, Jensen, Van den Bulck, Hölig, & Maeeele, 2015). The haziness of popular perceptions of reading in a digital reality is exacerbated by often too hasty policy decisions concerning the introduction of information and communications technology (ICTs) into schools in some countries and a dearth of sustained systematic efforts to teach new media literacies or “21st century skills” in others (Batorski & Jasiewicz, 2013). Simultaneously, there has been an ongoing debate about which parties involved – parents, educational institutions, the media industry, government agencies – should be responsible for children’s media education and behaviour (Lemish, 2015; Valkenburg, 2014).

This chapter aims at supplying a balanced and empirically grounded factual context for current debates about reading in general, and reading from digital devices in particular. We begin with a discussion of early theory and research on media use and reading. We then go on to an overview of what is known about reading in the context of media use and media preferences as based on cross-national
surveys and studies conducted in Europe since 2010. In our overview, we pay attention both to non-reading forms of media use and to reading in multimedia and non-multimedia settings across country populations and specific age groups. We also focus on everyday media use and reading in a family context, including patterns of use, parental guidance and family interactions around new media. As parents have the most crucial influence on their children’s present and future reading habits, we explore in detail the available findings on parents’ involvement in their children’s socialisation into reading. Finally, we are interested in the role of public and school libraries. We base our discussion on examples of national surveys and case studies, which provide culturally contextualised evidence about the use of digital devices for reading in households and educational settings across Europe. We conclude by indicating lacunae in the field of reading research in the context of wider media use as a means of gaining a comprehensive, constructive, and productive perspective on cultural and educational challenges that we face as individuals and societies engaging with digital media. We believe that these gaps can be reduced by research aligning experimental approaches with more traditional methodologies developed for example in literary studies or publishing studies. Finally, we also point out the need for the development of ethnographic approaches and fieldwork investigating children’s and young people’s every day reading practices in print and on screen.

2. Reading in the lives of European children and young adults

Public perceptions of and scientific debates about digital reading, i.e. reading from the screens of electronic digital devices, are unwittingly affected by earlier discussions about the alleged detrimental effect of electronic media for the language development and reading skills of the young generation. In this paragraph, we give a concise overview of scientific perspectives on the validity of this claim. First, we outline the main assumptions and results of early research on media use, particularly TV viewing, in relation to reading. Next, we present the debate about the relationship between new media (digital, off- and online devices and applications) and reading. We base our discussion on the multi-year, cross-national EU Kids Online project and national studies from several European countries.

2.1 Early theory and research on media use and reading

Paraphrasing Seth Lerer’s (2008) contention that ever since there were young audiences, stories have been told and written for children, one could also say that ever since children became readers, their parents, as well as educators, librarians,
politicians and other adults preoccupied with the appropriate management of childhood (Foucault & Gordon, 1980) have expressed concerns as to how and what youthful audiences read influences their psyche and body in the context of their family life, schooling and peer interactions. Texts addressed to children still constitute one of the most effective mechanisms for propagating and consolidating dominant ideologies. When books became a mass medium in the first half of the 20th century and when children's literature became a business of its own in the second half of the 20th century, ongoing censoring interventions into school reading lists or library resources and circulation reflect the belief in the exceptional status of reading as a socially and culturally formative activity. Harry Potter wars (Jenkins, 2006) concerning the impact of J. K. Rowling's fantasy series on children's imagination, literacy skills, civic engagement and morale, offer especially vivid proof that literature remains a powerful mass medium in the 21st century.

The emergence of TV as a widely accessible mass medium in the 1960s and 1970s caused serious concerns that it would impede children's reading, despite early evidence about the informal learning effects from television (Schramm, Lyle, & Parker, 1961). As Keith Roe (2007) summarises the growing academic effort in the US and Europe to assess "the TV effect", the belief in the negative correlation between TV viewing and children's reading acquisition and reading achievement, as well as the displacement hypothesis, which assumes that because of watching TV children spend less time performing activities fostering their development, including reading and doing homework, soon became the dominant theoretical perspectives shaping the scientific exploration of the social and cultural consequences of (increased) TV use. Hence, television viewing became associated with entertainment, impoverished cognitive stimulation, low concentration and non-creativity. Nevertheless, until the 1980s, there was a lack of solid evidence supporting the existence of any relationship between TV viewing and children's reading. Assessments of the mechanics, intensity, and possible directions of the TV influence were also ambiguous. This was the case because most research designs failed to take into account the now obvious mediating variables of age, gender, individual differences, or socioeconomic status. Roe (2007) points out that although large-scale longitudinal studies were undertaken to make sense of the dispersed and very often conflicting data gathered earlier, no satisfying consensus had been reached as to the actual complexity of the TV effect on reading. In an extensive review of research in the field, Susan Neuman (1991) concluded that the critical factor shaping the influence of TV exposure on children's academic achievement is not the medium itself but the context of family as a learning environment. On the other hand, Koolstra and van der Voort (1996) argued on the basis of their panel study of Dutch children that despite the ambiguous evidence, the inimical influence of TV viewing on children's early reading achievement should be seen as the
most reasonable working hypothesis. They also proposed the reading depreciation hypothesis, according to which television negatively affected older children’s attitudes to reading as a less pleasurable and less satisfying form of entertainment than TV. However, research has also revealed that reading print and TV viewing involve mental processes that are to some extent similar (Mackey & Robinson, 2003) and that comprehending film narratives can develop children’s reading skills and motivate them to read printed texts (Marsh & Millard, 2000; Kendeou, Bohn-Kettler, White, & van den Broek, 2008). Nevertheless, as Evans Schmidt and Anderson (2007) conclude, whereas research has not yet fully accounted for the relationships between reading and TV viewing, it is plausible that in younger children, too much time spent watching TV inhibits reading acquisition as it may discourage the development of the mental capacities necessary to master new academic skills such as visual imagination and attention span. They also propose another approach to investigating the TV effect: television as a medium is neutral; it is the content that determines its effects. As Lemish (2015) reports, studies indicate that in all age levels the number of viewing hours affects reading competence, that reading in home environments fosters children’s engagements with books, and that the presence of a TV set in a child’s bedroom has a negative influence on reading levels. Nonetheless, in a more general take on the relationship between watching television and reading books, Lemish stresses that although undoubtedly some children read more than their peers, these trends have nothing to do with television. As she argues, the blockbusting popularity of the Harry Potter and the Twilight Saga series, as well as the burgeoning market of products resulting from adapting children’s literature to new media, indicates that screen culture, which includes not only TV but also other audio-visual media and devices, has not usurped the unique status of reading as a leisure activity.

The question of researching what was happening to children’s and young people’s reading abilities and interests became even more complicated in view of the rise of new media, the development of digital devices, and the increasing dominance of visual culture. It soon became clear that television was now only one, and not necessarily the most significant, reason why children might neglect reading. It was argued that access to computers reduced the time children spent on other activities, including reading (Subrahmanyam, Greenfield, Kraut & Gross, 2001; Rosén & Gustafsson, 2014). Rosén and Gustafsson (2014) stipulate that one of the most negative effects of children’s home computer use on reading is the reduction of time spent on practising reading and hence improving one’s ability to comprehend complex continuous texts. Proponents of distraction theory state that the very variety of interactions, contents and formats enabled by the computer inevitably draws user attention away from learning activities including out-of-school reading (Rosén & Gustafsson, 2016). More positive approaches – the activation
and content theories – predicted that the influence of computer use may be beneficial for intellectual development as long as the user is cognitively stimulated by appropriate materials and adequate doses of interactivity (Rosén & Gustafsson, 2016). Yet such assumptions do find some reflection in real computer use only when it is motivated by learning tasks and goals (Rosén & Gustafsson, 2016). As Rosén and Gustafsson (2016) suggest, despite a number of empirical studies into computer use, the four theories (the distraction theory, the substitution theory, the activation and content theories) have not been tested systematically enough in relation to one another to warrant definitive conclusions.

An example of European research addressing this challenge is the study conducted by van der Voort, Beentjes, Bovill, Gaskell, Koolstra, Livingstone & Marseille (1998), which tested the differences in how and why children in the Netherlands and in the UK use ‘old’ media forms (books, comics, magazines and newspapers, television, video) and new forms of interactive media (electronic games and the personal computer). Significantly, the study classified TV as an ‘old’ medium, although it should be noted that the very division between old and new media is rather unproductive and artificial as the same contents can spread across all kinds of media, and not necessarily only from old to new ones. Moreover, users often engage in multitasking activities, for example surfing the Internet while watching TV, or alternating these activities. Such processes form the basis of transmedia entertainment and convergence culture (Jenkins, 2006). The participants’ use of various media in van der Voort et al.’s (1998) study was investigated not only with regard to the variables of age, gender, and socioeconomic status, but also in the context of the availability of these media in young users’ rooms. While the study revealed some significant national differences, for example in the percentages and age of children who did read, it showed first and foremost that in both countries, the amount of time spent reading to relieve boredom, for excitement, for relaxation or for learning decreased with age, while the amount of time spent on engaging with visual culture as mediated by computers increased. Simultaneously, the study indicated that an effective, and very simple, method of counteracting this trend could be providing children with direct access to reading materials in the form of book shelves in their bedrooms, which have become spaces for children’s individual use of media and “centers for entertainment and technology” (Thiel, 2007, p. 114). Finally, the study indicated SES-related differences in access to information and new technology as an emerging type of social inequality. A similar relationship was established in the UK Children Go Online study (Livingstone & Bober, 2005).

An example of a more recent national study of children’s use of television is the investigation of the long-term effects of intergenerational transmission of television tastes and viewing behaviours in the Netherlands, conducted by Notten,
Kraaykamp, & Konig (2012). The study revealed that, whereas one’s own cultural background and educational level outweigh the influence of parental influence, children’s imitation of parental practices constitutes the main element of parental media socialisation, which in turn is also affected by parents’ socioeconomic background and cultural capital. Other significant, albeit less direct, transmission processes constituting the cultural inheritance model are parents’ active media guidance behaviours (predominantly of restrictive and protective nature) and their influence on their children’s cognitive competencies (Notten et al., 2012). Parents’ socioeconomic status and educational background were shown as substantially relevant to the formation of individual television tastes, and especially to the preference for either highbrow or lowbrow content in later life. Finally, although parental influence plays the key role in the development of children’s cultural competence, the study indicated the need for further research into the importance of the influence of other socialisation agents (peers, teachers, librarians).

2.2 Research on new media and reading

As the Internet, online technologies and mobile devices became widespread in the past 25 years, research geared specifically at exploring the domestication and home ecologies (Lemish, 2015) of new media turned out to be of paramount importance. A major concern that needed to be addressed in this new field was children’s quick acquiescence of online competences, yet often without awareness of the risks accompanying these new opportunities. The earliest cross-national studies in this field are the Children and Their Changing Media Environment study (1987–8); SAFT (Safety Awareness Facts and Tools), conducted in the years 2003–4 and 2006; Eurobarometer (2003, 2004, 2005–6 and 2008); Educaunet (2005); Mediapro (2005–6) and the World Internet Project (WIP) (2007 until now) (Livingstone & Haddon, 2009). Consistent research into children’s media use, including reading in digital environments, has been systematically conducted in Germany since 1999 (the KIM series of studies (kids + media, computer internet)) and in the UK since 2005 (National Literacy Trust studies). An important example of such studies is also “Digital beginnings: Young children’s use of popular culture, media and new technologies” (Marsh, Brooks, Hughes, Ritchie, Roberts, & Wright, 2005), which explored young children’s (aged 0–6) interactions with popular culture, media and new technologies in the home through a survey of 1,852 parents and early-years practitioners. One of the key findings of this study was that young children witness and develop a wide range of practices, skills, and knowledge related to the use of popular culture, media, and new technologies from birth. Children’s use of media was also found to be usually active and conducive to playing, speaking and listening, and reading. This process of gaining new skills was supported
and facilitated by their parents and family members, who had concerns about the perceived amount of time children spent with new media and technologies. Nevertheless, they also felt their offspring benefited a lot from those activities and that media education should be a substantial element of school curriculum. Importantly, engagement with new media and technologies was found to be a social activity shared with other family members, as has been found for television viewing in the 1980s (Lull, 1980; Morley, 1986; Morley & Silverstone, 1990). Practitioners reported that the introduction of the use of ICTs into curricula had increased children’s motivation and engagement in learning. Commenting on the implications of their study for further research, Marsh et al. (2005) stressed the need for longitudinal and observational studies of children’s media use in family contexts and early-years settings, and especially of its influence on communication practices of young children and on their progress in speaking and listening, reading and writing. As the children studied in this research are now between 16 and 26, it would certainly be extremely revealing to explore how their media use has changed as they have grown. There could also be a correlation between these foundations and this cohort’s cognitive skills needed to cope with a transnational, networked and increasingly competitive information society based on immaterial labour and immaterial products, such as knowledge and communication (Hardt & Negri, 2004).

2.3 The EU Kids Online project

A breakthrough in the European academic effort to address children’s use of the Internet was the first EU Kids Online project (2006–9), an international network aimed at setting up, assessing and maintaining a publicly available and searchable database of empirical research on children’s Internet and online activities. Bringing together multidisciplinary researchers from 21 European countries, the project catalogued ca. 400 studies and mapped out key thematic and methodological trends and gaps in the evidence they provided. These findings in turn served as a basis for policy recommendations on, among others, the provision of safe Internet use for children. One of the most significant outcomes of the project for the purpose of this chapter was the recognition of the considerable overlap of offline and online spheres, and of the resulting embeddedness of the ICT in children’s everyday lives (Livingstone & Haddon, 2009). EU Kids Online also established that there was an urgent need for research on children’s critical interpretation

1. Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, France, Germany, Greece, Iceland, Ireland, Italy, the Netherlands, Norway, Poland, Portugal, Slovenia, Spain, Sweden and the United Kingdom.
and evaluation of online content. Typically, quantitative methods were unable to investigate the immediate, and often elusive, contexts of children’s everyday online activities, including reading, and their own perceptions of these experiences, which could be achieved by more child-centred, multimethod, contextual, naturalistic, and longitudinal approaches (Livingstone & Haddon, 2009). It should also be pointed out that in examining converging media environments, it is no longer sufficient to focus on only one medium (Hasebrink et al., 2015).

The database created by the EU Kids Online network was further expanded in the EU Kids Online II project. The search for European studies on media use conducted in 2012 yielded more than 800 additional studies, with the total number of research projects exceeding 1,200. The work on the database continued in new searches for studies in 2013. In 2010 the EU Kids Online network conducted a large-scale survey of Internet use among about 25,000 children aged between 9 and 16 and their parents in 25 countries (Livingstone, Haddon, Görzing, & Ólafsson, 2011). A new series of European surveys is being conducted in 2017–2018 as a response to the rapid changes in mobile appliances and the lack of continuity typically characterizing findings in this field. It will also be an attempt at multidisciplinary, multi-method, contextual, longitudinal and comparative research into the complexity of children’s everyday use of online technologies (Hasebrink, 2014). Significantly, the 2017–2018 surveys will concern children and parents whose media socialisation has been more intense and diverse than that of the cohorts participating in the 2010 survey, when fewer devices (notably smartphones and tablets) and applications were available.

An important result of this continued effort to track changes in children’s Internet experiences, relevant also to the study of reading in the digital age, is the identification of four groups of countries based on two indicators for the state of Internet diffusion these countries had reached in 2010 (Hasebrink, 2014). Countries in Group I (Denmark, Finland, the Netherlands, Norway, Sweden and the UK) are characterised by more than 75 per cent of their population being Internet users in 2009. In contrast, in countries constituting Group IV (Bulgaria, Greece, Romania, and Turkey), only 30–40 per cent of their population used the Internet in 2009. In countries from Group II (Belgium, France, Germany, Estonia, Ireland, Slovenia, Austria), Internet diffusion was between 58% and 71%, while in Group III (Hungary, Lithuania, Poland, the Czech Republic, Cyprus, Spain, Portugal, Italy), it was between 42% and 57%. The differences between the four groups show the unevenness of Internet diffusion across Europe in 2009, which in turn obviously affected the frequency and nature of children’s interactions with online technologies. Yet more importantly, country classification indicates that phenomena and trends observable in Groups I and II could reoccur later in countries from Groups III and IV, being at the same time inflected by more recent
changes in technological innovation and cultural practices concerning new media. In another grouping, based on measures of children’s experiences of online opportunities, risks and parental mediation (Helsper et al., 2013), European countries were grouped into the following clusters: countries characterised by ‘unprotected networkers’ (Austria, Hungary, Lithuania and Slovenia); countries in which users are ‘protected by restrictions’ (Belgium, France, Germany, Greece, Ireland, Italy, Portugal, Spain, Turkey and the UK); countries with ‘semi-supported risky gamers’ (Bulgaria, Cyprus, the Czech Republic, Estonia, Poland and Romania); and countries with ‘supported risky explorers’ (Denmark, Finland, the Netherlands, Norway and Sweden). As reading is one of the many activities in which children engage in digital environments, its contents and intensity depend also on users’ opportunities and risks management.

2.4 Insights from national studies

Apart from the multinational comparative EU Kids Online project, a substantial number of studies in Europe have been conducted on the national level, of which only very few highlights can be covered here. What connects these otherwise divergent studies is that they relate reading activity of children and youth to their computer use, mostly (but not exclusively) suggesting a trade-off between the two. In essence, these studies are mimicking research from the pre-Web era exploring the trade-off between watching television and reading time. In general, these studies concluded that as long as television viewing did not exceed moderate levels (up to 4 hours per day), it did not affect reading time and comprehension. Only when parents were allowing their children to spend an unlimited amount of time (over 4 hours per day) in front of the screen, which in fact often reflected their own viewing behaviour as well as the low expectations of their offspring’s educational attainment, did reading comprehension deteriorate (Neuman, 1988).

Corresponding conclusions are drawn in research on the displacement effects of computer and Web use in relation to reading in college students (Cai, 2005; Mokhtari, Reichard, & Gardner, 2009) and the general population (e.g., Netherlands: Huysmans, de Haan, & van den Broek, 2004; US: Robinson & Kestnbaum, 1999). Time spent reading for academic and recreational purposes and Internet time appear to correlate positively. The evidence suggests that reading and using Web sources are not functionally equivalent as they appear to serve additional rather than competing functions. However, studies exploring this relationship in children and teens are in short supply. A Dutch national study among 7–15 year olds showed that, with increasing age, children were turning to digital (including social) media more often and reading books less frequently, thus suggesting
evidence for the time displacement hypothesis. However, it also showed that among the 15 year olds, the higher use of TV and digital media did not correlate with a lower level of book reading, which could be expected if time displacement was indeed the case. In sum, the study demonstrated that time displacement as such can be conceived in at least these two different ways, which in turn lead to different conclusions (Huysmans, 2013).

The 2014 Polish comparative study of students in their final year of primary school (12–13 year-olds) and students in their final year of junior high school (15–16 year-olds) revealed some significant aspects of children’s reading as one of many forms of their engagement with new media. More than 70% of the respondents from the younger groups were found to use the computer systematically to visit social networks sites, listen to music, watch films, find news and information related to their interests, read texts created by their peers (blogs and fanzines) or communicate with others. 62% of the respondents in this age group also use it to do their homework. Significantly, 37% of these young users actively contribute content by creating their own websites or by blogging. As the study showed, the size of the group of creative young Internet users does not increase with age (Zasacka, 2015). As to reading literature as a leisure activity, very few respondents in both groups (9% of the twelve-year olds and 13% of the fifteen-year-olds) reported this activity. In both cases, girls did so slightly less frequently than boys. Texts read online most frequently are comic books – mostly because they are more easily available on the Internet. It was also established that in both age groups the frequency of turning to e-books is negatively correlated with parents’ educational background and the size of the home library. The results obtained through questionnaires were confirmed by interviews conducted with the participants. Students, including those who use the computer every day, declared that, regardless of their family background, they see reading printed books as more convenient, relaxing and healthier. They also like the tactile qualities of printed books (Zasacka, 2015). Hence, students rarely consciously use the resources of electronic libraries which are available for free. Nevertheless, the study also revealed that the Internet had become an environment that fosters interactions around reading: it is a source of information about books and a means of sharing this information with others. This is the case especially in the older age group, while young readers still tend to rely on their parents’ recommendations (Zasacka, 2015).

These results correspond to some extent to the findings of the German KIM study from 2014. While playing computer games or using the Internet has become a substantial element of children’s daily life, they continue to perceive reading paper books as an important activity. According to the study, every second child reads books regularly, with girls being more regular readers (61%) than boys.
Yet children's preference for traditional reading formats and materials has diminished considerably in the UK. As the study “The Reading Lives of 8 to 11-year-olds” 2005–2013 reveals, while in 2010 children aged 8 to 11 usually read books (fiction, non-fiction and poetry) outside class, by 2013 text messages and other technology-based materials had become typical reading material of this age group (Clark, 2014). An interesting finding of the study was that although more boys than girls recognised the connection between reading and future employment prospects, fewer boys than girls saw reading as cool. Moreover, children from higher socioeconomic backgrounds predictably read a greater variety of technology-based materials than their peers from families with fewer cultural and economic resources. Yet, as Clark (2014) points out, this difference is not necessarily a result of better access to technology, as there is no considerable gap in this respect between both groups. Moreover, as the study revealed, while fewer children from the low SES group enjoyed reading outside class, they nevertheless read a greater number of books outside class per month than their peers from the high SES group. According to the author, this may be the case because children from low socioeconomic backgrounds are more likely to associate reading with good future job prospects even if they perceive reading as an “image problem” and feel that their families do not support their reading (Clark, 2014).

The most recent National Literacy Trust's annual survey “Children's and Young People's Reading in 2015” revealed that in that year, children and young people on average spent more minutes reading materials online than they spent reading books (Clark, 2016), with the levels of daily reading increasing only slightly in comparison to 2014 and more substantially in comparison to 2013. According to the study, only 1 child in 7 rarely or never read outside class. Interestingly, significantly more girls than boys said they own an e-reader (38.1% vs. 28.2%). They also had more books at home than boys. These two factors may explain why girls are more likely to read diverse technology-based materials as well as books. Moreover, girls estimated that they were significantly more likely than boys to spend more time reading both something online and in a book, which is in turn reflected in more positive attitudes to reading on the part of girls. Finally, the study shows that the most conspicuous difference between boys and girls concerns the choice of TV over reading, with more boys than girls preferring TV (82.3% vs. 69.8%) (Clark, 2016). Children's attitudes and motivation to reading were explored in another recent UK study (Picton & Clark, 2015), which focused on the impact of e-books on students’ reading skills and motivation over the academic year 2014/15. The study was based on a school-based e-books project involving children's use of an e-book platform. The research revealed that the implementation of the e-book format in school practice resulted in an increase in reading performance and significant changes in children's perceptions of reading from negative to positive, which, as Picton and Clark
argue, also signalled their growing confidence in their own reading abilities. As the authors conclude, the combination of high level of support and encouragement at school with opportunities to read onscreen, for example in the form of a digital library, may significantly support literacy and learning (Picton & Clark, 2015).

The results of the empirical studies mentioned above indicate that despite concerns about the effects of the growing importance of digital media in children’s lives on their reading activities, we need to acknowledge the complexity of this interaction. Using digital devices and content involves textual decoding. Moreover, the time displacement hypothesis, according to which the time hitherto devoted to ‘serious’ reading is now being spent on more ephemeral content, is supported by the evidence only to a limited extent. Additionally, reading on digital devices such as e-readers and tablets might make reading appear more natural to young readers, thereby enhancing literacy development and learning processes. In short, we should bear in mind the limited validity of the popular criticism too easily equating traditional ways of reading as ‘good’ and digital reading as potentially damaging individual development and social and cultural well-being.

3. **Home literacy: Reading and media socialisation in the family**

The importance of the family context for acquiring language and reading skills can hardly be overestimated. A plethora of studies have demonstrated the crucial importance of a supportive environment for acquiring such skills. Factors shown to affect reading skills, motivation and behaviour include parents’ reading picture books and reading aloud in early literacy, talking with their children about books and giving a good example by reading themselves. Siblings and peers are – to a lesser extent – also shown to influence children’s reading. In this section, we provide an overview of what is known about how parental mediation influences media use, reading in general and digital reading in particular. In broader terms, as Lemish (2015) points out, the emergence of family leisure time and the growing significance of the home as the centre of indoor life is closely connected to the increasing presence of importance of media in family life. Finally, we also examine what is known about the role school and public libraries play in reading practices of the young generation.

3.1 **Parental guidance**

Studies in many countries have shown that a favourable home environment is a strong predictor of reading achievement and learning outcomes later in life. Furthermore, the earlier in life parents actively engage in language- and reading-promoting
behaviour, the more persistent these positive effects turn out to be (see e.g. Schoon, Parsons, Rush, & Law, 2010). Cultural reproduction theory accounts for differences in educational success between social groups by differences in parental cultural capital. According to this theory, parents raise their children within a specific cultural habitus. This set of preferences and competencies acquired during childhood influences educational performance and persists into adult life. Research shows that the quality and quantity of intentional and unintentional parental media socialisation is likely to depend on parents’ socioeconomic status, and in particular on their educational and occupational background, and on family size and composition (Notten & Kraaykamp, 2009a). Notten and Kraaykamp (2009a) also point out that parents’ investing in home media resources (books, TV, digital technologies) is a significant aspect of family socialisation activities. Many studies confirm that parental media resources and intergenerational transmission of cultural and media behaviour determine an individual’s educational achievement and cultural literacy, including both the attainment of reading skills and future adult literary tastes (Bus, IJzendoorn & Pellegrini, 1995; Leseman & de Jong, 1998; Van Peer, 1991; Notten & Kraaykamp, 2009). Notten and Kraaykamp (2009a) in their cross-national study of 53 countries also established that the “old” medium of books is most effective in improving children’s academic performance.

The latest edition of the multinational PIRLS study (2011) provides evidence for this finding (Araújo & Costa, 2015). In their analyses, Araújo and Costa (2015) divide the respondents, 4th graders, in groups according to the extent to which they are read to by their parents (low vs. high level) and parental educational level (where the split is between secondary and tertiary education as highest attained level). Consistently, reading scores are higher for children who experience a more favourable reading climate at home, as measured by the level of book reading with their parents. Moreover, the parents’ educational level (either the mother’s or the father’s, whichever was highest) plays an important role. In all countries, children with at least one highly educated parent score higher on reading ability than kids from low-educated families.

In light of the above, one of the remaining gaps in research concerning children’s use of new media, which happens far more intensely in the family home rather than at school or in other cultural institutions, is the exact significance and forms of parental guidance as a means of stimulating cultural competence, including reading preferences. An early study into parental media socialisation conducted in the Netherlands by Notten and Kraaykamp (2009b) revealed that parents from higher social strata both consume highbrow media content and value leisure reading as a socially desirable activity, thereby encouraging their children to develop the same tastes. Moreover, older mothers engage in more highbrow and less lowbrow media consumption, which also affects the formation of children’s
preferences and competencies. Children growing up in large families, in which parents’ attention is divided among siblings, experience less parental instruction with regard to media use and content. Finally, children living with divorced parents also participate in fewer parent-child interactions over media, do not receive much guidance concerning reading skills, and are less effectively protected from exposure to harmful media content (Notten & Kraaykamp, 2009b). Importantly, the study indicated the necessity of investigating the significance of parents’ gender in their media guidance activities, of research into parents’ own perceptions of their own role as educators, and of the extension of related research into other European countries. It is also worth considering whether the highbrow/lowbrow categorisation of culture has not become obsolete in light of the emergence of the ‘nobrow’ trend and ‘artetainment’, which rely on the fusion of high aesthetics and massive commercial appeal (Swirski, 2005). Finally, while the study provided useful insights into factors affecting the intergenerational transmission of cultural and media behaviour in the family context as well as its long-term effects, it was based, as the authors indicate, on retrospective data coming from adult media users, which may have resulted in over- or underestimation of certain factors (Notten & Kraaykamp, 2009b).

While the above-mentioned studies reveal general mechanisms and characteristics of parental mediation, they do not delve in detail into parents’ attitudes and the particular approaches they adopt to manage children’s media use. Nor do they ask whether any new strategies are needed especially for the mediation of digital environments, for example because of the personalised and portable nature of new devices (Haddon & Vincent, 2014; Mascheroni & Ölafsson, 2014; Livingstone et al., 2015). The EU Kids Online network has discovered the following types of parental mediation with reference to older children (9–16 years old): active mediation (sharing and discussing online activities), safety mediation (advising and guiding on managing risks), restrictions (rules and bans), technical mediation (use of filters, parental controls) and monitoring (checking the computer/social media/phones after use) (Livingstone & Helsper, 2008; Dürager & Sonck, 2014; Livingstone et al., 2015). On the one hand, these types of parental mediation reflect general parenting styles, e.g. authoritative, permissive or uninvolved (Baumrind, 1991; Livingstone et al., 2015); on the other, they are influenced by parents’ own digital literacy. Parents who believe that their children are more expert media users than themselves are likely to be less confident of mediating their children’s interactions with new media and thus less engaged in them and less aware of both risks and opportunities (Livingstone et al., 2015). Measuring parental guidance reliably poses difficulties, as both parents and children may overestimate or underestimate their attitudes and behaviours. Moreover, parental management of media use is often aimed not only at ensuring that the child benefits from certain activities, but also at meeting
parents’ needs, the most common being gaining enough time to deal with housework (Livingstone et al., 2015). The character of parental mediation depends on culture and country, with parents from Central and Southern European countries, Ireland and the UK adopting restrictive mediation; parents from Northern European countries preferring active mediation, and parents from Eastern European countries resorting to all types of parental mediation or being passive (Livingstone et al., 2015). The EU Kids Online survey (Livingstone, Haddon, Görzig, & Ólafsson, 2011; Livingstone, Hasebrink & Görzig, 2012) also revealed that parents with higher income are more likely to favour active mediation of Internet use, while restrictive parental strategies were used equally frequently by parents of different socioeconomic backgrounds. Finally, young parents of today belong to the new generation of ‘digital parents’, who were themselves socialised into the use of digital media and are now engaging in culturally socializing practices in relation to their own children. Therefore, productive complementary research addressing the fast-paced technological development of digital media and their influence on young generations must employ methods enabling immediate access to concrete parent-child interactions over media use and their socializing effects.

3.2 Parents’ views on reading in digital environments

The importance of family for the preservation of a reading culture with the aid of new technologies has also surfaced in the German study from 2012 “Digitale Angebote – neue Anreize für das Vorlesen” (Stiftung Lesen, 2012), in which 500 parents of children between 2 and 8 years old were asked about the use of picture books and children’s books apps as sources of reading materials. The study found that digital media had become accepted as a welcome expansion, and not a replacement, of traditional printed picture books. The choice between print and screen depends on particular circumstances in which the reading activity is to take place: print is seen as more suitable for bedtime reading, while screen is perceived of as more convenient when traveling. The study also showed that although fathers still read less to their children than mothers, they tended to choose electronic formats, which may be a way to encourage more fatherly engagement in family reading. If parents refrained from using apps, it was because of their lack of experience with new formats, which in turn signals the need to promote new forms of reading materials and advise on how to use them (Stiftung Lesen, 2012).

Parents’ views on possible uses of new technologies in activities aimed at supporting their children’s language and literacy development, as well as their attitudes to books and touch-screen devices, were also researched in a UK study by Formby (2014). The study found that nearly all children from birth to five years old had access to books in the home and 73% of children had access to a touch-screen
device at home. 26% of all children used a touchscreen at home to look at or read stories in a typical week, while nearly all children looked at or read print based stories in a typical week (95%). It was also established that the more children looked at or read print based stories at home, the better communication and language skills they had developed at age five. Parents were found to engage in diverse activities to support their children, such as visiting the library once a month or having an average of 89 children's books at home. Predictably, the size of the home library, as well as the frequency of parents’ own reading activities, could also be linked with children's better communication and language skills at age five. Interestingly, parents were found to project their own enjoyment of reading onto their children. The majority of parents also strongly agreed that their child should learn to use technology from an early age to do better at school. Last but not least, children of lower socioeconomic status who had access to tablets were found to be twice as likely to look at or read stories on a touchscreen daily, which clearly indicates that there are benefits to looking at or sharing stories using a touchscreen device, particularly for children of lower socioeconomic status, especially when they lack support from their parents (Formby, 2014). As Formby concludes, technology may enable disadvantaged three- to five-year-old children to read more and enjoy it. She also stresses the need for further research into parents’ communication with children when they are sharing a story in print or on a touchscreen.

A cross-national qualitative project “Young children (0–8) and Digital technology – a qualitative exploratory study” (Chaudron, 2015) applied such methods to address, among other topics, parents’ involvement in media socialisation processes. It aimed at examining young children’s (0–8 years old) and their families’ experiences with digital technologies, such as smartphones, tablets, computers, and games. By means of interviews and observations in the home context with ten families from each participating country (Belgium, the Czech Republic, Finland, Germany, Italy, UK, and Russia), the project generated data on how children between 0 to 8 years use (online) technologies, how parents guide media use, and how to determine potential benefits and risks connected with children's engagement with new technologies. Parents and children provided very insightful information about their use of the technologies. One of the key findings was that although children's reading and writing skills determine the scope of children's media interactions, they acquire digital literacy even before they learn to read and write. They do so by mastering how to identify visual cues, which in turn to a large extent enables them to use the Internet, Skype or social networks without adult intervention. The study also revealed that young media users learn from observing not only their parents but also other family members, i.e. older siblings and grandparents, with adults often remaining unaware of how children imitate their behaviour. Finally, thanks to ensuring direct access to parents, the project yielded
information on parents’ own perceptions of their role as educators and mediators. Although parents see digital technologies as challenging, especially in the context of children’s media use, they have a sense of control over media devices and their uses, often turning to their offspring as support in their household and parental duties. Nevertheless, parents recognise a number of risks related to their children’s interactions with digital technologies: economic consequences, incidental inappropriate content, and health or social impacts. The most frequently used restrictive strategies include establishing a set of rules concerning time and content. Most children participating in the study appeared to understand and follow the rules quite easily. On the other hand, the potential benefits parents acknowledge include the development of creativity, social skills, hand-eye coordination, and better educational prospects (Chaudron, 2015). A rather worrying outcome of the study is the conclusion that parents seem to be little aware of the actual digital activities of their children, and that they do not realise that their offspring are often capable of bypassing the safeguards they have set up. These findings indicate the need for policies aimed at encouraging more active parental involvement in shaping young users’ digital literacy (Chaudron, 2015).

An overview of parents’ views and activities more specifically in relation to children’s leisure reading of print and digital books can be found in the UK Book Trust study “The digital reading habits of children” (Kucirkova & Littleton, 2016). The survey of 1,115 British parents of 0–8 year old children revealed that most parents worry about such negative effects related to children’s reading interactive e-books as the increase in screen time (45%), loss of interest in print books (35%), exposure to dangerous content or advertising (31%), reduction of the attention span (26%), decrease in parents’ ability to monitor both children’s reading and their purchasing behaviours (21%), inhibition of educational attainment (14%), and harm to a child’s brain (10%) (Kucirkova & Littleton, 2016). Moreover, 76% of the parents participating in the survey indicated that they prefer print books for reading for pleasure over interactive e-books. Parents typically reported that they read print books with their child more than e-books, with 56% of parents indicating that they read print books with their child (almost) every day. Only 6% of parents reported that they read e-books with their children every day or almost every day. These proportions are reflected to some extent in the parents’ own reading practices: 29% of the parents reported that they read print books every day or almost daily themselves, while a mere 11% read e-books. Half of the parents said that they enjoy reading for pleasure very much, whilst 16% reported that they do not like reading very much or at all. Yet almost half of the respondents mentioned that they would welcome advice concerning interactive e-books. Interestingly, the study showed that even in highly digitised households print books are the preferred choice for children’s reading. Finally, the survey revealed
the significance of the age factor in parents’ decisions about children’s readings as well as children’s own preferences as reported by parents. Parents indicated that the best time to start reading with their child is at age 0–1 year for print books; 2 years for interactive e-books, and 3 years for simple e-books (Kucirkova & Littleton, 2016). As the authors point out, the survey findings indicate that parents’ concerns and doubts around their children’s access to and use of digital books need to be addressed through adequate policies, especially given that young readers exploring digital material with their parents are likely to become critical readers capable of assessing and rejecting inappropriate or poor quality content (Kucirkova & Littleton, 2016).

The above-mentioned evidence indicates that parental guidance and media socialisation efforts shape children’s (digital) reading to a considerable extent. These efforts are likely to be guided more by their beliefs about what is beneficial to children’s development than actual knowledge of factors exerting positive and negative effects. What is more, parental influence derives not only from conscious guidance efforts, but also from children’s observations of their parents’ reading and (wider) media behaviour. Finally, the cultural habitus connected to the family’s socio-economic status is reproduced through media socialisation, resulting in more intensive reading behaviour of children coming from higher SES families.

4. Libraries

An institution not to be ignored in parental efforts to ‘properly’ socialise their offspring is the library. The provision of public cultural and educational resources has the potential of offering a route into reading for disadvantaged groups and populations (Kleijnen, 2016; Kleijnen, Huysmans, & Elbers 2015; Nielen & Bus, 2015). According to the public resources substitution theory, high quality and appropriate quantity of public resources is likely to reduce the divide caused by SES-related differences in media use practices (Caro & Lenkeit, 2012; Araújo & Costa, 2015). On the basis of 1998 data from a family survey in the Netherlands, Kraaykamp (2003) studied the long-term effects of reading promotion of three stimulating

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2. The abovementioned studies by Chaudron and by Kucirkova and Littleton are contributions to DigiLitEY (The digital literacy and multimodal practices of young children), an international network of scholars conducting interdisciplinary collaborative research on young children’s diverse aspects of the presence of new media in the lives of children aged from 0–8 both in home and school settings across Europe. The aim of the network is to also generate knowledge on the implications for policies and practice concerning the provision and use of digital technologies in education and the regulation of children’s engagement with them.
factors: a supportive home environment with parents encouraging their children to read; prolonged library membership during childhood; and cultural education (e.g. classes on history and theory of literature) in secondary school curricula. Persons who as a child were stimulated to read literature by their parents turned out to be more avid readers of literary books and, to a lesser extent, of suspense novels. Moreover, their general reading level was higher in later life. Persons who preferred romantic fiction appeared to have copied this preference from their parents as well. Second, persons who were members of the library for a longer period had a stronger preference for literature and suspense novels. Third, cultural instruction in secondary school turned out to be quite effective in stimulating reading of literary novels in later life.

Many EU countries have developed reading promotion policies and initiatives based on combining e-reading with traditional formats and practices. Public libraries and school libraries in particular have the potential to raise awareness of the importance of reading for societies and to effectively contribute to the provision of equal access to literature and information. Most of the research into the influence of school libraries on children's academic achievement has been carried out outside Europe, mainly in the United States and Australia, where school libraries are staffed by teacher-librarians schooled as both librarians and educational specialists. In such an environment, positive effects of school libraries on academic achievement, reading literacy, and learning in a broader sense have been amply demonstrated (cf. Lance & Hofschire, 2012; Lonsdale, 2003; Todd, 2014). Not much is known to date, however, about the use of e-books (enhanced or not) in schools through school and public libraries.

As indicated in Promoting Reading in the Digital Environment, a 2016 report of a group of EU member states’ experts, libraries should focus, among other things, on developing e-lending of e-books and digital audiobooks, on using digital channels for public information, and on creating virtual and interactive network services offering educational and cultural contents (European Commission, 2016). While these goals should be realised by public libraries, school libraries also play a crucial role in reaching children, their parents, and educators. Irene Picton and Christina Clark (2015) point out that the benefits of including e-books in the school library, for example, include not only the expansion of the (print) library without the need for more shelf space, but also the creation of a more attractive collection: “An e-book library may reflect children's popular requests and usage levels, as pupils can identify and ask for the titles that they most want to read, and conversely less popular titles identified by usage records simply need not be rented again” (p. 36). Moreover, and perhaps most importantly, offering young readers more agency in their reading choices is one of the most powerful and effective ways to get them to read (Picton & Clark, 2015).
Other studies into the use of e-books by primary school students confirm that the in-built enhancements of e-books (stills as well as short videos) may help students to comprehend texts, stimulate reading fluency, enhance vocabularies and boost reading motivation (Verhallen & Bus, 2010; Smeets & Bus, 2012). Nevertheless, some studies reveal negative effects of enhanced e-books on reading skills and comprehension, as well as a more passive reading attitude. This is so because interacting with digital reading devices requires young readers to adapt to hard- and software and develop new reading strategies and even literacies. Moving from print to electronic text implies coping with changes to the text itself, to the graphics, to the reader’s role, and to the reading process (Felvégi & Matthew, 2012).

Finally, recent trends in e-book purchasing and e-lending in various countries show expectations about e-books supplanting printed books to have been overly optimistic. In the United States and the United Kingdom the market share of e-books published by the largest publishing houses has shrunk, whereas in countries like Germany and the Netherlands it has stabilised on a rather low level (around 6% of the turnover) (Author Earnings, 2016; Börsenverein, 2016; KVB, 2016; Tivnan, 2016). Therefore, it remains to be seen whether the digital revolution in book publishing will indeed turn out to be revolutionary. However, a recent judgement of the Court of Justice of the European Union (CJEU) has put e-lending (i.e. the lending out of e-books by public libraries) on an equal footing with the lending out of physical books. The Public Lending Right (PLR) may be expanded to include e-books as well as e-audiobooks, meaning that their authors can be financially compensated for the loans. Potentially at least, this might give digital reading through libraries a positive impulse.

5. Outlook

In this chapter, we have reviewed representative examples of European research into children’s use of new media and reading aimed at investigating various connections between growing up in a technology-saturated world and complex engagements with texts of various contents and formats either for educational purposes or for pleasure. We started out with a return to early theory and research on media (particularly television) use and reading. Subsequently, we examined cross-national surveys and studies conducted in Europe since 2010 to establish what is known about non-reading forms of media use and reading in multimedia and non-multimedia settings across country populations and specific age groups. We focused in particular on everyday media use and reading in a family context and parents’ perceptions of reading in digital environments and their awareness of their own role in fostering their children’s interest.
in reading. Finally, we looked at the role of libraries in shaping children’s reading experiences in digital environments. Our overview is of necessity fragmentary, as a book chapter cannot do justice to all the studies done in national and cross-national contexts. Nevertheless, the evidence we have discussed reveals the crucial influence of diverse family composition and education systems on the emergence of distinctive informal home literacies that coexist with learning within formal educational settings (Carrington, 2001). It is also clear that reading is now part of the evolving screen culture, thereby exemplifying both the challenges and the promises it brings.

In our discussion of the studies on reading we also tried to indicate cases that either reveal certain methodological limitations or exemplify exceptionally effective approaches that could be replicated elsewhere in Europe. In general, research efforts undertaken to study media use and reading can be roughly divided into large-scale international studies like PIRLS and PISA, in which reading is treated as a measurable activity only rather than as an often fragmented and irregular process (Maybin, 2013; Cremin, Motttram, Collins, Power & Safford, 2014), and narrower and in-depth explorations of children’s reading experiences with relation to their cognitive development and social relations. While the former studies record shifts in trends, e.g. in reading comprehension over time, the latter recognise children’s attitudes and everyday behaviours related to reading. Both rely on such methodologies as surveys, formal tests, focus groups, experiments, observations, interviews, and creative methods, and both provide vital data to be used in recommendations for reading policy and advocacy intended to ensure that, as Cremin et al. put it (2014, p. 5), children “develop as readers who not only can, but do choose to read, for pleasure and for life.”

Nevertheless, we feel that existing approaches and methodologies should be complemented by more thoroughgoing and in-depth research, yet unprecedented in Europe on a larger scale. The scholarly endeavour undertaken within E-READ and combined with research conducted in DigiLitEY will undoubtedly significantly broaden our understanding of the effects of digitisation on reading (Mangen & van der Weel, 2016). The gradually more and more frequent combination of experiment-based research (e.g. eye-tracking or neuroimaging) with methodologies developed within pedagogy, publishing studies, literary studies or media studies, may facilitate gauging the significance of such factors as text length and layout, haptic affordances, sensori-motoric and ergonomic aspects, perceptual processing, memory, emotional aspects, audio-visual affordances, spatiotemporal circumstances of reading or the development of the e-book market. Such interdisciplinary approaches may reveal a lot about the yet uncovered aspects of digital text reading and guide policies and recommendations related both to paper and screen reading.
Finally, future research will also have to face the challenge of reading as a transmedia phenomenon (Jenkins, 2006) experienced across various platforms and in multifarious contexts beyond schools or children's homes. It also has to take into account new forms of using media as well as old and new inequalities related to media use, stemming not so much from gaps in access to technology, but from gaps in users' awareness about the educational and cultural potential they offer. We agree with Barbovschi, Green & Vandoninck (2013) and Lemish (2015) that researchers should try to go beyond the traditional medicalisation frame of scholarly inquiry that sees children as having no views or opinions because children do not yet know what is best for them and do not behave responsibly. Lemish mentions the media diet frame, which proposes that there are good and bad mental 'foods' and that adults should socialise children to prefer and choose the former. She further argues that such an approach limits and oversimplifies discussions about children's complex relationships with media, as these interactions should be treated as resulting from the nexus of a child's unique individuality, the particular context of media experience and the social and cultural contexts in which this experience occurs, as 'media use as social action' approaches have demonstrated (Renckstorf, McQuail, & Jankowski, 1996). Hence, as Lemish contends, to account for the multidimensionality of media experiences, scholars cannot generalise about "effects", but need to focus on "roles", "consequences", or "influences" with regard to "some kinds' of communication, 'some kinds' of content, 'some kinds' of children, [and] 'some' kinds of conditions" (Lemish, 2015, p. 239). Simultaneously, Lemish proposes that this sensitivity to context and cultural situatedness should be combined with methods reconciling traditional research with child-centred methods. Such methods enable children's expression of their views on media-related debates framed by adults' discourses. They guarantee that these worldviews will be recognised as valid sources of knowledge about children as active and well-informed creators and consumers of culture, including reading materials they access in various settings. An example of a pioneering study acknowledging both the cultural situatedness of digital practices and the voices of concrete young users as they engage in the digital world in their everyday lives is Sonia Livingstone and Julian Sefton-Green's *The Class: Living and Learning in the Digital Age* (2016), based on the authors' fieldwork at a school in London. Furthermore, combining traditional ethnography with digital ethnography (Murthy, 2008) into 'multimodal ethnography' (Dicks, Soyinka & Coffey, 2006) may be a useful comprehensive response to the challenge of investigating reading as an increasingly technologically mediated everyday activity in new media environments. Using online questionnaires, e-mail interviews, digital video, social networking websites and blogs not only increases participation in research but also provides access to the often elusive and easily forgettable practices of respondents in natural settings. As a result, these methods
achieve greater collection of more personal and intimate qualitative data than face-to-face interviews and standardised questionnaires (Murthy, 2008). Murthy also argues that while digital ethnography may replicate physical ethnography, it nevertheless enables privileging the voice of respondents, which in turn may be especially useful in research on and with children, as it is likely to shed a new light on adult researchers’ conclusions about why some children are reluctant to read while others read avidly both on paper and on screen, for example. Through combining theories and methodologies from various disciplines – notably cognitive and educational psychology, pedagogical and educational science, cultural sociology, and information and communication science – a pluralistic picture of the constantly changing forms and practices of reading might emerge. Such a picture might be just what is needed to better inform public policy and public discourse about the benefits and risks involved in the digitalisation of children’s and adults reading.

References


Chapter 1. Reading and digital media


CHAPTER 2

Designing digital texts for beginner readers
Performance, practice and process

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This chapter summarises issues that designers consider when they are producing reading materials for beginning and emerging readers, including the constraints imposed by technology. We suggest ways of engaging with users of e-books so that their needs can be considered. We conclude by summarising the typographic parameters that are likely to benefit children's reading.

1. Introduction

This chapter identifies the role of research in typography, and in graphic information design, that is relevant to the design and use of materials for children's reading. By ‘design’ we mean the visual organisation of type and pictures on paper or screen), and by ‘process’ the ways in which design is developed to meet the needs of its intended reader group).

Much of what we know about the impact of design on reading comes from the field of legibility research. ‘Legibility’ in this context is the speed and accuracy with which text on a page can be read (after Pyke, 1926; Zachrisson, 1965; and dos Santos Lonsdale, 2014). In this chapter we present findings from legibility research within a broader framework of considerations that designers use when they organise text and pictures on page or screen. These findings will highlight the multi-variate nature of design decision-making, which makes it resistant to strong rule-bound recommendations. The substrate – screen or paper, for example – on which reading materials are displayed is one of the variables that designers must take into account. Most of the research we refer to is concerned with reading on paper, rather than reading on screen. Therefore we consider how much of this
research is transferable directly to children’s digital reading and suggest that, in the absence of guidelines that can be applied universally, an information design approach may be a helpful alternative. Such an approach emphasises the importance of understanding the needs of and eliciting feedback from beginner and emerging readers (and indeed those who read with them) to find out which typographic attributes enhance the reading experience.

We have organised this paper by first summarising the issues that designers consider when they produce material for beginner and emerging readers. This is followed by a discussion about typography and the use of space, and a short section about the interrelation of text and illustrations. This is then set in the technological context of e-reading and the impact that such technology has on design decisions. Finally, we look at ways of engaging with the users of e-books for beginner and emerging readers to suggest approaches to designing with their needs in mind.

We recognise that use of digital resources for beginning and emerging readers in schools is expanding and use of tablet devices at home is widespread. Actual penetration in both spheres is hard to track because of rapid change: in 2014 in the UK it was estimated that tablet devices were used in 60% of primary schools (TechKnowledge, 2014). Many e-books for beginner and emerging readers are multi-modal, incorporating sound and animation as well as pictures and text. There is considerable literature on what Bateman refers to as “modalities of information presentation”, covering the dynamic of text and image and how both can be used to convey meaning (see Bateman, 2014; Kress & van Leeuwen, 1996). Almost all e-book platforms allow the reader to interact with texts, for example by making notes which can be private or shared with other readers, to look up the definitions of words in the text and, often, to listen to the text being read aloud. There are a number of ‘learning to read’ apps that provide work-alone classroom e-learning for beginning readers. The app ‘Hooked on phonics’, for example, claims 5m users (2016). Multimodality presents many interesting design challenges but is beyond the scope of this chapter.

2. Considerations that affect designers’ decisions

Book and information designers are concerned with structuring a text so that its meaning is clear to readers. They help readers find their way around a text, by using headings, contents pages and indexes, and consider whether to organise the content as continuous text or, for example, as a list or a table. They think about where to position illustrations in relation to the text, as well as about the position of both illustrations and text within the format of a display substrate (in a book, a page or double-page spread). They choose typeface and type size for different elements of a text and use space to make the text easy to read. Design decisions
about each of these are constrained by the technology that is used to produce and disseminate the text. Richard Southall (1984, p. 83) used the term “graphic capability” to refer to the potential of typesetting technologies to articulate document structure, describing it as constrained by “the number of characters, typefaces, and type sizes and the facilities for defining amounts of horizontal and vertical space, that the system offers.”

Constraints imposed by technology affect the design of devices used for e-reading. After Waller (2012) we use the term fixed layout when the positions of text and pictures on the substrate are fixed in relation to each other and to the boundaries of the substrate (as with PDFs, which may be scaled). A flowed layout is where the position of text and pictures may change according to the size and proportions of the substrate (e.g. on a Kindle) depending on the size of the device and its software capabilities as well as design parameters applied by both designer and reader. For fixed page layouts designers have considerable control over the typographic variables, and print conventions remain relevant; for flowed page layouts there may be much less designer control, dependent upon the e-reading format. In flowed texts control may require considerable technical understanding to implement, together with significant resources for testing that the designed text auto-adapts successfully on a wide range of device formats and sizes.

In thinking about the reading needs of specific user groups as beginner readers, design decisions may be influenced by particular constraints. For example, in reading material for beginners illustrations play a key role, so designers are concerned with ensuring that the text and related illustration(s) appear on the same page or double-page spread. This cannot be relied upon in e-books with flowed texts presented on a range of possible devices. Designers consider how the physical and material attributes of books may affect the child’s reading experience. Some reading books, for example, are small enough to be easily manipulated by children’s hands; ‘big books’ are designed to be read aloud, often with large groups of children.

In summary, the design of a specific book encompasses the visual experience of reading – navigation, page layout, illustration, typeface and typography as well as aspects of the physical experience: what it is made of, its size, texture, weight in relation to the reader and the circumstances of use. The design of a specific e-book can manage only the visual experience of reading, and then only within the constraints of the physical device. Other aspects of the reading experience are constrained by the design of the software (e.g. Kindle or iBooks), operating system (e.g. Android, Windows or Apple iOS), and hardware (tablet, laptop, phone). Even e-books that display facsimiles of printed pages require different modes of interaction and engagement to navigate the text, for example (Mangen, 2017). The next section presents a more detailed account of typefaces, type size and the use of space, in relation to children’s reading.
3. Typefaces, typography and the use of space

To describe the variables that affect text typography, Twyman (1982) introduced the terms ‘intrinsic’ and ‘extrinsic’. Intrinsic features refer to properties of the characters themselves: typeface or style of letterform; character set (the characters that are available for use); variants of a typeface (italic, bold). Extrinsic features refer to what can be done to the characters by changing the space between or around particular characters, or their colours. In print, intrinsic and extrinsic features of text affect whether or not text is comfortable and easy to read. In e-books, typographic choices extend to how links and interactive elements are signalled. Manipulating a single variable may lead to automatic changes in other variables. For example, if type size is increased, fewer words may appear on a line, possibly extending the content over more pages than in the original size; conversely, vertical line spacing may be reduced to accommodate the same content on a page, creating a denser appearing text; or, if line spacing increases automatically to accommodate the increased size, content may be extended further over more pages. Changes in overall page format will be even more marked when examining factors such as the impact of illustration or other non-textual materials on pages. Although the impact of extending texts over multiple pages in e-books for children has not been studied, there are indications of a cognitive ‘cost’ of needing to make mouse clicks while reading prose in studies of adult readers using computers (Wright, Lickorish, & Milroy, 1994). This may be relevant to beginner readers having to read content across multiple pages, particularly those experiencing difficulties in reading.

The visual attributes of books for beginners stem from tacit knowledge based on typographic tradition, publishers’ expertise and teacher opinion (e.g., Raban, 1984; Woods et al., 2005). Typography in books for beginner readers has also attracted the attention of psychologists interested in legibility research. For typographers, legibility research is a controversial field because the validity of some of the research is difficult to ascertain: test material is often not shown in research reports, and testing is undertaken in laboratory conditions rather than ‘real life’ settings (see Lund, 1999; Bessemans, 2012; Beier & Dyson, 2014). There is, however, increasing recognition that the gap between experimental results and design experience needs to be bridged (Dyson & Suen, 2016), a notion eloquently expressed by Dillon (2004; 2017) in relation to designing usable electronic texts.

The integration of knowledge arising from research and from practice in defining the visual appearance of books for children’s reading has considerable historical precedent. Walker (2013) provides a 100-year historical overview of books for young readers in the UK from the end of the nineteenth century, drawing attention to the various factors that have influenced their design (teachers’ opinions; typesetting technology and available typefaces; economic constraints faced by publishers,
and views about legibility research and the effect of reading on a child’s eyesight). Her timeline of examples of books for children’s reading reveals a wide variety of approaches to their design, many of which would not accord with what we would think appropriate in the twenty-first century. In the 1920s, for example, it would have been conventional to set books for beginner readers in a large type size with justified lines (that is, text aligned at both sides of the page), which meant that space between words varied from line to line in order to make lines with slightly varying amounts of text fit (Figure 1). In this instance, justified setting was conventional in book production; using a large type size to protect children’s eyesight was publishers’ acknowledgement of recommendations in a report produced by the British Association for the Advancement of Science (1913).

Figure 1. A page from ‘Ring-o-roses series’, Six wee crabs, London: Cassell & Co, c. 1929. 24-point type is set with no additional line feed; this and that the text is set justified (that is, with a straight right-hand edge) means that the word spacing varies from line to line. This arrangement is unlikely to benefit children’s reading.
Much of the early legibility research with relevance to children was undertaken in the context of ‘school hygiene’ and ‘hygiene of reading’, which aimed to ensure that the type that children read in their books did not harm their eyesight (see Huey, 1908; Venezky, 1984). This work led to recommendations for particular kinds of typeface, type size and spacing in books for beginner readers (e.g., Kerr, 1904; Gunn, 1906). Later legibility researchers, usually psychologists (including Cyril Burt, Miles Tinker and Bror Zachrisson), undertook work with young readers, testing different versions of a page of type (for example, showing variations in line spacing, line length and type size) and measuring speed of reading or comprehension. Watts and Nisbet (1974) provide a useful, concise review of this and other research relevant to typography in children’s books, thereby drawing attention to the range of typographic variables that text designers have at their disposal when designing. Despite the volume of research there is still no consensus about the visual attributes of texts that are best for beginner readers, although most would agree that text should not be set in all capitals nor be justified. There remains debate as to whether serif or sanserif type is easier to read (Walker & Reynolds, 2002/3), whether or not lines should be broken according to the sense of the text (Raban, 1982), whether single-storey a’s, g’s and other infant character modifications should be used (Coghill, 1980; Walker & Reynolds, 2002/3), how much space should be used between lines and words (Haber & Haber, 1981; Reynolds & Walker, 2004; Reynolds, Walker & Duncan, 2006), and whether text for beginners should be set larger than that for more fluent readers (Hughes & Wilkins, 2000; Wilkins et al., 2009).

With the growth of multimedia in classrooms and elsewhere in the 1980s and 1990s researchers became interested in typography on screen. Guidelines and primers introduced typography and page layout to new users of electronic publishing. For example, Rockley (1994) presented straightforward guidelines ‘based on related research and practice’, for the use of multi-media, and included ‘novice’ as one of her levels of user experience. Horton (1990) offered guidelines for the design of on-line documents, based on a literature review. Philips and DiGeorgio (1997) described and illustrated a number of alternative layout patterns for headings, text and illustrations. Walker and Reynolds (2000) summarised research relevant to screen design for children’s reading, including navigation, typography and layout of text on a screen, and Dyson (2005a; 2005b) provided a more general review of research relevant to reading on screen. Much of this work related to technologies no longer in use in classrooms, and did not add much to what we know about designing for reading on paper.

For children’s reading there remains debate about which typefaces are most appropriate. Just as important, if not more so, is the relationship between size of
type, space between the lines and letters, and the length of the line. These issues are discussed in the next section.

3.1 Typefaces

An issue that has interested both typographers and those engaged in legibility research is whether reading is better supported through distinctive word shapes (assuming word recognition is paramount), or easily distinguishable letter shapes (because readers build up words by recognising individual letters). Historically, a distinctive word shape has been promoted by designers as being key to reading, though with recognition that the features of individual letterforms (i.e., internal shapes, contrast between thick and thin strokes) also contribute to word recognition (see, for example, Spencer, 1969). In the 1990s theories began to emerge suggesting that words may be recognised from a set of critical features, the majority of which were related to the distinctive features of individual letters and their position in a word (see Smith, 1994, pp. 119–131). Recent evidence has elucidated further the roles of letter by letter and whole word reading, and the aspects of letter design that contribute to their identification; this has been usefully summarised by Beier (2012, pp. 22–30) with reference to related research. Pelli and Tillman (2007) examined the contribution of different processes underlying word reading and found that the three processes of letter by letter identification, whole word identification and use of context to predict words operate together in fluent readers, with letter by letter reading contributing more than the other two strategies. Other research suggests that word shape is not critical to word recognition (Larson, 2004; Dyson, 2013) and that words cannot be read if their individual letters are not individually identifiable (Pelli, Farell & Moore, 2003). Letters are identified by detecting independent features (around 7 features per letter) (Pelli et al., 2006). Fiset et al. (2008) suggest that, in Latin script, the terminations (areas where strokes begin or end) carry the most significant cues to letter identification, with intersections, curves and direction of features also important. Cues to letter identification, of course, vary across scripts.

Type designers traditionally strive to create evenness and harmony in the appearance of the characters of a typeface. Improving legibility through modifying letters to increase their distinctiveness has been proposed (Fiset et al., 2008) and explored (e.g. Kolers, 1969; Beier & Larson, 2010). Studies aimed at less fluent readers focus on heterogeneity/irregularity among the characters as a means of improving reading. Wilkins et al. (2007) introduced distortions to Times New Roman to create uneven strokes and distances between strokes. The reading rate of fluent adult readers was not affected, but children with literacy difficulties read the
distorted words faster and with fewer errors. Wilkins has posited that this effect is due to disruption of the stripe patterns of lines of type on a page created by standard typefaces. Bessemans (2012) has found that a more irregular rhythm (and possibly form) facilitates reading for visually impaired children. Other studies suggest that consistency in letter appearance improves reading efficiency. Known as the font-regularity effect (Sanocki, 1987) or ‘font tuning’, the benefit of consistency is considered to be the result of the perceptual system developing a set of recognition parameters over time, which it can apply throughout a text (see Sanocki & Dyson, 2012).

Clear distinction between letters is important for children’s reading. A question often raised in relation to typefaces for children’s reading is whether serif or sanserif typefaces are more appropriate (a serif type has small lines attached to the end of a stroke, a sanserif type does not). For example, many teachers favour the use of sanserif typefaces because they relate to letterforms that children are learning to write; but there has been no research that concludes that sanserif type is actually easier for children to read. Walker and Reynolds (2002/3) found that children read text set in serif (Century Schoolbook) and sanserif (Gill Sans) equally well. Bessemans (2012; 2016) found that the children (aged 5 to 10) made fewer mistakes when reading text set in a serifed typeface (DTL Documenta) than when reading text set in Frutiger. Ripoll (2015) found that beginners could read cursive, serif and sanserif equally well (though they preferred the cursive one they were familiar with).

To further simulate handwritten forms, and at the request of teachers, many typefaces used in children’s books are designed with alternative character shapes for some letters, typically those for a, g, l and t and capital I and Figure 1 (Figure 2). Known as ‘infant’ or ‘schoolbook’ characters, they are similar in form to those that children learn to write. In some typefaces such practice means that there are similarities in letter shapes; for example, in very round-looking typefaces with short ascending and descending strokes, lower-case o, a and g look very similar (Figure 3) and can cause confusion at the word level. A study by Walker and Reynolds

![Figure 2. 'Infant,' 'schoolbook,' 'single storey' are all terms used to describe alternative forms of some letterforms that are thought to be helpful for beginner readers. Sometimes letters are redrawn to look like handwritten forms; sometimes they are drawn to be clearly distinguished from similar-looking letters. The most widely-used infant characters are 'a' and 'g', and letters that might be confused such as capital I, lower-case 'el' and figure one.](image-url)
(2002/3) found no difference when children read text set with infant and non-infant characters, although some children recognised that single-storey a and g were for writing, and double-storey ones for reading. Bessemans (2012; 2016) also found that children (aged 5 to 10) had no problems concerning the use of non-infant characters in type.

Some typefaces have been designed especially for children’s reading. In the 1980s, for example, Rosemary Sassoon produced Sassoon Primary. Designed in consultation with children, this typeface has characteristics of handwritten letterforms, notably a slight slant and ‘exit strokes’ to lead from one letter to the next (Sassoon, 1993). Another approach has been to consider the characteristics that typefaces might have and whether these are likely to help with letter and word recognition, for example, long ascending and descending strokes. Fabula was designed as a screen font in the late 1990s to support bilingual story books for children. It aimed to make a distinction between characters that could be easily confused and to have a friendly and informal feel (see Figure 4). Twinkl, launched in 2016, shares many of Fabula’s attributes, and is available in a series of weights (Figure 5).

Shep was the sheepdog, but he did not like sheep. He said they were silly and boring.

Figure 3. In some typefaces, such as Avant Garde Gothic, shown here, there is very little differentiation between the letter shapes, and this is likely to confuse beginner readers.

Figure 4. The typeface Fabula was designed to have generous ascenders and descendents, differentiation between a and o, and rounded stroke ends to give a friendly and informal feel. There is a clear distinction between characters that might be confused.
Shep was the sheepdog.

3.2 Type size, vertical and horizontal space

In printed materials for adults it is generally accepted that, for type sizes for reading at normal distances, legibility is increased by adequate vertical separation of lines of type. In typographic terminology, this means the addition of two or three extra points of space. It is argued that the additional space makes it easier to follow each line and facilitates an accurate, even sweep of the eyes from the beginning of each successive line (see Tinker, 1968, p. 320). Generous space between lines may also help with word recognition, as there will be less visual interference or ‘contour interaction’ from lines above and below the line that is being read (Hughes & Wilkins, 2002). The optimum amount of additional space depends on several factors, including the size of the type and whether it is sanserif or serif, and the length of the line. Precise metrics for spacing are therefore difficult to specify and are a further example of a decision designers make, based on experience. There has been very little experimental work on line spacing in books for children, and the results have generally been inconclusive (Tinker, 1968). Sassoon (1993) reported on a study with 8–13 year-old children of different abilities who were shown examples of differently spaced text, concluding that it is difficult to define a generally applicable practice as children at different levels of reading have different requirements and preference. This view was supported in qualitative studies.

Figure 5. The typeface Twinkl shares many of the characteristics of Fabula. It is available in a range of weights [thanks to Twinkl educational publishers and to Type Together].
undertaken by Reynolds and Walker (2006) who found that most of the children in their sample preferred a reasonably generous space between lines, with perceptions of a text that was very widely or very closely spaced, respectively, as ‘did not look like a real book’, or was ‘too difficult’.

The optimum line length for reading printed texts, for adult readers, is between 50 and 70 characters, or 8–12 words (Spencer, 1969; Hochuli, 2008; Bringhurst, 1992). Tinker (1968) conducted studies of line spacing with Grade 1 children (six- and seven-year-olds). He recommended that with 18- or 24-point type, lines should be relatively short, with 6 to 8 points of additional space. In practice though different 24-point typefaces have different appearing sizes (see, for example, Legge & Bigelow, 2011); and the visual appearance is also affected by the space between the lines (see Figure 6). Taking a different perspective, Raban (1982) found that for beginning readers, breaking lines after ‘and’ and between phrases caused less disruption of reading than breaking according to line length. Following this phrase-based breaking practice resulted in lines of text of considerable variation in length, and a very ragged right-hand edge (see Figure 7).

Historically, horizontal space – between letters and words – has not been thought by legibility researchers to be as important as type size, line length and space between the lines (see Huey, 1908; BAAS, 1913). This may be due to the prevalence of justified setting, which effectively varies word spacing from line to line in order to maintain straight borders on both the left and right side of the page (Figure 8).

Justified setting was used in reading books until around the mid-1940s, though in the 1920s some were set unjustified with even word spaces. Hartley (1987) concluded that unjustified text was more suitable for screen reading. In the latter part of the twentieth century it was fashionable in typography for adults for words to be very tightly spaced, a practice criticised by Yule (1988) and Sassoon (1993) with regard to children’s books. Although in Raban’s (1984) study, teachers thought that spacing was less important than typeface or type size in choosing books for children, they thought that for beginner readers (5- and 6-year-olds) word spacing was more important than line or letter spacing. In terms of whether more or less space between words helps beginner readers, Reynolds and Walker (2004) found that, with realistic reading materials discussed in a classroom setting, children were very tolerant in relation to variation in the use of horizontal space. As in Hughes and Wilkins’s (2002) study, they found that horizontal space more or less affected perceptions of ease of reading: that tight spacing looked ‘difficult’, or that wide spacing made type look ‘bigger and thinner’. The relation between word spacing and line spacing is also important. Typographers are concerned with ensuring that the space between the lines of type is greater than that between the words. If not, and especially if the text is justified so that the word spacing varies
from line to line, distracting vertical ‘rivers of white’ may impede the reading process. This effect can often be seen in some children’s reading books in the early part of the twentieth century.

But Shep was a good dog. So every day he sat with his nose on his paws and counted sheep. Then one day he fell asleep.

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But Shep was a good dog. So every day he sat with his nose on his paws and counted sheep. Then one day he fell asleep.

Figure 6. Examples of 24-point type set according to the parameters set out by Tinker (1968), for 6–7 year old children. It shows that different typefaces have different appearing sizes. The typefaces shown are Century Schoolbook, Twinkl, Gill Sans and Garamond.
But Shep was a good dog. So every day he sat with his nose on his paws and counted sheep.

Figure 7. Breaking lines according to sense, or to anticipate the word on the following line may help beginners keep track of the sense of the narrative.

Figure 8. Examples of space between words and line endings.

But Shep was a good dog. So every day he sat with his nose on his very big paws and counted sheep.

Figure 8a. Unjustified setting – where the space between words is equal – is recommended for beginner and emerging readers, and words should not be hyphenated.

But Shep was a good dog. So every day he sat with his nose on his very big paws and counted sheep.

Figure 8b. Justified setting results in a straight right-hand edge and the space between the words varies from line to line.

4. Pictures and text

Book designers are concerned with the functional and positional relationships of text and image. There are a number of descriptive frameworks that define these, though most are applicable more generally than to children’s reading (e.g., Williams, 1993; Duschatel, 1978; Emery, 1993; Schriver, 1997). Pictures also play a strong motivational role – if a book is visually attractive young readers are more likely to engage with it (Levie & Lentz, 1982).

Much of the early research that considers the relationship of text and pictures, including in reading primers, is summarised in Goldsmith (1984). Many studies, particularly those concerned with the acquisition of individual words, concluded
that pictures were a distraction from word learning, though the validity of some of this work is questionable because the quality of the illustrations and test materials was poor and the results complicated or inconclusive. Kozma (1991) cited research by Winn (1989) which suggested that for knowledgeable readers, pictures should be placed early in the text if they are used at all, and that less knowledgeable readership would benefit from interspersed pictures, juxtaposed with the corresponding text. Horton (1990) concluded that related text and graphic should be placed next to each other and that this was more important than balancing text and pictures for aesthetic reasons. Goldsmith (1984), however, commented that if an illustration was positioned near the top of a page, readers are more likely to pay attention to the text that follows. She also commented on the converse – that a particularly attractive illustration placed at the bottom of a page may distract the reader from reading / being aware of the text above it (e.g., Peeck, 1987; Filippatou & Pumfrey, 1996). In practice there is considerable variation: Walker (2013) identified typical text/picture positional relationships evident in print reading books from the end of the nineteenth century until the beginning of the twenty-first.

What these analyses have in common is the recommendation that a picture should be in the same field of view as the text that relates to it. In e-reading, the ability of the designer to control the spatial relationship of picture to text may be limited. In fixed modes picture positions can be controlled precisely within a 'page' but in flowed modes much less so, and with more effort from the designer/developer. Custom applications offer the most control but in return for a large investment in design and development effort.

5. **E-reading formats and the control offered to the designer**

The design of pages for reading extends beyond the typography and use of illustrations discussed above. Designers must work within the constraints of the technology available to present text in a way that responds to the needs and expectations of readers, and to how and where they read. The introduction of new technologies, from typewriters at the end of the nineteenth century, to desktop publishing in the 1980s influences how text is presented (Walker, 2001). At each stage of technological transition there is a tendency for producers of text to replicate the conventions of the old technology that readers are familiar with, and then, as new technologies become familiar, for new conventions to become established. Design for reading, at least on paper, is bound by conventions that affirm readers’ expectations of visual presentation or graphic genres (Waller, 1991; Kostelnick & Hassett, 2003; Moys, 2017). Conventions and reader expectations are not yet affirmed for e-reading, though research on the location of web objects (that is, any content
contained in a web page) may provide useful pointers; see Bernard (2000, 2001); Shaikh & Lenz (2006); Roth et al., (2010).

The visual experience that can be offered to beginning readers depends on:

- The physical size, colour gamut and pixel resolution of the hardware device on which the visual experience is rendered (see Sorkin, 2016). These will affect the appearance of the text: for example, how crisp, black or grey letter images appear. There are (in 2017) a large number of variants in both the physical size and the pixel resolution of tablet devices used in classrooms, which makes it likely that different readers of the ‘same’ e-book will have different reading experiences.

- The format repertoire of the page description language, markup/browser combination or programming language used to render the reading experience to the display – that is, the graphic capabilities of the software. Software varies in its capability to draw shapes accurately, place items precisely on the display, select and render typefaces, place pictures etc. The combination of hardware device and software are the publishing ‘platform’. There are many publishing platforms on the market and even the dominant one (Kindle) contains many significant variations caused by the different software versions and hardware platforms on which it is used.

- The locus of control over the graphic capabilities of the software; that is, who gets to choose how the software capabilities are rendered to the display surface for a particular device and when that control is exercised. For example, the reader of an e-book may be allowed to change the size of the type which they are reading to suit their preferences. The ‘designer’ may be able to specify a type size when formatting a particular e-book for publication. And the publishing platform may have limits on the range of sizes which can be selected for e-books published on that platform, together with restrictions on how much the designer and the reader is able to change sizes within the system’s limits.

All of the above vary in the e-reading experiences of beginner readers today. In an ideal world, teachers, publishers, designers, reading researchers and authors would select the publishing platform that best meets the child’s needs and the nature of the e-reading material. In practice, factors such as market share of platforms, the need to use particular Digital Rights Management (DRM) systems to protect sales, compatibility with school-wide asset management systems, etc. are likely to be the main factors in choosing platforms. There are over 20 fairly widely-used technical standards that cover e-book formats, each supported by one or more e-book software applications. As technology develops, new standards are introduced and old ones sometimes superseded. A reasonably full listing of standards is available
in Wikipedia. These standards vary widely but fall into main categories plus a few ‘exceptions’. The next two short sections summarise the technical constraints imposed by flowed and fixed page layouts.

5.1 Markup-based e-books: Flowed page layout

Most e-reading file standards are based on ‘semantic markup’ of the text and pictures in a book. The markup is then combined with ‘stylesheets’ to control how those elements appear on the e-reader screen (see Goldfarb & Rubinsky, 1990, for the principles of separating the semantics and appearance of documents). This is essentially the same process that is used to create web pages, and many e-reading file standards are closely based on the HTML (Hypertext Markup Language) and CSS (Cascading Style Sheets) standards. None, however, are entirely compatible with HTML/CSS (HTML contains text and codes which identify whether each part of that text is a paragraph, a heading, a hyperlink, etc. CSS is a ‘style sheet’ which says how a paragraph etc. should be displayed: its colour, typeface size, line spacing etc.). Moreover, most incorporate optional or required use of proprietary digital rights management software, to prevent unauthorised copying of the e-book. This adds some complexity to the design process.

On the web, pages are viewed in Internet browser software such as Internet Explorer, Chrome or Firefox. A given set of HTML and CSS files will display near-identically on any web browser, and open standards for HTML/CSS specify what that appearance should be. E-reader software products such as Kindle or iBook can be seen as ‘browsers’ for one or more e-reading file formats. They often require, or focus on, proprietary markup and style formats, so there is no real equivalent of the consistency in appearance across web browsers. Where E-readers do support ‘open’ standards such as EPUB2 or EPUB3, they tend to do so in idiosyncratic and partial ways (IDPF, 2010; IDPF, 2017).

All e-book software can accept and display ‘flowed’ books provided in ‘EPUB’ markup defined by the International Digital Publishing Forum. Designers influence the look and behaviour of an EPUB e-book mainly by creating CSS stylesheets for it. The resulting EPUB file is submitted to an e-book publishing service, such as Kindle, Apple iBook or Android Play, and is in turn made available to users of appropriate devices and services. This process creates different user experiences on different devices and services even if the same original code is submitted. For example, on a Kindle, the designer’s style instructions for space between the lines

may be overridden by Kindle’s defaults (or by the user’s stored preferences). This limits the control the designer has over the user/reader experience. Current developments in e-reader standards and devices e.g. EPUB 3 are tending to increase the control over the reading experience available to designers.3

5.2 Pictures of pages: Fixed page-layout

Most e-reading platforms support one or more fixed layout file format, most commonly PDF, or a format based on PDF. Most integrated texts – books with large numbers of illustrations and close relations between text and image – are carefully-designed for print and published electronically as ‘pictures of pages’. The key advantage of fixed layouts is that designers have complete control over how the page is arranged. PDFs may be appropriate in situations where the physical size, resolution and operating system of users’ devices is controlled and consistent; this may be true within a particular institution or school system. However, fixed layouts have disadvantages for a number of reasons including:

- accessibility features such as read-aloud may be unavailable
- by default fixed-layout formats ‘scale’ to the size of the device they are displayed on. Type and pictures are likely to be displayed at a different (normally smaller) size than they were designed for. The user can normally enlarge by zooming into a part of the page, sacrificing a complete view of the page as it was designed.

The impact of these features on usability will depend on the particular e-book or series of e-books (for example, a publisher’s integrated reading scheme) and would need specific usability testing. There are therefore no generally-applicable research results to provide guidance.

6. Finding out what works with beginner and emerging readers

The impact of technology on the visual attributes and materiality of e-reading and the resulting variations that occur emphasise the importance of eliciting feedback from users as part of the design process. Involving children in this is regarded as good practice in HCI (e.g., Druin, 2002; Bruckman et al., 2012; Nielsen, 2010). Druin, for example, identifies the roles that children have assumed: from ‘users’ to ‘testers’, ‘informants’ and, latterly, ‘design partners’, summarising the historical

context of each approach, the methods used, the impact on the technologies concerned, and the challenges and strengths of working with children in each case. Information designers also take seriously the need to involve the readers and users of their work in its development and typically elicit feedback through:

- observation and feedback sessions to discover how children use and report using reading materials, with a view to understanding what works well within a particular learning setting (see e.g., in relation to classroom use of CD-ROMS, Walker, Reynolds & Edwards, 1999)
- exploration of whether there are specific aspects of the design of e-books that affect an individual child’s reading
- user testing to find out whether materials under development are easy for children to read and use; in this case, aspects of the design that appear to cause difficulties can be revised and the materials re-tested in an iterative process
- preference judgements, which may produce generalisable findings, to discover whether different devices and/or layout strategies have different levels of appeal to children; children may make their choice of books according to different design criteria from those of teachers, parents, or other adults.
- investigative examination, to produce generalisable findings, of whether there are aspects of the design of materials that affect the reading performance of children at different stages of reading development; such investigation may focus on specific reading tasks, such as letter, grapheme or word recognition, sustained reading or searching for information within a page or a document.

These approaches vary both in their intentions – from diagnostic testing to investigatory research – and in the level of formality of the investigation; see Dyson (2017) for a characterisation of different types of testing according to purpose. Depending on the goal of testing e-books or other digital reading materials, study tasks may range from group discussions to individual testing of reading performance. Studies of performance may yield information about the process of reading (for example, by tracking eye movements and the characteristics of reading errors or pages accessed) or its outcomes (the time taken to read, comprehension, successful retrieval of information); see Dillon (2004) for further discussion of the process–outcome distinction.

As we have seen, the design of texts of any kind involves the manipulation of multiple variables, from typeface choice, size, line length, and vertical spacing of lines, through to the number of lines on a page and the differentiation of different types of text (for example, headings and paragraphs). A decision-making process is needed in order to decide which variables are most important to control and which allow variation in order to examine the specific issue of interest. Involving a designer with experience in text design may help steer decisions
about which variables to hold and which to co-vary with the manipulated variable. Options for controlling these variables may be limited in published e-books but it is still important to be aware of them and their potential effects on readers’ responses.

7. Concluding remarks

As this chapter has discussed, there is limited research on the impact of visual design of digital reading materials on children’s ability to carry out reading tasks. Although much research from printed materials is likely to be transferable to on-screen materials there are still unknown factors. For example, how does the relative brightness of digital displays affect children’s reading? How does the physical form of e-readers and tablets and the different cues they provide to position a text affect children’s reading, e.g. motivation, information access, ease of reading, and satisfaction? Lack of research into such issues contrasts to research that has focused on the multi-modal and interactive potential of e-books; for example, de Jong and Bus (2003), Kurcikova, Littleton and Cremin (2015). Similarly, although reading research indicates the importance of choice of materials (see, for example, reviews by Gambrell, 2011 and Wigfield & Guthrie, 2000) there is limited research on how the design of reading materials might influence choice. As discussed above, children’s perceptions of books are likely to influence their willingness to start or persist in reading them (see Walker, 2005). Many contemporary children’s books reveal considerable typographic variety including words in all-capitals that ‘shout’; words and phrases in bold to emphasise something important; different typefaces mixed in the same word; and straight and curved lines of type within a single page. Some children are motivated by such variety and may be motivated by the options that some digital devices offer for manipulating the text: if a word or concept is not understood they can look it up; when text is not big enough they can increase the size, and so on.

In this chapter we have drawn attention to evidence from research and practice that provides some general indication of the treatment of the features that are likely to help beginner and emerging readers (see Table 1). Awareness of these will assist in discussions between educationists and designers and may inform design decisions relevant to fixed modes of e-readers.

In the absence of evidence on which to base clear recommendations for e-reading, we recommend that obtaining feedback from children and teachers (through surveys, performance and preference testing) is essential for successful reading. This way of working also has historical precedent in information design in non-educational contexts (see examples in Black et al., 2017) and demonstrates
<table>
<thead>
<tr>
<th>Issues that designers consider when making books for beginner and emerging readers</th>
<th>Treatment of typographic feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment of line-endings</td>
<td>Unjustified/ranged left so that the space between words is even (Hartley &amp; Burnhill, 1971; Hartley, 1987) Break lines according to sense and to anticipate words on a following line (Raban, 1982)</td>
</tr>
<tr>
<td>Spaces between words and lines</td>
<td>A little wider than for adult reading (Reynolds &amp; Walker, 2004; Hughes &amp; Wilkins, 2002)</td>
</tr>
<tr>
<td>Space between the lines and length of lines</td>
<td>The appearing space between the lines should be greater than that between the words so that lines of type are clear. Longer lines require more space between them than shorter ones. (Reynolds, Walker &amp; Duncan, 2006; Sassoon, 1993; Hughes &amp; Wilkins, 2000; Phillips &amp; DiGeorgio, 1997)</td>
</tr>
<tr>
<td>Treatment of paragraph beginnings</td>
<td>Research with children using printed materials suggests that either a line space with no indent, or an indent with no line space are likely to be equally suitable. A new line with no additional space is likely to be less helpful. (Hartley, Burnhill &amp; Davis, 1978)</td>
</tr>
<tr>
<td>Typeface or font</td>
<td>Both serif and sanserif typefaces are suitable for beginner and emerging readers (Walker &amp; Reynolds, 2002/3; Bessemans, 2012; Rippoll, 2015) There should be clear differentiation between the character shapes of letters that might be confused, e.g., o and a; h and n. Discriminability can be helped through, for example, using a non-infant d and g; using a font with long ascending (for example for ‘h’s and ‘k’s) and descending strokes (for example, for ‘y’s and ‘g’s) (Walker, 2005)</td>
</tr>
<tr>
<td>Type size</td>
<td>Generally, type should be set larger than for adult readers. However, the space between the lines and the length of the line contribute to the perceived appearing size of the type. (Woods et al., 2005; Walker, 2005; Rippoll, 2015)</td>
</tr>
<tr>
<td>Pictures and text</td>
<td>Related text and pictures should be adjacent, (rather than positioned for aesthetic reasons).</td>
</tr>
<tr>
<td>Headings</td>
<td>A heading should relate to the text that follows it. There should be more space above than below to help readers with this. Designers use headings and sub-headings to clearly articulate a visible hierarchy using, for example, size, boldness and indentation (see, for example, Hartley &amp; Trueman, 1985)</td>
</tr>
</tbody>
</table>
further value in working with insights obtained through evaluating documents with intended users, and within particular contexts of use.

Looking ahead, design for e-reading requires collaboration between and involvement with children, teachers, and technologists. Information designers welcome this way of working and also understand the relationship between language and its visual presentation, whether through type or images. In the words of Andrew Dillon (2017, p. 298):

Much as doctors use test findings and medical science in a skilled reading of contexts and patients to reach a diagnosis, a skilled designer needs multiple forms of knowledge to make the right choices. The science does matter, the principles of good design will always apply, but creating useful, usable, and attractive information tools requires a representation of human actions in context to enable appropriate design constraints to be envisaged. Such representations are worthy of our serious attention now.

References


Chapter 2. Designing digital texts for beginner readers


Cognitive processes and digital reading

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Regardless of the medium, reading is a complex skill involving the execution and coordination of many cognitive processes. Reading comprehension in skilled readers is the end-product of processes that are fast, efficient, interactive and strategic. These processes, some of which may be described as lower level (e.g. word recognition) and some as higher level (e.g. inference-making), rely on aspects of executive function including attention, working memory, executive control and metacognition. This chapter examines the involvement of these four aspects in both print and digital reading. We explore how on-screen reading of linear and non-linear text (hypertext) makes additional demands on executive function, potentially threatening comprehension and learning. We also consider how technology may confer processing advantages for readers with particular difficulties. Recommendations aimed at preventing shallow processing when engaging with digital text are presented. Having reviewed the literature, we speculate on how the potential of technology may be harnessed in order to encourage reading, to improve assessment, and to increase knowledge.

1. Introduction

Psychologists and educationalists have studied print reading for more than a century, leading to a significant body of research and a high level of understanding of the cognitive processes involved in skilled reading. As both the amount and quality of digital reading increases, however, there is a need to increase our knowledge of the skills and processes involved in digital reading and to understand how reading digital text impacts cognitive functioning. The introduction of computers, tablets, smartphones and other digital devices into everyday life has transformed how individuals interact with written information. More importantly, these new technologies have made it possible to tailor text in accordance to individual needs.
and preferences. With rapidly advancing technologies and new features such as Enhanced eBooks – containing embedded media, interactivity, and narration – flooding the market, many questions arise as to how new technologies may impact an individual’s ability to engage with written text. As adults, we know experientially that text format can impact the ease of reading and determine whether or not we will engage with text content, for example carrying out sustained reading on an e-reader (Hayler, 2011) or the screen of any digital device. While our level of engagement in these instances may be modulated by complex motivational factors, converging evidence from the fields of typography (Dyson, 2004) and cognitive science (e.g. Coiro, 2015; Koriat, Ackerman, Adiv, Lockl, & Schneider, 2014; Kornmann, et al., 2016; Montani, Facoetti, & Zorzi, 2014) indicates that a multitude of cognitive processes may be influencing these behaviours, and that these cognitive processes are themselves affected by the modality of text display.

Decades of research point to reading being a complex process involving many components that are generally accepted to reflect either lower-level or higher-level processes. The former include word recognition, syntactic parsing and semantic-proposition encoding, while higher level processes engaged in comprehension include updating, inferencing, inhibition, and strategic processing or metacognition. Importantly, all of these processes – both higher level and lower level – operate within the constraints of a limited capacity cognitive system, consuming cognitive resources according to the extent to which they are automated. When a process is executed automatically it makes minimal demands on working memory, whereas less automated (i.e. controlled) processes make relatively large demands on working memory (Ashby & Rayner, 2006; Samuels, 2006; Stanovich, 1990). Consider word recognition, for example. Fluent readers recognise words quickly and seemingly effortlessly, leaving significant cognitive capacity for more demanding (less automatic) activities such as inference-making. It should be noted, however, that even higher level processes can become more automated as reading skill improves and metacognitive experience accrues (e.g. Perfetti, 2007; Reynolds, 2000). In this chapter we focus on how digital reading (in comparison to print reading) is changing the executive function demands of text processing, specifically focusing on attention, working memory, executive control and metacognition. While we would not claim that other more linguistic reading processes associated with e.g. word recognition and syntactic parsing do not differ in any way in print and digital reading, we contend that digital reading makes particular, increased demands on executive processes, a contention we explore here.

The term ‘digital reading’ can refer to any engagement with a large range of text formats including books, newspapers, magazines, websites, blogs, and forums. As Walker, Black, Bessemans, Boormans, Renckens and Barratt (2018; this volume)
highlight, some of these formats are ‘fixed’ in the sense that the reader can make only minor, if any, adjustments to them in terms of appearance via sizing, etc. (e.g. e-books). In fixed formats, readers typically progress through the text and engage with content in an order determined by the author. In contrast, less ‘fixed’ formats such as websites may contain hyperlinks which enable readers to engage with content according to their needs, motivations or knowledge at that particular point in time, meaning that a reader may experience the same overall content in different ways depending on their orientation and approach in a specific reading session. The flexibility inherent in hyperlinked text also means that different readers may engage with the content in different ways, rendering an overall text structure that may be more or less similar to that originally envisaged by the author. Of course, digital reading may involve engaging with more than one text or source in any reading session. Salmerón and colleagues (Salmerón, Strømsø, Kammerer, Stadtler, & van den Broek, 2018; this volume) discuss advanced digital reading skills in contexts where readers need to navigate, integrate and evaluate multiple sources. The focus in this chapter is on the reading of single texts, but it should be pointed out that considerable heterogeneity in terms of text length and linearity exists within the experimental stimuli used in the reviewed studies. Four cognitive processes of interest – attention, working memory, executive control, and metacognition – are discussed in discrete sections. It will quickly become obvious to the reader, however, that it is difficult to maintain a clear delineation between the processes, and our discussion of each invariably includes reference to one or more of the others. One consequence of the interrelatedness of concepts is the potential arbitrariness of where we discuss relevant literature. For example, when a reader decides to pause in order to use a dictionary or an online glossary, metacognition, shifting of attentional focus, and updating of working memory are among the many cognitive processes and skills invoked. Our approach to this challenge is to align literature with what might reasonably be assumed to be the predominant concept; for example, while the decision to re-read a section of text due to a self-assessment of comprehension difficulties will have implications for the updating of working memory, we discuss these issues within the context of metacognition. We re-iterate however that it is difficult to discuss the role of any single process in either print reading or digital reading without invoking the involvement of one or more of the others, and we encourage readers to reflect on the multi-componential nature of reading.

The chapter is organised as follows. We commence by considering the role of visual attention in the context of linear text with its relatively static format before discussing how the more dynamic nature of hypertext presents challenges for working memory and executive control. For each cognitive process we summarise what is known about its role in print reading then proceed to discuss parallel
research concerning digital reading. We close the chapter with an overview of research on metacognition, highlighting its relevance when reading for learning, problem solving or assessment.

As will become evident when compared with traditional print-based reading, there is relatively little research on digital reading in general, and only a small proportion involving children. Furthermore, within this context it is timely to emphasise that knowledge and understanding of the developmental patterns of relevant cognitive processes are still very much emerging. While advances in knowledge regarding the development of attention, working memory, executive function and metacognition in children and young people have been considerable in the last two decades, we predict significant advances in the next decade as researchers avail of increasingly powerful, and accessible, technologies.

2. Attention

Attention can be seen as a set of guiding selection processes for received perceptual information; these processes restrict the amount of external stimuli being submitted to further processing by the limited human cognitive system, to avoid its overload (Anderson, 2004; Driver, 2001; Carrasco, 2014; Goldberg & Wurtz, 2013; Kandel, 2013; Nobre & Mesulam, 2014). Attention is critical to all aspects of everyday functioning, including meeting basic needs, interacting with others and learning or recalling new information. The term encompasses a range of operations from low-level orienting towards sensory stimuli, through to higher-level processes. The latter can be put into different categories such as attention shifting, divided attention, focused attention, sustained attention, or selective attention (Driver, 2001; Lezak, Howieson, & Loring, 2004; Wager, Jonides, & Reading, 2004).

Following Broadbent (1958) and Mullane, Lawrence, Corkum, Klein and McLaughlin (2016), successful learning processes comprising effective identification, learning, and memory can only take place if the individual has acquired a sufficient level of sustained attention. Since working memory and attention have limited capacity, they mutually guide each other: whereas memories of experiences influence an individual’s decision-making processes on what attention should be drawn to, the regulation of the contents encoded into memory is performed by attention (Chun & Turk-Browne, 2007).

2.1 Attention and reading

Attention can be seen as a prerequisite of effective and successful reading as it enables the individual focus on text content, leading to improved reading
As a volitional and effortful activity, successful reading for meaning relies upon multiple aspects of attention: at a basic level individuals need to be able to orient themselves to visual text and move their attention in the direction of the new information. While reading we have the impression of our eyes moving steadily and smoothly along the lines. However, quite the contrary is the case: as we read our eyes are engaged in an alternating process of short and rapid movements, or saccades, versus fixations (Reichle, Rayner, & Pollatsek, 2003).

Whereas almost no visual information is processed during the short saccadic eye movements (20–50 msec) (Ishida & Ikeda, 1989; Wolverton & Zola, 1983), most information processing occurs in the brief periods (200–250 msec) while the eyes remain stationary (Erdmann & Dogde, 1898; Huey, 1908). The amount of distinct orthographic elements (e.g. letters, letter clusters or syllables) that can be processed in parallel during a single fixation has been termed perceptual span (Rayner, 1998) or visual attention span (Bosse, Tanturier, & Valdois, 2007; Bosse & Valdois, 2009). Research has consistently shown a close relationship between this span and the development of reading ability, with improvements in reading associated with accompanying increases in the amount of information processed regarding the number and nature of letters to the right of fixation (see Häikiö, Bertram, Hyona, & Niemi, 2009; Rayner 1998, 2008).

Such findings suggest that the act of learning to read itself may contribute towards the refinement of the visual attention skills so integral to the act of reading. However in terms of other aspects of attention needed for successful reading e.g. orienting or sustaining attention, the development of these skills is subject to broader maturational influences which are still in the process of being fully understood. For example, as the prefrontal cortex matures, a process that extends into adolescence, young people are gradually able to apply more cognitive control to their attention (Casey, Giedd, & Thomas, 2000), helping them to refrain from immediate gratification and to focus on working towards future goals (Posner & Rothbart, 2007). These processes are defined as executive processes and determine not only a well-functioning memory and successful learning, but also the effective acquirement of academic skills (Checa, Rodriguez-Bailon, & Rueda, 2008; Posner & Rothbart, 2007; Rueda, Posner, & Rothbart, 2005).

The majority of researchers studying attentional development in typically and atypically developing children (e.g. Huang-Pollock, Nigg, & Halperin, 2006; Kratz et al., 2011; Mezzacappa, 2004; Mullane, Corkum, Klein, McLaughlin, & Laurence, 2011; Rueda et al., 2004; Sobeh & Spijkers, 2012; Weatherholt, Harris, Burns, & Clement, 2006) have taken the Attention Network Theory (Posner & Petersen, 1990) as their reference model. The essence of this theory is to define attention as being constituted of three neural networks: alerting, orienting and executive
network. While some components of attention develop very early and are relatively matured by the time a child enters formal education, other aspects of attention continue to develop well into middle (7–9 years) and late (10–12 years) childhood (Casey et al., 2000; Posner & Rothbart, 2007; Ridderinkhof, van der Molen, Band, & Bashore, 1997; Rueda et al., 2004; Simonds, Kieras, Rueda, & Rothbart, 2007; van der Molen, 2000). Alerting, as the ability to reach and maintain an alert state (Posner & Rothbart, 2007), seems to develop in a protracted manner, reaching maturation past middle childhood (Mullane et al., 2016). Orienting, as the ability to move visual attention towards a particular stimulus, seems to mainly develop before the age of 6 or 7 (e.g. Wainwright & Bryson, 2002), with some specific aspects completing maturation towards the end of late childhood (e.g. Iarocci, Enns, Randolph, & Burack, 2009). The executive network is mainly concerned with an individual’s voluntary control of attention, with the main function of resolving interferences when there is a simultaneous activation of correct and incorrect responses (Posner & Di Girolamo, 1998). Elementary aspects of executive attention may already be found in infants at the age of 6 to 7 months (Berger, Tzur, & Posner, 2006; Sheese, Rothbart, Posner, White, & Fraundorf, 2008). However, since these higher order processes of guiding an individual’s behaviour towards long term goals (Posner & Rothbart, 2007) are executed by the prefrontal cortex of the brain, their development continues through late childhood and adolescence (Band, van der Molen, Overtoom, & Verbaten, 2000; Casey et al., 2000; Mullane, et al., 2016). Based on this model it could be suggested that orienting and executive network potentially play a part in success or failure in reading acquisition.

2.2 Attention and digital reading

The fast-paced development around digital reading has led to research struggling to catch up to answering questions regarding the influence of new technologies on an individual’s ability to engage with written text, including the assumed novel demands on attention caused by the introduction of new approaches to reading (Schneps, Thomson, Chen, Sonnert, & Pomplun, 2013a). There are two key ways in which digital reading could potentially impact attention. The first is through changes in the formatting and visibility of text. Traditional print, due to its relative permanence on the page, has developed a uniform set of standard page sizes, font sizes and letter-spacing norms, designed for a hypothetical “average” reader. In contrast, as highlighted in Walker, Black, Bessemans, Boormans, Renckens and Barratt (2018; this volume), digital text is often presented via software that allows for completely individualised modification of print: page brightness contrast, size/spacing or type of font (de Leeuw, 2010; Dyson, 2004; O’Brien, Mansfield, & Legge, 2005), and within a variety of page formats and text window sizes (Schneps,
The second key change is the growth of hypertext and non-linear text presentation, compared to the linear presentation common to paper books.

Regarding the impact of digital text formatting on attention, this area has arguably been investigated in most depth in relation to struggling readers, a population who are largely defined by their difficulties in reading traditional print-based text. A recent series of studies by Schneps et al. (Schneps et al., 2010; 2013a; b) has looked at the effect of display screen sizes and consequent varied linewidths on struggling readers’ comprehension. It was found that a small, smart-phone sized reading window can facilitate reading comprehension and fluency. The above studies, as well as work by other research groups (e.g. Zorzi, et al., 2012) has found positive correlations between increased inter-letter spacing and improved decoding and comprehension for struggling readers; this is a formatting parameter that has only become more easily adaptable with the increased prevalence of digital text. The advantages for struggling readers of both increased inter-letter spacing and a smaller text window can potentially be explained by the phenomenon of visual crowding (Schneps et al., 2013a), something that can have a particularly deleterious impact for struggling readers (Martelli, Di Filippo, Spinelli, & Zoccolotti, 2009; Moores, Cassim, & Talcott, 2011; Spinelli, De Lica, Judica, & Zoccolotti, 2002; Zorzi et al., 2012). Crowding can be described as difficulty with recognition of distinct objects, such as individual symbols or letters, when they appear in a clutter (Pelli et al., 2007). Whilst the causes of crowding for struggling readers are still being fully elucidated, psychophysical studies do support the notion that crowding is intimately linked to the allocation of spatial attention (Petrov & Meleshkevich, 2011). With digital design features such as altered letter-spacing and altered text-window size thus allowing us to accommodate for individual differences in basic attention processes, many other opportunities for supporting attention, as opposed to challenging it, may exist.

Regarding the proliferation of hypertext, while later sections of this chapter discuss the implications for executive control and working memory, the ubiquitous presence of blue, underlined words, used to signal hyperlinks, has more basic attentional implications. Eye-tracking research by Fitzsimmons (2017), for example, has shown that the mere presence of a single coloured word within a written sentence will reduce the likelihood that the word is skipped (as long as the colour does not have reduced contrast, e.g. grey – blue does not appear to reduce contrast, Gagl, 2016). When readers know that a coloured word is explicitly a hyperlink that can be clicked in order to provide more information, gaze fixation times show further attentional modulation. In an interesting follow-up study using custom-made hypertext Fitzsimmons (2017) found that gaze fixation time was increased especially when low frequency words contained a hyperlink. Fitzsimmons interpreted
this behaviour as reflecting re-evaluation of the prior content, given the potential mismatch between the presence of a hyperlink, suggesting importance, and location of the hyperlink on low frequency and thus potentially less consequential words. This example, however, also shows the close interdependence between lower level cues to information salience and higher levels of both linguistic and metacognitive processing.

In sum, it is clear that the presentation of text in digital formats is altering how we attend to the written word in ways that we are only just beginning to understand. Hypertext, bringing with it the presence of hyperlinks, provides new external markers of text salience that are likely to provide both affordances and challenges to a reader’s attentional capacities. Some aspects of digital text appear to have particular attentional benefits for struggling readers, for example the ability to more easily reduce crowding effects, however a lot more work is needed to fully understand individual differences in how attention and technology interact. Implications for comprehension were raised in this section; comprehension is explored further in the next section where we consider the central role of working memory in reading and understanding print and digital text.

3. Working memory

The contribution of working memory to skilled reading and to the development of reading skills has been shown consistently over several decades since Daneman and Carpenter’s (1980) seminal work on working memory span and reading comprehension (e.g. Cain, Bryant, & Oakhill, 2004; Gathercole, Alloway, Willis, & Adams, 2006; Leather & Henry, 1994; Nouwens, Groen, & Verhoeven 2016; Seigneuric, Ehrlich, Oakhill, & Yuill, 2000). Research has consistently shown that readers – children and adults – with a high working memory span perform better on measures of comprehension than readers with a low working memory span. We return to this issue later when we consider a number of models of reading comprehension.

The working memory model of Baddeley (e.g. Baddeley & Hitch, 1974; Baddeley, 1986, 2000, 2007) is undoubtedly the most widely applied within the relevant literature. Baddeley and Hitch’s model comprises four components – phonological loop, visuo-spatial sketchpad, episodic buffer and central executive. The first two are considered to be slave systems for short term retention and rehearsal of verbal and visual or spatial material respectively while binding of material is purported to be the main function of the episodic buffer. The central executive manages resources and allocates attention. The functions of updating, inhibition, shifting or switching and cognitive flexibility are commonly associated with the
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3.1 Working memory and reading

It is widely accepted that reading is the construction of meaning – of comprehending and actively responding to the text being read. When we consider some definitions of reading comprehension, it becomes clear why working memory is an inherent part of the reading process. Durkin (1993) described comprehension as the essence of reading. He defined reading comprehension as “...intentional thinking during which meaning is constructed through interactions between text and reader” (Durkin, 1993, p. 76). Harris and Hodges (1995) defined reading comprehension as “the construction of the meaning of a written text through a reciprocal interchange of ideas between the reader and the message in a particular text” (Harris & Hodges, 1995, p. 39). The transaction between reader and text was also emphasised by both Kucer (2001) and Rosenblatt (1978).

Most text and discourse researchers use the term mental representation to refer to the outcome of text comprehension processes (e.g. Kintsch, 1988, 1998; van den Broek, Young, Tzeng, & Linderholm, 1999). McNamara and Magliano (2009) critically evaluated seven comprehension models in an attempt to uncover the foundations of a comprehensive model of reading comprehension. Two of these models – Construction-Integration (Kintsch, 1988, 1998) and Landscape Model (Linderholm, Virtue, Tzeng, & van den Broek, 2004; Tzeng, van den Broek, Kendeou, & Lee, 2005; van den Broek, Rapp, & Kendeou, 2005; van den Broek et al., 1999) – are particularly relevant here as we consider the involvement of working memory in digital reading (though elements of several other models reviewed by McNamara and Magliano are pertinent too). We also discuss a further influential model, the CC Reader (Just & Carpenter, 1987, 1992).

Kintsch’s (1988) construction-integration model is one of the most influential theories of comprehension. In this model, three levels of representation are proposed: surface representation, propositional textbase, and situation model. Kintsch viewed text comprehension as a process of construction, where a reader combines background knowledge with information presented in the text. The resulting levels of representation depend on the reader’s purpose. A key component of Kintsch’s model is inferencing, an activity which places demands on working memory. As readers progress through text, related knowledge is activated
and the reader needs to make decisions about the extent to which inferences and elaborations should be integrated.

The Landscape model (van den Broek et al., 1999) aims to represent the online activation of concepts as a reader progresses through a text. As attentional and working memory resources are limited, the number of concepts which can be active simultaneously is limited, which means that activation will fluctuate as concepts vary in relative importance and relevance during reading. Van den Broek et al. (1999) proposed that activation of specific concepts might result from four potential sources of activation. These are (1) the text currently being read, (2) the text that has just been read, (3) the text read previously, and (4) background knowledge. There is substantial support for the Landscape model and the proposal that readers are constructing a mental representation of text as they read. Although there is insufficient space to consider the supporting evidence here, the Landscape model serves to highlight the dynamic nature of reading.

Of course the construction of a mental representation of text involves much more than inferencing and the activation of background knowledge. Lower level processes such as word recognition, syntactic parsing and semantic-proposition encoding are necessary for comprehension. The Capacity Constrained READER, or CC READER model (Just & Carpenter, 1987, 1992), was developed in an attempt to explain how comprehension is constrained by working memory. This computer simulation of the reading process illustrates how individual differences in working memory capacities impact on reading. According to the model, a number of factors such as syntactic complexity, linguistic ambiguity, memory load, and time constraints can alter the demands made on cognitive capacity which in turn influences reading comprehension performance. For example, higher levels of syntactic complexity or linguistic ambiguity increase demands on the limited capacity of working memory. If capacity is exceeded as a result of one or more of these factors, comprehension suffers. Just and Carpenter (1992) proposed that individual differences in working memory capacity mean that comprehension will be constrained more for some people than for others. Of course reading experiences for many people have changed significantly since their proposals about capacity constraints on comprehension and the development of the CC Reader. We are only beginning to understand how different aspects of digital reading make particular demands on working memory; the remainder of this section highlights some relevant findings from research on both children and adults.

3.2 Working memory and digital reading

This subsection's focus on hypertext reflects historical and recent findings where the majority of researchers have manipulated the complexity of hypertext in
their efforts to learn more about the involvement of working memory and other executive functions in digital reading. Hypertexts are non-linear computer-based texts that consist of individual pages connected via hyperlinks (Naumann, Richter, Christmann, & Groeben, 2008). When navigating hypertext, readers click on hyperlinks in order to move from one page to another. Hyperlinks tend to be organised in two main ways – in a hierarchical structure or in a network structure. In the former, each node or page is linked to one above (superordinate) or below (subordinate) whereas nodes or pages can be linked in any way in a network structure. In both hierarchical and network structures, the presentation of information is said to be nonlinear, enabling different readers to encounter the information in different ways as they access pages in a self-directed order by choosing to follow or ignore particular links (Boechler, 2001). In their review of the effect of cognitive load in hypertext reading, DeStefano and LeFevre (2007) suggested that reading and navigating hypertext are likely to place (extra) demands on working memory when compared with traditional linear reading. While the decisions concerning whether and when to follow links will invoke additional metacognitive load, remembering both the navigational steps, as well as the content of multiple nodes will implicate working memory. This contrasts significantly with linear text which requires the reader to make predominantly forward and back decisions alone.

While our focus here is on working memory, the process of hypertext reading – as opposed to reading linear text – is one area where distinctions between working memory and other executive functions such as inhibitory control and switching become more difficult to make. Consider the theories and models presented previously. From the perspective of Kintsch’s construction-integration model, building and maintaining a text representation is already demanding; when interruptions to the flow of reading are introduced via the inclusion of hyperlinks and the associated decision-making imposed on the reader, the increased demands on working memory are likely to impact on the development of the representation, thus placing comprehension under threat. Indeed it can also be argued that the cohesion of the text being read can be threatened by the presence of the hyperlinks, making it difficult for the reader to construct a coherent representation, even without the disruption experienced by following hyperlinks. Hypertext by its very nature introduces more interruptions to the reading process, making the role of metacognitive strategies such as comprehension checking and fixing crucial, thus going beyond working memory alone.

In addition to overlapping influences of working memory and metacognition in reading hypertext, there is a growing body of research on the interaction between text structure and reader knowledge in both print reading (e.g. Bohn-Gettler & Kendeou, 2014; Wylie & McGuinness, 2004) and hypertext reading (e.g. Amadieu, van Gog, Paas, Tricot, & Mariné, 2009; Calisir & Gurel, 2003). The
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main conclusion from studies on print reading is that readers with a higher level of prior knowledge cope better than less knowledgeable readers with texts that are less structured whereas low knowledge readers benefit from more structured text. DeStefano and LeFevre (2007) corroborated these findings specifically in the context of hypertext. They observed that the comprehension of readers with less knowledge of the subject matter of the text was more adversely affected by hypertext than those with a higher level of relevant knowledge. In tandem, there was evidence that readers with lower working memory capacity struggled more with the hypertext than those with a higher working memory capacity.

Digital text potentially enables the reader to alter the level of text complexity by choosing to either follow or ignore links. As such, the structure of the text can be under the control of the reader. If high knowledge readers benefit from a lack of structure (e.g. Salmerón, Cañas, Kintsch, & Fajardo, 2005; Salmerón, Kintsch, & Cañas, 2006; Shapiro & Niederhauser, 2004) then creating their own version of the text via hyperlinks may actually enhance their understanding and increase knowledge. In contrast, readers with less prior knowledge will not possess the schema which would enable them to benefit from an exploration of links. Interestingly, however, Calisir and Gurel (2003) found evidence that low prior knowledge readers did benefit from hypertext if the text was structured in a way that emphasised the inherent structure of the information. The reading comprehension scores of their low prior knowledge readers were better after reading hierarchical hypertext than after reading a more complicated hypertext (i.e. one containing both hierarchical and network structures) or a linear presentation. This suggests that the complexity of the hypertext is a critical factor when making decisions about its usefulness for readers with higher or lower levels of prior knowledge. Burin, Barreyro, Saux and Irrazábal (2015) assessed the effects of text structure, prior knowledge and working memory capacity on comprehension and navigation of digital text. They showed that low prior knowledge readers are more disadvantaged by network hypertexts than hierarchical hypertexts, and that a combination of low working memory and low prior knowledge results in the weakest performance on a comprehension test. In contrast, high prior knowledge readers can benefit from engaging with network hypertexts where they need to make more of an effort in building a coherent representation; readers with more knowledge looked at more pages, made more non-linear jumps in reading and returned to the home page more often. This pattern of behaviour was also more apparent in individuals with high working memory capacity.

We finish this section with a consideration of the role of spatial working memory in hypertext processing. While previous research has not identified a clear role for visuo-spatial working memory in print (linear) reading (e.g. Seigneuric et al., 2000), some interesting findings have started to emerge from hypertext studies.
Kornmann et al. (2016) proposed that multi-perspective hypermedia environments make large demands on working memory, and spatial working memory in particular. Testing 9–12 year-olds, they found that both spatial working memory and the ability to process different perspectives correlated with navigational behaviour. Importantly, children with high spatial working memory capacity were able to engage in effective navigational behaviour leading the researchers to conclude that children with lower spatial working memory capacity would be better served by more linearly structured environments. Pazzaglia, Toso and Cacciamani (2008) investigated the role of verbal and spatial working memory in hypertext navigation in a group of middle school children aged 11–12 years. Children engaged with a geography-learning program – a hypermedium – that enabled exploration of European countries and presented information about geography, politics, economy, culture and society. They interacted with the hypermedium in order to perform two tasks – a semantic task requiring linking of verbal information from across the program, and a mapping task which tapped with visuospatial representation of the multimedia environment. Regression analyses indicated domain-specific involvement in tasks demands, with verbal working memory predicting semantic task performance and spatial working memory having a role in the spatial representation constructed by the children. Jones and Burnett (2007) examined the role of spatial skills in hypertext navigation in 10–11 year-olds. Although not strictly a study about reading, they observed that children with high spatial ability completed tasks in shorter time, became lost less frequently and were able to complete maps of their route through the hypertext more accurately than those with low spatial ability. The influence of navigational skills is examined more fully in Salmerón, Strømsø, Kammerer, Stadler and van den Broek (2018; this volume).

The role of visuo-spatial ability in hypertext reading by 11 year-olds was investigated by Salmerón and García (2012). Using a hypertext with a navigation overview and a printed linear text, they did not find any relation between visuo-spatial skill and the processing of either text type as measured by performance on comprehension questions requiring the retrieval of information or inferencing. While this finding is unexpected, the authors suggest that the use of such overviews might not increase cognitive (working memory) load, provided that the overview is not very complex in terms of number of nodes and levels. In line with the study by Pazzaglia et al. (2008), they concluded that visuo-spatial skills are involved when the structure of the document or information is not clear but that they are less important when overviews are provided.

In summary, engaging with digital text places considerable demands on working memory. For young readers making the transition from learning to read to reading to learn, visuo-spatial working memory skills appear to be increasingly important. Technology offers authors the opportunity to enhance their text via
hyperlinks, resulting in reader engagement with text that has enhanced possibilities for learning but also increased risks for comprehension and learning. As the following sections emphasise, learning from digital text requires a complex interplay of processes, with a reader’s progression through text involving – ideally – a constant monitoring of their expectations, goals, success and difficulties. This monitoring draws on an individual’s metacognitive ability – their ability to be aware of, and to act on, their own thinking. Effective updating of working memory in order to build a mental representation of the text being read demands inhibition of irrelevant or less relevant information, mental shifting ability and metacognitive skill.

4. Executive control

Executive function is a broad term that encompasses many higher order skills necessary for independent, goal-directed behaviour, including holding and manipulating information in working memory, planning/sequencing multi-step tasks, and ascertaining the ‘big picture’ from a complicated set of details (Denckla, 1989). It can also include metacognition, or ‘thinking about thinking’, which is explored further in the next section of this chapter. Cognitive control thus supports flexible behaviour by selecting actions that are consistent with our goals and appropriate for our environment (Badre, 2008). Having already considered attention and working memory, we focus now on other aspects of executive function.

4.1 Executive control and reading

Sub-processes of executive control that are important for reading include directing cognitive processes (Gaskins, Satlow, & Pressley, 2007; Schumacher, 1987), prioritizing (Gaskins et al., 2007), metacognitive monitoring and self-checking (Gaskins et al., 2007), selecting and choosing (Schumacher, 1987), and shifting, organising and managing (Gaskins et al., 2007) one’s actions and behaviours. In addition, a sub-component of executive function playing a crucial role in reading comprehension is planning (Gaskins et al., 2007; Schumacher, 1987; Sesma, Mahone, Levine, Eason, & Cutting, 2009). After controlling for commonly acknowledged contributors to reading comprehension (i.e., attention, decoding skills, fluency, and vocabulary), executive control seems to make a significant contribution to reading comprehension but not to word recognition skills (Sesma et al., 2009). Although reading comprehension requires good linguistic skills, successful comprehension is also thought to depend on higher level executive skills such as reasoning, critical analysis and effort allocation across various sections of the reading task (see Bjork, Dunlosky, & Kornell, 2013, for a review; Vellutino, Scanlon, & Lyon, 2000). Hence,
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4.2 Executive control and digital reading

Reading and studying in linear (printed) text contexts includes, for example, choosing to read one section of material carefully whereas only skimming another, choosing to underline one sentence but not another, and choosing one interpretation of a complex topic and ignoring another (Schumacher, 1987). These same processes of utilising executive control are also important in digital reading environments, thus there is no need for total replacement of offline reading strategies with newer online reading strategies, but rather the need for extension and diversification of previous reading processes (Coiro, 2015). However, different digital reading environments, such as search engines, websites, virtual gaming environments, and blog interfaces will create additional executive control demands for readers, for example, paying attention to context cues in choosing the most effective reading strategy for a prevailing context (Coiro, 2015). Thus, in digital learning contexts, comprehension of information requires purposeful, critical and flexible mindsets from learners (Coiro, 2015).

As noted already, in digital reading environments, especially hypertexts, readers need to construct their own navigational pathways through hyperlinked texts (Coiro & Dobler, 2007; Coiro, 2015). This process presumes at least four different cognitive strategies, all of which are sub-processes of executive control: planning, predicting, monitoring and evaluating (Coiro & Dobler, 2007). The strategies in digital contexts can be very similar to the strategies readers use in reading printed text (Coiro, 2015): they plan and make predictions, monitor their understanding and evaluate their responses during and after reading. However, printed texts are usually longer and readers do not have to conduct this self-regulated cycle so often. In online environments, readers encounter continuously new series of hyperlinks, which force them over and over again into the cycle of planning, predicting, monitoring and evaluating. Planning directs readers to consider selection and effective choosing of online sources. For instance, the Internet presents a place where learners are connected with an unlimited amount of sources representing different global perspectives (Coiro, 2015). Digital reading involves, though, more than just collecting information; readers also need to prioritise and select between different sources. In digital reading environments, cognitive abilities connect with multiple source comprehension skills, a term by which Goldman et al. (2013) mean selection, coordination and synthesis of information that comes from multiple sources.

Multiple source comprehension skills are especially involved in a specific case of reading in digital media, namely information seeking, which includes goal-directed web-searches. Information seeking also involves other aspects of
executive control, such as predicting, monitoring and evaluation. Generally, information seeking consists of five processes: (1) constructing the problem or setting goals for the web search task, (2) reading to locate relevant information by employing adequate search queries (involves predicting), analysing search results and scanning efficiently for relevant information within the web sites (involves monitoring), (3) reading to evaluate information critically, (4) reading to synthesise information within and across different sources (involves multiple source comprehension), and (5) reading to communicate information (Cho, 2013; Coiro et al., 2007; Guinee, Eagleton, & Hall, 2003; Kiili, Laurinen, & Marttunen, 2008; Kiili, Laurinen, Marttunen, & Leu, 2012; Leu, Kinzer, Coiro, & Cammack, 2004; Leu, Kinzer, Coiro, Castek, & Henry, 2013; Rouet, 2006). As a reminder, however, our approach in this chapter is to restrict our focus to reading single texts; processing issues associated with multiple sources are discussed more fully in Salmerón, Strømsø, Kammerer, Stadtler, and van den Broek (2018; this volume).

Executive control processes such as shifting mindsets flexibly (Gaskins et al., 2007) might also be essential in digital reading comprehension. For instance, the contexts of online reading environments are multiple and rapidly changing, requiring learners to monitor their own actions, and to move between reading-to-locate processes (e.g. skimming search results) and deeper processes of meaning construction (e.g. when finding a relevant source). In addition to executive control processes such as shifting, learners need to employ inhibitory control in digital reading environments. They need to learn to pay attention to relevant materials and resist distractions. Of course the nature of the online reading environment also requires multiple physical actions, such as typing, clicking and scrolling, though these actions are performed mostly automatically and at an unconscious level when these skills are fluent.

The increased use of digital learning environments, and especially simultaneous use of different kinds of technologies, has aroused worries concerning the effects of daily media multitasking (MMT) on our cognitive control. Small, Moody, Siddarth and Bookheimer (2009) compared brain activation while reading printed and online text in participants with Internet searching experience and participants who did not have such experience. Interestingly, those with previous Internet searching experience and those without prior experience show similar brain activation while reading typical text (Small et al., 2009). However, during an Internet search task those without prior experience showed similar activation patterns as during reading, whereas experienced participants showed activations in larger brain areas (i.e. in frontal pole, right anterior temporal cortex, cingulate cortex, and hippocampus). Such findings, along with other recent brain research on multimedia use (for a review, see Loh & Kanai, 2015) have led some researchers to suggest that increased everyday MMT might have a negative effect
on our executive control abilities, leading to the development of a shallow mode of learning, which is characterised by quick scanning, reduced contemplation, and memory consolidation (Loh & Kanai, 2015). For instance, when individuals are distracted by the multiple streams of media, heavy media multitaskers seem to have more problems with concentration and attention than those who multitask infrequently (Ophir, Nass, & Wagner, 2009).

Results relating to multitaskers are inconsistent, however (see e.g. Minear, Brasher, McCurdy, Lewis, & Younggren, 2013, who failed to replicate the results of Ophir et al., 2009), and the effects of multimedia and Internet usage have been questioned due to the lack of conclusive and empirical data (De Bruyckere, Kirschner, & Hulshof, 2016). A recent study including both behavioural testing and functional magnetic resonance imaging by Moisala and colleagues (2016) seems to suggest that adolescents’ extensive daily multimedia use is associated with behavioural distractibility and increased recruitment of brain areas involved in attentional control. However, increased multimedia usage has also been associated with forms of attention control where better integration of multiple sources of information, but poorer inhibition of distractors have been observed (Loh & Kanai, 2015). The role of distractors, such as static or video advertisements, is not, however, straightforward. Recent results suggest that readers may learn to avoid being distracted by these visually salient distractors (see Simola, Hyönä & Kuisma, 2014) or that the effect of advertisements depends on the task the reader is performing (Pasqualotti & Baccino, 2014). Overall, findings on the impact of Internet use, multimedia use and task-switching performance are inconsistent and more research is needed.

In summary, executive functions have an essential role in reading, with recent research suggesting that the processing of digital text requires an even greater involvement of these functions. At the same time, there is growing concern about how our multi-media environment is affecting our ability to focus our attention, to inhibit less relevant information in any context and, generally, to invest appropriate mental resources in order for successful learning to occur. As the following section will demonstrate, digital technology appears to affect readers’ ability to make accurate judgements about their learning, as well as about the effort that needs to be expended if the benefits of technology are not to become threats to learning.

5. **Metacognition**

Metacognition is ‘cognition about cognition’ (Furnes & Norman, 2015). As highlighted in the previous section, metacognition is involved in the monitoring and control of various cognitive activities (e.g. Koriat, 2007; Metcalfe, 2000). Flavell
(1979) distinguished between three facets, namely, metacognitive knowledge, strategies and experiences. Metacognitive knowledge is the individual’s stored knowledge or beliefs about themselves and others as cognitive agents, about tasks, about actions or strategies, and about how all these interact to affect the outcomes of any sort of intellectual enterprise. Metacognitive experiences are conscious cognitive or affective experiences that occur during the enterprise (Flavell, 1979). Metacognitive strategies are used to control cognition in order to achieve a goal (Efklides, 2008). In this final section of the chapter we highlight the crucial role of metacognition in reading and conclude with some educational recommendations.

5.1 Metacognition and reading

Researchers have established the importance of metacognitive knowledge for reading in children (e.g. Anderson & Armbruster, 1984; Baker & Beall, 2009; Roeschl-Heils, Schneider, & van Kraayenoord, 2003) and adults (for review, see Baker, 1989). Findings across age groups indicate that better readers (i.e. comprehenders) appear to have better control of their cognitive activities during reading, and that they seem to engage in more appropriate behaviours such as re-reading, integrating information, planning ahead and making inferences (Anderson & Armbruster, 1984) than less skilled readers. Of particular relevance to our current focus is Baker’s (1989) conclusion that while better adult readers demonstrate metacognitive skill in terms of awareness and management of their cognitive abilities, there is considerable room for improvement.

One example of a model of reading where metacognition has an integral role is Walczyk’s compensatory encoding (C-EM) model (1995, 2000) which proposes that individuals can engage in two types of activities if they encounter a difficulty while reading – compensatory behaviours and compensatory strategies. Compensatory behaviours, which include pausing and looking back, are fast, fix-up activities which should involve minimal disruption to the reading process. In contrast, compensatory strategies such as re-reading are more time-consuming activities which disrupt the flow of reading and are likely to impact mental representation. Although Walczyk did not distinguish between print and digital text when developing his C-EM model, his ideas about the impact of compensatory behaviours and strategies are relevant in both contexts.

5.2 Metacognition and digital reading

The reading experience of children and adults has markedly changed since the influential work of Anderson and Armbruster (1984), Paris and Oka (1986) and Baker (1989). This chapter has already considered how the processing of digital text, and hypertext in particular, imposes higher cognitive demands than does
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printed text. Given a widely acknowledged need to improve metacognitive knowledge with regard to print reading in order to improve comprehension and learning, we now review evidence relating to metacognition within a digital context that includes reading for problem solving and assessment.

Aspects of executive function that are often overlooked in the context of computerised learning are learners’ metacognitive knowledge and the effectiveness of their metacognitive strategies. Finding that the mere presence of an e-book near learners hindered recall of studied information, Morineau, Blanche, Tobin and Guéguen (2005) suggested that electronic devices provide a contextual cue that leads to shallower processing, resulting in inferior cognitive performance. Regulatory decisions, such as activating in-depth processing of the to-be-studied materials and deciding when to stop learning, are at the focus of metacognitive research in this domain. According to this approach, there are two levels of processes involved while facing any cognitive challenge, the object-level and the meta-level (Nelson & Narens, 1990). In particular, while learning, object-level processes involve the transfer of information from an external source to the learner’s memory system. The meta-level of learning regulates the object-level processes by setting goals, deciding among appropriate strategies, and terminating activities, based on spontaneous subjective assessment, or monitoring, of one’s own knowledge (see Bjork, Dunlosky, & Kornell, 2013). Indeed, empirical studies dealing with memorisation and reading comprehension tasks have shown a causal link between monitoring output and decisions regarding allocation of study time (Metcalfe & Finn, 2008; Thiede, Anderson, & Therriault, 2003).

Only a few studies have directly examined the effects of the reading medium on metacognitive strategy use. Ackerman and Goldsmith (2011) compared metacognitive monitoring and control during learning on screen to that which takes place on paper with a population of undergraduate students who had a strong preference for reading on paper. Screen learners showed screen inferiority: compared with paper learners, they achieved lower test scores along with a more pronounced overconfidence. As subjective confidence directs regulatory decisions, overconfidence is undesirable (Dunlosky & Thiede, 1998; Greene & Azevedo, 2007; Winne, Hadwin, & Perry, 2013). Replicating the study in a population of undergraduates who had only moderate paper preference, Ackerman and Lauterman (2012) found that screen inferiority could be eliminated but only when time pressure was not imposed; mild time pressure appeared to disrupt metacognitive strategies. Notably, participants’ predictions of their own success rates on screen did not reflect variations in performance in light of the time frame. This insensitivity of judgments for screen, but not for paper, was also found recently with a brief problem-solving task which takes only 1–2 minutes to perform (Sidi, Ophir, & Ackerman, 2016; Sidi, Shpigelman, Zalmanov, & Ackerman, 2017), the results
of which suggest less effective metacognitive monitoring on screen than on paper, regardless of the reading burden involved and task duration. The authors also considered individual differences in beliefs regarding the effectiveness of learning on screen versus on paper. Interestingly, they found that medium preference was associated with metacognitive processes such that the best calibration was achieved by those who studied on their preferred medium, regardless of the study medium. Lauterman and Ackerman (2014) suggested two effective and simple to apply methods for eliminating screen inferiority: (i) gaining experience with the challenging reading comprehension task, and (ii) asking participants in advance to produce keywords summarising the text’s essence.

On the one hand, this review brings the good news that media equivalence is possible, regardless of reader preference. On the other hand, the findings of screen inferiority under time pressure in readers who did not expect it to be as strong is worrying. Screen inferiority under time pressure is particularly problematic in educational and admissions exams which include reading comprehension tasks and are often conducted online (e.g., Graduate Management Admission Test, GMAT). It is particularly troublesome in light of the findings regarding dependency in medium preference, as it means that the relative grade is expected to be affected by the match between the testing medium and participants’ preferences. Still, it should be noted that screen inferiority has been found only when task characteristics legitimated shallow processing. This was the case under time pressure and when the problem-solving task was presented as a preliminary phase before another task (e.g. Sidi, et al., 2017). These findings are in line with the notion that computerised environments provide contextual cues eliciting shallow processing, as suggested by Morineau et al. (2005). However, they carry more hope, because they provide guidelines for eliminating this problem – framing the task as important and doable.

Understanding the conditions under which screen inferiority is expected may aid interpretation of the mixed results regarding media effects found in the literature. First, media equivalence is expected when participants adopt an active mode of processing. For example, this is the case with text editing (Eden & Eshet-Alkalai, 2013; Hargis et al., 2017). Second, imposing a limited time-frame may result in equivalence between the media in test scores and overconfidence (e.g. Norman & Furnes, 2016; though Ackerman & Lauterman (2012) found that restricted time did not remove screen inferiority). Third, asking participants to make fine-grained (i.e. for individual concepts) judgments about their learning may result in more accurate assessments than when they are required to reflect on their learning from larger sections of text (Vössing & Stamov-Roßnagel, 2016). It is possible that as individuals’ metacognitive experience with screen-learning increases, they will be better able to engage metacognitive strategies which enable them to overcome screen inferiority.
We are not aware of studies which have directly examined media effects on monitoring and self-regulation of effort among children. However, research suggests that metacognitive knowledge develops throughout the school years (Koriat et al., 2014). Given that the studies above found association between improvement in learning per se and improvement in metacognitive strategies, methods for recruiting in-depth processing are expected to promote both aspects also when considering children's computerised learning. Thus, in line with the literature reviewed above, methods which engage students with in-depth processing on screen are expected to be effective.

The increased use of computerised study environments in schools should be considered in light of the literature reviewed above. First, studies repeatedly show that even when K-12 students perform tasks which at their surface level look identical to their paper versions, they often achieve lower performance on screen than on paper (e.g., Mangen, Walgermo, & Brønnick, 2013). Second, there are indications that students, even those who study in paperless classes, still prefer paper reading, at least for some of their daily reading tasks (Seok & DaCosta, 2016; Shonfeld & Meishar-Tal, 2016). Third, technological advances do not yield the large differences that many people still expect. For instance, a salient feature of iPads is that the readers should get a reading experience which mimics paper yet comparisons between laptop computers and iPads often reveal no differences in reading comprehension, mental workload, and even attitudes (e.g., Janjua, 2016). While studies using up-to-date teaching methodologies, like those involving games installed on mobile devices, have identified an increase in enjoyment and motivation, they have not always found improved performance relative to traditional learning methods (e.g., Furió, Juan, Seguí, & Vivó, 2015). Moreover, the use of games, even when successful in study outcomes, does not provide generalisable learning skills of comprehension in other learning tasks that schooling aims to develop. Finally, scientific studies across various disciplines highlight the direct and indirect negative effects of computerised learning on human cognition, learning, and behaviour (see Selwyn, 2015, for a review). Nevertheless, educational systems are predicted to continue the adoption of technology. Thus, our review should not lead to the conclusion that computers are harmful in general, but should direct efforts to finding conditions that allow effective learning on screen (see Gu, Wu, & Xu, 2015; Nichols, 2016, for reviews). In particular, we encourage teachers to be active in engaging students in computerised learning so that they may adapt their learning behaviour to the advantages of this environment in an effective manner.

Our review of research on metacognition showed that individuals tend to engage in relatively shallow processing when reading and working in a digital context. Several approaches can be taken into consideration when considering methods for recruiting in-depth processing in computerised environments. First, the
transfer of effective methods from paper to a computerised environment is relatively easy to implement. Indeed, when students engage in reading comprehension tasks, they often use tools which are also available on paper (e.g., highlighting), even in the presence of tools with clear advantages for computerised learning (e.g., looking up unfamiliar terms via online dictionaries, Van Horne, Russell, & Schuh, 2016; Molin & Lantz-Andersson, 2016). A second approach is to employ methodologies for triggering in-depth processing which are opened up by the technology. For instance, Yang, Hwang, Hung, and Tseng (2013) employed concept maps on mobile devices to support learning of 6th graders from a printed science book. This method was more effective than learning from the book alone and the children showed a high level of acceptance of this tool. Finally, a unique advantage of computerised environments is the ability to adjust the learning tasks to each individual student’s strength and weaknesses (Shute & Towle, 2003; see Özyurt & Özyurt, 2015, for a review). For instance, when Mustafa and Sharif (2011) employed a system adapting educational materials to the student’s learning style they found better academic achievements among students who learned in line with their personal learning style than among those who studied the regular curriculum (see also Dolenc & Aberšek, 2015).

In a nutshell, readers and learners appear to behave differently when engaging with printed versus digital presentation of texts for learning and for problem solving. As computer-based learning environments are unlikely to disappear, overcoming screen inferiority should be a high priority for researchers and designers of modern study environments. The reviewed literature suggests that computerised learning and problem solving can be as effective as on paper, but that people spontaneously tend to use shallower processing on screen. Encouragingly, there is evidence that this is not inevitable, and that readers, if guided properly, can adapt more active engagement which can be expected to result in enhanced learning outcomes.

6. Conclusions and future directions

In today’s classrooms and homes, children and young people are expected to acquire efficient reading skills in a digital environment which presents opportunities as well as challenges. Technology can be at the same time engaging and distracting, meaning that readers need to develop robust metacognitive skills as they negotiate an interactive, on-screen environment. It will be apparent from our review of existing literature that we are only beginning to understand the cognitive demands of processing digital text, and that more research is needed on all of the processes and skills addressed in this chapter. Within the particular context of
hypertext, we concur with DeStefano and LeFevre’s (2007) suggestion that a model of learning from hypertext should incorporate prior knowledge, working memory capacity and the ability to impose structure on information. Recent work on metacognition demonstrates the influential role of metacognitive awareness in all interactions with digital text. In the decade since DeStefano and LeFevre’s review, opportunities for digital reading have increased in quality and quantity, and there is a clear need for a better understanding of how readers engage with digital text, and of how different types of digital text challenge and support different readers.

No-one would deny that several influential models of reading have served researchers, educators and policy makers well in terms of explaining what reading involves and in permitting predictions about performance and outcomes. It should be recognised, however, that none of these models were intended to describe or facilitate predictions about reading digital text in any of its guises. Notwithstanding the challenge of doing so, we suggest that the goal of research in the next decade should be to consider whether, and to what extent, our existing conceptualisations of the reading process are appropriate for the digital environment. Where they cannot explain the intricacies of reading in the twenty first century, new conceptualisations will be required.

On the flip side, we suggest that an increase in knowledge about the role of cognitive processes in reading might inform the development of digital technology and its associated potential. It is not inconceivable to imagine that text might be adaptable on several dimensions according to the needs or preferences of a reader. Given what we know about (i) the operation of executive functions within a limited capacity cognitive system, (ii) the influence of linguistic and world knowledge, and (iii) reader motivation and engagement, it might be desirable for digital reading environments of the future to be flexible beyond design features already discussed in this chapter such as font and window size. Dimensions on which text might be increasingly adapted in order to match reader characteristics include linguistic and structural complexity, length, as well as the extent to which text content is presented independently or integrated with other sources (e.g. links to other e-books, for example). Armed with meta-cognitive knowledge readers might be able to tailor a text in line with their relative strengths and weaknesses in various aspects of executive function, as well as their relevant prior knowledge in order to increase its accessibility, relevance and interest in a given context. While any such flexibility would require significant technological advances, (not to mention further progress in our understanding of individual differences in reading) we speculate that at least two levels of adaptability might be achievable in the future. At a generic level readers would indicate their preference for text suitable for a particular purpose, e.g., reading to entertain, reading for information searching, or reading to evaluate and critique. At a personal level,
readers might be able to drive text adaptations through provision of data about their working memory capacity, their tendency to be distracted, etc. Teachers and parents might avail of opportunities to vary texts for children on dimensions relating to challenge or engagement, for example. Such actions would help realise one of the exciting affordances that digital reading can offer: an unprecedented opportunity to individually tailor reading material to the skill and interest profile of each unique reader. This alignment of literacy and the individual is explored further in Ben Yehudah, Hautala, Padeliadu Antoniou, Petrová, and Leppänen, (2018, this volume).

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Chapter 3. Cognitive processes and digital reading


Comprehension processes in digital reading

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The Internet offers readers the unique opportunity to access rich information scenarios, but doing so requires the use of advanced digital reading skills. Examples of such scenarios are searching and acquiring information from multiple sources (e.g., hypertext, images, videos) and participating in the social exchange of information (e.g., web forums, social networks, commenting newspapers). In such scenarios, the reader has to cope with (a) the constantly growing number of available information sources, (b) the different formats in which digital information is presented, and (c) the varying quality of the information available. To deal with these affordances, individuals need to possess reading skills that go beyond what is needed to understand a single text alone. Such advanced reading skills include: (a) search and navigation skills to select relevant web pages and hyperlinks and to avoid getting lost in hyperspace; (b) the ability to integrate multiple pieces of information and multiple presentation formats (texts from different web pages, text and animations); and (c) critical evaluation skills (e.g., assessing the trustworthiness of information on a web page and evaluating the quality of a comment from a social network). Existing literature suggests that children and adolescents possess some of these skills, but that students at all levels struggle to apply them in complex scenarios. In the present chapter, we aim to review the literature regarding the skills needed to master the affordances of advanced digital reading scenarios.

1. Introduction

One of the goals that readers pursue in digital environments is to acquire knowledge from a variety of hyperlinked sources. These need to be navigated, they involve a variety of formats, and they often vary in terms of quality (from comprehensive
reviews from experts, to less coherent blog posts by laypersons). Competent digital reading involves mastering the skills needed to cope with these characteristics: *navigation* of hypertext documents (e.g. selection of what sources to read, how to sequence the reading), understanding and *integrating* different sources of information (e.g. connecting information from different web pages) and *evaluation* of information (e.g. evaluating the quality of the claims in a web page) (Afflerbach & Cho, 2009; Leu et al., 2015).

Established models on text comprehension are relevant to digital reading, but they do not necessarily account for the wide range of contexts that readers may encounter when entering complex text environments (McNamara & Magliano, 2009; Rouet, 2006). The three competencies we emphasize here are, however, clearly related to basic processes described in contemporary models of text comprehension. Integration is highlighted as a central process in these models (see McNamara & Magliano, 2009) and evaluation has also been underscored as a central process in readers’ efforts to extract meaning from text (Singer, 2013). Navigation has traditionally been studied as a process distinct from comprehension of a single text, however, because it is considered to play a particularly important role in hyperlinked digital environments (e.g. Cho, 2014; Leu et al., 2015).

The three competencies may be closely related and readers’ engagement in any one of them may support or trigger the other two (Figure 1). For example, a student may work on an inquiry assignment on dinosaur extinction and start by googling the term (=navigate). A Search-Engine Results Page (SERP) shows a number of potential information sources, with the first two representing competing theories about the issue. Thus, the student needs to study both in order to identify the nature of the controversy (=integrate) and consider whether they complement or contradict each other. Also, the student needs to evaluate if both sources seem reliable. If not, more navigation may be needed in order to find relevant and useable information sources. Hence, there is a reciprocal relation between the three competencies.

![Figure 1. Three main competencies of comprehension processes in digital reading](image-url)

In the following, we summarize the available knowledge on the three main competencies. For each competence, we *review* current findings on the spontaneous...
application of the respective competence, identify individual differences in the mastery of the competence, and discuss how the design of digital reading interfaces may influence its application. In a separate section, we outline the main methodologies used to study comprehension processes in digital reading. For expository purposes, we treat each of the three competencies as separate entities although, as mentioned, there are interdependencies. It is also important to note that the degree to which each competency is needed varies from task to task (e.g. searching for medical information, integrating documents for class assignment).

At the end of the chapter, we discuss major aspects of digital reading that remain unresolved and suggest future directions for research, including some aspects related to the interdependencies of the competencies identified.

2. Navigation

When reading to learn, efficient navigation is essential to handle the vast amount of information available on the Internet and to ensure that readers construct a coherent representation of the issue while avoiding distraction and becoming lost in cyberspace. This competence involves not only searching and scanning for goal-relevant information, but also sequencing navigation towards relevant information through hyperlink selections (Cho, 2014).

2.1 Navigation: Description of the competence

When searching and scanning for relevant information, readers must specify an initial problem space to be fulfilled, such as finding a particular datum, answering a comprehension question, or building a deep understanding of an issue. Such problem spaces define what type of information readers already have and what is still needed and is thus relevant for their task (Brand-Gruwel, Wopereis, & Walraven, 2009). Readers may then access a search engine and create a specific search query that represents their information needs, or directly jump to a known web page with potentially relevant information. The identification and selection of potentially relevant hyperlinks from a SERP requires that readers evaluate the relevance of the information.

2.1.1 How readers select web pages

Search engines help their users sort through huge amounts of information that are available on the Internet and find documents relevant to their current information needs. Readers, however, must still choose between a large number of alternatives for which only sparse (mostly text-based) information, namely a title, an excerpt from the respective web page, and its URL (uniform resource locator), are
provided (Rieh, 2002; Wirth, Böcking, Karnowski, & von Pape, 2007). Based on this information, predictive judgments about the relevance and trustworthiness of available documents have to be made (Rieh, 2002). There is large empirical evidence that in such decision situations of high uncertainty individuals often rely on heuristic cues to decide which alternatives to select instead of a systematic evaluation of all given information (e.g., Hilligoss & Rieh, 2008; Metzger, Flanagin, & Medders, 2010; Wirth et al., 2007). Such cues, for instance, can be (a) the ranking position of the search result in the SERP, as readers direct most attention to the search results at the top of the first SERP and predominantly select these links (Fu & Pirolli, 2007; Wirth et al., 2007), (b) keywords indicating a high semantic relevance of the website to a user’s current information need (Fu & Pirolli, 2007; Pirolli, 2007; Rouet, Ros, Goumi, Macedo-Rouet, & Dinet, 2011), and (c) source cues such as information about the type of the website (e.g., an official institution, a forum, or a shop) indicating the trustworthiness of an information source (Hilligoss & Rieh, 2008; Kammerer & Gerjets, 2014a; Rieh, 2002).

In summary, readers tend to use heuristics to quickly select relevant web pages for their goal and, during this step, seldom evaluate the quality of the results to filter less reliable pages. Interestingly, failing to use source cues at this step is related to lower learning outcomes in class assignments (Goldman, Braasch, Wiley, Graesser, & Brodowinska, 2012; Wiley et al., 2009), which suggests that navigation and evaluation competencies should work in conjunction to ensure that readers select both relevant and reliable pages.

2.1.2 How readers navigate across web pages

Once readers select a web page, they must decide which (usually embedded) hyperlinks they want to navigate to and in which order. Efficient navigation, usually defined as the ability to stay in a sequence of pages that are relevant to the readers’ goal, is predictive of readers’ success in several advanced digital reading tasks including studying for a long course (Puntambekar, & Goldstein, 2007; Sullivan & Puntambekar, 2015), reading for comprehension (Salmerón, Cañas, Kintsch, & Fajardo, 2005; Salmerón & García, 2011), reading to prepare a summary (Naumann, Richter, Flender, Christmann, & Groeben, 2007; Richter, Naumann, & Noller, 2003), and performing a science inquiry task (Goldman et al., 2012).

How do readers navigate through hyperlinks while constructing meaning from hypertext? A classical approach to answering this question consists of using a multidimensional scaling technique to identify patterns of navigation behavior. In this line, Lawless and Kulikowich (1996, 1998) identified three main navigational groups of students: knowledge seekers, feature explorers and apathetic hypertext users. Knowledge seekers spend most of the reading time on content-related documents, feature explorers focus on the non-textual features of the hypertext
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(e.g., images, videos, maps), and apathetic users spend short intervals of time on content-related documents, seeming to follow a random reading order. Not surprisingly, knowledge seekers learn more than the other groups.

A different approach to studying navigation is to analyze the strategies readers use to select hyperlinks. Prior research has identified two main reading goals followed by hypertext readers: coherence and interest. Readers may decide to select hyperlinks by trying to maintain high semantic coherence between the currently read section and the linked page, avoiding big 'semantic jumps' between pages that often occur when interest drives navigation. The coherence reading goal is positively related to comprehension of the information conveyed in the hypertext (Salmerón et al., 2005), probably because by navigating between conceptually related sections the reader can simultaneously pay attention to and subsequently integrate both units of information (van den Broek & Kendeou, 2015).

In complex hypertext documents, where dozens of hyperlinks are available, readers using a particular navigation goal (e.g., coherence or interest) have to manage information overload, usually by means of scanning or quick inspection of the material, with the resulting risk of missing relevant information (Cromley & Azevedo, 2009). As recent research has shown, comprehension of the hypertext by readers who scan a lot is inadequate (Salmerón, Naumann, García & Fajardo, in press).

Whereas most previous research has focused on textual navigation, recent studies provide new insights about how readers navigate through mostly visual environments, which allow the user to manipulate the presentation of the information. In this line, Kornmann et al. (2016) found that the more readers adjust the perspective of the information to the task demands, the more they learn.

In summary, navigation is essential for digital reading because it can either support or hinder comprehension and integration of information.

2.2 Navigation: Individual differences

Previous studies have identified key individual differences in the acquisition and efficient use of navigation. From a developmental perspective, the ability to identify relevant web pages from SERPs has achieved an adult level already at upper secondary school. Younger students (e.g., grades 5 to 7), however, base their selections or ratings more on superficial cues such as highlighted keywords than on the underlying semantic information contained in the search result descriptions (Keil & Kominsky, 2013; Rouet et al., 2011). Once adult-level performance is achieved, several cognitive factors contribute to mastering navigation, such as reading skills, working memory, and epistemic beliefs. Reading comprehension is usually defined as the ability to fluently perform several aspects of text processing such as idea
identification, inference generation, or macro-level elaboration (Kintsch, 1998). These skills facilitate the selection of relevant search results based on the content rather than on superficial keywords (Rouet et al., 2011). In addition, skills to comprehend single-texts (e.g. ability to decode and to make inferences) support the location of relevant information in digital texts without hyperlinks (Vidal-Abarca, Mañá, & Gil, 2010), as well as in hypertexts (Coiro, 2011; Naumann, Richter, Christmann, & Groeben, 2008). Students with good single-text comprehension skills are not only better at navigating using a coherence goal (Salmerón & García, 2011), they are also less distracted by misleading cues such as irrelevant word matching between the task goal and the hyperlink tag (Salmerón, Cerdán, & Naumann, 2015).

Another relevant factor is working memory (WM), a cognitive processing resource of limited capacity that involves the simultaneous storage and manipulation of verbal or visuospatial information during cognitive activity (e.g., Baddeley, 2012). Greater visuospatial WM capacity and ability to mentally process visuospatial information are related to efficient navigation, such as spending more time on exploring and comparing the contents of the hypermedia environment from various perspectives and less time with the processing of irrelevant contents (Juvina & van Oostendorp, 2008; Kornmann et al., 2016). Students may need some training on navigation before the effect of visuospatial WM takes place (Naumann et al., 2008). Overall, results suggest that efficient navigation across pages demands that readers process not only the semantic relations between pages, as evidenced by the role of reading skills on navigation, but also the spatial relations between pages and between the sections on a particular page. There is less consensus regarding the role of two other factors on navigation: prior knowledge and epistemic beliefs. Studies looking at web page selection have shown that domain experts are more successful in locating relevant web pages than non-experts (White, Dumais, & Teevan, 2009). Research also suggests that a lack of domain expertise may be compensated for with expertise on search skills (Vibert et al., 2009). Laypersons with high domain knowledge tend to scrutinize search results more thoroughly before selecting than students with less knowledge (Kammerer & Gerjets, 2013; MaKinster, Beghetto, & Plucker, 2002). Studies looking at navigation across web pages, however, indicate that readers with high prior knowledge do not necessarily navigate in a more efficient manner than those with low prior knowledge (Lawless, Mills, & Brown, 2002; Sullivan, Gnesdilow, & Puntambekar, 2011; Sullivan, & Puntambekar, 2015), probably due to overconfidence in their understanding. To prevent this, the task could explicitly demand navigation in a coherent way. In such task, students with higher domain knowledge navigate in a more coherent sequence (Salmerón et al., 2006). As for the role of epistemic beliefs, the belief that the Internet in general is a reliable knowledge resource is related to increased selection of objective (i.e., scholarly, factual) search results and increased time spent on such websites (Kammerer, Amann, & Gerjets, 2015; Kammerer & Gerjets, 2012). However, these findings
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were not replicated in a different study (Kammerer, Bråten, Gerjets, & Strømsø, 2013). Regarding navigation across pages, research indicates that more ‘sophisticated’ beliefs that knowledge is complex are related to processing more pages, whereas more ‘naive’ beliefs that knowledge is simple are related to spending more time on single pages (Pieschl, Stahl, & Bromme, 2008). Again, these patterns have not been replicated in other studies (Bendixen, & Hartley, 2003). To conclude, further research is needed to clarify the role of prior knowledge and epistemic beliefs in the selection of search results and navigation across web pages.

2.3 Navigation: Design influences

2.3.1 Design influences in the selection of web pages
Currently most search engines display results as a list. This format has a strong influence on readers’ selection of pages, with readers visually inspecting and selecting mostly the top 2–3 results (Pan et al., 2007). Although a list interface simplifies and thus supports the selection of web pages, this may come at a price, especially if the results on the top of the list are not totally relevant or trustworthy. Other search engine presentation formats have been proposed to cope with such risks. For example, in a grid interface the impact of the position of the search results on selection is substantially reduced, as compared to a list interface (Kammerer & Gerjets, 2014a). Other presentation formats aim to provide additional information not available in lists. Overview interfaces display the results in groups and tag them according to different criteria, such as the source type (Kammerer & Gerjets, 2012), the rhetorical relations between web pages (Salmerón, Gil, Bråten, & Strømsø, 2010), or a tag cloud with important terms associated with the search (Gwizdka, 2009). Again, in such interfaces the effects of result position on the list are reduced, which suggests that readers are being more careful in their selection.

2.3.2 Design influences in the navigation across web pages
Design characteristics also facilitate navigation, i.e., the selection of relevant links, and prevent access to irrelevant ones. Adaptive navigation support is used to modify hypertext documents to cope with students’ learning challenges (Brusilovsky, 2001). For example, the ScentTrail system (Olston & Chi, 2003) aims to enhance the salience of hyperlinks on a page that may be relevant for the user’s goals. The system calculates the semantic relation between users’ goals and the available links, and subsequently increases the size of links rated as more relevant for the students’ task. A study on a complex commercial website revealed that users are faster in locating different information on the site when using the ScentTrail system as compared to a non-modified version of the site (Olston & Chi, 2003).

Hyperlinked structures may be particularly challenging to navigate if they are not visible to readers and if they overload their processing capacities. From a
design perspective, a way to prevent comprehension problems due to navigation load is to provide navigation guidance such as organizational overviews. Overviews are graphical representations of the hypertext structure, which depict the available documents or nodes and their relations. Readers can use the overview as a mental schema in which to incorporate the information distributed across the different hypertext nodes, which may facilitate their navigation and comprehension. Overviews that convey the semantic organization of the hypertext information and follow a hierarchical structure support comprehension to a greater extent than non-semantic or networked organizations, such as spatial arrangements of nodes or alphabetical lists (for a review, see Amadieu & Salmerón, 2014).

By navigating, readers establish links between potentially related information sources. Establishing those links, however, does not necessarily imply that readers are constructing a coherent mental representation of relevant documents. In order to do that, readers also need to integrate content, both from the different information sources and from what they already know about the issue in question.

3. **Integration**

Learners’ comprehension of information presented on different digital information resources will partly rely on their ability to integrate information across various kinds of representations. Such integration is often a demanding task. In Kintsch’s (1998) influential construction-integration (CI) model such processes are described in detail, emphasizing how readers construct a mental representation of a text based on its lexical and syntactic surface and make inferences based on the text’s coherently related parts. Integration, thus, requires that the reader’s prior knowledge is connected to the new information such that the two become associated in memory. While a reader processes a text, the mental representation of that text continually develops as information across the text is integrated with what the reader already knows, from earlier sections of a text and from his or her semantic background knowledge. The text’s author will normally facilitate such processes of integration by introducing different kinds of cues like verbal organizers, indications of semantic relations, or by reminding the reader of background knowledge necessary for comprehension (Rouet, 2006). A more demanding situation occurs when readers have to integrate information across several information resources, often containing various kinds of representations.

3.1 **Integration: Description of the competence**

3.1.1 *How readers integrate information from different web pages*

In real life, readers are regularly confronted by a number of information sources representing different perspectives or contradicting information on the same issue.
If a reader’s goal is to understand more about that issue and not only search for some factual information, the reading process will involve the often challenging task of integrating information across multiple sources. When readers approach the web they will also encounter diverse types of information, including mixed genres and mixed modalities, and thus will have to deal with the sometimes overwhelming task of constructing a coherent understanding from a multitude of different representations of an issue or situation. One of the main characteristics of online text comprehension is that the readers are also “authors” of an integrated mental representation by selecting and integrating different pieces of information (Afflerbach & Cho, 2009).

Whereas the author of a single text normally aims to present a coherent story or description, the task of constructing coherence is left to the reader when multiple information sources are involved. Content across multiple information sources may be partially overlapping, partially unique, and partially contradictory. When reading on the web, an important task is to identify and select information that should be included in the process of constructing an integrated representation of the material. If information partially overlaps across documents, readers’ representation of that content may be more or less automatically updated as they proceed through the documents (Kurby, Britt & Magliano, 2005; van Oostendorp, 2002), whereas integration of unique or contradictory information may require more strategic inferential processes from the reader (Bråten, Anmarkrud, Brandmo & Strømsø, 2014; van den Broek & Kendeou, 2015). Sometimes documents containing overlapping information may also present a need for strategic monitoring of the potential intertextual links. Two web-texts on the same topic may differ in style and partly use dissimilar terminology in referring to the same phenomena. The reader faces the challenge of deciding whether those documents are referring to the same thing and whether documents using the same terminology actually refer to the same thing (Rouet & Britt, 2014). Thus, integration across documents may sometimes require expertise on the topic of interest regarding both rhetorical conventions and terminology.

3.1.2 How readers integrate across online modalities
The demands of integrating information across multiple textual documents often increase when those documents contain not only written information but also spoken or visual information in the form of pictures, graphs, animations, or videos. There are several models (e.g. Mayer, 2005; Schnotz & Bannert, 2003) describing how text and pictorial information are processed through separate channels, with this potentially resulting in a richer and more accessible mental representation than if only one channel is used. These models also emphasize, however, that the integration of words and images is a quite demanding process requiring efficient use of cognitive capacity.
Reading on the web may imply that readers attend to more than one window within the same application (or even different applications) and sometimes also simultaneously to several windows related to different tasks. In addition, it is not uncommon that readers switch between different media, for example between printed text and different digital devices. Whereas a few studies indicate that media multitasking does not necessarily affect text comprehension, students’ reading times do increase with multitasking (Fox, Rosen, & Crawford, 2009; Subrahmanyam et al., 2013). It has been argued that media multitasking may be a misleading term, as several studies indicate that people do not attend to several media simultaneously but rather switch between media. Also, several studies show that such task switching tends to impair learning (Kirschner & van Merriënboer, 2013). For example, Ophir, Nass and Wagner (2009) find that heavy media multitaskers were less inclined to ignore irrelevant information than light media multitaskers. Research on reading in an environment of multiple digital reading devices has so far been limited. Given research from other fields (e.g., Kirschner & van Merriënboer, 2013) on task switching or multitasking, there are reasons to believe that – at least habitual – multitasking decreases comprehension of digital texts. However, more research is needed.

3.2 Integration: Individual differences

Preliminary evidence for individual differences in integration comes from studies using success rate as a dependent variable in a set of digital reading tasks, some of which demand that readers integrate information located in different hypertext nodes. From this approach basic computer skills and reading skills emerge as relevant factors.

Basic computer skills include actions of accessing, saving, and communicating information using an interface. Individual differences partly explain the success in digital reading tasks, even after controlling for the effect of other factors such as reading skills or navigation efficiency (Goldhammer, Naumann, & Keßel, 2013; Hahnel, Goldhammer, Naumann, & Kröhne, 2016). Similarly, there is evidence revealing that reading skills improve digital reading in several tasks, including reading to comprehend (Coiro, 2011; Naumann et al., 2008; Salmerón & García, 2011; Sung, Wu, Chen, & Chang, 2015), and question-answering tasks (Naumann & Salmerón, 2016; Salmerón et al., 2015; Salmerón et al., in press; Sung et al., 2015). Although evidence suggests that basic computer and reading skills positively predict success in digital reading tasks, some of which demand integration, the specific involvement of such skills on integration tasks is not yet clear.

Recent efforts to identify factors specifically affecting integration processes have shown that relevant prior knowledge is necessary to integrate and solve
inconsistencies between information in different texts. Beker, Jolles, Lorch, & van den Broek (2016) demonstrated how information from one text can help solve an inconsistency in another. That is, relevant information from a previously read text was spontaneously activated when readers encountered the inconsistency, which indicates intertextual integration. Considering the multitude of information resources on the web, intertextual integration may be more challenging in more ecologically valid settings. According to a research review on hypertext reading, this may at least be the case for low knowledge readers (DeStefano & LeFevre, 2007). Those readers seem to benefit from more structure and fewer choices, whereas the lack of such conditions does not affect high knowledge readers’ comprehension. Additionally, several studies indicate that readers’ working memory may affect their capacity to integrate information across information sources (DeStefano & LeFevre, 2007).

3.3 Integration: Design influences

As we discussed above, integration of textual and visual information will improve readers’ comprehension. But the benefits of multimedia learning seem to rely on a careful design of the learning material (Paas & Sweller, 2014), whereas the more or less random mix of modalities presented on the web increases the cognitive load of readers attempting to synthesize information across different sites. One of Mayer’s design principles (Mayer, 2005) is, for example, to eliminate external distracters such as extraneous words, pictures, and sounds (Issa et al., 2011). While searching for information resources on the web such distracters seem hard to avoid. Thus, dealing with multiple forms of representations on the web requires more cognitive effort than processing information in a well-designed multimedia learning environment. The multimedia effect, assumed to positively affect readers’ integration of information, may turn out to hamper integration when readers attempt to integrate information across more or less random information resources on the Web.

Does the nature of the reading material impact readers’ integration of information across texts? While reading printed texts, skilled readers make connections between different parts of the text in order to capture the main ideas. The nature of digital texts presents several new challenges to readers’ efforts to generate both intra- and intertextual connections. A number of features of different digital devices hypothetically could affect readers’ integration of information within and across texts. These features include screen size, browser design, navigation of menus, scrolling, dynamic links and images, and the need to open and close windows and tabs. Studies comparing reading on paper versus reading on screen show mixed results (e.g. Mangen, Walgermo & Brønnick, 2013; Margolin, Driscoll, Toland, & Kegler, 2013; Singer & Alexander, in press), and often such comparisons focus on the reading of one single linear text presented either on screen or in print.
More features of the ergonomics of the reading situation need to be researched. Prior studies on reading from screens indicate that such features as line length, number of columns, and the size of screens affects reading time and, in some studies, also comprehension, though results are mixed (Dyson, 2004). Results from a study by Sanchez and Wiley (2009) showed that scrolling negatively affected readers’ text comprehension, and that readers who had lower working memory capacity were most challenged by the scrolling procedure. However, some researchers propose that scrolling is not a problem provided that line length is moderate and that there is additional space between paragraphs (Dyson, 2005). Thus, the length of the text may interact with other features of the text and in some cases affect readers’ integration of information across windows.

Results from some studies indicate that browser design is related to readers’ processing of digital texts (e.g. Olive, Rouet, Francois & Zampa, 2008; Wiley, 2001). Specifically, whether the browser design facilitates integration across texts affects the reading process and comprehension. For example, Wiley (2001) tested if a two-window browser afforded learning from multiple web-sites better than a single-window browser. The results showed that a two-window browser supports processes of integration across the web-sites more than a single-window browser does, but only when the reading task required such integration.

In summary, interface design influences integration of digital information. Careful design is necessary to maximize readers’ comprehension and integration. Additionally, readers need to consider what textual information to include, and what to exclude, in the integration processes. Thus, they must continuously evaluate new information according to certain criteria.

4. Evaluation

The Internet is a marketplace of opinions where traditional gatekeepers of trustworthiness are missing. Consequently, readers are required to evaluate information in terms of relevance and trustworthiness. In an optimal case, this will help readers make appropriate metacognitive decisions such as whether or not to process the contents of a website more deeply or to decide which knowledge claims to accept as valid in a discussion in social media.

4.1 Evaluation: Description of the competence

4.1.1 How readers evaluate information from web pages
Critically assessing the relevance and determining the trustworthiness of contents and sources are important cognitive processes in the web page browsing stage. What looks promising in the brief description of a SERP may turn out to be of
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little relevance once full access to the document is provided. Similarly, access to more comprehensive author information provided on an ‘about us’ page may add to a reader’s perception of the extent to which the information can be trusted. Thus, relevance and trustworthiness, both separately and in concert, contribute to a reader’s perception of the relative usefulness of a website against the background of the reader’s goals.

In their content-source-integration model, Stadtler and Bromme (2014) distinguish between two ways of accomplishing decisions about the relative trustworthiness of knowledge claims. Readers can either make first-hand decisions by comparing what they read against what they believe to be true based on their world knowledge (i.e., they answer the question “what is true?”), or they can make second-hand decisions by scrutinizing source information (i.e., answering the question “whom to believe?”). When readers process unfamiliar contents in particular, their prior knowledge may be too fragmentary to make truly informed first-hand decisions. In this case, second-hand decisions, i.e. evaluating sources, may be a better way to judge trustworthiness.

Digital readers often draw on their prior knowledge when judging the trustworthiness of information, even when their prior knowledge is fragmentary (Kiili, Laurinen & Marttunen, 2008; Scharrer, Bromme, Britt & Stadtler, 2012). This reliance is particularly high when scientific information is presented in a seemingly easy and popularized way, that is, without the use of specialist language, as is the case on many web pages (Scharrer, Britt, Stadtler, & Bromme, 2013; Scharrer et al., 2012; Scharrer, Stadtler, & Bromme, 2014).

Digital readers seldom use source information to make trustworthiness judgments, and if they do they tend to rely on rather superficial cues such as professional-looking design (e.g., Brem, Russell, & Weems, 2001; Eastin, Yang, & Nathanson, 2006; Gerjets, Kammerer, & Werner, 2011; Halverson, Siegel, & Freyermuth, 2010; Strømsø, Bråten, Britt, & Ferguson, 2013). This behavior is not due to a lack of adequate knowledge because many readers, even from secondary educational levels, are able to name or to consider adequate criteria against which to evaluate online information. These include source characteristics, such as the expertise or intentions of a source, the date of publication, and the extent to which information accuracy is assured through editorial quality checks (Kammerer & Gerjets, 2014b; Keck, Kammerer, & Starauschek, 2015; Paul, Macedo-Rouet, Stadtler, & Rouet, 2016). However, students often fail to apply these criteria when facing the complexity of reading online (Walraven, Brand-Gruwel, & Boshuizen, 2009).

4.1.2 How readers evaluate information in social media

People read on the Internet not only to acquire knowledge. The rise of social networks has increased the extent to which people read to solve personal problems or
to look for emotional support (Gazan, 2010). Before the Internet these uses were mostly limited to face-to-face interactions. For example, Kim and Oh (2009) analyzed the characteristics of “best answers” in Yahoo! Answers, a social question-answering forum in which users post questions and others submit answers. Users posting the questions tend to rate as “best answers” those that include statements of emotional support (e.g. “Your words really helped”), agreement (e.g., “Finally, someone who agrees with me”), and experience (e.g. “Thanks to the other person who posted the big list of symptoms”).

A major challenge of reading information from social media is that the quality and credibility of information is highly variable, and readers have to handle this problem without the credibility cues available in face-to-face interactions. When two authors provide conflicting information in social networks, such as web forums on daily life topics (Salmerón, Macedo-Rouet, & Rouet, 2016) and blogs on scientific controversies (Winter & Krämer, 2012), readers prefer messages that were written by experts rather than by laypersons. Such preference interacts with the type of evidence provided by the author and with the reader’s developmental or educational level. Primary school students are more likely to recommend expert messages referring to personal experience whereas undergraduates are more likely to prefer expert messages referring to another information resource (e.g., a hospital web page) in support of author claims (Salmerón et al., 2016). The appeal to personal experience may be more relevant when readers seek emotional support from social networks, such as when reading about risk-related topics (Betsch, Ulshöfer, Renkewitz, & Betsch, 2011).

In summary, users of social media tend to be cautious when it comes to accepting information from others, however, they may rely on unreliable cues, such as personal experience, when reading about topics such as perceived health risks.

4.2 Evaluation: Individual differences

There are important individual differences in the acquisition and use of evaluation. The existing small number of studies on evaluation from a developmental perspective indicate that this skill changes during middle and high school in qualitative rather than quantitative ways. Eastin et al. (2006) found that eight- to eleven-year-old children evaluated a website lacking source description as more credible than the same page with author credentials. Salmerón et al. (2016) found that fifth and sixth grade students recommended more often forum comments that included personal experiences as support, whereas undergraduate students favored the messages backed by documentary evidence.

For adult students, prior knowledge, self-efficacy, and epistemic beliefs are key factors in their evaluation processes. Readers’ trustworthiness judgments seem to be influenced by their level of prior knowledge. Readers lacking prior
topic knowledge are particularly likely to trust clearly false information when it is presented within a professional layout (Fogg et al., 2003; Lucassen, Muilwijk, Noordzij, & Schraagen, 2013). Notwithstanding the widespread neglect of source information, many readers exhibit a high degree of trust in their evaluation competencies (Ivanitskaya, O’Boyle, & Casey, 2006; Kuiper et al., 2008). Ivanitskaya et al. (2006) report that in a sample of university undergraduates the majority of students considered their research skills good or even excellent, whereas many of them were unable to judge the trustworthiness of health-related websites and did not differentiate between various information sources. Adult readers are better calibrated: In a study with in-service teachers, Andreassen and Bråten (2013) found that readers’ self-efficacy in evaluating sources predicted their use of relevant source features when evaluating the trustworthiness of web sources. The poor calibration of younger readers poses a problem to educators who want to train students’ evaluation skills because students likely lack the motivation to work on their evaluation skills if they already consider them good or excellent. Finally, another important reader characteristic that has emerged from the literature are individuals’ epistemic beliefs (e.g., Barzilai, Tzadok, & Eshet-Alkalai, 2015; Kammerer et al., 2015; Kammerer et al., 2013; Mason, Pluchino, & Ariasi, 2014). For instance, Kammerer et al. (2015) found that the more participants believed that Internet-based knowledge claims need to be critically evaluated, the more time they spent on reliable web pages from official institutions and the less time they spent on subjective web pages such as forum pages and commercial web pages.

4.3 Evaluation: Design influences

According to the content-source-integration model (Stadtler & Bromme, 2014) presented above, one can distinguish between evaluation based on content and evaluation based on source features (e.g., metadata on the text such as who wrote it, where and when it was published, or text genre). The design of a digital text also presents information about the text and, thus, may affect readers’ evaluation. This was clearly demonstrated when Fogg et al. (2003) had people comment on the credibility of web pages. Data were collected across a number of different sites on topics such as finance, health, news, and travel. The most frequently referenced evaluation categories were visual design (e.g., professional looking) and structure of the sites’ information (e.g., well organized). The potential impact web pages’ visual design has on readers’ evaluation was confirmed in a study by Robins and Holmes (2008), which showed that web pages perceived as having a professional graphic design were considered more credible than those without such designs. Likewise, Flanagin and Metzger (2007) found that web pages’ genre familiarity (e.g. news organizations, e-commerce) affected people’s evaluation of site credibility. Of course, the multitude of genres and genre-mixes on
the Internet presents a challenge when readers depend on their familiarity with genres to evaluate digital texts.

Results from the above studies indicate that the design of digital texts is an important factor in readers’ decision on whether to read a digital text critically or not. Results from the Robin and Holmes (2008) study showed that readers only spent 2–3 seconds on a web page before responding with a credibility judgment. Thus, participants apparently have evaluated the digital text before they had time to engage with the content or to reflect carefully on other adequate source features. It is interesting to note that participants in this study were graduate students in library and information science. This suggests that educational initiatives targeting critical reading of digital texts may be helpful to students at all levels.

A way to stimulate readers to attend to and evaluate source information more critically is by presenting contradictions between web pages (e.g., Barzilai & Eshet-Alkalai, 2015; Kammerer & Gerjets, 2014b; Kammerer, Kalbfell, & Gerjets, 2016; Strømsø, Bråten, Britt, & Ferguson, 2013). Teachers could take advantage of this effect in their design of online reading tasks such as Webquests (Segers & Verhoeven, 2009) by incorporating web pages with clear contradictory claims.

5. Methodologies for the study of digital reading

In order to capture the complexity of the different competencies of digital reading (navigation, integration, and evaluation) researchers need to use advanced methods that allow tracking of students’ text processing while reading (eye-tracking, log-files, and verbal protocols). In addition, research uses different methods to capture how that processing reflects in actual comprehension and learning.

5.1 Eye tracking

Eye-tracking methodology continuously tracks the position of the eyes while they move across visual stimuli such as text or pictures presented on web pages. Thus, eye tracking allows one to determine whether, for how long, and in which order individuals pay attention to certain information (cf. Scheiter & van Gog, 2009). Based on the assumption that what is being fixated by the eyes is being processed in the mind (eye-mind-assumption; Just & Carpenter, 1980), eye-tracking data is a strong indicator of individuals’ moment-by-moment cognitive processing (cf. Rayner, 2009). It provides insights into cognitive processes at a very fine-grained level, which, for instance, allows differentiation between initial reading and re-reading (cf. Hyönä, Lorch, & Rinck, 2003). It also provides data concerning cognitive processes that do not lead to overt actions (e.g., when deciding not to click
on a certain hyperlink). Moreover, it seems highly suited to unravelling quick and automated or unconscious cognitive processes, which are difficult to express verbally (cf. Scheiter & van Gog, 2009). However, in order to correctly interpret eye-tracking data (e.g., whether longer fixation times on an object indicate increased interest or rather comprehension difficulties), combinations with other type of data, such as verbal protocols or log-files (see below) are extremely helpful.

5.2 Log files

Navigation is most often measured in the literature through readers’ log files, which record traces of their clicks on the hypertext. Log-file indexes can consider visits to particular web pages (e.g., number of visits, reading time, pages relevant for students’ goals) and capture some characteristics of the navigation sequence (e.g., percentage of transitions between semantically related web pages) (Naumann, 2008). In most studies navigation is assessed by focusing on the characteristics of the web pages visited but not looking at the specific processes that motivated particular navigation moves. This limits the power of the literature to inform psychological models of digital reading because an identical index (e.g. click on a page relevant to the students’ goal) may reflect very different underlying processes (e.g. heuristic or elaborated processing). Winne (2010) has argued that a way to solve this problem is to include in the studies theoretically motivated hyperlinks, so that the selection of a particular hyperlink can be linked easily to a unique theoretical explanation (for a recent example of this approach see Salmerón et al., 2015).

5.3 Verbal protocols

Verbal protocols have been a common method to capture processes of digital reading (e.g. Anmarkrud, McCrudden, Bråten & Strømsø, 2013; Goldman et al., 2012; Greene, Yu, & Copeland, 2014). Ericsson and Simon (1993) have described verbal protocols as one valid way to study cognitive processes, provided that the materials and task are sufficiently challenging. Pressley and Afflerbach (1995) reviewed the use of verbal protocols in studies on reading and showed that such protocols could also be appropriate for the study of text comprehension. The method, also referred to as the think-aloud method, asks subjects to report their thinking as they read. Verbalizations are recorded, transcribed, and coded. It has been suggested that thinking aloud while reading may affect task performance and that it prompts reading aloud. However, a number of studies indicate that thinking aloud does not necessarily affect peoples’ cognitive processing, provided that researchers follow specific procedures emphasizing that subjects should verbalize whatever comes into their mind and not respond to specific questions (Fox, Ericsson, & Best, 2010; Hertzum, Hansen, & Andersen, 2009).
5.4 Evaluation tasks

Evaluation tasks are most often used in order to assess readers’ judgments about a document’s credibility. These tasks come in a number of different formats, for example by asking readers to rank websites according to reliability and then asking them to justify the ranking (Wiley et al., 2009). Justifications are coded, with coding schemes typically including justifications both by content (e.g. evidence, explanations, arguments) and by source (e.g. author, affiliation, date of publication). Another approach is to ask participants to rate websites on a scale according to trustworthiness, expertise, and convincingness of information, with those scores together representing website credibility (van Strien, Kammerer, Brand-Gruvel, & Boshuizen, 2016). Rating of trustworthiness has also been used in order to investigate how participants emphasize different kinds of source features in making such ratings, with students instructed to rate the importance of different source features (e.g. layout, URL address, or author) when evaluating how trustworthy websites were (Andreassen & Bråten, 2013). Whereas the above studies accentuate measures of different aspects of a websites’ credibility, Walraven, Brand-Gruvel, and Boshuizen (2013) emphasize both credibility and relevance. They instructed students to select from SERPs websites that were appropriate to certain topics and then to indicate on what information in the SERP they had based their decisions. Thus, criteria for both relevance and reliability were scored. Likewise, students were presented with a set of websites and asked which they would use given a specific task, and then highlight on which features they based their decision. Although evaluation tasks are most often used to measure students’ judgments concerning aspects of credibility, they could also be used to investigate other criteria such as relevance.

5.5 Memory and comprehension tasks

Measures of readers’ memory for or comprehension of digital information do not essentially differ from reading measures related to printed texts. For example, memory for factual knowledge from digital sources has been assessed by having participants verify whether statements are true or false (e.g. Amadieu, van Gog, Paas, Tricot, & Mariné, 2009; Mason et al., 2014) or by multiple-choice tests (e.g. Stadtler & Bromme, 2007). Comprehension of digital documents has frequently been measured by the use of short open questions (e.g. Stadtler & Bromme, 2007; Walraven et al., 2013) or student essays (e.g. Anmarkrud et al., 2013; Mason et al., 2014; van Strien et al., 2016). The essays are scored according to criteria related to the writing task and the focus of the study. For example, to investigate readers’ attitude strength and biased information processing van Strien et al. (2016) scored arguments according to whether they were attitude-consistent/inconsistent. In
studies focusing on readers’ multiple documents comprehension, student essays are typically scored according to whether readers are able to incorporate positions from different information sources in their understanding of a set of websites. For example, Mason, Junyent, and Tornatora (2014) used this method to investigate whether participants identified corroborating evidence or contradictions across sources, whereas Anmarkrud et al. (2013) used it to code argumentative reasoning according to if and how opposing positions from the information sources were used in essays.

Amadieu et al. (2009) used another kind of measure of intertextual comprehension. They included the same kind of sentence verification test as described above to test memory for factual information, but in order to answer correctly students needed a conceptual understanding based on at least two information nodes in a hypertext. Given that coding of essays is a rather time-consuming process, sentence verification tests may be an alternative when measuring integration across digital information sources. However, developing valid and reliable sentence verification tests is also a demanding process.

6. Discussion and future directions

In the previous sections, we have reviewed the current state of knowledge about the three main competences involved in the comprehension of digital texts. Although there is substantial evidence regarding how readers navigate, integrate, and evaluate information from digital texts, there are still unresolved issues such as how these competencies interact and how they are acquired during adolescence. In the remainder of this chapter, we discuss some of these issues and how new methodologies could help to shed further light on digital reading.

As our review illustrates, most previous research has studied the competencies of navigation, integration, and evaluation in isolation. During actual reading students usually need to coordinate all three competencies, depending on task demands. For example, while reading to complete a class assignment, students need to navigate through a hypertext to a page with potentially relevant information for the assignment. Once they have located such a page, they may need to evaluate the quality of the claims on the page before deciding if those claims should be integrated together with the information previously found in other sources. Failure to implement any of the competencies may result in a failed assignment. The question arises whether these three competencies are independent or form a single general skill. A recent study by Hahnel et al. (2016) suggests that relations between the skills are not obvious. They analyzed teenagers’ ability to select web pages (using a test to select web pages from SERPs) and to navigate
across hypertext. Although the ability to select web pages was positively correlated with efficient navigation, this correlation disappeared once single text comprehension skills were accounted for. Thus, it is possible that teenagers develop each of the three competencies, at least to a certain degree, as separate skills.

A crucial task for future research will be to better understand how individuals acquire the three skills, both inside and outside of formal education. One factor that may promote skill acquisition is extended practice with digital texts. Recent evidence suggests that this relation is not straightforward and may vary according to the demands of the tasks that students pursue when they engage with digital texts. Specifically, Naumann (2015) has reported that high exposure to information tasks, such as searching the web for particular information, is positively associated with teenagers’ efficient navigation and comprehension in digital reading tasks. The opposite effect was found between the time expended on social tasks, such as using e-mail or chatting, and comprehension. A different aspect related to this development is how competencies involved in digital comprehension interact with single text comprehension. Exposure to social tasks in digital texts has also been identified as a negative predictor of single text comprehension (Duncan, McGeown, Griffiths, Stothard, & Dobai, 2015). In summary, there is a potential risk that time invested in social activities in digital texts may prevent students from being exposed to more complex academic language, which is necessary to develop their general deep comprehension skills. Because this evidence comes from correlational studies, a note of caution is necessary before proposing causal connections between the acquisition of digital text competencies and its effects on single text comprehension skills. Future research should also determine if the effects of exposure on acquisition follow different patterns for the three competencies of digital reading identified in the chapter.

Intense exposure to digital texts alone is obviously not enough to make individuals become proficient comprehenders of digital information. This is why, recently, an increasing number of attempts to promote the skills of navigation, integration, and evaluation have been presented (for an overview, see Stadtler, Bromme, & Rouet, in press). These range from parsimonious educational scaffolds (e.g., prompting procedures) to more comprehensive workshop-like interventions, and have been tailored to groups of primary students (e.g., Macedo-Rouet, Braasch, Britt, & Rouet, 2013; Zhang & Duke, 2011), secondary students (e.g., Gerjets & Hellenthal-Schorr, 2008; Kammerer, & Werner, 2011; Mason et al., 2014; Stadtler, Paul, Globoschütz, & Bromme, 2015), and adults (e.g., Kammerer, Amann, & Gerjets, 2015; Stadtler & Bromme, 2007; Stadtler, Scharrer, Macedo-Rouet, Rouet, & Bromme, 2016; Wiley et al., 2009). The available empirical evidence suggests that it is indeed possible to promote the skills of navigation, integration, and evaluation, although reported effects are often limited in magnitude and restricted to
short-term behaviour changes. Future research will have to demonstrate to what extent the available interventions facilitate sustainable change in the ways learners approach digital texts. Another limitation of the current evaluation studies is that the instruction has usually been provided by the researchers themselves. Studies of this kind are certainly a valuable starting point, but they do not inform us of whether similar learning gains would be obtained when instruction is provided by teachers and under regular classroom conditions. Against this background, future research needs to focus to a greater extent on training teachers how to incorporate the promotion of navigation, integration, and evaluation skills into their regular curriculum.

Finally, future research may see an expansion of the toolbox of methodologies for investigating the processes described in this chapter. A particularly interesting and potentially powerful set of methodologies consists of neuro-imaging techniques. Although the application of techniques such as fMRI, EEG/ERP, or MEG is still in development even for the study of comprehension processes in traditional, single text reading situations, they have the potential to reveal details of the time lines of the various component processes outlined above as well as of the interactions between neural structures (for a review see Price, 2012). Application of these methods has allowed important advances in our understanding of integration and evaluation processes during reading of sentence pairs and is likely to do the same in the future for our understanding of comprehension processes in digital reading.

Comprehension of digital texts is a unique combination of navigation, integration, and evaluation of information. In this chapter, we summarized our current knowledge about these competencies and we emphasized the need to focus on their interrelations. We expect that our review will open up interesting new avenues for research.

References


CHAPTER 5

Affordances and challenges of digital reading for individuals with different learning profiles

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The ability to successfully learn using digital media is becoming one of the most important skills for students of the 21st century and requires a range of cognitive and metacognitive skills. Children with learning disabilities, however, often have weaknesses with these skills, and may experience difficulties reading and understanding texts presented digitally. On the other hand, digital texts allow for different supports that may be beneficial for children with learning disabilities. Thus, it is important to examine the influence of digital environments on the reading abilities of individuals with specific learning difficulties. In this chapter, we review both the challenges and affordances of digital environments for individuals with reading difficulties and attention deficits. We then examine the contribution of digital interventions and electronic books to the promotion of literacy skills in these populations. We conclude with a call for more rigorous research to understand the challenges that children with different learning profiles face when learning with digital materials.

1. Introduction

Today’s youth are surrounded by a rich repertoire of technologies. Children across ages and socio-economic status have access to tablets, computers and cell phones and spend a substantial amount of time occupied with on-screen activities, such as searching for information, playing games, and communicating through social networks (Marsh, Brooks, Hughes et al., 2005; Zevenbergen, 2007). Successful interactions using digital media often depend upon children having the necessary
cognitive and metacognitive skills (See Wiley et al., Chapter 3; Salmeron et al., Chapter 4 this volume). For example, when looking for information, children must learn to formulate a search term and then critically evaluate search results (e.g. Salmerón et al., Chapter 4). This process becomes more complicated for children with specific learning disabilities, such as those with dyslexia or ADHD. When reading Internet search results, for instance, slow recognition of words may directly interfere with the integration of information in working memory. In addition, difficulties with sustained attention may present a further obstacle to comprehension of long digital texts filled with multimedia elements. On the other hand, digital technologies can allow for supportive elements that may be particularly helpful among populations with learning disabilities. Thus, it is essential to understand the influence of digital technologies on the reading of children with specific learning difficulties.

One such population is children who struggle to read due to developmental dyslexia. This reading disability is one of the most common learning disabilities affecting 4–9% of students (Pennington, 1995; Wright & Zecker, 2004; Landerl & Moll, 2010). Developmental dyslexia is characterised by inaccurate, slow and dysfluent reading even at the word level, despite adequate reading instruction and normal intelligence (APA, 2013; Shaywitz & Shaywitz, 2013; Landerl & Wimmer, 2008). The primary reading disability may be accompanied by difficulties in other levels of linguistic and cognitive processing, for example, reading comprehension (Kirby & Savage, 2008) and working memory (Moll, Göbel, Gooch, Landerl & Snowling, 2016). Developmental dyslexia has a hereditary and neural basis that affects the development of neural networks important for proficient reading (e.g. Démonet, Taylor, & Chaix, 2004; Blomert, 2011). Children with dyslexia often experience reading difficulties that stem from less automated grapheme-phoneme mapping, which may be due to fuzzy phonological representations or problems accessing these representations (Blau et al., 2010; Ramus, Marshall, Rosen & van der Lely, 2013; Vellutino et al., 2004). Difficulties with reading often have a negative effect on an individual’s self-esteem as a learner and therefore influence the individual’s overall engagement in both print and digital reading (Riddick, 2002).

Comorbidity between dyslexia and other learning disabilities is also substantial, as well as with Attention-Deficit Hyperactivity Disorder (comorbidity rate with ADHD is around 30%; Landerl & Moll, 2010; Germano, Gagliano, & Curatalo, 2010). ADHD is a neurodevelopmental disability characterised by difficulties with inattention, impulsivity and hyperactivity (DSM-V, APA, 2013). The prevalence of ADHD in children and adolescents worldwide is estimated at 5–7% (Willcutt, 2012). Children with ADHD often struggle in school, and their academic difficulties extend from childhood to college (Lewandowski, Gathje, Lovett, & Gordon, 2013). A large survey of adults in the USA reported an ADHD
prevalence of 4.4% (Kessler et al., 2006), many of whom continue to secondary education. College students with ADHD represent one of the largest disability groups (Weyandt & DuPaul, 2006). In general, students with ADHD often have negative classroom behaviours, which include lower motivation, poor study skills, and less engagement in academic activities. These behaviours are thought to mediate the lower achievement scores that characterise this population (Barkley, 1997; DuPaul et al., 2004). In a meta-analysis of 72 studies that were published from 1990 to 2006 (Fraizer, Youngstrom, Glutting, & Watkins, 2007), ADHD samples had consistently lower achievement scores than age-matched controls, with the largest effect sizes in the area of reading (d = 0.73). Since many learning activities involve reading large amounts of textual material it is important to examine how this population comprehends digital text of various length and complexity.

In this chapter, we discuss how reading on digital devices provides affordances but also challenges for children and adults with different learning disabilities, particularly those with reading and attention deficits. We first review the effect of the medium on digital reading in individuals with reading and attention deficits. We then consider their online reading behaviour and discuss how the multimedia embedded in digital texts may affect their reading comprehension. Lastly, we discuss how digital interventions and educational electronic books support literacy skills among children with specific learning disabilities.

2. Reading in a digital medium

Findings from research investigating the impact of digital devices on reading processes have not been consistent. Research has found an advantage for print over digital medium (e.g., Mangen et al., 2013) or no impact of medium on reading (e.g., Poiron et al., 2016). This research has focused mainly on typical readers. It may be the case, however, that those who struggle with traditional print-based text may be helped by the affordances of the digital medium. Indeed, a large body of research exists on how to optimise typography, page layout and content to improve digital text accessibility for dyslexic readers (for a review see McCarthy & Swierenga, 2010). Research indicates that struggling readers seem to benefit from a larger-than-typical font size (Rello, Pielot, Marcos, & Carlini, 2013) and sparser layout in general (Rello, Kanvinde, & Baeza-Yates, 2012). Recent work has shown that introducing slightly larger spaces among letters within a word also has a positive impact on reading (Marinus et al., 2016). Since digital devices allow the reader to easily adjust different aspects of the text's format and display, they may be particularly suitable for this population (See Chapter 2 in this handbook on informational design of digital texts).
Schneps, Thomson, Chen, Sonnert, and Pomplun (2013) investigated the effects of e-readers on reading comprehension and speed of 103 high school students with dyslexia. Results indicated that many adolescent dyslexic readers achieved a faster reading speed on digital devices that displayed only a few words per line, as compared to reading on paper with typically longer lines. This may account for some struggling readers’ preference to read on tablets instead of paper (Hughes, 2013). Other studies, however, did not find an advantage for digital devices when reading comprehension of learning disabled populations was considered. For instance, Twyman and Tindal (2006) reported no significant differences in the comprehension achievements of struggling readers in grades 11 and 12 who read from a computer-adapted history textbook, relative to their peers who studied with the print textbook. Similarly, Srivastava and Gray (2012) found that differences between language impaired and typical learners in reading comprehension tasks were not influenced by the display medium.

In a comprehensive study, Minguela, Solè and Pieschl (2015) compared 15 year old skilled readers (being above the 80th percentile in a standardised reading comprehension test) and less-skilled readers (scoring at 30–40 percentiles) on a digital reading task. Students read an expository social science text within special software, which required them to click a box to receive the next text segment or to reread a previous one. After reading the text, students answered superficial and deep comprehension questions and rated their confidence level in their ability to answer comprehension questions correctly. The skilled readers outperformed the less-skilled group both in their accuracy on comprehension questions and in the calibration of their confidence ratings. There was no group difference in the overall reading time of the text. During the first pass reading of the text, less-skilled readers read more slowly and in a more linear fashion than the skilled readers. The results of this study point both to the metacognitive skills necessary for comprehension of digital text – monitoring ongoing comprehension, selecting portions of the text to read according to one’s reading goals – and to the less-skilled readers’ failure to make use of learning strategies, such as selective re-readings. Taken together, it is apparent that weaknesses displayed by less-skilled readers in print transfer to online reading environments.

Considering individuals with ADHD, there are only a handful of studies that have compared print and digital text comprehension in this population. Shaw and Lewis (2005) presented primary school children with a text comprehension task that was either in a traditional setting (i.e., paper-and-pencil task) or on a laptop computer. They hypothesised that a digital environment would be more engaging for children with ADHD, which would result in better performance on multiple-choice comprehension questions. Consistent with previous studies in print, children with ADHD were less accurate than their peers. Interestingly, in the digital
condition, the reading comprehension of the ADHD group improved to the level of the age-matched control group. In addition, the ADHD group spent more time-on-task in the digital relative to the paper conditions, supporting the view that a digital context has a positive effect on the ability of children with ADHD to sustain attention on an academic task.

Moving to high school pupils, Stern & Shalev (2013) investigated the influence of the display medium on reading comprehension of short expository passages in adolescents with and without ADHD. Results indicated significant improvements in the performance of those with poor sustained attention when the text was presented on screen with double-spacing between lines. They did not find a main effect of display medium. A recent study that examined the influence of the display medium on comprehension of relatively long texts (Ben-Yehudah & Brann, 2017), however, found that the performance of university students with ADHD was much lower than an age-matched control group in the screen condition, but not in the paper condition. Moreover, they found that individuals with ADHD were significantly more overconfident of their knowledge after reading the digital text (as measured by prediction of performance), as compared to their confidence level after reading the print text.

The findings of the studies discussed here suggest that an important affordance of digital text is the ability to customise the display, which can be of great help to those who struggle to read. Individuals with dyslexia benefit from the ability to change font size and line spacing in the text. The digital medium is not always better for comprehension as compared to print among those with reading or attention deficits. For example, short passages presented on screen seem to facilitate comprehension among children and adolescents with ADHD, possibly due to a higher level of children's engagement in the task. On the other hand, comprehending longer texts, which requires higher levels of sustained attention, is better when the text is presented in a traditional print medium than in a digital one. Beyond the medium of presentation, it is important to understand how readers with different learning profiles respond to the demands of digital reading, such as in the case of searching for information on the Internet.

3. Information search challenges

Compared to print reading, digital texts place additional demands on readers’ executive functions, metacognitive regulation and motivation (Salmeron et al., Chapters 4; and Wiley et al., Chapter 3), which may negatively affect children with reading disabilities (McCarthy & Swierenga, 2010). Computer skills also influence motivation to engage in digital reading. A study of 320 fifteen-year old students
found that self-reported basic computer skills was strongly associated with digital reading ability (Goldhammer, Naumann, & Keßel, 2013). Learning disabled students master the very basic Internet browser control functions without significant difficulties (e.g., forward, back, open, close and scroll, hyperlink recognition, Internet searches and writing a URL-address), demonstrating that they have the capability to navigate in cyberspace (Harrysson, Svensk, & Johansson, 2004). Moreover, search engines’ auto-correct function for misspellings generally helps struggling readers to write accurate search queries. Although recordings of eye movements reveal that they look less at the search engine’s autocomplete suggestions than typical readers (Berget & Sandnes, 2015b).

It is somewhat obvious that online reading skills are correlated to some extent with traditional reading skills (Goldhammer et al., 2013). In a study on a large-scale PISA sample of Spanish fifteen-year-old students, Javier Gil-Flores, Torres-Gordillo, and Perera-Rodríguez (2012) reported that the traditional (print-based) measures of reading comprehension were the best predictors of the students’ online reading skills. A study of university students examined the relationships between print-based reading abilities (fluency, comprehension and vocabulary, as measured by the standardised Nelson-Denny Reading Test), and web-based skills, such as information search, recall and recognition memory, and learning from web-pages (Boechler, Levner, Leenaars, & Steffler, 2006). This study found that pre-existing vocabulary knowledge was associated with long-term learning from textual information in web-pages, and print-based reading comprehension was associated with long-term learning from images in web-pages. Interestingly, reading fluency was related to immediate recall memory of web-pages. As for information search, only reading fluency predicted response times in this activity.

Few studies have examined the online reading skills of learning disabled school-age children. Chen (2010) investigated these skills together with the online learning strategies of learning disabled fifth and sixth graders, who were compared to an age-matched control group. This study found that both the learning-disabled children and their non-disabled peers experienced difficulties with online reading skills, but the children with learning disabilities had poorer online learning strategies. In addition, dyslexics relative to typical readers needed more time to search for information online, possibly because they formed more queries and made more misspellings on search terms (Berget & Sandnes, 2015c).

One method used to examine online reading behaviour is eye-tracking. Eye movement measures, such as gaze location and duration, reveal detailed information about what readers pay attention to during web search tasks. Although studies have examined the online reading behaviour of typical readers, only a few studies with relatively small sample sizes exist on individuals with dyslexia. For
example, Al-Wabil, Zaphiris, and Wilson (2008) compared two dyslexics’ and two control adult readers’ eye-movement scan paths during web search tasks. In their exploratory analysis they found a larger variability in the scan paths of dyslexic readers, which they suggested reflects less strategic viewing of online information compared to the typical readers. Sung, Wu, Chen, and Chang (2015) studied fifth graders’ performance and eye movements during web tasks. Not surprisingly, they found that the typical readers outperformed the dyslexic group on the behavioural tasks. Regarding eye movements, these revealed that the students with typical or above average reading skills viewed more topic sentences in the goal-directed reading condition than in the case of free browsing. The dyslexic students, however, did not exhibit such task-modulation of their viewing behaviour. The researchers concluded that typical readers are better at adjusting their reading strategy according to the requirements of the task. Thus, weaknesses in reading skill can make it harder for dyslexic readers when navigating online.

4. The influence of multimedia

A prevalent characteristic of digital learning environments is the ability to simultaneously display text and multimedia elements (e.g. pictures, movies, sounds and speech). These multimedia materials are found to support learning compared to text alone presentations (Mayer, 2005). There is little research, however, on how children with different learning profiles cope with the myriad information presented in different formats. A common view is that visuals added to textual information helps individuals who struggle with reading. For example, traditional print books offer illustrations to support story comprehension; technology-enhanced storybooks broaden these experiences with additional nonverbal support in the form of sound, animation and games (de Jong & Bus, 2002). These multimedia elements can facilitate children’s attention to the meaning, phrasing, and textual features of the story (e.g., title, reading direction, and other concepts about print). In a recent review, Bus, Takacs, and Kegel (2015) discussed the benefits and pitfalls of using multimedia features in electronic children’s books concluding that effective design and use of these features may indeed improve the learning conditions of children from risk groups, such as immigrants and low income families, thus turning them into successful learners.

In a comprehensive study of children from immigrant language-minority families, Verhallen, Bus, and de Jong (2006) found that multimedia stories with animated pictures, as compared to static ones, helped this population to focus their attention on significant details of the storyline and improve their linguistic skills. Among older students, when the use of animations was compared to the
use of traditional study materials during a statistics class, both typical and dyslexic readers favoured the animations (Taylor, Duffy, & Hughes, 2007). Somewhat surprisingly, the typical readers found animations to be more useful than did the students with dyslexia.

Beacham and Alty (2006) compared learning outcomes among university students with dyslexia in three different conditions: text only, text and diagram, and speech and diagram. Rather surprisingly, they found that the text-only group showed the largest gains from pre- to post-test. The authors concluded that the speech and diagram condition may be difficult for dyslexics because it contains a higher working memory load, while the text and diagram condition may be difficult because it contained more redundant information together with the demand for text-figure integration. In contrast, the text-only condition forced the students to focus on the verbal content, which seemed to improve their understanding. Support for this conclusion comes from findings that dyslexic individuals spend more time studying pictorial elements as compared to typical readers. Adults with dyslexia gaze longer at visual elements in infographs and their comprehension scores are lower relative to typical readers (Kim, Lombardino, Cowles, & Altmann, 2014).

How do multimedia elements in digital text influence children with ADHD? Solomonidou et al. (2004) examined the influence of multimedia elements, such as text, pictures, videos and narrated items on learning outcomes of school-age children with ADHD. They found that 5th and 6th grade students with ADHD benefited from learning materials that contained short presentations of videos and narrated items, whereas activities that had students read long texts or watch long videos were harmful to the learning process. In contrast, Fabio, Antonietti, & Tiezzi (2003) found that simultaneous presentation of different multimedia elements improved the performance of students with ADHD so they reached a level similar to that of their typically-developing peers, while an auditory-only presentation of the same information did not improve their performance.

The positive impact of multimedia information on learning may be due to several factors. First, it is well-known that motivation and engagement play a large role in learning, particularly in children with learning disabilities (Barkeley, 1997). Hypermedia learning environments increase both motivation and engagement by providing a change from traditional learning and by presenting the same concept in different ways. This novelty effect together with the learner’s ability to access information according to personal interests and learning style is particularly beneficial for individuals with ADHD, who have difficulties sustaining attention. Presenting information in written text, pictures and sounds also increases the likelihood of acquiring new knowledge through multiple sensory channels, as claimed by the classic dual coding theory (Paivio, 1991).
5. Digital supports and interventions

The benefits of learning in a media-rich environment have been supported by studies on both typically-developing students (e.g., Mayer, 2005; Najjar, 1998; Sweller, 1999) and those with learning disabilities (Hall, Hughes, & Filbert, 2000; Maccini, Gangon, & Hughes, 2002). A hypermedia environment enables elaboration of written information by connecting it to other types of media such as oral narratives, pictures, sounds, videos and animations. Through these hypermedia features, students have access to supports such as word pronunciations, vocabulary definitions, and a study guide, all of which help to comprehend the text and build long-term knowledge. Further, hypermedia-based learning is self-paced allowing the student adequate time to allocate attention and engage in each concept.

A common type of digital support used by students with learning disabilities is computerised readers, known today as text-to-speech programs. MacArthur and his colleagues (2001) showed that students with learning disabilities, from grades 4–12, understood a text better when the unfamiliar words were read to them by the computerised reader, which provided access to the word’s meaning and consequently improved their reading comprehension in comparison to a control group. Other studies, however, did not find an association between the use of computerised readers and gains in comprehension, for younger learning disabled students in grade 2–5, (Wise, Ring, & Johnson, 2000) or for older students in 5th to 8th grade (Mansef-Williamson, Dunn, Hinsaw, & Nelson, 2008).

Many studies have shown that digital supports such as hyperlinks from the central text to study questions, online glossaries and explanations of new concepts improve reading comprehension. In a study from the 1990’s (MacArthur & Haynes, 1995), students with learning disabilities in grades 5–7 made gains in comprehension after the use of digital supports that included graphics, text outline and questions, speech synthesis, online glossary, links from questions to helpful text, and explanations of major concepts. These positive effects of digital supports were also documented by Lange, McPhilips, Mulhern, and Wylie (2006), who found that in secondary education students with learning disabilities improved their reading comprehension when it was supported with various hypermedia tools, such as speech synthesis, online dictionary, spell checker and a homophone deletion tool. More recently, Ortlieb, Sargent, and Moreland, (2014) examined the effects of MyON, a digital learning environment with many built-in supports, on reading comprehension of 58 struggling readers in 4th grade. The use of MyON was compared to reading a hybrid and a traditional printed text. The results showed that in the MyON condition the struggling readers significantly outperformed those who read in the latter two conditions.
Built-in digital supports have been part of reading intervention programs for children with dyslexia for some time. In this field, digital supports are known as computer-assisted training. Torgesen, Wagner, Rashotte, Herron, and Lindamood (2010) tested the value of a computer-assisted training that is based on the well-known Lindamood intervention program for students with dyslexia (Lindamood & Lindamood, 1998). One hundred and twelve 1st graders at risk for reading disabilities were assigned to one of three training conditions: a computerised Read Write and Type (RWT) program, a computerised version of the Lindamood Phoneme Sequencing Program for Reading, Spelling, and Speech (LIPS), or a non-computerised traditional treatment (control group). A comparison of the pre- and post-training data showed that the groups with the computerised interventions did significantly better than the control group on all of the tests: phonological, word-level, spelling and comprehension, but there were no reliable differences between the two computerised interventions. These findings indicate the utility of supplementing teacher-based interventions with computer-assisted training for young readers (see also Balajthy, 1995). In older students, Slavin and colleagues (2008) observed that digital interventions are especially effective when they are integrated and directly linked to the curriculum of adolescent students.

Educational digital games are often included in computer-assisted training programs for children at-risk for learning disabilities. Saine, Lerkkanen, Ahonen, Tolvanen, and Lyytinen (2010) found support for the use of digital games in fostering early reading skills among 166 students at-risk for reading disabilities. Students received either Graphogame, a digital game that offered drill and practice on specific literacy skills, or activities with flash cards and plastic game boards. Results indicated that those exposed to the Graphogame training significantly outperformed their peers on measures of reading fluency. Moreover, they learned word-level reading skills earlier, and by grade 2 they reached a level of word reading fluency comparable to that of typical age-matched peers. While showing great promise, most of the computer-based reading interventions do not yield large effect sizes (Wijekumar, et al., 2013). This suggests a growing need for research that explores the influence of extrinsic factors on intervention efficacy, such as the role of teachers as effective mediators of digital training.

Educational electronic books (e-books, technology-enhanced storybooks) are another form of digital text that includes built-in supports for comprehension. Many studies have shown that e-books are helpful for children with language impairments, which later manifest as learning disabilities, because they provide both verbal and nonverbal sources of word meaning (Korat, Levin, Atishkin, & Turgeman, 2014). Moreover, educational e-books often have activities designed to enhance specific early literacy skills. For instance, e-books contain a feature that allows children to listen to a narrator reading the text, which increases their
exposure to advanced vocabulary (Salmon, 2014). In addition, e-books motivate children to engage with stories through interactive features that elicit actions from the children and respond to their activity (Smeets & Bus, 2015). For example, clicking on a character (or object) that is presented on a screen results in audio information about the character; clicking on a specific word (or phrase, sentence) activates re-reading of the text (Korat & Shamir, 2008). Although the interactive multimedia features of e-books promote the development of oral language and early literacy skills, these features must match the story’s plot to have a positive impact on story comprehension (Labbo & Kuhn, 2000).

Other populations that benefit from an early exposure to educational e-books are pre-school children from low SES families and second language learners. Animated features in e-books help children at-risk for a delay in language development draw their attention to details in the story (Takacs, Swart & Bus, 2015) and develop their linguistic knowledge and literacy skills (Verhalleen et al., 2006). Segal-Drori and her colleagues (2010) examined the effects of e-book versus print reading on early literacy skills and emergent decoding of kindergarten children from low SES families. They concluded that the group that read the e-book with adult mediation attained the largest growth in phonological awareness and word reading, relative to the other groups. Thus, e-books are a good resource for rich linguistic input and independent exposure to early literacy experiences and can be particularly beneficial for young students, especially those with language and reading disabilities and those from low SES families and second language learners.

Few studies have tested the effect of computer-assisted training on the academic achievements of students with ADHD. In this field, digital training is framed as learning on screen. The view that this type of learning is beneficial for individuals with ADHD derives mainly from gaming studies that observed similar success rates on computer games for children with and without ADHD (Shaw, Grayson, & Lewis, 2005). Indeed, many aspects of computerised activities appear to capture attention and increase the level of engagement in individuals with ADHD (Xu, Reid, & Steckelberg, 2002). Consistent with this view are subjective reports from individuals with ADHD, who described feeling at ease when academic material is displayed in a multimedia setting and having a more positive perception of learning in this context (Solomonidou, Garagouni-Areou, Zafiropoulou, 2004). It is important to note, however, that characteristics of the study material, such as length and complexity, have a significant impact on the affordances of computerised environments for individuals with ADHD.

One of the first studies to examine the benefits of computer-assisted learning for children with ADHD was in the field of mathematics. This seminal study by Kleiman, Humphrey, and Lindsay (1981) found that participants with ADHD
worked longer to solve mathematics problems when they were presented on screen as compared to paper, and they solved twice as many problems correctly. Ford, Poe, and Cox (1993) reported similar findings for primary school children with ADHD symptoms, who used mathematics software with no time constraints to solve math problems. Interestingly, when the same participants used a reading tutorial in a drill-and-practice format they did not experience any benefits of on screen learning in this domain. Later studies, which had stricter criteria for the inclusion of children with a clinical diagnosis of ADHD, also found benefits for on screen learning in this population for a variety of academic tasks, including science problems, reading comprehension and math (Bennett, Zentall, French, & Giorgetti-Borucki 2006; Shaw et al., 2005; Solomonidou et al., 2004).

Fabio and Antonietti (2012) examined how traditional classroom instruction and hypermedia instruction influence the acquisition and retention of different types of knowledge (i.e., declarative, procedural and conditional) in middle school students with ADHD, with ADHD and learning problems, and in a control group of typically-developing peers. They found that hypermedia instruction was better than traditional instruction in all groups and for each type of knowledge (explicit, implicit, and declarative). The hypermedia condition had a large positive influence on learning in the ADHD groups, with the highest benefits for declarative knowledge. When the clinical groups were compared, the effect of the instruction method was significant only in the ADHD group without additional learning problems. Notably, in the clinical groups, differences in performance between acquisition and retention phases were the lowest in the hypermedia condition. Since the hypermedia instructional tool was designed to help students to form links between their existing knowledge and new knowledge acquired in the learning task, it is not surprising that such self-paced learning resulted in better understanding of the concepts, as compared to traditional classroom instruction that included only an oral explanation of the same concepts.

It appears, therefore, that students with various types of learning difficulties benefit from computer-assisted training and the use of educational software during learning activities. There are several aspects of computer-assisted learning that are particularly beneficial for students who struggle with reading and/or attention-related difficulties. First, educational software enables students to learn at their own pace, while providing reinforcement and corrective feedback (Bender & Bender, 1996; Ford et al., 1993; Xu, Reid, & Steckelberg, 2002). Second, the multimedia aspects of educational software and Internet webpages, such as graphics, sounds, videos and interactive animations, play an important role in maintaining attention on the learning task and presenting the information in different modalities. Although encouraging, it is important to make sure that the characteristics of the computerised activity are suited to the needs of the learner. As reported by Solomonidou and colleagues (2004), the students with ADHD in their study
benefited from the educational software only when the material contained short presentations of videos and narrated items. When the computerised activities required reading longer texts or watching longer videos without narration, the software was harmful to their learning process.

6. Conclusions

Although the research evidence is sparse and spans a wide range of learning difficulties, age groups and tasks, it indicates that readers with dyslexia, those with attention deficits, and young children at-risk for impoverished linguistic knowledge, do benefit from the affordances of digital learning environments with built-in supports. Some promising digital supports include those that enable vocabulary growth, accurate decoding, and links to conceptual knowledge. Other features of digital learning environments that are beneficial to reading comprehension are the ability to control perceptual processing of the text and gain information from multimedia elements. The studies to date support the effectiveness of computerised interventions in helping children at-risk for dyslexia develop pre-reading and basic reading skills, although research is needed with regard to the specific features of digital interventions that are effective and related to long term reading gains. Moreover, students often express a more positive attitude towards learning when the materials are digital as compared to a printed format. Unfortunately, digital environments also pose some challenges for individuals with learning and attentional difficulties.

Reading in digital environments places demands on the skills that are poor among children with reading and attentional deficits. For example, searching the Internet requires metacognitive and strategic reading skills, skills that are weak among individuals with dyslexia. Thus, reading disabled individuals show difficulties in domains such as navigation and information search which are based on reading hypertext. Several characteristics of digital environments may also exacerbate the difficulties experienced by ADHD students in sustaining attention during reading tasks. This is apparent when tasks require comprehension of lengthy text, when the learning material is difficult, and when the study period is extended. In these conditions the attentional demands are high and have a negative effect on self-regulation of learning in digital contexts (Ackerman & Goldsmith, 2011).

Digital texts, however, can also be adjusted to help the learner. Struggling readers can control font size and line spacing, and readers with attentional difficulties can focus their attention with the help of multimedia elements. Individuals of all ages can benefit from multiple representations of the same information as when multimedia elements are used to support textual information. These elements within digital text draw children’s attention to and increase their engagement in learning and independent reading, and are important when the learner has reading and attentional
difficulties. Considerable research has also shown that technological affordances that allow for independent reading and vocabulary growth, as in e-books, may be helpful for children who struggle with language and literacy because of their home environment, such as children from families with a low socio-economic background, an immigrant status and second language learners (Smeets & Bus, 2015).

An important conclusion derived from this review is that much more rigorous experimental research is needed to understand the challenges that children with different learning profiles face in digital reading and online enquiry. For example, there are more studies on the perceptual affordances of digital reading and less about the higher-level cognitive challenges that individuals with dyslexia experience in this environment. Across both dyslexic and ADHD populations, further studies are needed on text comprehension in digital environments, using balanced study designs and different types of study materials. Moreover, it is important to investigate the influence of long-term learning with digital materials on fluctuations in reading comprehension. To date, there is no longitudinal study that has followed young school children from their first exposure to digital textbooks until they become experienced users of such learning materials. Another age-group that has been neglected in this field is university students with learning disabilities and attentional deficits. How does this population cope with the vast amounts of textual material that they need to read and understand in order to complete a university degree? The current move towards the use of digital textbooks in higher education warrants a closer investigation of digital text comprehension in university students with ADHD and those with other learning difficulties, such as dyslexia.

Despite the scarcity of rigorous research, the implications of the current findings for pedagogical practice are rather straightforward. Students with different learning difficulties are likely to experience difficulties in most forms of digital reading, and like all students, they would benefit from rather versatile support in learning to make best use of constantly changing digital literacy practices and technology in their lives. There is much research yet to be done on the combined effect of the teacher and the digital support strategies on intervention efficacy for students with reading disabilities and attentional deficits.

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Emotional and motivational aspects of digital reading

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Emotions guide our actions and have a profound influence on how we approach, experience and later remember information. This chapter provides an overview of the role of emotions in reading and describes how emotional processes differ across digital and print texts. After introducing what emotions are and how they can be measured, we discuss the influence of text genre on inducing emotions. We further explore the effects of digital texts on the emotional experiences in narrative and expository text reading. We then consider the importance of the reader’s motivational orientation, as it may influence preferences for digital vs. print texts. Finally, we discuss the impact of the communicative and collaborative aspects of digital reading environments on the emotions emerging during reading. It is evident that little is known about the impact of digitalisation on emotional processes during reading, and more theory-based research is needed.

1. Introduction

Readers often experience a host of emotions while reading. One factor that influences these emotional experiences is the genre of text being read. The emotions experienced while reading literature can differ greatly from those experienced when reading a textbook. On the one hand, literary scientists have approached reader emotions mostly from the perspective that literary texts are written to induce emotions in the reader, either by form or by content (Miall & Kuiken, 2002). Of particular interest has been how readers become immersed in the story (e.g., Douglas & Hargadon, 2001), such that they are engaged with the text and
transported to the story world. Educational scientists, on the other hand, have approached reader emotions from a different perspective. Their interest lies in understanding how readers learn from texts, and they focus on how the cognitive processes related to learning and emotions are intertwined (e.g., D’Mello & Graesser, 2012). As both text genres and the approaches used to examine emotions in each genre differ, we discuss emotions and the influence of digitisation on emotional process separately for literary and for expository texts.

In order to identify how emotional processes are influenced by the medium of reading, we must first understand how digital reading differs from 'traditional' print reading. One way that digital texts differ from print texts is that they can be structured as hypertexts in which readers navigate from the original document to an infinite number of other documents. Both literary and expository texts can be structured as hypertexts: hypertext novels allow readers to construct their own story by selecting from alternative story lines. Expository hypertexts such as Wikipedia allow the reader to navigate through multiple documents. In addition, digital texts may contain multimedia such as sound and dynamic visualisations that are not found in traditional print media. Yet another difference is in the technology: digital texts may be presented on a computer screen, a tablet, an e-reader, smart phone, or even via virtual reality goggles. These technologies may change the perceptual and haptic experience of reading, which in turn may impact emotional processes during reading.

Readers’ attitudes and prior experience with digital reading environments are also likely to have an impact on the digital reading experience. Further, the motivational orientation (Deci & Ryan, 1985; Sweet, Guthrie, & Ng, 1998) of the reader may be important in choosing preferred reading media. Finally, as people use more technology in their everyday lives, reading has become a more social, interactive activity. Social media is often used to find interesting blog posts and newspaper articles, and a lot of people engage in sharing and commenting. This interactive aspect of reading has an impact on emotional processes as well.

Despite the strong involvement of emotions in reading across genres, there is little empirical research on the influence of digital media on emotional and motivational processes. In the present chapter, we provide an overview of the role of emotions in reading, and describe how emotional processes might be different in digital reading environments when compared to traditional printed media. We first briefly describe what emotions are, and how they usually are measured. We then review emotional processes during literary and expository text reading, particularly in the context of digital texts. Finally, we explore the motivational aspects of digital reading, and consider reading in the context of online collaboration and communication.
2. What are emotions and how are they measured?

Basic emotions refer to discrete emotional states such as happiness, sadness, fear, anger, disgust, surprise and interest, which are thought to have a specific and fixed set of neural and bodily expressions (see Tracy & Randles, 2011). Defining what is meant by ‘emotion’, however, is not a simple task, as there are several different theoretical views of what even the basic emotions are (see e.g., Ekman & Cordaro, 2011; Izard, 2011; Levenson, 2011; Panksepp & Watt, 2011) or whether they exist at all (Kagan, 2010). According to one view, emotions are multi-component responses to opportunities or challenges that are relevant to the individual’s goals (see Oatley, Keltner, & Jenkins, 2006). Within this perspective, an emotion has multiple components: (a) a conscious mental state with a recognizable feeling directed toward an object (e.g., happiness about seeing a friend); (b) a bodily change (e.g., increased heart rate); (c) recognizable expressions of face, tone of voice or gesture (e.g., smile); and (d) a readiness for action or social interaction, (e.g., readiness to approach a friend and give a hug). Emotions are related to, yet different from moods. Emotions or emotion episodes typically last a brief and limited amount of time, from seconds to minutes, whereas moods typically refer to a maintained state of emotion that may last hours, days or even weeks. Also, emotions tend to be triggered by a specific object or event, whereas moods need not have a specific object and one may not even be able to identify what triggered his or her mood. Both moods and emotions fall under the umbrella term ‘affect’.

A central component of many theories of emotion is appraisal. This refers to a process in which an event is evaluated with respect to its novelty, valence, and its relevance to an individual’s goals or needs (see Ellsworth & Scherer, 2003). Appraisal is a continuous process and the emotional experience changes as reappraisal – and conscious cognitive processing – takes place. For example, something that initially triggered fear, characterised by negative valence and high arousal, may be later experienced as a more complex emotion of excited curiosity. The changing nature of the emotional experience poses challenges to measuring emotions.

Measuring the emotional state of a person is one of the most difficult tasks in affective science (see Mauss & Robinson, 2009). Suggested methodologies include questionnaires, psychophysiological measurements, coding of facial, gestural and vocal responses, and brain imaging techniques. An often used questionnaire is the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988), in which respondents are presented with a list of 20 emotion words and asked to rate on a 5-point scale how much of the specific emotion they have experienced in a given time frame. Emotional experience can also be measured non-verbally, using pictorial assessment such as Self-Assessment Manikins (SAM; Bradley & Lang, 1994). In SAM, respondents are presented with pictorial representations of
human figures that vary in three dimensions relevant to the emotional experience: pleasure (i.e. valence), arousal and dominance. For example in the pleasure dimension, the pictures range from a smiling face to a frowning face, with more neutral expressions in between; and in the arousal dimension, pictures range from a sleepy and calm figure to a wide-eyed, excited expression. The task is to choose the image that best describes the respondent’s own reaction.

Sometimes psychophysiological measures related to the activation of the autonomic nervous system (ANS), usually based on electrodermal or cardiovascular responses, are used to examine emotional reactions. Measures such as skin conductance, skin temperature, respiratory activity, heart rate variability, pupil dilation, and blood pressure can be used as indices of ANS activity (see Kreibig, 2010). One problem with these measures is that while they reflect the valence and arousal dimensions of the emotional reaction, they might not be sensitive to the distinct emotions (Mauss & Robinson, 2009).

In addition to the psychophysiological changes, the recognisable changes in facial expression (Ekman & Friesen, 1978), tone of voice (Augustine, Srinivasan & Richards, 2015; Eyben, Wöllmer, & Schuller, 2009) or gesturing (Westlund, D’Mello, & Olney, 2015) that may reflect emotions can be systematically observed. Facial muscle activity, namely the activation of muscles related to the furrowing of the eyebrows (corrugator supercilii) and smiling (zygomatic major) can be measured with facial electromyography (EMG). The Facial Action Coding System (FACS; Ekman & Friesen, 1978) can be used to analyse facial micro expressions, and there are software tools that utilise the coding scheme to automatically analyse facial expressions in still images or video (e.g. El Kaliouby, Kodra, Jha, & Mediratta, 2014; Loijens, Krips, van Kuilenburg, den Uyl, Ivan, et al., 2014). The problem with facial expressions is that while they do seem to reflect the valence dimension of an emotional reaction, there may be individual differences related to e.g., gender, culture, age, and the social context (Mauss & Robinson, 2009).

Different complex emotions emerge in different parts of the brain and involve partly specific, partly overlapping neural networks (Koelsch et al., 2015; Saarimäki et al., 2016). Brainelectrical and neuroimaging techniques such as EEG, fNIRS or fMRI can thus be used to study emotional processes (see e.g., Lindquist, Wager, Kober, Bliss-Moreau, & Barrett, 2012, for a review). Indeed, brain activity in emotion-related networks has been used to measure emotional engagement when reading stories (Hsu, Conrad, & Jacobs, 2014; Hsu, Jacobs, Altmann, & Conrad, 2015; Hsu, Jacobs, Citron, & Conrad, 2015).

In summary, measuring emotions is not a simple task, as different theoretical views do not converge on what an emotion is. Moreover, the nature of the emotional experience may be constantly changing as reappraisals of the situation...
occur. Despite these challenges, different methodologies such as questionnaires, psychophysiological measurements, coding of facial, gestural and vocal responses, and brain imaging techniques have been used to tap into the different aspects of emotional experiences.

3. Emotions in literary text reading

Even simple stories can induce emotions and recognisable emotional bodily sensations (e.g., Nummenmaa, Glerean, Hari, & Hietanen, 2014). Nummenmaa et al. (2014) presented aural short stories that induced subjective feelings of so-called approach-oriented emotions – anger and happiness – and found that listeners consistently reported increased activity in the upper limbs as part of this experience. Conversely, story-induced sadness was accompanied by decreased activity in the upper limbs. Short poems, much like songs or movie clips, can also induce very specific moods of short durations (Lüdtke, Meyer-Sickendieck, & Jacobs, 2014). Research further shows that readers keep track of story characters’ emotional states (e.g., De Vega, Leon, & Diaz, 1996; Gernsbacher, Goldsmith, & Roberston, 1992; Gernsbacher, Hallada, & Robertson, 1998; Gygax, Oakhill, & Garnham, 2003; Komeda & Kusumi, 2006), and even short stories describing the emotional status of a story character engage brain areas related to emotional processing (Ferstl, Rinck, & von Cramon, 2005).

Interestingly, it is possible to evaluate the potential a text has to induce an emotional reaction in the reader on the basis of the individual words used in it (Jacobs, 2015b). Previous research shows that emotionally valenced words (Bradley & Lang, 1999; see also Montefinese, Ambrosini, Fairfield, & Mammarella, 2014; Redondo, Fraga, Padrón, & Comesaña, 2007; Söderholm, Häyry, Laine, & Karrasch, 2013; Vö, Conrad, Kuchinke, Urton, Hofmann, & Jacobs, 2009), such as ‘happy’ and ‘death’, typically produce faster responses in a variety of explicit and implicit tasks (e.g., valence decision, lexical decision) than do neutral words such as ‘table’ (for review see Citron, 2012; Jacobs et al., 2015; cf. also Ponz et al., 2013), and during sentence reading, emotionally valenced words are read faster than neutral words (Knickerbocker, Johnson, & Altarriba, 2014; Lüdtke & Jacobs, 2015; Scott, O’Donnell, & Sereno, 2012). The valence and arousal values of individual words within a passage can be used to evaluate the different dimensions of the emotion potential of text: while mean valence and arousal values across the whole passage reflect the global emotion potential, the variance of these values can be used to evaluate the valence or arousal span. A mixture of negatively and positively valenced or low and high arousal words – i.e. a wide emotion span – can induce feelings of surprise, interest or suspense in the reader (see Jacobs, 2015b).
In other words, the emotional experience of reading literary text (see Miall, 2004) is at least to some degree attributable to the lexical features.

Emotional experiences during literary reading are often described at four levels: evaluative, aesthetic, narrative or self-modifying (see Miall & Kuiken, 2002). A literary piece evokes emotions by its contents and form, which contribute to the understanding as well as to the enjoyment of it. Evaluative feelings refer to the emotions induced by the interpreted text and the reading activity itself: readers may experience pleasure, enjoyment and satisfaction of reading. Artefact emotions or aesthetic feelings (Miall & Kuiken, 2002; Tan, 1996) are triggered by the formal aspects of text, and they serve to capture and keep the readers’ attention. For example, if a writer has an exceptional writing style, readers may experience e.g. interest, fascination or surprise (Tan, 1996, 2000). Fiction emotions (Tan, 1996) or narrative feelings (Miall & Kuiken, 2002) refer to emotions deriving from comprehending the plot or feeling at one with the characters. Empathy and sympathy are typically classified as narrative feelings (Miall & Kuiken, 2002). Sympathy refers to feelings when the reader is a witness in a fictional scene, understands how it concerns a story character and then has emotional reactions to that character. Empathy means that the reader takes up the character’s psychological perspective and imaginatively experiences what he or she experiences. In their model of narrative engagement, Busselle and Bilandzic (2009) highlighted the importance of such perspective-taking for the reader to understand the motivation behind the actions of the characters of the story and to follow the plot.

Both empathy and sympathy impact emerging emotional processes during literary reading. Sympathy seems to be related to the activation of personal memories: Cupchik, Oatley and Vorderer (1998) showed that after following instructions to be a spectator during reading (i.e., to adopt a ‘sympathetic perspective’) readers reported remembered emotions more often than fresh emotions. Empathy with a fictional character opens the way for identification (Coplan, 2004). During identification readers adopt the characters’ “goals, run their actions on our planning processes, and discover these plans meeting vicissitudes” (Oatley, 1994, p. 66). Empathically engaging with characters in such a way may maintain and sharpen empathic skills (Cupchik, Oatley, & Vorderer, 1998). Indeed, Altmann, Bohnr, Lubrich, Menninghaus and Jacobs (2012) showed a positive correlation between empathic ability scores (Davis, 1983) of readers and connectivity between brain areas associated with mentalising and emotion when comparing the reading of neutral and negatively valenced stories. Empathy also opens the possibility of self-modifying feelings, i.e. shifts in the way the reader perceives him or herself, when certain changes happen in the reader’s own self-interpretation through metaphoric identification with the story characters (Miall & Kuiken, 2002).
The personality of the reader plays an important role in how literary texts induce emotions as well, e.g., through feelings arising when the reader is reminded of personal experiences from the past (see Seilman & Larsen, 1989). For example, the trait ‘Openness to new experiences’ correlates with emotional experiences related to artistic objects (Furnham & Chamorro-Premuzic, 2004) and may aid perspective-taking, enabling readers to place themselves in the shoes of fictional characters (Taylor & Carlson, 1997).

It has been suggested that readers of fiction who meet artistic simulations of social problems in books tend to have better abilities of empathy and theory of mind and perform better in social reasoning tasks (Mar, Dijkic, & Oatley, 2008). In an attempt to test these ideas in an experimentally controlled setting, Dijkic, Oately and Moldoveanu (2013) examined whether exposure to fiction increases empathy in readers. The results were puzzling: fiction seemed to increase empathy in readers with low levels of Openness to new experiences, and decrease empathy in readers with high levels of Openness. Thus, while there seems to be a correlation between exposure to literature across the lifetime and empathetic abilities (Mar et al., 2008), one should be careful in making causal inferences.

In summary, even short narratives can induce emotions in the reader, and the emotional experience could be partly attributed to the features (i.e., valence and arousal) of the words used in the text. More generally, literary texts induce emotions in the reader by their contents and form, and there are individual differences in how readers experience feelings, such as empathy.

4. Immersion in digital literary reading

During literary reading, readers may become so absorbed by the text that they feel transported to the fictional world. These episodes of ‘total’ attention fully engage readers’ representational (i.e., perceptual, enactive, imaginative, and ideational) and emotional resources (Tellegen & Atkinson, 1974). With changing technology, the modes of reading and, as a consequence, the possibility of immersion might change. Understanding how different modes of presenting literary texts impact immersion is important because without being immersed in the fictional world during reading the reader is less likely to be touched by the work of art and its enjoyment is lower (see e.g., Miall & Dobson, 2001). Moreover, one could claim that the immersed reader is more likely to experience narrative feelings (empathy, sympathy) during reading. In the present discussion, we explore the influence of technology on immersion within the context of digital hypertexts.

Literary hypertexts differ from traditional print in that the structure of the text is not necessarily linear, as readers have the opportunity to choose among
different hypertext links and, thus, follow their own path within the hypertext. The development of the character’s traits, the plot, and the plot outcome all depend on the choices the reader makes while navigating through hyperfiction. It is precisely the stability of the fictional characters’ traits, the inflexibility of the plot’s outcome (Gerrig, 1993) and the fictional world’s narrative realism (Green, 2004), however, that contribute to higher immersion. Thus, it might be that hypertext environments do not support immersion. On the one hand, Douglas and Hargadon (2001) assume that hypertexts can lead to immersion, which is based on slightly different mechanisms than in the case of printed texts, such as story-driven reading, agency, role-playing and interaction. On the other hand, Ryan (2001) suggests that hypertexts may disrupt immersive experience “because every time the reader is asked to make a choice she assumes an external perspective on the worlds of the textual universe” (p. 20). Thus, as hypertexts require readers to interact with the text by choosing which links to follow, the immersive experience is likely to be different from that when reading printed texts.

Another difference between digital hyperfiction and traditional print is that, in addition to text, hyperfiction may include sound or dynamic visual images, and can be presented in a virtual reality environment. A recent review of emotion-related neuronal responses to different media (words, narratives, pictures, sounds, videos or virtual reality) concludes that immersion is a crucial modulator for emotional responses in different media types and that the ‘immersion potential’ of media is a function of both their realism and complexity (Schlochtermeier et al., 2015). In other words, hyperfiction that includes graphics and sounds is potentially more immersive than traditional print.

In a systematic literary analysis of one section of Caitlin Fisher’s hyperfiction Waves of Girls, Miall (2004) examined the effect of the design of links, graphics and sounds on readers’ feelings (see Miall & Kuiken, 2002). They hypothesised that since hyperfiction reading is story-driven, narrative feelings must play a significant role in the readers’ experiences. However, they noted that when “linked sequences of lexias provide only a brief focus on a given character or setting” (Miall, 2004), which is mostly the case in hypertext literature, it is likely to undercut narrative feelings. They further observed that when the author displays a lyrical style, aesthetic feelings can be equally aroused; however, when the reader is directed to new links, one lexia after another, she may experience “a kaleidoscope of aesthetic feelings rather than an emerging and meaningful pattern” (Miall, 2004). Deep, phenomenologically immersed reading in the hyperfiction context, according to Miall, is unlikely due to the rapidly changing (emotional) focus of the reader. Thus, self-modifying feelings are also unlikely to occur. It is only the experienced readers of hyperfiction who are prepared for the linking structure of digital text, and enjoy putting together the puzzle of different information, who experience
the evaluative feelings that are the sources of pleasure in reading. Inexperienced hyperfiction readers may experience fewer evaluative feelings and miss out on the consequent pleasure of reading.

Miall and Dobson (2001) also investigated readers’ experiences during reading of hypertexts and linear text. In their study, Elizabeth Bowen’s “The Demon Lover” and Sean O’Faolain’s “The Trout” were presented on a computer screen either in a structurally linear form or in hypertext form. In the hypertext form, links were placed on words or phrases that were related either to the plot, a character, or stylistic features of the story. Non-experienced readers of hyperfiction reported feeling either confused, or feeling like they must have missed something after using links. For these readers, the evaluative feelings in general were not of enjoyment. Participants who reported pleasure in the hypertext condition commented on the puzzle game-like quality of hypertexts and also a greater sense of control through linking. Narrative feelings were disrupted, however, because 75 per cent of the participants who read the hypertext version complained about difficulties following the narrative and that their reading patterns became fragmented due to the links. Readers’ emotions and the identification with the characters were significantly lower in the hypertext condition and belong rather to the category of generalised comments of involvement as opposed to the more specific and emotionally charged experiences of the linear readers. The authors concluded that “…hypertext, as a vehicle for literary reading, seems to distance the text from the reader. The absorbed and personal mode of reading seems to be discouraged” (Miall & Dobson, 2001).

Finally, the intangibility of digital texts may influence the immersive experience of reading. The printed book is a physically and functionally unitary object in which the content cannot be distinguished from the material part (Mangen, 2008). It can grab our full attention and is designed to exclude any other distinctive perceptual or cognitive surplus, which has the potential to guarantee phenomenological immersion. The digital text, by contrast, is designed to facilitate technological immersion with its intangibility, changeability, and special features that split the attention and encourage scanning. This feeling of virtuality is heightened by not sensing or seeing the page by page progress through the digital text, which diminishes the overview of the text organisation. The experience of reading a digital text is further affected by clicking and scrolling, which may distract the readers’ attention and give the leading position to haptic experience over perceptual and cognitive (see Mangen, 2008). This might be only true, however, as long as these processes (e.g., scrolling) are novel and require conscious control.

Mangen and Kuiken (2014) were the first to empirically compare the immersive experiences during reading the same texts in print and on a tablet. They used the Narrative Engagement Scale to measure immersion and developed an Interface
Interference Questionnaire to detect haptic dissonance, a sense that something is missing or is awkward in the reading experience while using a tablet. Their results suggested that tablet readers felt stronger dislocation within the text and awkwardness in handling the medium independently of having a previous experience with the device. However, only when the short narrative text was labelled as ‘non-fiction’ did the readers report the attenuation of narrative engagement while reading on a tablet. When the same short text was introduced to readers as ‘fiction’ there was no evidence of differences between digital and print reading. Thus, results highlight the importance of genre for readers’ emotional engagement with digital texts.

In summary, while it seems plausible that immersion may be influenced by the typical characteristics of digital texts, there is very little research conducted on the emotional engagement during reading of digital and print texts. The existing research suggests that prior experience with literary hypertexts is important in whether immersion is disrupted by the links and the multimodal material often present in hyperfiction.

5. Emotions in expository text reading

Text genre influences how readers approach text information (Zwaan, 1994) and is likely to impact their emotional engagement with text during reading (Mangen & Kuiken, 2014). Expository texts are usually written to convey information and, unlike narrative texts, expository texts often present unfamiliar content, explained through abstract logical relations (Stein & Trabasso, 1981). Apart from the complexity of ideas, the structure of expository texts can vary: information may be presented in sequence, as a description, in a compare-contrast or problem-solution format, as causal chains (Meyer & Freedle, 1984; Meyer et al., 2002; Simonsen, 1996) or as a combination of these. As expository texts are often read for the purpose of learning novel information, readers employ different processing strategies during reading of expository texts than they do during reading of narratives: factual details are of central importance in expository texts, whereas in narratives readers concentrate more on general thematic information (McDaniel & Einstein, 1989). Whereas literary texts are thought to provoke emotions mainly by their structure and content, the emotional processes during expository text reading are likely to arise from the cognitive processes related to learning. Instead of being ‘immersed’ in the story world, a reader of expository text might be more or less engaged with the learning task, which has implications for the emotions arising during reading.

The Control-Value Theory of Achievement Emotions (see Pekrun, 2006; Pekrun, Frenzel, Goetz, & Perry, 2007; Pekrun & Perry, 2014) describes how emotional and
cognitive processes are intertwined during learning tasks, including reading. At the core of the theory are achievement emotions, which are related to the learning outcomes (e.g. pride in a good grade) or learning activities (e.g. excitement of learning new things). Achievement emotions can be categorised along three dimensions: object focus (outcome vs. activity), valence (positive vs. negative) and activation, which refers to the arousal level (activating vs. deactivating). Achievement emotions are influenced by appraisals of control and value. These emotions influence the use of learning strategies, available cognitive resources, motivation, and self-regulation of learning, all of which are related to the learning outcomes. For example, if the reader’s focus is on the activity of learning new facts, a positive activating emotion of enjoyment may arise during reading. This, in turn, impacts the strategies utilised, and may result in good learning outcomes. In contrast, if the reader’s focus is on getting a good grade on an exam, the reader may experience anxiety, which is a negative activating emotion. This influences the available cognitive resources and may have negative consequences for learning.

Along these lines, Mills, D’Mello and Kopp (2015) found that if readers focused on the outcome (“I need to learn these things”) and it was given a high consequence value (“so that I will get out of here faster”), they experienced lower valence and higher arousal. This, in turn, was related to longer reading times and better learning outcomes. Arousal mediated the strength of the link between consequence value and knowledge transfer but only when the texts were difficult. In sum, the control-value theory of achievement emotions explicates how emotions arise in the learning environment as a result of appraisal processes, and how emotions impact learning and achievement. The theory also posits that learning processes and achievement outcomes may have further impact on the learner’s emotions.

The mood of the reader has an impact on how readers process and also remember text information. Bohn-Gettler and Rapp (2011) examined how happy, sad, and neutral moods influence the type of inferences the readers make during reading of expository texts. They found that readers in a happy mood were more likely to engage in text-based inferencing, which is thought to increase the coherence of the text representation. Readers in either happy or sad moods were more likely to paraphrase parts of text they were reading, and also had better memory for important details in text, than readers in neutral mood.

The Control-Value Theory of Achievement Emotions has recently been expanded to cover epistemic emotions, which are thought to be evoked by epistemic beliefs (i.e. beliefs about the nature of knowledge) the reader holds (Pekrun, Vogl, Muis, & Sinatra, 2016). According to this view (see Muis, Pekrun, Sinatra, Azevedo, Trevors, Meier, & Heddy, 2015), readers may experience surprise, curiosity, enjoyment, confusion, anxiety, frustration or boredom during learning
activities, depending on their topic-specific epistemic beliefs. For example, readers who believe that knowledge about climate change is uncertain experience less anxiety and frustration when they encounter conflicting information about the consequences of climate change (Muis et al., 2015). Emotions guide the comprehension strategies utilised during reading, which then influence learning outcomes. Confusion, surprise, and positive activating emotions (enjoyment and curiosity) increase the use of deep processing strategies, and negative activating emotions (anxiety, frustration) increase the use of shallow processing strategies. Negative deactivating emotions (boredom) decrease the use of any type of strategies. Deep processing strategies are thought to have a positive, and shallow processing strategies a negative, impact on learning outcomes.

The Control-Value Theory of Achievement Emotions (Pekrun, 2006; Pekrun et al., 2007; Pekrun & Perry, 2014) can be applied to examine the impact of digital environments on emotional processes during reading, as it explicates the roles of learning environment and the reader’s appraisal of the learning task in the emotional experience. For example, it could be hypothesised that if the digital learning environment offers features such as enhanced interactivity during the learning task, personalised instruction, and rapid feedback, positive activating emotions (enjoyment and curiosity), effective learning strategies and good learning outcomes could be expected.

Indeed, there is some evidence suggesting that advanced learning technologies, such as intelligent tutoring systems, educational games and simulation environments, can increase experiences of emotions that are beneficial for learning (D’Mello, 2013). The results of a meta-analysis of emotional experiences during learning with different technologies showed that engagement/flow, boredom, confusion, curiosity, happiness, and frustration were the predominant affective states during learning tasks. Importantly, advanced learning technologies enhanced experiences of flow and engagement and decreased experiences of boredom and frustration when compared to simpler computer interfaces.

D’Mello and Graesser (2012) examined learners’ transformations through different emotional states (flow, confusion, frustration, boredom, delight, surprise, and neutral) while interacting with AutoTutor, a digital learning environment. They found that confusion (supposedly caused by a mismatch between learner’s prior knowledge and learning material) was either followed by successful resolution of the conflict and return to a state of ‘flow’, or frustration, which could be followed by boredom if the reader failed to solve the conflict. However, D’Mello and Graesser did not link the transitions between emotional states to actual interaction events with the AutoTutor, nor did they assess learning outcomes. Nevertheless, the results imply that emotions play an important role when reading expository texts in digital environments.
In summary, emotions that arise during expository text reading are closely intertwined with the learning processes, as the reader’s appraisals of the learning task influence the experienced emotions. One important aspect of the appraisal processes, and thus the emotional experience during reading of expository texts, is the motivational orientation of the reader (Pekrun, 2006; Pekrun et al., 2007; Pekrun & Perry, 2014). If designed carefully, with optimal matching of an individual and the learning content, then digital environments have the potential to positively influence the motivation of the reader.

6. Motivational aspects in digital reading

As we discussed, literary and expository texts may induce different types of emotional processes. Further, readers are likely to approach expository and literary texts with different motivational orientations. Readers can be driven by intrinsic or extrinsic motivation (Deci & Ryan, 1985; Sweet, Guthrie, & Ng, 1998). Intrinsically motivated readers deliberately seek opportunities to engage in reading. They enjoy reading for itself and experience immersion during reading frequently. Extrinsic or goal-oriented motivation includes external factors that make the reader engage with a text.

The motivational orientation of readers may be important in determining whether they prefer reading in digital or printed texts. In a study by Rockinson-Szapkiw et al. (2013) students could choose which textbook format they would prefer to prepare for a course exam. The majority of students (80.3%) chose to use traditional print textbooks due to portability, familiarity, useful features such as note taking, their difficulty reading from the screen and individual learning style. Lower costs were mentioned as a decisive factor both in choosing traditional and e-book format.

Chen and Granitz (2012) used qualitative analysis to identify readers’ attitudes toward printed and digital books as well as toward a future shift in product form. Participants frequently mentioned the role of aesthetics, immersion and escape in connection to printed books. They also reported that e-books take away social bonding experiences and the feeling of ownership and also mitigate identity construction because others cannot see the types of books that people possess. These subjective interviews confirmed the felt changes (lacks) in sensory (e.g. tactile and olfactory) experiences that the shift from paper to digital involves (see also Mangen, 2008).

In contrast, digital media such as e-books allow for a wide range of individualised reading experiences. Larson (2015) argued that the special features of e-books (including audio narration) may increase their likeability. In the study, the
majority (81%) of students, who were provided with assisted teaching on how to use e-books, reported that they preferred reading e-books over print texts, because their concentration and interest was increased (see also Miranda, Williams-Rossi, Johnson, & McKenzie, 2011).

People are also likely to prefer different media for different types of reading activities. Sellen and Harper (2002) analysed work activities in office settings and identified a pattern a document goes through in everyday routine: digital for searching, paper for integrating multiple sources, paper for planning, digital for drafting, paper for editing/proof reading, digital for finalising, mostly digital for distribution and workflow, paper for reading (especially longer documents) and digital for archiving/filing (Fortunati & Vincent, 2014, p. 39). In Fortunati and Vincent’s conclusion this analysis revealed a close intertwining of paper and digital versions of the same text. The readers’ motivations also play a crucial role in choosing printed versus digital form: if reading for pleasure the paper support is preferred, if the text requires strategic reading the screen is preferred, because readers can rely on all the applications connected to a computer.

Previous research suggests that there are age differences in the attitudes toward digital technology: primary school children prefer to read printed texts, whereas those in secondary prefer digital texts (McGeown et al., 2016). College students still choose printed books over e-books to learn (Woody, Daniel, & Baker, 2010; Rockinson-Szapkiw, Courduff, Carter, & Bennett, 2013; Stone & Baker-Eveleth, 2013). Tveist and Mangen (2014) also found gender differences among secondary-school students: boys were more likely to prefer reading on the e-reader. We can conclude that a positive digital attitude (Thorvaldsen, Egeberg, Pettersen, & Vavik, 2011) and a preference to use the computer for different purposes is most widespread among teenagers. However, it is important to note that while teenagers mainly use computer and digital devices for social purposes, avid readers from this generation still prefer printed books (Tveist & Mangen, 2014).

In summary, a reader’s motivational orientation is important in whether digital or traditional printed form for text is preferred. Moreover, different media are preferred for different types of reading tasks. For example, a digital format is probably preferred for reading in social media, whereas traditional print form may be preferred for textbooks.

7. Digital reading as a part of communication and collaboration

In digital environments, reading is often an interactive activity. For example, people read news articles, blogs, Facebook posts and tweets, and often respond to these by commenting or replying. The comments and replies are read by other
people, subjected to further commenting, and so on. Earlier studies showed that up to 30% of electronic communication is emotional or socio-emotional in nature (Rice & Love, 1987). Emotions can be expressed in text with emoticons. Research suggests that the use of emoticons embedded in texts is not random; they are used in a similar way as emotions are manifested in oral communication (Provine, Spencer, & Mandell, 2007).

Emotional states can be transferred to other people without their awareness. This phenomenon is called *emotional contagion* (Hatfield, Cacioppo, & Rapson, 1992). An interesting finding is that emotional contagion effectively takes place in digital environments, without face-to-face contact and in the absence of any non-verbal cues. In a massive study examining emotional contagion in Facebook, it was found that if people received less positive posts in their newsfeed, they were less likely to post positive news and more likely to post negative texts on their own wall (Kramer, Guillory, & Hancock, 2014). These results demonstrate that digital texts that contain emotionally loaded content influence how people feel and interact in digital environments.

Emotionally loaded comments can also impact belief formation, and exposure to strongly emotional argumentation such as *uncivil language* (e.g. “Whoever says this kind of crap is a complete idiot!”), which is unfortunately common in social media, may bias people's opinions on the topic. In a large-scale study on risk perception of nanotechnology (Anderson, Brossard, Scheufele, Xenos, & Ladwig, 2014), it was found that if a newspaper article on nanotechnology was accompanied by uncivil commentaries of other readers, readers' views about potential risks of the technology were polarised. The impact depended on how strongly readers supported the issue and on the religiosity of the reader. Uncivil commentaries caused high-supporters to downplay and low-supporters to emphasise the potential risks. Highly religious readers saw nanotechnology as more risky if they were exposed to uncivil in comparison to civil commentaries on the topic. In other words, some readers seem to be more prone to the emotional biases in digital environments than others.

Thus, interacting in a digital environment poses novel challenges to readers, requiring strong socio-emotional skills. That is, readers must understand social rules and appropriate behaviour in digital environments and recognise potential privacy threats and pretentious actors (Eshet-Alkali & Amichai-Hamburger, 2004). Demonstration of socio-emotional skills within a digital environment is also thought to require a good command of advanced digital literacy skills (see Chapter 4 in this volume, Eshet-Alkali & Amichai-Hamburger, 2004), and to differ as a function of age and experience with digital environments. For example, college-age students showed better socio-emotional skills than high school students or adults (Eshet-Alkali & Amichai-Hamburger, 2004), suggesting that both
digital literacy skills and also experience is crucial in understanding social rules and appropriate behaviour in digital environments.

An important aspect related to the socio-emotional skills required in interacting in digital environments is *ethical knowledge*, which can be defined as knowledge related to privacy, respect for others, and knowledge of technology’s socio-cultural implications (Calvani, Fini, Ranieri, & Picci, 2012). In a survey of Italian adolescents (Calvani et al., 2012), only 61-62% of the respondents gave correct answers to questions on sharing private information in internet and about online payments. A fairly low percentage of the respondents knew how to correctly quote information found in the internet (59%). A much higher percentage of the respondents (76%) correctly recognised offensive comments.

In summary, reading in digital environments may be interactive in nature, meaning that readers respond to and comment on the texts they read. The distinction between an author and a reader becomes diffuse, as reader comments become part of the text. This poses challenges to the reader, as we all are prey to emotional contagion and biases induced by uncivil language. Readers should possess the necessary socio-emotional skills and knowledge to act appropriately in interactive reading environments.

8. Future directions

In this chapter, we reviewed theoretical and empirical work on emotional and motivational processes during reading, with an emphasis on digital reading. As reading in digital environments often entails communication and collaboration, we also touched on the emotional aspects of reading within communicative and collaborative digital contexts. It is evident that relatively little is known about emotional processes during reading, and even less about the impact of digitalisation on these processes. However, understanding of how emotional processes change when reading is transferred from traditional print context to digital environment is important and should be grounded in theory. The Control-Value Theory of Achievement Emotions (Pekrun, 2006; Pekrun et al., 2007; Pekrun & Perry, 2014) briefly presented in this chapter provides one such promising framework for understanding the interplay between emotions and reading comprehension (for more theoretical views see e.g. Bohn-Gettler & Rapp, 2014; Jacobs, 2015a,b).

One way in which digital environments differ from traditional print media is that digital environments support the use of hypertext. To understand how hypertext influences emotional processes during reading, research should continue to compare reading of linear texts and hypertexts. In addition, a potential
future direction would be to examine the factors that support a positive hypertext reading experience. For example, the dictionary function that allows a reader to check the correct translation of a term might lead to deeper understanding of the text being read than any analogue book, especially when reading in a foreign language (see Ben Yehuda et al., this volume). Hypertext may also be accompanied by multimedia presentations that can enhance immersion and building of a good mental model. The ingredients of a positive hypertext reading experience likely depend on text type too: in literary texts, a positive hypertext reading experience could mean high immersion; in expository texts, learning outcomes could be used as criteria.

Reading on an e-reader, a tablet, a computer screen or a good old fashioned hardcover are all very different types of reading activities. As readers are likely to prefer different media for different reading purposes, the emotional experience may depend both on the type of device as well as on the type of reading material. The same person might prefer reading a poem in a leather-bound book, a novel as an e-book, but would choose hypertext documents when preparing to write a paper for a course work. Why readers choose certain type of media for certain purposes is an open question. The motivational orientation of the reader, which may vary depending on the reading task at hand, may be important. The interaction between media and the type of text in the emotional experience during reading is one obvious topic for future research.

Finally, readers are likely to have different degrees of prior exposure and experience with different types of media, and this may have a significant impact on the emotional experience. A common assumption is that ‘digital natives’ that have grown up with digital technologies would be more skilful and feel more comfortable with novel technologies. At the same time the digital divide between those who have access to and interactions with technologies and those who do not is becoming more prominent. Thus, instead of cross-sectional comparisons between different age groups or simple comparisons between different media, one should control for the amount of prior exposure and experience with the type of media being investigated. Longitudinal studies are needed to fully understand how digital media influences emotional and motivational aspects of reading.

Empirical studies will benefit from methodological development, namely, triangulation of different methods to gain better understanding of the reading process. Brain imaging methodologies will offer insights into the nature of the emotional processes occurring during reading (Jacobs, 2015b). Moreover, combinations of methodologies that allow examining reading in relatively ecologically valid conditions while providing extremely good temporal accuracy of the reading process, such as combining eyetracking with EEG, psychophysiological measures, facial expression analysis, and limb and body motion capture, will yield rich data
on which emotional reactions can be time-locked to unfolding of the text as the reader navigates through it.

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CHAPTER 7

Literacy education in the digital age

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Beginning readers in the early 21st century have unprecedented access to digital books and reading materials that provide them, and the adults supporting them, with many opportunities as well as many challenges. In the present chapter, we consider children’s early literacy experiences in a digital world. We review research on the influence of digital texts on early reading and explore how digital technologies are being integrated into educational literacy practices, both in the preschool and school age years. The success of this integration necessitates attention to multiple parts of the educational ecosystem, from individual learners to educators, and through to local and national educational policy.

1. Introduction

A critical concern in the field of early childhood education is how to teach children the skills they will need to participate in a changing literacy landscape. Print literacy continues to be highly valued in early childhood classrooms. As the use of digital technologies increases and new technologies appear (Guernsey & Levine, 2015), however, children are required to understand information presented on different devices and in different modalities. This presents considerable challenges to parents and early childhood educators who need to find the optimal balance between a more traditional notion of literacy and new literacies.

This chapter explores the impact of digital technology on how children learn to read. First, we review the impact of multimodality and digital books on how children read. We then look at the many challenges schools face as they seek to integrate digital technologies in their literacy education and to find the right balance between print and screen literacy. Finally, we consider the implications for teacher education and further research in the field.
2. The changing literacy landscape and early reading

In order to appreciate the changes taking place in the learning lives of children, it is prudent to consider the diversity of technologies that children engage with from a very early age. The wide range of hi-tech toys, devices (e.g. remote controls, digital TV boxes) and specialised computer software packages specifically developed for young users, have expanded the repertoire of children's home experiences (Zevenbergen, 2007). Traditional storybooks that have long held a significant place in children's early literacy development (Neuman, 1999) are being substituted by electronic sources (Burnett, 2010). Children brought up in such digital environments often explore the functions of technology without being explicitly taught to use them (Marsh et al., 2005; McPake, Plowman, & Stephen, 2013). They learn how to use devices in innovative ways as they incorporate digital technologies in their play (Edwards & Bird, 2015). The influence of digital technologies on children's play is so extensive that even in print-centric, technologically-restricted classrooms, children invoke new technologies using crayons and paper, for example, to create cell-phones and tablets (Wohlwend, 2009).

Through their experiences with a diversity of technologies, children learn to extract meaning from a host of symbols and texts. For example, research by Levy (2009) showed that 3-year-olds learn to interpret meaning from the pictures, symbols, sounds, and colour in digital texts. She found that as children searched for and played games on the Internet, they became familiar with the meaning of different symbols and pictograms, e.g. symbol of Internet Explorer (‘e’) as the source of different games on the Internet, and the symbol of ‘timer’ as the sign for ‘you have to wait’ and ‘don’t touch it’. Children also made sense of textual prompts, like ‘play’ and ‘exit’ in the context of playing video games, despite the fact that printed prompts were not accompanied by any other iconic images. Such use of visual cues and context to aid in word reading is characteristic of the pre-alphabetic stage of reading development (Ehri, 2008), in which children are learning that visual symbols can represent words, but do not yet have letter knowledge. Thus, this pattern of results shows that interacting with digital tools can support the development of the literacy skills necessary for reading both on screen and in print (Neumann & Neumann, 2014).

The exact degree to which children's emerging knowledge of the characteristics of digital text is related to their knowledge of conventions of print reading is currently unclear. Further, little is known about how differences between print and digital texts, such as fixed vs. flexible directionality (e.g. where to start reading, reading from top to bottom, left to right) and traditional vs. more fluid structure (e.g. where is the beginning, middle and end of the story, which word or which page are to be read first), influence children's developing reading skills. One of the
few research studies conducted in this field (Segal-Drori et al., 2010) found that 5 and 6 year-old children from low socioeconomic status families experienced significant gains in their concepts about print after reading an e-book with adult instruction, more so than when they read the e-book independently, or when they read the print book with an adult. The study used print and electronic versions of books that were specifically designed to promote educational development. In the e-book versions, automatic dynamic visuals, intended to bring the story content to life, were activated after reading/listening to the text of the story on each page. The authors reported only score totals for the concepts of print measure, thus it is unclear which specific print-related concepts were developed in each condition. What is salient, however, is that the interaction with digital books aided in the development of literacy skills which are important for reading across modalities. Deserving of future exploration is the role of adults in fostering children’s knowledge about concepts of print across print and e-books.

Indeed, the important role of adults in supporting early experiences with e-reading is highlighted by studies showing the fragmented reading of children who are left alone with digital texts filled with games and hotspots (Bus, Takacs, & Kegel, 2015). Without guidance, children may prioritise the exploration of interactive hotspots and become distracted from focusing on the story itself (de Jong & Bus, 2002). They may be less likely to finish listening to the digital narration and spend the majority of their time clicking on games, illustrations and icons instead of focusing on the story text (de Jong & Bus, 2002). This may compromise comprehension. Therefore, the ability of children to comprehend multimodal texts, and the ways such comprehension can be supported, are important for parents, caretakers, and educators to understand.

3. **Multimodality in early reading**

The experience of multimodality is not an exclusive characteristic of reading in a digital environment. Children growing up with picture books use illustrations to understand the meaning of text. They learn that besides the motivational function, illustrations can serve as an additional resource for meaning-making, particularly before they have learned to decode. According to the Dual Coding Theory (Paivio, 1986), reading illustrated books enables children to connect linguistic and non-linguistic information and develop a more complex representation of the concepts presented in the story (Mayer, 2001). Illustrations provide children with a deeper understanding of the events and the characters of the story as the visual information gives them clues through facial expression, body posture and character actions (Prior, Willson, & Martinez, 2012).
Similarly, in digital texts, the story text is often interwoven with a variety of non-linguistic cues, such as sounds and typeface colours (Flewitt, 2011; Jewitt, 2008). When the non-linguistic cues offered by digital text match the story text, the meaning-making process is enhanced (e.g. Bearne, 2003; Hassett, 2006). Additionally, different interactive elements (such as puzzles, animations, picture zooms, interactive dictionaries, etc.) can help children become actively involved in the meaning-making process. Such elements may also increase children's attention, motivation and engagement. However, as Bus, Takacs, and Kegel (2015) point out, clicking on ‘hotspots’ or games that are incidental to story content may interfere with comprehension. Coordinating simultaneous activities, which demand different cognitive processes or switching between two or more tasks, may distract the child so that s/he misses important story information. Consequently, access to many interactive features inconsistent with the narrative may result in poorer performance of the child when retelling the story (e.g. Labbo & Kuhn, 2000).

Children's experience with different modes of representing meaning may also influence their ability to produce multimodal texts to communicate their own stories. Several exploratory studies on this topic are found in the literature. These include a multimodal text-making project which afforded 4–5 year-old children opportunities to improvise and refine their print literacy practices (McKee & Heydon, 2014), a study of email exchanges initiated by a 6-year old child (Mavers, 2007), and examples of different multimodal texts created by 6–8 year-old children (Bearne, 2009). These studies demonstrate how multimodality affords children opportunities to express themselves even when they are unsure of how to do so in writing.

In summary, exploring the multimodal affordances of digital texts may heighten children's engagement and motivation, and aid their comprehension, particularly before they can read. Further, multimodal text making may offer children new ways of expressing themselves. It is important, however, to be aware of the negative effects of interactive and multimodal elements unrelated to the text that can interfere with children's ability to attend and comprehend. Thus, it is important to understand the influence of digital texts on children's literacy development in both the home as well as in early childhood education settings. The latter context becomes our focus in the following sections.

4. New literacies

The prevalence of digital texts in children's homes and early childhood education settings has brought about a rapid change in the notion of literacy and school literacy practices. This paradigm change, referred to as ‘new literacies’ or
‘multiliteracies’, implies changes in the position of print, the reader and learner, and the role of the teacher in the classroom (Jewitt, 2008). It is unclear what specific impact employing multimodality as the preferred textual landscape in the classroom will have on the learning of individuals in the long-term (Kress, 2005). The reading of multimodal texts goes largely unnoticed in the curriculum and its assessment (Bearne, 2004). Instead, the acquisition of print reading skills is continually given precedence in schools (Anning, 2003; Marsh, 2003; Pahl, 2002). In the context of literacy education, however, an exclusive reliance on the development of the specific skills required to ‘crack the code’ – such as phonemic awareness, phonics and knowledge about print – is insufficient to succeed in the 21st century (Levy, 2009). Even recent policy documents, e.g. the National Literacy Strategy for All in Malta (Ministry for Education and Employment, 2014) have put increased emphasis on digital literacy. Therefore, the crucial challenge is “to consider to what extent digital technologies can be incorporated within classroom literacy programs without reducing the importance of the rich, imaginative and cultural knowledge that is derived from books” (Walsh, 2010, p. 211).

5. Digital books in early education settings

Digital technologies are transforming the way in which children read, write, and engage with stories (Burnett, 2010; Marsh, 2006; Parish-Morris et al., 2013). Some teachers use digital interactions to motivate their students, while others struggle to incorporate digital resources into their regular literacy instruction (Abrams & Merchant, 2013; Flewitt, Messer, & Kucirkova, 2015). Digital books, including e-books, story and book apps, have been found to support pleasurable reading at home (Kucirkova, Messer, Sheehy, & Flewitt, 2013) and in the classroom (Falloon, 2014). Digital books offer affordances not available with printed text. Children can increase the visual display of images, the legibility of texts, and the alignment of textual (story, text, illustration, paratext), usability (navigation, customisability, safety and privacy, value) and multimodal (animation, interactivity, narration, sound/scape) features (Meyers, Zaminpaima, & Frederico, 2014). E-books also offer inbuilt feedback on word meanings (Grant, 2004; Medwell, 1998), as well as picture cues and audio features (Doty, Popplewell, & Byers, 2001). Such affordances can enhance readability (Yokota & Teale, 2014) and increase reading motivation (Ciampa, 2012; Larson, 2010; Maynard, 2010). These features also encourage multisensory, creative and playful engagement with reading materials (Roskos, Burstein, Shang, & Gray, 2014), with opportunities for interaction and the co-construction of meaning (de Jong & Bus, 2002; Roskos, Burstein, & You, 2012).
Christ and Wang (2015) identified 5–6 year olds’ approaches to reading tablet app books in two Midwestern US classrooms and explored how these were related to comprehension. In a previous study with print books, Christ, Wang and Chiu (2015) had found that within reading buddy dyads, more collaborative peer interactions were related to better reading comprehension outcomes. Replicating this finding within a digital reading context, the authors recommended that teachers provide opportunities for social reading and facilitate collaboration to support an integrated approach to multimodal reading. In a separate study of 110 kindergartners (mean age 5.6 years), children who worked with digital books in a paired peer learning context with same age peers gained an advantage, over those who worked individually with the same digital materials, in phonological awareness, emergent reading, and story comprehension (Shamir, Korat, & Barbi, 2008).

A number of factors including previous exposure to tablets, technological and overall literacy skills and gender come into play when considering the type of engagement that children have with e-books (Plowman, 1995). Falloon (2013) studied the design features of apps for enhancing literacy, numeracy and problem-solving skills of young children and discovered a wide range of influencing factors. These included the effect of embedded instructional scaffolds (e.g., modelling, reflection time), corrective and formative feedback, text-to-speech functionality, imposed interaction parameters, impediments (e.g., web links, advertisements, buying content) and the entertainment/education balance. Bus et al. (2015) offered design suggestions for maximizing the potential of digital storybooks for learning and for minimizing potential negative effects on the development of literacy skills. They found that animated pictures, sometimes enriched with music and sound, that matched the simultaneously presented story text, helped readers integrate nonverbal and verbal information and therefore promoted storage in memory. They concluded that well-designed technology-enhanced books may be particularly suited to improve learning conditions for vulnerable children and ‘at risk’ groups.

Many limitations of e-books, when compared to print books, arise from the drawbacks of multimodal texts discussed earlier. Thus, some types of e-books may lead to poor performance on story comprehension, vocabulary, and recall tests (Bus et al., 2015; Chiong et al., 2012; Parish-Morris et al., 2013; de Jong & Bus, 2003). Graphics and sound effects that did not reinforce the text, negatively affected students’ ability to retell story events (Trushell, Maitland, & Burrell, 2003). Further, an observational study by Lewis and Ashton (1998) reported that during an e-book reading activity, students spent 65% of their time on non-reading activities including clicking on hotspots and playing games. Thus, interactive elements, even those intended to support literacy, may also be distractions (de Jong & Bus, 2003; Moody, 2010; Shamir & Korat, 2006).
Electronic books may also have a negative effect on parent-child interactions. The more digital features there were in an electronic book, the less parents engaged in supportive reading styles and the lower the children’s overall story comprehension (Krcmar & Cingel, 2014). Other studies have found that although adults often spend less time interacting with children during e-book readings than they do with traditional books, the overall talk was more complex (Kim & Anderson, 2008), but less expanded (Korat & Or, 2010) when reading e-books. Parent-child dialogic reading and children’s story comprehension were both negatively affected by the presence of electronic features (Parish-Morris, Mahajan, Hirsh-Pasek, Golinkoff, & Collins, 2013). Chiong, Ree, Takeuchi, and Erickson, (2012) explored how digital books related to parent-child story reading. They compared how 32 pairs of parents and their 3–6 year-old children read print books, basic e-books, and enhanced e-books together. Enhanced e-books seemed to be less effective in promoting shared reading. However digital texts could still be beneficial to less motivated readers, who might otherwise avoid text altogether.

To summarise, digital books offer affordances that potentially support individual readers’ text comprehension and engage struggling readers (Coiro, Knobel, Lankshear, & Leu, 2008; Lankshear & Knobel, 2003; Leu, Kinzer, Coiro, & Cammack, 2004; Reinking, 1992; Reinking, 1998; Reinking, 2001). Teachers need to understand not only these affordances, but also the limitations as they integrate digital technology into the curriculum (International Reading Association, 2009; National Council for Teachers of English, 2008). Much research is still needed to understand what specific skills and strategies children acquire while using digital learning material, and teachers must be educated about how to create opportunities for the students to learn new literacy practices.

6. Finding the right balance

Early childhood educators have conceptualised digital technologies as both a blessing that supports academic competences, such as literacy development, and a threat to the notion of real communication and to well-established conceptualisations of preschool practice (Hernwall, 2016). Studies have indicated differential benefits and limitations of the use of touch screen technologies in pre-school contexts. For example, Price et al. (2015) investigated 2–3 year-olds engaged in a finger-painting activity with physical paint and paper and in a colouring activity on a tablet computer. They analyzed the children’s touch-based interactions, the different types and qualities of touch, the composition of the final paintings, and the way these differed in each environment.
Findings indicated that the tablet computer enhanced speed and continuity, allowing for more mark making. However, it limited the number of fingers used for the activity and the sensory experience of physical paint, which led to more uniform pictures on the tablet. The authors suggested that the use of technology should complement other activities, such as physical painting, which involve messy and sensory experiences. Indeed, pre-kindergarteners in a Head Start program who had access to both print and e-books and were thus exposed to words multiple times in both print and digital settings, saw gains in their vocabulary knowledge. These children further benefitted from the increase in book reading options afforded by e-books and from additional affordances (such as hotspots) (Roskos, Sullivan, Simpson, & Zuzolo, 2016), thus supporting the utility of including both print and digital texts in preschool classrooms.

Parents and teachers, however, may lack the knowledge and experience with digital technologies necessary to enhance children’s learning. They may also prefer print books over digital ones when reading with young children. Based on results from a national survey of UK parents of 0–8 year-old children, Kucirkova and Littleton (2016) proposed that parents need support to learn about how best to read high quality digital books with their children, and to understand how to find a balance between print and e-books. According to NAEYC (National Association for the Education of Young Children) and FRC (Fred Rogers Center for Early Learning and Children’s Media) (2012), “the adult’s role is critical in making certain that thoughtful planning, careful implementation, reflection, and evaluation guide decision-making about how to introduce and integrate any form of technology into the classroom experience” (p. 5). Indeed, more than half of the parents reported that they would like to receive advice on how to use digital media with their children in order to support their child’s learning. About 31% of the parents reported feeling confused about how to use e-books with their child.

A model was designed by Kucirkova (2016) to guide adults’ selection and use of digital books with early years and primary school-aged children. It was based on an extensive literature review and included information on criteria for evaluating children’s digital books, and the learning outcomes these might support, as well as guidance on using digital books in the classroom. She also developed an app guide, in conjunction with the National Literacy Trust of the UK.¹

¹ See http://literacyapps.literacytrust.org.uk/.
7. **Challenges for schools**

Schools and teachers face several challenges that relate to the embedding of digital tools in educational systems which historically privilege print. Oftentimes, the mandated literacy curriculum lags behind new literacy research and there may be an exclusive emphasis on print literacy in the school. Teachers should not abandon these traditional literacy practices, but work to use technology with a similarly rigorous pedagogical framework (NAEYC & FRC, 2012). Without training, however, teachers may have trouble understanding how to incorporate technology in a way that proves consistent with learning theories (Falloon, 2013). Further, teachers may be constrained from embedding new forms of digital textual practices (Mills, 2016), and may experience resistance to change.

Some national education systems are embracing technology, with varying degrees of success. They see schools as the main agents to prepare their children for the challenges of the future. There is considerable investment in bringing hardware and software to schools, teachers and students throughout Europe. The first OECD PISA assessment of digital skills, however, revealed that schools may not be prepared to take advantage of the potential of technology in the classroom and give students the skills they need in today’s connected world (OECD, 2015). Still, the importance of ensuring that children have acquired the basic skills of reading and writing and of navigating the digital landscape makes finding effective means of integrating technology into the curriculum critical.

In Turkey, for example, the Ministry of National Education embarked on a nationwide project to provide each classroom with an interactive whiteboard and each student with a tablet (Akcaoglu, Gumus, Bellibas, & Boyer, 2014). The emphasis of the nation-wide technology implementation programme was on digitisation rather than integration, including the creation and distribution of digital copies of textbooks. The only thing both the students and teachers were able to do with these new digital tools was to read preloaded digital books. There was concern that this was not sufficient to bring about gains in the students’ cognitive skills because of the lack of creative tasks with the technology. Indeed, when interviewed, teachers felt there had been minimal impact of the technological tools on their teaching practices. They thought that the tablets were not any different from regular paper books and were dissatisfied with the professional preparation they received. A plea was made for a better alignment of the assessment system, which was still very much high stakes, to the objectives of the curriculum. Thus, for the integration of technology in the classroom to be effective, there needs to be an emphasis on situated, ongoing professional development, changes to the curriculum and assessment, and a shift to improving teaching and learning through the use of innovative pedagogical techniques that make the best use of appropriate
technological tools (Eady & Lockyer, 2013; Moeller & Reitzes, 2011). Such tools can help diagnose and address individual student learning needs and help students to actively and independently organise their learning.

Digital technologies were used as learning tools in Plan Ciebal, an interinstitutional project in which laptops were distributed along with internet connectivity and a range of educational programmes to elementary foreign language classrooms in Uruguay (Banegas, 2013). Blended learning, involving both remote teachers through videoconferencing and face-to-face learning with classroom teachers, was implemented for the students. Ferrando, Machado, Perazzo and Vernengo (2011) analysed the effects of the programme on learning achievement in mathematics and language. They found that, compared to a control group, Plan Cebial had a positive impact on children’s achievement in mathematics, but not on language achievement.

Countries like Korea, Singapore and China have encouraged schools to integrate digital books on tablets into their formal school curriculum to improve academic performance (Kim, 2012; Sun & Luo, 2013; Sun & Jiang, 2015). Jahnke and Kumar (2014) illustrated how children in Odder schools in Denmark used iPads across the curriculum. The teachers created new forms of digital, didactical designs in their teaching practice through the use of multiple apps and a focus on creativity, production, and collaboration in the learning process. They fostered student engagement by activating the students’ knowledge in different forms (e.g. peer-reflective actions, and personalised learning through learning expeditions). One preschool teacher believed recognised that this improved students’ reading and writing skills. She believed that the combination of different tasks, such as taking pictures, inserting audio files, as well as using written words helped students’ reading and writing skills and simulated real life. In another Odder classroom of seven year-olds, children uploaded pictures from the internet or from photos they took with a camera, generated speech bubbles, and included text. While these reports are encouraging and high levels of iPad use were reported, it will be important for future studies to be able to experimentally link reported changes in learning and behaviour to measures of student learning and engagement.

Viriyapong and Harfield (2013) identified a number of challenges to the introduction of tablets in elementary schools in Thailand. The first was content accessibility – teachers reported that many students did not have adequate reading skills for the activities provided on the devices. Secondly, where children could read the content, teachers described how the user interface afforded a somewhat passive style of interaction. As a result many students completed the entire body of activities within as little as a month and at a superficial level of engagement. A third issue was teacher preparation and support. Many teachers did not have a tablet themselves and so could not engage in the required lesson preparation. In
addition, a number of teachers used the tablets as an alternative to teaching rather than as a complement to traditional classroom activities, having not been given support in how to best use the tablets for learning. A final issue was evaluation of learning outcomes. Teachers had no way to monitor how students were using the tablet to achieve learning objectives set out in the curricula. In Viriyapong and Harfield's case study, a lack of such monitoring software resulted in learning outcomes for individuals, classes and schools remaining unclear, despite the scale of the project.

In another large-scale initiative to introduce digital tablets into classrooms, a national project launched in Malta in 2014 aimed to make tablets available to all 7–8 year-olds in schools. The tablets were intended mainly to support the national policy of balanced literacy teaching and learning. Findings from a study (Mifsud & Grech, 2016) of five primary classrooms involved in the project showed that teachers integrated the use of tablets in their teaching for a number of creative literacy activities in the two languages of schooling, Maltese and English. Relevant apps were used to support reading and writing activities, such as reading comprehension, guided and creative writing. The teachers reported improved student performance in literacy outcomes for both languages. However, they requested more pedagogical and technological support structures for using the tablets in schools.

8. The integration of digital technologies into literacy instruction

Many literacy teachers struggle to effectively integrate and teach both traditional and new literacy skills within a confined curriculum and a limited timeframe (Hutchison & Reinking, 2011). According to Hutchison and Woodward (2014), the challenges for teachers when integrating digital technologies into literacy instruction include: inadequate technological knowledge, expectations of students' ease with technology, inappropriate expectations for assignments, and limited conceptions of the purposes of technology. Teachers, therefore, require a clear instructional planning framework to integrate tablets into their teaching. They also must draw on their technological, pedagogical, and content knowledge (TPACK) to integrate technology into their classroom instruction (Mishra and Koehler, 2006).

Hutchison and Woodward (2014) devised the Technology Integration Planning Cycle (TIPC) as a guide to help teachers to integrate digital technology into literacy instruction in meaningful ways. Teachers used TIPC to plan instruction with explicit instructional goals related to course, grade-level, and state and national standards. It is a reflective cycle and the instructional objectives can be revisited according to the affordances of the digital tool. Similarly, Northrop and
Killeen (2013) presented a framework for integrating tablets into classrooms to effectively and engagingly teach early literacy skills. They modified and applied the instructional framework of gradual release of responsibility (Duke & Pearson, 2002; Pearson & Gallagher, 1983) to tablet use. Within this model, the teacher first explains and models the activity, followed by guided and independent practice by the student. However, such proposed models need to be tested and researched more extensively in diverse contexts in order to better determine their effectiveness.

Investigations into how new technologies are being used in the classroom reveal a diversity of experiences with regard to literacy learning with tablets in classrooms. Tablets may be used effectively and in a variety of ways in classrooms to offer opportunities for early literacy learning. For example, a study of 13 teachers of different grades from across 11 states in the US by Karchmer (2001) revealed that students were more motivated to write when their work was published online for a wider audience. In a study by Flewitt et al. (2015) the use of iPads for innovative early literacy learning activities was investigated in three settings: a children's centre nursery (3–4 year-olds), a primary school reception class (4–5 year-olds), and a special school (7–13 year-olds). The researchers observed how iPads were integrated into each setting over a two-month period and conducted pre-and post-study interviews with staff. Overall, even initially reticent teachers reported that carefully planned literacy-related iPad activities positively impacted children's engagement and motivation. Teachers also noted how the iPads facilitated opportunities for communication, collaboration and independent learning, allowing children to demonstrate abilities potentially not seen outside of the digital context. Teachers particularly valued the opportunities iPads afforded them to deliver national curriculum guidelines in new and different ways, and to help equip all children with higher levels of technological confidence and competence.

Sandvik, Smørdal, and Østerud (2012) observed a group of Norwegian 5 year-olds who used tablets for language and literacy activities, such as creating fairy tales individually and collaboratively. Interactional sequences between the children and the teacher when using the apps were analysed according to a coding procedure from videotaped data. They found that some of the apps facilitated children's understanding and production of meaning. The tablets further provided the children with immersive experiences which were especially beneficial to second-language learners by helping them develop skills like narration, reasoning and negotiation problem-solving.

The potential of tablets for supporting literacy learning in special education has also been examined. Kucirkova, Messer, Critten and Harwood (2014) described the way in which a multimodal story app used by children with language and social-emotional difficulties fostered their motivation to engage in communication and literacy-related activities such as story-sharing and
story-creation. Teachers appreciated that they could individualise the app to the specific needs and learning goals of a wide range of students with complex profiles and use of the app positively affected the classroom social dynamics. Such results attest to the great potential technology may hold for students who struggle in traditional classrooms.

9. A case for more cohesion and integration

To conclude, this chapter has highlighted the complexities present for parents, caregivers and educators in integrating digital and print literacy into children’s early reading experiences. There are commonalities and continuities between the forms; for example to read via both modalities, children need to acquire the basic skills of letter-sound decoding and learn to link the resultant word forms to meaning. There are also key differences with, as a primary example, the increased multimodality of digital books, which makes reading a far less linear experience. For adults who have learned to read via print books and for educators who have learned to teach reading via print books, this shift creates a scenario where adults, as reading ‘experts’, do not necessarily have all the answers yet, in terms of how to best foster the resulting ‘multi-literacies’ that children must learn. As described above, this reality can create challenges as well as exciting opportunities.

Parents and educators need to recognise how print and e-books can complement each other. Young children appear to be developing sophisticated strategies in order to make sense of digital texts. If teachers are expected to build upon these strategies, more research in the dynamics of technology-enhanced classrooms is needed to fully understand these strategies, and build upon them to ensure that all students are included. We need to deepen our “understanding of how young children read digital texts at home and at school. Such knowledge is crucial in order to inform curricula and pedagogy on the teaching of reading to 21st-century children” (Levy, 2009). Further research is also required to investigate the effects of tablet writing on literacy development. Such research should illuminate policy and practice in this field and provide the sufficient basis for parental and early childhood teacher education.

Teacher preparation and continuous professional development must inform teachers of the literacy skills necessary to succeed in today’s work environment (Mikulecky & Kirkley, 1998). Teachers need to be prepared to use these skills and to integrate technology seamlessly within their literacy curriculum (Karchmer, 2001). They need to be presented with positive models of technology integration in the literacy curriculum (Calderhead & Robson, 1991).
References


Rapid advances in digital technologies are transforming patterns of learning to read, as well as ‘reading to learn’. The latter refers to the process of reading in the service of learning, in school and beyond, and is a major purpose for reading beyond the earliest school years. When reading to learn, contemporary e-learning trends either promote the supplementary use of ICT in face-to-face settings or the use of such environments for comprehensive delivery of learning materials. Such changes make it imperative to understand the basic elements of reading in digital environments to support learning. In this chapter we first introduce the basic elements that can be used to build an effective digital reading environment to improve learning. The chapter then considers the instructional design principles that best promote learning through digital reading and explores the impact of digital interfaces on traditional reading-to-learn strategies.

1. Introduction: Transition from learning to read to reading to learn

Even before the recent breakthroughs in information and communication technologies (ICT), reading to learn, or ‘learning from text’ (Maclellan, 1997) has been a crucial vehicle of education for both children and adults. The invention of the World Wide Web (i.e., WWW), by Tim Berners-Lee in 1990, can be considered a pivotal moment as it led to a dramatic change in learning through digital media, enabling the potential delivery of educational content in a more enriched environment. There are several terms to refer to the kind of learning that occurs in digital environments such as web-based education, web-based instruction/learning, technology/computer assisted learning, distributed learning, online
education/learning, and digital/electronic learning environments. Among such terms, ‘e-learning’ can be considered the most prominent, inclusive, and generally accepted term to describe learning through digital environments.

The impact of e-learning on teaching and learning habits can be examined under two headings: (a) supportive use of e-learning to supplement face-to-face practices, (b) comprehensive use of e-learning to deliver the main content and learning materials in a synchronous (e.g. video conferencing, chat) or asynchronous manner (e.g., forum, discussion groups, email). Both forms of teaching and learning are now common across education systems, especially within secondary and tertiary education.

Three key forms of digital information delivery are important to consider: (a) hypertext, (b) hypermedia, and (c) multimedia. Hypertext is digitally displayed text which, in contrast to linear text, contains electronic links to other text, creating a non-linear text structure. Hypermedia takes this one step further, presenting information digitally in a non-linear fashion but also including graphics, video and sound, as well as text and hyperlinks. Multimedia similarly presents varied content such as text, graphics, audio, and images but in contrast to hypermedia it does not necessarily include hyperlinks and thus non-linearity. Even though hypermedia is a form of multimedia with links to the other resources, the term multimedia has a broader use in the field of education and is used commonly to refer to the delivery of e-learning content. Sometimes, the terms multimedia and e-learning are also used interchangeably. In this regard, we frequently use the term ‘multimedia’ to discuss digital reading throughout the chapter.

A final key term to define is that of ‘instructional design.’ Instructional design has been described as “instructional experiences which make the acquisition of knowledge and skill more efficient, effective, and appealing” (Merrill, Drake, Lacy, & Pratt, 1996, p. 2). In this chapter we are particularly concerned with instructional design within a digital context.

Chapters 3–5 of this volume discuss the skills that individual learners must develop in order to successfully navigate and comprehend digital text: Many advantages have been attributed to digital reading materials such as personalizing learning for struggling students (Puente, 2012), supporting interactivity around multiple reading resources (Merga, 2014), and increased engagement (Brown, 2016). However, online reading is arguably also more complex than traditional print reading, requiring the employment of multiple skills simultaneously such as locating information, synthesizing across multiple sources and critically evaluating the quality of information found (Leu, Kinzer, Coiro, Castek, & Henry, 2013).

This chapter is written from an instructional design perspective, reflecting the disciplinary background of the authors. We start by considering the instructional design principles that best promote learning through digital reading. In the second
half of the chapter we review strategies that have commonly been associated with successful reading to learn, and discuss the impact of digital interfaces on these strategies as well as highlighting current gaps in instructional design knowledge.

2. Instructional design for promoting learning through digital reading

Even if learners have acquired the necessary skills for building digital reading capacity, ill-designed instructional content will diminish an individual’s ability to successfully utilise these skills and achieve their learning goals. Poor designs may cause confusion, lack of comprehension and boredom. Figure 1 conceptualises the interaction between delivery format (e.g. face-to-face, e-learning), medium (e.g. plain text, hypermedia), and methods of instructional design; while the medium either enables or constrains a specific method, the method draws on the capabilities of the medium (Kozma, 1992). Medium and method are inseparable parts of a successful instructional design. Moreover, it can be maintained that what brings us from ‘reading to learn (i.e. textbooks)’ to ‘digital reading to learn (i.e. multimedia applications)’ can be explained simply by the interaction of the medium and method.

![Figure 1. A framework representing basic elements to improve learning through digital reading](image)

Considering the medium in more depth, it is possible to classify instructionally relevant characteristics of the media as technology (delivery media), symbol systems (e.g., words, pictures, audio, video, animation) and processing capabilities (Kozma, 1991). Advances in online connectivity and digital compression technologies help learners to access any type and size of media anywhere in the world. Processing capabilities and interaction tools within personal or portable digital devices have improved as well, meaning that instructional design principles can increasingly be applied across multiple media, as opposed to being medium-specific (Samaras,
Giouvanakis, Bousiou, & Tarabanis, 2006). However, as instructional media continue to transcend many constraints in terms of technology, processing capacity and the symbol systems that can be embedded, this potentially raises new questions about cognitive effects of multimedia on learning. This in turn impacts the ‘method’ as conceptualised by Kozma, i.e. the instructional design. Several instructional design theories (or frameworks) have been proposed to support intrinsic meaning and reduce cognitive effort. For instance, Paivio’s (1986) Dual Coding Theory considers the dual functionality of the human cognition, and maintains that images and verbal representations exist in two separate subsystems, which complement each other while facilitating the retention of information. As there are two information processing systems, it is better to use more than one communication channel during learning. A complementary theory is Cognitive Load Theory (Chandler & Sweller, 1991), which posits that the processing capacities of visual and verbal working memories are severely limited. Following the contributions of both theories, and attempting to address the specific context of multimedia platforms, Mayer (1997) proposed the Generative Theory of Multimedia Learning and suggests empirically effective ways to present words and visuals simultaneously in a digital environment, while also minimizing the probability of cognitive overload. Mayer’s ideas are explored in more depth in the next section.

3. Digital design principles

Designing digital texts that support learning can be best achieved through employing research-based principles that consider how the human mind works. Mayer describes three demands on a learner’s cognitive processing during the process of learning: extraneous processing, essential processing, and generative processing (Mayer, 2009). While Mayer is concerned with learning from information technology in a broad sense, much of this learning does involve text reading within a multimedia context, making the principles incredibly relevant to this volume.

Extraneous cognitive processing is processing that does not support the intended learning objective and may be caused by design aspects such as poor layout, or redundant/surplus informational content. A key aim of effective instructional design is therefore minimizing the presence of any elements that may add extraneous processing burden:

- **Reducing extraneous processing** (Mayer, 2005b):
  - *Signaling*: Add cues to highlight the organisation of the essential material.
  - *Redundancy*: Eliminate redundant presentations as people learn better from “graphics and narration” than “graphics, narration and on-screen text”.


- **Spatial contiguity**: Present corresponding printed words and graphics close to each other.
- **Temporal contiguity**: Present graphics and narration simultaneously rather than successively.

The second type of cognitive processing described by Mayer is essential processing, which is the processing needed for the basic act of mentally representing the material being presented in real time. The processing load is determined by the intrinsic complexity of the information being presented, and in Mayer’s conceptualisation of learning, as with extraneous processing, instructional design should seek to minimise the burden of this type of cognition:

- **Managing essential processing** (Mayer, 2005a):
  - **Segmenting**: Present multimedia message as learner-paced segments rather than a continuous unit.
  - **Pre-training**: Present the names and characteristics of the key concepts before the instruction.
  - **Modality**: Use spoken words rather than printed ones.

The final type of processing that Mayer delineates is generative processing, which involves taking the material represented, organizing it and integrating it with existing knowledge. Both cognitive capacity and volition may play a role in an individual’s ability to engage in this type of processing at any point in time, though again, instructional design can be employed to positively foster generative processing:

- **Fostering generative processing** (Mayer, 2005c)
  - **Personalisation**: Present words in a conversational style rather than a formal style.
  - **Voice**: Use a human voice rather than a machine voice.
  - **Embodiment** (Mayer & DaPra, 2012): Employ on-screen agents that display human-like gestures, movement and eye contact.
  - **Image**: Do not use a static image of the speaker on screen as it may distract the learners.

The results of many empirical studies demonstrate that employment of these principles can improve student learning and retention (see Mayer, 2009 for an overview) so it is clear that information technology, at its best, can be used to present information in ways that optimise reader processing to a degree that printed text perhaps cannot match. However, the flexibility of digital design is also potentially a double-edged sword, for just as reader processing can be optimised, formats created without learning in mind may also do the opposite. For this reason this
chapter also considers reader strategies that can be employed in digital environments, to mitigate both design-induced processing challenges and the inherent complexity of informational material for learning.

4. Reading strategies for learners to foster higher-order thinking skills: Use of reading strategies via digital media

Reading strategies are defined as mental or physical problem-solving activities for the comprehension of a text (Pressley & Afflerbach, 1995). Reading strategy instruction has been shown to help readers at a variety of stages of learning to read (Dole, Duffy, Roehler, & Pearson, 1991; Slavin, Cheung, Groff, & Lake, 2008), as well as readers with differing levels of language proficiency (Zhang, Gu, & Hu, 2008). With the recent rise of digital media use across learner groups, reading strategies are increasingly being adapted to digital learning environments. A summary of key instructional strategies and the evidence base of their application to digital contexts follows.

4.1 Previewing

Previewing is a strategy employed prior to reading, enhancing both reading comprehension and vocabulary knowledge (Burnett, 2011). It is also referred to as ‘pre-reading activity’ and is thought to be a bridge between the text’s content and a reader’s existing knowledge schemata (Chen & Graves, 1995). While previewing, students review the title, section headings, graphic aids, and captions to get a sense of the reading text. This process is taught to augment students’ comprehension and awareness prior to actual reading and to facilitate and accelerate reading activity. Rose and Sherry (1984) describe the types of previewing as: (a) oral previewing, in which the learner reads the assigned selection aloud; (b) silent previewing, in which the learner reads the assigned selection silently; and (c) listening, in which the teacher reads the assigned selection aloud and the learner listens silently (Eaton et al., 1978). In a study by Hawkins and colleagues (Hawkins et al., 2010) listening previewing was found to be particularly effective at enhancing comprehension compared to silent reading, though there are likely to be individual differences in the type of previewing that is most helpful (Rose & Sherry, 1984). Researchers have pointed out that previewing can help focus students’ attention only on the most significant information (Dole, Valencia, Greer, & Wardrop, 1991) and that when led by a teacher, the strategy can highlight what is important through the inherent questions and/or directions (McCormick, 1989).
Previewing is suggested as a traditional reading strategy; however, without any adaptation, this strategy can be utilised in digital reading. Indeed, one could argue that with the increased amount of text available to readers via digital devices, previewing text has become an increasingly important skill, not just to provide a framework for comprehension but also to determine the potential relevance of the text to a wider reading goal. This speculation was supported in a study by Davis and Neitzel (2012), which looked at the reading behaviours of sixth and seventh grade students (age 11–13) while reading expository text in a digital versus print format. Texts of equivalent length were used which contained the same graphic content and captions. The digital text, however, differed in containing hyperlinks which took the reader to additional text, images and captions not available in the print version. The students were significantly more likely to preview when reading the digital text i.e. skimming the text and picking out key details before deciding where and how to read, a behaviour the authors attribute to the greater amount of text the students had to navigate in the digital condition. Interestingly, however, despite greater strategy use by students overall for the digital reading compared to the print reading, comprehension performance between the two groups was not significantly different. Such a result would suggest the essential role of previewing and strategic reading in digital environments in order to maintain optimal comprehension levels. In support of this conclusion Herold (2014) also suggests that teachers should be alert to ensure all students have previewing skills within digital contexts, including scanning a text for headlines, overall organisation and other key content indicators.

4.2 Generating and answering questions

This strategy requires students to ask and answer questions regarding the text they are reading. Such an approach is integral to well-known reading comprehension methodologies such as Reciprocal Teaching (Palinscar & Brown, 1984) and Questioning the Author (Beck, 1997). Palinscar and Brown (1984) suggest that by asking students to compose questions about the content of a text, they are being encouraged to focus on the main ideas, as well as self-monitor understanding. In turn, the task is encouraging inferential analysis on the part of the reader and integration of information, which enhances the recall of information (Davey & McBride, 1986).

Regarding answering questions after reading, on the one hand this strategy increases learning from text, particularly for adults (Anderson & Biddle, 1975) although the effects are less clear for children (e.g., Fischer, 1973; Levin & Pressley, 1981; Watts, 1973). Higher level questions are found to be facilitative in both productive and reproductive knowledge (Andre, 1979). On the
other hand, question generation during reading may: (1) focus the student’s attention on content (Palincsar & Brown, 1984); (2) improve reading comprehension and memory for text by making readers more active while reading (Singer & Donlan, 1982); and (3) require students to play an active, initiating role in the learning process (Collins et al., 1987; King, 1994; Singer, 1978). Davey and McBride emphasise (1986) that students must be fully trained in how to generate good integrative questions, which were defined as questions capturing large units of meaning (Rich & Pressley, 1990). Supporting this finding through a review of multiple intervention studies, Rosenshine, Meister and Chapman (1996) reported that teaching students the cognitive strategy of generating questions resulted in gains in comprehension, as measured by pre-post testing; studies included in this review spanned from elementary through to college-age students.

The strategy of generating and answering questions may also be easily carried out in a digital environment, with digital platforms potentially offering greater flexibility in ways to prompt the use of such strategies. An example of this would be the Universal Design for Learning (UDL) ‘Book Builder’ software, created by the US-based Center for Applied Special Technology (CAST). Book Builder is software primarily designed for pre-college age students from which books can be created and accessed, allowing for inbuilt prompts to the reader concerning e.g. the essential question. Although published studies confirming the effectiveness of such software are still relatively few, some studies do report positive outcomes from the use of similar strategies in digital English language-learning environments (Dreyer & Nel, 2003; Yu, Chang, & Wu, 2015). Thus, digital media environments provide increased infrastructure for the implementation of questioning strategies. It is significant, however, that students still need explicit coaching, either online or offline, on how to use this strategy successfully.

4.3 Evaluating an argument generated from the reading

An argument is a claim made by the author of a text that is supported with reasons or evidence. While evaluating an argument, a reader determines its value or persuasiveness and judges whether it is good or bad and whether it is based upon rational criteria. Effectiveness of an argument is dependent upon whether its specific claims are supported by reasons and evidence from the text. Evaluating an argument is often used in the classroom as a follow-up activity in a reading session, especially within the humanities or language classes, and traditionally may be heavily scaffolded by teacher prompts and questions. Similarly to the question-generating strategies described in the section above, digital instructional design
can build these types of prompts directly into the text, as well as allowing more easily for asynchronous dialogues to occur via interactive elements such as those integral to programs such as Google Docs, or more specialised packages such as Actively Learn (c.f. Caitlin, 2015). Looking more to the future, researchers in the field of artificial intelligence are devising computational algorithms that can parse text and generate evaluative arguments from it, tailored to the users’ preferences (Carenini & Moore, 2006).

4.4 Contextualizing

According to Perin (2011), contextualising is the bringing of basic skills (contextualised basic skills instruction) and content area instruction closer together to increase proficiency in reading, writing, and mathematics skills (Baker, Hope, & Karandjeff, 2009; Heller & Greenleaf, 2007; Lee & Spratley, 2010). Similarly, Mazzeo, Rab, and Alssid (2003) describe contextualisation as the use of different instructional strategies to link the learning of foundational skills and academic or occupational content in a specific context that is of interest to the student. Pearson (2010) contrasts these definitions above, where contextualised instruction aims to teach basic skills for the purpose of meaningful application, with the concept of integrated instruction. Here the primary goal is to teach the disciplinary content; however some basic skill support may be needed in order to achieve this. Whether instruction is contextualised or integrated, the connection of basic skills instruction to applications and life goals is clearly important, since it places students’ interests and needs at the centre of education (Dewey, 1966; Dowden, 2007). Use of authentic materials that may result in more active, generalizable learning is an integral component of this process (Simpson & Nist, 2002). Connecting information and providing dynamic links to meaningfully-related material is something that digital media can arguably achieve a lot more effectively than traditional print media. Examples range from purpose built platforms that provide digital libraries of media and text, sortable by reading level and topic (e.g. StudySync, c.f. Catlin, 2016), to more public, unregulated platforms for sharing information, e.g. Wikipedia and YouTube. Taking contextualisation one step further, studies that compare the use of digital virtual worlds in education suggest positive benefits. For example, Ijaz, Bogdanovych, and Trescak (2016) compared comprehension of study material concerning a historical city in three different learning conditions: reading of an expository text on the topic, watching an educational documentary video or entering a virtual simulation of the city and interacting with its avatar inhabitants. As well as enjoying the learning experience more, the group exposed to the virtual context demonstrated 20% greater comprehension of the study materials as compared to the other two groups.
4.5 Annotating

Annotation is an active strategy to support learning while reading and rereading (O’Donnell, 2004). It enables readers to engage with text and encourages active reading. It is a result of readers’ communication with the text and understanding of the text in a tangible form (Cook & Mayer, 1983). Relevant literature indicates that annotation use is an important variable contributing to reading comprehension and helps instructional designers to accommodate for different types of learning styles (Akbulut, 2008).

Annotation includes the following activities for active learning: (a) writing short summaries in the students’ own words; (b) generating numerous ideas in an organised form; (c) providing samples of concepts grasped from the text; (d) visualising information sensed from the text onto graphs or charts; (e) writing possible test questions; (f) identifying confusing and ambiguous ideas with a question mark; and (g) underlying key words and phrases (Simpson & Nist, 1990). Annotation and associated techniques have been demonstrated to help college students improve their understanding effectively over time (Nist & Simpson, 1988).

There are many applications of the annotation strategy in electronic reading. Looking at annotations provided within the text (i.e. not generated by the reader) Al-Seghayer (2001) investigated annotations in three formats – text, still image and video – during vocabulary learning. The researcher found that video annotations related to unknown words were most effective in building mental imagery and providing motivation to learn. Similarly, Akbulut (2007) investigated the immediate and delayed effects of different annotations provided to help with vocabulary learning; the study revealed that students who had access to word definitions along with different types of visuals had significantly higher vocabulary gains than those who had access to definitions only.

A key advance that digital media can offer is the possibility of social annotation, where online material, including text, can be commented on, highlighted, and shared across networks (Razon et al., 2012). This is distinguishable from reviewing tools in Microsoft Word, which also offer digital text annotation but where social sharing is manually achieved and asynchronous in time. For example, Johnson, Archibald and Tenenbaum (2010) found that the annotations made in small team collaboration resulted in improvement on reading comprehension and meta-cognitive skills. Equally, Wolfe (2008) noted that when different annotators have potentially presented different or contradictory viewpoints on a piece of text this increases the opportunities to deepen students’ reflections about the text. In a literature review of 19 studies on the use of social annotation in higher education Novak, Razzouk and Johnson (2012) found positive evidence for social annotation’s ability to increase students’ reading comprehension and meta-cognition compared to non-social control conditions. The authors also noted, however, that
students need a familiarisation period when initially exposed to such technology for the first time, to ensure the demands of navigating a new interface do not interfere with core content learning. Nevertheless, overall the promise of social annotation for learning appears strong.

4.6 Recognising story/text structure

Recognising story/text structure is a reading strategy that is applied to make the organisational structure of a text maximally salient. In the case of stories, key features that may be drawn out are the setting, the key characters, the main event and the outcome. The intent is that this will help as a recall and retrieval prompt (Meyer, Brandt, & Bluth, 1980). Carrell (1985) hypothesised that the underlying reason why the structure of narration of a text triggers better recall is the high level of interaction with the readers’ formal schemata, background knowledge about and experience with organisation of texts. Carrell further maintained that the situation is consistent for the impact among second language learners. Empirically, embedded story-structure routine instruction, including strategies of students’ self-questioning, story-structure analysis, and summarising, has been found to improve secondary students’ text comprehension, both for students with and without learning disabilities (Fagella-Luby, Schumaker, & Deshler, 2007).

Digital adaptations of this strategy are already being designed, such as the web-based intelligent tutoring systems described by Wijekumar, Meyer & Lei (2012). An example implementation within non-fiction text utilised an animated pedagogical agent which supported learners as an expert and guide. The agent first modelled the utilisation of reading strategy to learners. Learners were then allowed to practice similar types of texts. They were provided with multiple attempts until they correctly demonstrated that they could employ the strategy. Reading texts were also enhanced with multimedia materials (e.g., tables, pictures, videos, text-to-speech, vocabulary support, etc.) when applicable. Critically, this implementation within a large-scale randomised control trial of 2,643 4th grade students (age 9–10) yielded statistically significant gains in reading comprehension for the group receiving the intelligent tutoring, as measured by standardised tests. Such multimedia tools also provide a promising impact to close the gap between disadvantaged and advantaged students as well (De Jong & Bus, 2002; Korat & Shamir, 2008; Korat & Shamir, 2007; Elbro, Rasmussen, & Spelling, 1996; Edyburn, 2007; Korat, 2010; Montali & Lewandoski, 1996).

4.7 Graphic and semantic organisers

Graphic organisers are visual illustrations of verbal statements (Jones, Pierce, & Hunter, 1988). Graphic organisers are recommended by educators as a tool to foster
critical thinking and improve students’ self-regulation of learning (Singleton & Filce, 2015). The term can encompass concept maps, mind maps, Venn diagrams and many other types of plots. Such organisers can be used before reading to activate and organise background knowledge, during reading to help draw out main ideas, as well as after reading to map relationships between themes or to help students to recall important information. In a study of middle school students that compared a group of students who were exposed to instructional material either with or without guidance in the use of graphic organisers, the graphic organiser group was more effectively able to identify the main idea of the text, identify supporting details, deal with vocabulary, fact and opinions, as well as make inferences (Sam & Rajan, 2013). These authors also emphasise that graphic organisers work best if generated by the students themselves, as opposed to the provision of pre-made organisers; when students create their own graphic organisers, they need to comprehend, summarise, and synthesise the information they glean from the text (Jones, Pierce, & Hunter, 1988).

Graphic organisers have been found helpful for reading comprehension in either a first or second language (Suzuki, Sato, & Awazu, 2008). Comprehensive syntheses of research indicate that graphic organisers are effective for improving reading comprehension not only among typically developed students, but also among learning-disabled students at different educational levels (Ciullo, Falcomata, & Vaughn, 2015; Dexter & Hughes, 2011; Kim, Vaughn, Wanzek, & Wei, 2004).

As with many of the other strategies discussed so far in this section, students working on digital platforms have new opportunities for graphic organiser generation (Cohen, 2006). Programmes such as Inspiration and Kidspiration provide learners with a flexible space to map and connect words, symbols and ideas, with an ability to edit and revise in ways that would be a lot messier and more cumbersome using pen and paper. Ideally, these graphic organising tools should be compatible with the platforms learners are using to access or generate digital text (Strangman, Hall, & Meyer, 2004), thereby allowing readers to use words or statements directly from the text or summarise the text with their own words to transfer them into graphic organiser software. In a study by a group of US-based education researchers, the writing outputs and the nature of graphic organisers were compared for a group of primary school children who wrote one sample with the help of a digital graphical organiser (Kidspiration) and one sample with a pen and paper-generated graphic organiser (Lorenz, Green, & Brown, 2009). Although the sample was small, the authors concluded that despite the children’s overall familiarity with technology, enthusiasm was greater for the digital graphical organiser generation, which translated into greater concentration and focus on the task. It also appeared that the effects of technology were impacted by the gender and reading ability of the learners. Overall, use of the computer generated graphic organiser increased the writing quantity and number of ideas for boys slightly more than girls. In turn, middle-ability students were the group most likely to improve in the organisation.
of their final paper through use of the computer-based graphical organiser. This study highlights interesting potential interactions between technology use and learner characteristics that are also described in Chapters 3 and 5 of this volume.

4.8 Keyword writing and summarising

In this strategy set, readers identify the main ideas and refine them in their own words. This type of processing helps readers to understand the content and the structure of the text. Keyword identification draws readers’ attention to the main themes, while summarising presents the main argument of the text in brief form. Keyword writing and summarising require creative synthesis of the ideas identified during the outlining process. These strategies are presumed to support critical reading and encourage deep understanding. It has also been found that these strategies are more actively, purposefully, and efficiently utilised by successful learners as compared to unsuccessful students (Loranger, 1994). In the electronic form of these strategies, the features discussed under annotation and graphic organisers may also be applicable. Hence, readers can mark-up text or summarise their comprehension with comments, balloons, or graphical organisers like concept maps and advance organisers. As discussed, these tools can be used not only offline but also via online social environments and dedicated software platforms.

Keyword writing has also been highlighted elsewhere in this volume (see Chapter 3, this volume) as a strategy that may be particularly critical in digital text processing. In Chapter 4 the work of Ackerman and colleagues (Ackerman & Lauterman, 2012; Lauterman & Ackerman, 2014) was discussed in relation to self-assessment of knowledge during digital text reading. Ackerman and Lauterman (2012) reported an overall “screen inferiority” effect for learning information from digital text relative to learning the same texts from paper even in a tech-savvy population, within the context of over-confidence in individual’s self-assessment of their learning. Particularly relevant here is the finding that screen inferiority in both learning outcomes and prediction of performance can be overcome by keyword writing after a delay (Lauterman & Ackerman, 2014). This line of research suggests that the default state of mind when learning texts on screen is of shallow processing. The strategy of keyword writing after a delay guided learners to engage in a similarly effective mode of learning on screen as they do spontaneously on paper.

5. Conclusion

Both popular and academic discourses debate whether we are experiencing a qualitative shift in what reading fundamentally is as a result of text digitalisation, or whether this is just a transition in which the basic essence of reading remains
constant (Spiro, DeSchryver, Hagerman, Morsnik, & Thompson, 2015). In this review of the changing nature of ‘reading to learn’, it is clear that a learner in the early 21st century is likely to be exposed to text that is less linear, more multimedia, and more interactive than in previous eras. However, the discussion of reading strategies in paper versus digital settings also demonstrated many continuities in the types of strategies needed/how they are implemented via digital interfaces. Arguably what is changing is the frequency with which different strategies need to be employed, e.g. the greater need for previewing, as well as the moment-to-moment choices facing the learner in terms of what information to access and how. The continued advance of multimedia instructional design research is thus crucial in ensuring that the exponential increase in information and its available formats remains coupled with a deep knowledge of human information processing and its limits, but also its possibilities.

References


CHAPTER 9

Digitisation of reading assessment

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As screen reading becomes the new standard, valid measures for capturing the defining features of reading ability as it moves from paper to screens must be developed. With the ongoing digitisation of many international and national large scale assessments, questions about the role of testing mode become especially pertinent. This chapter explores the question of how testing mode impacts the design of digital reading tests as well as children’s performance on them. We discuss how findings from empirical research on mode effects can inform the design of reading assessment and consider the pedagogical implications of a move to digital assessment.

1. Introduction

Schools and teachers experience expectations that every child develop a level of reading competence that enables him or her to master a variety of text types in print and digital modalities. Children’s reading competence is therefore constantly monitored in schools throughout the world using large-scale testing at regional or national levels, to ensure that children reach a baseline proficiency of reading (Russell et al., 2003). In addition, there are a range of international tests allowing for cross-national comparison and measurement of trend. Recently, there has been a move towards digitisation of these large-scale assessments. Digital testing allows for the assessment of skills important in an increasingly technological world, such as digital competence and screen reading. There are also many economical, practical and political advantages to testing in the digital mode. The transition from the print to the digital mode, however, may affect children’s test performance, as well as how reading is conceptualised and taught in the classroom.

This chapter focuses on the mode-related factors that are important to consider with the increasing digitisation of large-scale assessments. Central research
questions include: Do digitised reading tests measure the same reading competence as the paper version of the test? Does increasing digitisation of assessments influence the texts selected and thus the reading skills assessed? What role do digital skills play in digital reading comprehension tests? And how may the increasing digitisation of testing influence classroom practices?

To begin to address these questions, we review extant empirical research on the effects of digitisation on reading and discuss how mode effects may impact both children's performance on digitised assessments, as well as the choice of texts and items for digital tests. We consider how the design of several large-scale national and international reading tests and children's performance on them are influenced by the transition to a digital mode. Finally, we discuss how findings from empirical research can inform future reading assessment, on the one hand, and the teaching of reading in classrooms, on the other.

2. Assessing skills digitally

Computer-based testing has a long history in the US military and in psychology (Russell et al., 2003 provides a historical overview), but is rather recent in education. All the international assessments (e.g. PISA, PIRLS) are being digitised in some form in the time period of 2015–19. There are several reasons why assessment is becoming increasingly computer-based (Computer-Based Assessment; henceforth CBA). One is that digital technologies are becoming widespread tools for learning, at least in some parts of the world. Thus, digitising assessments follows from the general agreement that digital tools have their place in modern education, and that children should learn how to use technologies in ways that support learning. Another reason is that digitised assessment, although initially expensive, is becoming less costly than paper-based assessment (Scheuermann & Björnsson, 2009). The technological infrastructure required for testing is increasingly present in participating schools. In addition, most of the scoring can be automated, meaning that expenditure on man-hours is reduced. A further advantage to digitisation is that digital testing formats benefit research, as automatic data collection and scoring eliminates the risk of bias and scoring mistakes, although the risk of data loss due to technological failure is a point of concern (e.g. in the PISA ERA, see Haldane, 2009). A more pressing concern with digitised assessments, however, is that, of yet, we do not know the extent of mode effects on student performance.

Screens and keyboards have different affordances than paper and pens. They may invite different kinds of motor action and cognitive processing that can affect aspects of the reading skills assessed. For example, if developing readers mainly scan (Liu, 2005) when they are socialising online or searching the Internet for
information, video clips, or music (see Livingstone et al., 2014 on UK children’s media use), this scanning approach may transfer to all kinds of on-screen reading, including text comprehension on digital assessments. One consequence of this might be that digitised reading tests would assess this scanning behaviour instead of the full range of children’s reading skills.

Reading achievement measured via the employment of computers and keyboards may also depend on the respondent’s mastery of basic digital skills. These ‘gatekeeper skills’ may mask children’s true reading competence (or mathematical competence, see Jerrim, 2016) on such tests. Further, there is evidence of visual fatigue as an effect of continued LCD screen exposure (e.g., Benedetto et al., 2013; Blehm et al., 2005), but it is largely unknown how, for young readers, such eye strain and visual fatigue may interfere with low- and high-level cognitive processes during reading. Thus, as international and national assessments move to digital formats, important questions of test validity arise: Do we really test what we aim to test when reading assessment among children is digitised? How can we be sure that we are measuring the same phenomenon in digital versus paper-based test modes? (See Newton, 2014, for a discussion of validity in educational assessment.)

3. Digitisation of reading assessment: Cognitive considerations

One line of research relevant for understanding the influence of test format on performance is addressing potential effects of text medium on reading comprehension, recall and retention. Overall, the issue remains unsettled. Some studies show reading comprehension to be superior on paper (e.g., Kim & Kim, 2013; Mangen et al., 2013; Rasmusson, 2015; Singer & Alexander, 2016), whereas other studies find no significant differences between the two media (e.g., Ball & Hourcade, 2011; Margolin et al., 2013; Porion et al., 2016; Rockinson-Szapkiw, Courduff, Carter, & Bennett, 2013). A few studies are worth looking into more specifically, as they yield insights of particular significance to digitised reading assessments among children.

Kerr and Symons (2006) conducted one of the very few studies assessing children’s reading comprehension on paper and screens. Participants were 5th grade students who read two expository texts – one in print and one on a computer screen. The texts were relatively short (372 and 411 words). Kerr and Symons found that the children read more slowly and recalled more of the text material that they read on screen. When calculating comprehension efficiency (the product of recall and comprehension accuracy of recall and reading rate) on paper versus screens, however, Kerr and Symons found that reading on paper was associated with more efficient reading comprehension than reading on screen. These findings led to the
conclusion that, if given enough time, children may be able to comprehend equal amounts of information from paper and computer, but that comprehension is less efficient when reading on a computer screen (Kerr & Symons, 2006).

Sampling somewhat older students, Mangen et al. (2013) compared reading comprehension in 10th-graders in an urban area in Norway. Using materials from international and national reading assessments, they had students read one expository text and one narrative (fiction) text, both of which were about four pages long. The expository text was multimodal (i.e., consisting of information in different modalities: verbal text, graphics, tables), whereas the narrative text had one illustration only. One group of students read both texts as pdfs on a laptop, the other group read them on paper. Students read the texts in class and answered a number of multiple choice reading comprehension questions afterwards. Results showed that, overall, students who read both texts on paper scored better than those who read both texts on the laptop when basic skills levels were controlled for (Mangen et al., 2013). There were no differences with respect to text type. Additional analyses showed an interaction between basic reading skill and reading comprehension in that reading on screen had a stronger negative effect for students with low scores on the word chain test than for students with higher scores on the word chain test (Walgermo, Mangen, & Brønnick, 2013). This indicates that reading on screen may be particularly adverse for low-performing students, a finding that – if replicated – would seem to have implications for reading assessment.

In a more recent study, Rasmusson (2015) used material from the IEA (International Association for the Evaluation of Educational Achievement) Reading Literacy Test (the 1991 RLS) to compare outcomes on print versus screen reading. In her study, participants (N = 117) read both short (approx. 180 words) and somewhat longer (approx. 680 words) texts, of three types (narrative prose [fiction]; expository prose; documents [i.e., “structured presentations of information in the form of charts, graphs, maps, lists, or sets of instructions […]” (Rasmusson, 2015, p. 10)). Overall, results indicated a small difference in favour of print. More detailed analyses showed that students scored higher on paper than on screen for expository texts. Moreover, and perhaps somewhat unexpectedly, the difference between media was more pronounced for short than for long texts. However, given the modest effect sizes (d = 0.15 in total [across texts]; d = 0.04 for narrative fiction, d = 0.07 for documents, and d = 0.28 for expository prose; see Rasmusson, 2015, p. 13), the differences should not be overestimated.

Another recent experiment (Singer & Alexander, 2016) compared reading comprehension and performance judgments and calibration of two different types of texts on paper and screen. The respondents’ age was 19–20 years, and two thirds were female. The texts were short enough to fit on one screen/page (approx. 450 words each). Singer and Alexander (2016) found that, across text type, the majority
of participants reported a preference for reading on screen. However, there was a discrepancy between students’ preferences and their performance on some of the comprehension measures. While there was no difference between modes for identification of main ideas, participants performed better in print when measured on comprehension pertaining to key points in the text, as well as when asked to recall other relevant information. The authors conclude that, “medium mattered little […] only when the big idea or gist was required” (p. 12), and suggest future studies replicate their findings with younger readers and longer texts requiring scrolling and page turning.

Related to students’ comprehension ability is their metacognitive skill, or their ability to monitor their own reading (e.g., knowing when to slow down or re-read to ensure adequate comprehension; being able to use appropriate reading strategies for a variety of texts and purposes, see Wylie et al., Chapter 3). In one study assessing the influence of text medium on metacognitive ability (Ackerman & Goldsmith, 2011), university students studied expository texts (1000–1200 words long) on paper and on screen and predicted how well they would perform on a subsequent comprehension measure. Results showed superior performance in print when time was self-regulated. In addition, participants reading on screen were significantly more overconfident with respect to their subsequent performance compared to print readers. A more recent study (Norman & Furnes, 2016) with young adults, however, found no differences between paper- and screen-based texts on metacognition and learning.

In summary, it seems fair to expect that the transition from paper-based to screen-based reading assessment entails a handful of ‘unknowns’ with respect to test validity. In particular, these unknowns pertain to effects of screen affordances on reading comprehension and metacognition, especially among children. Moreover, little is known about how digitisation may differently affect readers with different reading profiles, such as young learners and struggling readers (for more on this topic, see Ben Yehudah et al., Chapter 5).

4. Digitisation of reading assessment: Navigating issues of text selection

Digitisation of reading assessments entails a host of implications for text selection, and questions concerning how digital tests present texts of different length are particularly salient. Higher-level cognitive skills involved in certain kinds of inferential – often called ‘deep’ (Wolf & Barzillai, 2009; Baron, 2015; Wolf, 2016) – reading require texts of appropriate length and complexity that can accommodate items specifically aimed at assessing readers’ ability to read critically, reflectively and analytically. Reading lengthy texts on screen, however, entails issues of
navigation (esp., scrolling) that may affect key cognitive aspects of reading, hence representing a potential threat to the validity of the assessment.

Findings from empirical research indicate that, if scrolling is required, reading on screens may have an additional cognitive cost (Baccino, 2004; Piolat, Roussey, & Thunin, 1997; Wästlund, 2007). The visual instability caused by scrolling may disrupt the ongoing reconstruction of the structure of the text for which, in contrast, the fixity of paper may provide helpful cues. Research has shown that having a good spatial mental representation of the physical layout of the text (e.g., how it is structured on the page; often aided by headings, sections, etc.) supports reading comprehension (Baccino & Pynte, 1994; Cataldo & Oakhill, 2000; Kintsch, 1998; Piolat et al., 1997). For instance, Cataldo and Oakhill (2000) found that good comprehenders were better than poor comprehenders at remembering and relocating the order of information in a text, suggesting a relation between mental reconstruction of text structure and reading comprehension. To this effect, the fixity of text printed on paper may support the reader's construction of the spatial representation of the text by providing fixed spatial cues (Mangen et al., 2013). Such cues are absent in the digital mode.

Reading experiments exploring mode-effects tend to opt for short texts not requiring any page turning, or have the experimenter turn the pages (on paper or on screen) on cues from the participant (e.g., Kretzschmar et al., 2013). Hence, the amount of research systematically assessing the effect of scrolling versus page turning on reading comprehension is scarce. In an early study (Piolat et al., 1997), participants were asked to read a short expository text in either a page-like or a scrolling format. Results showed that readers in the page-like presentation condition were better able to relocate information than readers in the scroll condition. Perhaps more importantly, the page-like presentation led to better memory for text information details than the scroll condition (Piolat et al., 1997).

In a more recent study, Sanchez and Wiley (2009) compared reading comprehension of complex informational texts using a scrolling versus a page-by-page format. In addition, participants’ working memory capacity (henceforth WMC) was assessed, to see whether readers’ WMC made a difference for reading in the scroll format. In two between-group experiments, the on-screen presentation format was manipulated while the content was held constant, and participants’ WMC was measured with a standard complex span test. In two experiments, participants read somewhat longer texts (2700 and 3500 words), presented either as a single, unitary page in scroll (with sub-headings), or divided into discrete pages (with the same sub-headings). Comprehension performance was tested by asking participants to write a short argumentative essay about main concepts in the texts. Across experiments, results indicated that the scrolling format had a significant \( p < .05 \) negative effect on participants’ reading comprehension. The negative effect was
particularly pronounced for participants with low-WMC, whereas scrolling had little impact for those with high-WMC. The authors provide three possible explanations for these results: firstly, scrolling may require readers to maintain a surface representation of a text and engage in comprehension processes simultaneously. Hence, scrolling can exacerbate the cognitive load, making low-WMC readers particularly vulnerable. Alternatively, those with lower WMC may have difficulties controlling their visual attention while scrolling and are therefore prone to disorientation and distraction during reading. Finally, when faced with scrolling and lacking aids such as page breaks, low-WMC readers may fail to engage in the consolidation or integration processes necessary for successful comprehension (Sanchez & Wiley, 2009).

The above findings illustrate how the shift from print to computers, and in particular to a scrolling interface, may compromise comprehension of extended-text reading (e.g., Wästlund, 2007; Sanchez & Wiley, 2009). The potential effect of this central feature of digital reading assessments on students’ performance is largely unknown, but important to understand, particularly within the frame of the ongoing move in international assessment towards reconceptualising reading in ways that are more compatible with digital than with paper-based reading. In practice, this entails using shorter texts, and also more multimodal and dynamic material and items (e.g., simulations and multimedia clips in forthcoming PISA tests), in which the amount of verbal texts may be considerably reduced, along with the range of reading skills assessed. Thus, with all large scale international assessments being digitised in some form (e.g. PISA, see below), it is of great importance that we understand the effects of new testing modes and formats on children’s performance on these tests.

5. High stakes assessments: ILSA International assessment

Cross-national skills assessment, referred to as International Large-Scale Assessment (ILSA), are characterised by high standards of measuring achievement in instrument construction and psychometric quality (Baumert et al., 2009). Such assessments include the Progress in International Reading Literacy Study (PIRLS) and the International Computer and Information Literacy Study (ICILS includes some reading; Fraillon et al., 2014). Both these assessments, as well as TIMSS (Trends in International Mathematics and Science Study, outside the scope of this chapter) are initiated by the IEA. The Programme for International Student Assessment (PISA) and Programme for the International Assessment of Adult Competencies (PIAAC), are conducted by the Organisation for Economic Co-operation and Development (OECD). ILSAs are designed to measure the educational outcome at
national levels, and not the school, classroom or student level. Although ILSAs are considered low-stakes assessments in terms of the potential impact on individuals, they are potentially high-stakes with respect to the decisions countries make on the basis of ILSA results (Wagemaker, 2014).

5.1 The IEA-assessments PIRLS, ePIRLS

The International Association for the evaluation of Educational Achievement (IEA) at Boston College is responsible for developing the PIRLS studies (Solheim, 2013; Mullis & Martin, 2015) measuring reading literacy. PIRLS assesses reading literacy among a carefully selected, representative sample of 4th graders (approximately 10 years of age) in a large number of countries. PIRLS is carried out every fifth year, using some of the same texts and items to measure changes in reading achievement.

In 2016, the PIRLS study included an additional, optional digital test of online reading called ePIRLS. The aim of ePIRLS is to measure online reading in a simulated web-environment, and in contrast to PIRLS, it does not contain any literary texts (Mullis & Martin, 2015). The ePIRLS results yield additional information about a mode-defined type of reading among the same age group as PIRLS in those countries implementing it.

5.2 The OECD-assessments PISA and PIAAC

The PISA (Programme for International Student Assessment) assessment is overseen by the OECD (Organisation for Economic Co-operation and Development), and PISA spans even more countries than PIRLS. Importantly, PISA tests older children, i.e. 15-year olds (regardless of school grade), and it takes place more frequently: every third year. In addition to PISA, the OECD produces an assessment of basic skill levels among 16 to 65-year olds, shedding light on how groups within these young and adult populations compare in e.g. reading. The Programme for the International Assessment of Adult Competencies (PIAAC) assesses skills in literacy, numeracy and problem solving in technology-rich environments.

PISA includes several skills or competencies in the same test, measuring mathematical, scientific and reading literacy. The major domain of the PISA test varies for each cycle before it is repeated. Consequently, every ninth year, more data, and more varied data, are collected on reading than on the other domains. Nonetheless, as reading is part of the test in every PISA-cycle, any large changes in the levels of reading skills in a population can be detected in every three-year cycle.
In 2009, when reading was the major domain, 19 countries and economies took part in the PISA Electronic Reading Assessment (ERA). The ERA tested online reading in a simulated web-environment as an addition to the paper-based study the same year (Frønes et al., 2013), much like the present PIRLS and ePIRLS complement each other. Unlike the ePIRLS, the PISA reading assessment employed both stable screen text formats and texts requiring scrolling. Since then, PISA has taken more steps than PIRLS towards full digitisation of assessment: in 2018, when reading again is the major domain, the assessment’s new items will be digital only (with the exception of a few non-member countries that, for lack of technological resources, will employ a paper version of trend items only).

In 2018, with reading measured via CBA only, PISA marks a clear break with the traditional paper-based test and commences a new tradition of understanding and assessing reading literacy skills. Reading items include dynamic item formats, as opposed to just displaying pdfs of paper-based items digitally. Such digital enhancements invite critical reflections around construct validity. Whereas paper-based reading tests are also multimodal (requiring combining static visual material with verbal text), the inclusion of dynamic modalities introduces a radically different dimension to the construct of reading. The effects of such an expansion on, e.g., verbal text comprehension, is largely unknown.

6. Changing definitions, changing texts

Reading competence is commonly referred to as ‘reading literacy’ in the international assessment frameworks, but the exact reading skill and the definitions of reading used by test developers vary in some respects that influence the texts chosen for test administration (cf. below).

The PIRLS 2016 definition of reading literacy is formulated thus:

> Reading literacy is defined as the ability to understand and use those written language forms required by society and/or valued by the individual. Readers can construct meaning from a variety of texts. They read to learn, to participate in communities of readers in school and everyday life, and for enjoyment.

(Mullis & Martin, 2015, p. 12)

The most recent PISA definition of reading literacy is:

> Reading literacy is understanding, using, evaluating, reflecting on and engaging with texts in order to achieve one’s goals, to develop one’s knowledge and potential, and to participate in society.

(OECD: PISA 2018 Draft Reading Literacy Framework, 2016, p. 10)
Thus, even though PISA, like PIRLS, includes fiction in the reading test, the PISA definition does not mention reading for enjoyment. Indeed, although the PISA reading test contains more texts, it includes less fiction than PIRLS does. It therefore appears that there is less focus on engagement in literary reading in PISA, and the texts in the PISA reading test are shorter than those offered to the younger students in PIRLS.

Similarly, the PIAAC description of functional reading competence differs from the PISA definition in a slight but important way. PIAAC defines reading competence as:

understanding, evaluating, using and engaging with written texts to participate in society, to achieve one’s goals, and to develop one’s knowledge and potential.

(OECD The Survey of Adult Skills: Reader’s Companion, 2013, p. 21)

The PIAAC definition does not mention the term “reflecting on” (included in PISA), nor reading “for enjoyment” (in the PIRLS definition). This shift away from reflection and enjoyment is accompanied by less varied text material than the other tests, as the PIAAC assessment contains no fiction, i.e. literary texts (it may still contain narrative, factual texts, however). There is also a difference in the demands made on the respondents’ writing skills. PIAAC employs multiple choice items (tick off) like the other assessments, but in contrast to these the PIAAC respondent does not have to construct written responses to open questions. Instead, PIAAC employs so-called ‘selected responses’, where respondents merely highlight text parts which they gather contain the correct answer.

One notable consequence of the mode change from paper to screen may be the marginalisation of longer, literary reading. Admittedly, it is difficult also in paper-based testing to measure long-form literary reading. Yet, the PIRLS framework flags the importance of reading for enjoyment by including it in the definition, and the test includes many fiction texts (even if these cannot be full novels). Herein lies an acknowledgement that the target group of the PIRLS assessment should be encouraged to engage in sustained reading of interesting texts, a practice supported by research that links book reading to good reading comprehension (Cunningham & Stanovich, 1997; Guthrie et al., 1999; Pfost et al., 2013). Eyre et al. (2017) raise similar concerns about the reduction of text length in digital reading comprehension assessments. They claim this entails a change of the “construct being assessed from the ability to comprehend longer passages of text to the ability to comprehend short blocks of text” (p. 24).

Thus, with the tendency in digitised reading assessments towards increased multimodality and shorter texts, engaged reading of long, linear texts – “deep reading” (Baron, 2015; Wolf & Barzillai, 2009) – seems destined to further neglect.

The table below highlights this trend. It presents the effect of digitisation on the selection of texts used in each of the international assessments. Text types
are given as fact versus fiction (or neither in some tests) and the table illustrates how fiction, a genre typically associated with sustained, or deep, reading, is losing ground as digitisation and reading (online) for information increases.

<table>
<thead>
<tr>
<th>Acronym</th>
<th>First year</th>
<th>Skills</th>
<th>Text types</th>
<th>Medium: Paper or CBA</th>
<th>Age group or grade</th>
<th>Number of countries in most recent survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIRLS (similar to 1991 RLS)</td>
<td>2001</td>
<td>Reading</td>
<td>Fiction and fact</td>
<td>paper</td>
<td>4th grade (9–10)</td>
<td>50</td>
</tr>
<tr>
<td>PISA (first round, 3-year cycles)</td>
<td>2000</td>
<td>Reading, mathematical and scientific literacy</td>
<td>Fact and fiction</td>
<td>paper</td>
<td>15</td>
<td>72 (in 2015)</td>
</tr>
<tr>
<td>PISA CBAS</td>
<td>2006</td>
<td>Scientific literacy</td>
<td>–</td>
<td>CBA addition</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>PISA ERA</td>
<td>2009</td>
<td>Online reading literacy</td>
<td>Fact</td>
<td>CBA addition</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>PISA maths and problem-solving</td>
<td>2012</td>
<td>Mathematical literacy and problem-solving</td>
<td>–</td>
<td>CBA addition</td>
<td>15</td>
<td>32</td>
</tr>
<tr>
<td>ICILS</td>
<td>2013</td>
<td>Information and Computer Literacy Study</td>
<td>–</td>
<td>CBA</td>
<td>8th grade or 13 years of age</td>
<td>21</td>
</tr>
<tr>
<td>PISA</td>
<td>2015</td>
<td>Science, reading, mathematic, and financial literacy</td>
<td>Fact and fiction</td>
<td>CBA Paper was still an option</td>
<td>15</td>
<td>72 (in total, i.e. both CBA and paper versions)</td>
</tr>
<tr>
<td>PISA collaborative problem-solving</td>
<td>2015</td>
<td>Collaborative problem-solving</td>
<td>–</td>
<td>CBA addition</td>
<td>15</td>
<td>32</td>
</tr>
<tr>
<td>ePIRLS</td>
<td>2016</td>
<td>Online reading literacy</td>
<td>Fact</td>
<td>CBA addition</td>
<td>4th grade</td>
<td>14</td>
</tr>
<tr>
<td>PISA</td>
<td>2018</td>
<td>Reading, mathematical and scientific reading</td>
<td>Fact and fiction</td>
<td>CBA only</td>
<td>15</td>
<td>?</td>
</tr>
<tr>
<td>ICILS (first repetition)</td>
<td>2018</td>
<td>Information and Computer Literacy Study</td>
<td>–</td>
<td>CBA</td>
<td>8th grade or 13 years of age</td>
<td>?</td>
</tr>
</tbody>
</table>
7. What large-scale assessment has taught us about mode-differences

Since extensive background data is collected on students, ILSA results can be used to explore the relationships between student scores across modes and demographic factors (e.g. gender, socioeconomic status, immigrant status, access to and use of computers and the Internet at school and at home). The PISA report Students, Computers and Learning: Making the Connection refers to data from the 2012 cycle in which mathematical literacy was the major domain (OECD, 2015a). The study documents how in spite of the “strong cross-country correlation, mean paper and computer test scores differ by at least 10 PISA points in one-in-three [of 32 countries implementing both modes] economies” (Jerrim 2016, p. 495). The top-performing Shanghai-China students turn out to be the ones with the greatest deviation in mathematical performance between the two modes of assessment (ibid.). Shanghai children performed on average a full 50 points lower in the digital test. They were also among those with the least computer access. It appears, therefore, the difference in scores across modes may be a case of digital skills functioning as ‘gatekeepers’ of competence.

Further analysis revealed that the mode of assessment was related to several differences in performance in the PISA 2012 survey. Exploring distributional effects on gender, socioeconomic status (SES) and country of birth, i.e. immigrant status (while controlling for factors such as access to computers and self-reported ‘test effort’), Jerrim (2016) found that the gender gap tends to widen in favour of boys in CBA compared to the paper-based mathematics test. In 28 out of 32 countries the mode-difference is significant ($p < .05$), but it actually varies whether the gender gap widens or is reduced (cross-country correlation is, in other words, low). On the other hand, the variable SES exhibits weaker associations with CBA scores in mathematics, meaning that digital testing appears to reduce the impact of low socioeconomic background. Differences in scores between students of immigrant versus native backgrounds, appear at first glance to be equal across the two modes of assessment, but closer inspection reveals that some countries experience a much greater immigrant versus native gap, in favour of native, in the computer test mode compared to the paper test (e.g. Germany and Sweden) (Jerrim, 2016).

Another important finding from the more recent PISA 2015 main survey is included in the official report (OECD 2016b). The well-known gender gap in reading literacy in favour of girls became significantly smaller in all OECD-countries, except for (South) Korea (OECD, 2016b), while the international average did not decrease. There is reason to believe that boys performed better on the digitised test at the cost of the performance of girls. If so, this adds to Jerrim’s (2016) conclusions that CBA discriminates against girls, in reading as well as in maths. Martin and
Binkley (2009), on the other hand, suggest that paper tests discriminate against boys. The possible gender bias of (perhaps each of the two) mode of test administration deserves closer study before CBA is accepted as a standard test mode.

7.1 Pedagogical implications 1: Designing assessments sensitive to reading across modes

Considering the variation in scores on national levels that digital versus paper-based PISA assessments have yielded so far (see above, e.g. Jerrim, 2016), it seems wise to treat the reading literacy construct conservatively by developing tests and defining frameworks which recognise the differences, affordances, and limitations of reading in two modes. Whereas ePIRLS does exactly this, by keeping the paper format for its young readers, and offering the digital ePIRLS as an addition, the PISA assessment substitutes one mode of testing for another, without really acknowledging any difference in its definition of reading literacy (above). In 2018, the PISA reading assessment combines pdf-presentations (for the trend items), with more online-imitating reading employing multiple texts and searching, hyperlinks and higher level processes, such as comparing and finding contradictions in texts. The navigation component common to the PISA reading assessments in recent years is not a part of the new framework for PISA 2018, nor the next three cycles.

Thus, it seems that PISA 2018 aims to measure both traditional text reading on screen and digital reading without clearly distinguishing between them. As noted earlier, however, reading digital texts, with affordances such as multimodality, hyperlinking, and ‘authorless’ and/or contradictory sources requires students to have a set of skills that may be different from reading printed text (Alexander et al. 2012; see also Chapter 4 by Salmerón et al. in this book). Test developers seem to assume that children’s expansive use of digital technologies by default fosters these skills. For some children, however, even simple navigation may be a challenge. Thus, for test developers as well as for educators and practitioners, it is necessary to keep in mind that digital reading may involve a different set of skills than print reading and that not all children have mastered them.

7.2 Pedagogical implications 2: The influence of digitised reading assessment on classroom practice

Digitised testing may have subtle, but nonetheless important, implications for how we, implicitly and explicitly, define and understand what constitutes reading competence in the classroom. For example, large-scale assessment of reading comprehension has influenced classroom practice (Wixson & Carlisle, 2005), and it has contributed to the priority modern schooling gives to basic skills and the
consequent monitoring, at national or state levels, of skill development. Further, “assessment for accountability” has become an established educational term in some countries (Mehrens, 1992, p. 3), and “teaching to the test” is a well-known phenomenon.

The sheer quantity of high-stakes tests, international assessments included, can lead to reading instruction aimed at passing the benchmarks of those tests. Indeed, some countries have “aligned their curricula and tests to the design of PISA” (Hopfenbeck & Baird, 2014, p. 7). Reading instruction, however, should support many aspects of reading competence, not only those that typically occur in tests. Further, with the increasing digitisation of large-scale assessment, there is a risk that the digital assessment in itself functions as a spearhead for ‘modern’ digitally-based school activities which may or may not be well suited for promoting a broad range of reading skills, such as reflection and evaluation. In other words, an indirect effect of high-stakes digitised assessment may be that computers (and the Internet) are considered as ideal tools, not only for testing, but also for learning.

There is little evidence in the research literature suggesting that screens and/or the Internet are superior to paper when children learn to read, nor when they read to consolidate and expand their reading competence. Indeed, comparing the results of PISA Online (digital reading) scores and the paper-based PISA reading scores, the above-mentioned OECD report (2015a) concluded that there was no appreciable improvements in student achievement in reading, mathematics and science even in countries which had invested heavily in ICT for education (OECD, 2015a, p. 3). Results suggest that limited use of ICT in school may be better than no use at all, but that “using [ICT] more intensively than the current OECD average tends to be associated with significantly poorer student performance.” (p. 16). Moreover, in the same report, patterns in the relationship between computer use at home and in school, and performance in reading, indicate that “it is not necessary to use computers frequently to perform well in digital reading” (p. 160; italics ours). Hence, based on what we currently know about the affordances of paper and screens and the development of reading proficiency, there seems to be reason to emphasise that, for many purposes of reading instruction and pedagogy, it is sensible to continue to use the conventional medium of print.

8. Concluding perspectives

Important as it is for reading assessments to reflect ongoing changes in the media and text ecology, it is worth stressing that an operationalisation of reading as a skill predominantly based on reading in digitised environments runs the risk of ignoring key cognitive components of reading, namely, those that are not
as easily implemented in digital environments. In particular, such components pertain to the reading of lengthy, linear, and predominantly written (verbal) texts. Thus, as (national and international) reading assessment is increasingly digitised, it is crucial to keep in mind those aspects of reading which are not easily implemented in a digitised environment, and quite plausibly not even possible to assess with electronic platforms, as well as the possible influence of testing mode on performance.

The more we learn about reading on paper and on screens, the more it seems that each has its particular effects on reading. The arguably most salient case in point pertains to the issue of text length and the associated extent of scrolling required for navigation. As mentioned, there is evidence that scrolling negatively affects cognitive text processing (e.g., Wästlund, 2007; Sanchez & Wiley, 2009). The effect of this central feature of navigation in digital assessment is largely unknown, but could perhaps explain why a Norwegian field trial (in 2015 for the national reading test to be digitised in 2016) found that 10-year old children needed more time to get through the CBA than the paper version of otherwise identical reading tests, and that comprehension was better on the paper version (Støle et al., in prep.).

As national assessments transition to digital forms, this shift will inevitably shape the reading instruction of the future. As an example, a key barometer of US students’ reading performance over time is provided by the National Assessment of Educational Progress (NAEP), which is introducing a digital reading assessment in 2017. Current publicly accessible information about these tests suggests the addition of multimedia clips and scenario-based assessment contexts (NCES, 2016), which signals a significant broadening of what counts as reading.

Hence, the digitisation of reading assessment leads to questions of a normative nature: What kinds of reading and what components or aspects of the multidimensional construct of reading comprehension are endorsed and considered most important to measure? A task of paramount importance for future reading research of any theoretical and methodological orientation is to devise empirical studies that explore the factors contributing to successful reading outcomes during the reading of different kinds of material, on an increasing variety of reading devices.

Teachers and education agencies need to critically evaluate the potentially far-reaching consequences of the digitisation of assessment. Given the prominence afforded to high-stakes tests, there can be pressure for educators to emphasise the what and how of international assessments, potentially leading to greater focus in the classroom on skills that are tested directly. Thus, practitioners as well as stakeholders must keep in mind that these large scale tests are developed to provide
information to authorities and stakeholders at national levels and not to provide
guidance for teachers on how to best teach reading in the classroom.

There is still an urgent need for more empirical research on children and young
students’ reading performance on different devices and for different purposes.
Cross-national as well as national digital reading tests yield new and important
insights about how children and young people master reading on screens versus
on paper. When used correctly and wisely, insights from assessments may help
the reading teacher navigate a complex media landscape and make pedagogically
appropriate choices of technologies and texts for the developing reader. If, how-
ever, we use them as models for reading instruction, we run the risk of not teach-
ing children what they need to become competent readers in both modalities.

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CHAPTER 10

Learning to read in a digital world

Discussion

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Understanding how to best support children as they learn to read in an increasingly digital world involves recognizing the many child- and text-related aspects of children's digital reading experience. In the current chapter, we consider how children's reading skills, goals, as well as the properties of digital text influence children's reading development in digital environments. We further discuss how schools, parents, media creators, and policy makers can help shape children's reading experience in digital contexts so that each child is given the tools, skills, and opportunities she needs to reach her full potential in both print and digital environments.

1. Introduction

The chapters in this volume reveal the multitude of issues and perspectives that must be considered as we study how children's reading develops in an increasingly digital world. Each chapter has highlighted a specific aspect of the text, the child, and the child’s environment that may influence reading development in digital contexts. Accordingly, children's cognitive skills (Wylie et al., Chapter 3; Salmerón et al., Chapter 4; Ben-Yehudah et al., Chapter 5) and emotions (Kaakinen et al., Chapter 6) play an important role in reading development in digital environments, as do the properties of the text being read (Walker et al., Chapter 2), the purpose and motivation for reading (Deszcz-Tryhubczak & Huysmans, Chapter 1), and the way in which digital tools are used and taught in the classroom and for assessment (Kaakinen et al., Chapter 6; Mifsud & Petrova, Chapter 7; Baturay et al., Chapter 8;
Stöle et al., Chapter 9). It is essential, then, that all these aspects of children’s digital reading experiences be considered both separately and in combination when trying to understand how to support children’s reading development in digital environments.

Children’s path to reading involves the ongoing acquisition of knowledge about language and the written word and the skills necessary to decode and comprehend texts (Biancarosa & Snow, 2006; Juel, 1988). To understand the influence of digital texts on this development, we must build upon models of reading that recognise the contribution of multiple child- and text-related factors in shaping reading development. Several such models exist; for example, the RAND model (RAND Reading Study Group, 2002) highlights the importance of the reader, the text, the task requirements and their interaction for meaningful reading. In addition, Jenkins model (Jenkins, 1979), as applied to reading behaviour (van den Broek, Fletcher, & Risden, 1993) posits that for an outcome of interest, such as successful reading comprehension, underlying variables (e.g. properties of the text, reader skills) and their interactions must be taken into account, particularly if disparate study findings are to be integrated. Below, we consider how characteristics of the reader, the text, the reading goal and their interplay are influenced by and in turn influence reading in a digital environment.

![Figure 1. A triangle model of research on the development of digital reading (adapted from Jenkins, 1979; RAND, 2002)](image)

1.1 Reader skills and experiences

An individual’s experience reading digital text will always be influenced by the unique constellation of skills, attitudes and experiences that he/she brings to the task. For children and young people learning to read, their relative exposure to print versus digital text, before and during their school careers, may influence preferences, motivation and the relative ease with which they read in either modality, as well as perceptions of which modality represents “real” reading. In unpublished data (Thomson & Prieler, 2017), for example, 5 year old UK children demonstrated a tendency to perceive reading print books as “real” reading, with eBooks regarded more as games (see also Deszcz-Tryhubczak & Huysmans, Chapter 1).
For both print and digital reading, an individual’s cognitive profile will also impact the ease and efficiency of reading – for example strong working memory, attention, executive function and language skills are a boon to reading (Wylie et al., Chapter 3). The impact of weaknesses in such skills on digital reading, however, highlights the interplay between reader skills and text properties. For example, Ben-Yehudah et al. (Chapter 5) note that for individuals with attention deficit hyperactivity disorder (ADHD), short passages presented on screen can reduce the performance gap with age-matched peers. In contrast, comprehension of longer texts, requiring high levels of sustained attention, demonstrated a screen-inferiority effect, with better performance in the traditional print medium.

1.2 Text properties and content

Comprehension of digital text is intrinsically influenced by the properties and format of the text. This is not unique to digital text; research on print has demonstrated the impact of different variables on comprehension (e.g. font type and size, page size, and column structure (see Walker et al., Chapter 2). It is clear, however, that the digitisation of text potentially broadens the number of text formats individuals are exposed to. Further, it has arguably reduced the privileged position of text designers as text is now presented via a more diverse range of text window sizes (e.g. smartphones, tablets, desktop PCs), and frequently flows to fit the parameters of any given device, potentially reducing the intended couplings between e.g. text and images (e.g. Walker et al., Chapter 2).

The presence or absence of hyperlinks in digital environments is another property of digital text that influences the relative linearity of a piece of text. While some hyperlinks, such as those to word definitions or translations, are designed to facilitate meaning-making, while other types, for example advertisements, can cause distraction. The effect of these text properties, however, can only be determined through their interaction with the characteristics of different readers. Thus, each reader has distinct proclivities to follow links, in keeping with his/her specific goals, as well as differentially-developed strategies for maintaining comprehension in such a multi-layered informational context (Salmerón et al., Chapter 4). Consequently, the influence of different digital text properties can best be understood when reader characteristics, such as a reader’s skills and knowledge, as well as the readers’ goals, are also considered.

1.3 Reading goal/task

Children’s goals in digital environments may be many and varied and will greatly influence their reading behaviour. Thus, for example, skimming a digital article in search of keywords elicits shallower reading behaviour and may make readers
more vulnerable to distraction than reading a gripping story posted by a friend (Fitzsimmons, 2016). In addition, how schools introduce digital texts, design assignments, and model digital reading behaviour can influence children’s reading goals (Mifsud & Petrová, Chapter 7). Many schools, however, lag behind other aspects of society in terms of uptake of technology, as well as usage of the non-linear text formats that are more native to digital formats. As a result, in many countries (e.g. the UK and Poland) children are reporting more digital reading occurring outside of school and for a wider variety of goals (e.g. social communication and reading news/information related to their interests; see Deszcz-Tryhubczak & Huysmans, Chapter 1). This trend highlights the more social goal of reading that digital text is engendering, which is also marked by distinct text properties of informality and brevity.

In the face of such brevity and the abundance of hyperlinked text requiring frequent within-text decisions as to what content to read next, an open question for the field is the degree to which digital text can support ‘immersive’ reading experiences (Kaakinen et al., Chapter 6) that have traditionally been experienced when reading print-based literary texts. This is an area where more developmental research is sorely needed. It is also clearly a question that intersects closely with text property variables.

2. Summary

The transition from print to digital text precipitates shifting societal patterns of reading and shifting skillsets needed to carry out these activities. Researchers are identifying how reader and text-related factors set digital reading apart from its print predecessor and have begun to explore the complex influence of these different factors and their interaction on reading behaviour, e.g. how does flipping pages versus scrolling (text properties) affect reading assessment performance (reading task) (Sanchez & Wiley, 2009); how does a child’s working memory profile (reader skills) impact navigation of hyperlinked text (text properties) (Lee & Tedder, 2003)? Continuing to pursue research that considers reader skills, goals and text properties will be essential for gaining a better understanding of the complex interplay between reader and text-factors in digital environments and for determining how to best support children’s reading development.

Even as future research will prove invaluable for our understanding of reading development in digital contexts, our current knowledge suggests a range of implications for schools, parents, media creators, and policy makers to help provide opportunities for children to succeed in both digital and print worlds.
2.1 Implications of learning to read in a digital world: Schools

Mifsud and Petrová (Chapter 7) outline many of the curricular, classroom organisation, and teacher preparation challenges and opportunities that face schools in preparing their students to be literate individuals in a digital era. In terms of basic access to digital text, the 2015 PISA report (OECD, 2015) makes clear the manner in which schools are lagging behind in matching their students’ wider technology usage: in 2012, “96% of 15-year-old students in OECD countries reported that they have a computer at home, but only 72% reported that they use a desktop, laptop or tablet computer at school, and in some countries fewer than one in two students reported doing so” (p. 3). Beyond this digital access gap, there may also be an even bigger disconnect between predominantly linear text reading at school, even on computers, and more non-linear, socially interactive, web-based reading in children’s wider lives. As Salmerón and colleagues (Chapter 4) note, the latter types of activity entail an emerging set of advanced reading skills that children must master, including focused searching and navigating of hypertext and multimedia sources, integrating multiple sources of information as well as critical evaluation of the quality of claims being made (Afflerbach & Cho, 2010). These are skills that must be taught and addressed in schools.

In many cases, however, there is also the matter of how educators are trained to help their students learn from digital text and to be critical consumers of the vast amounts of information available to them via hypermedia. Although there are many examples of teachers using digital resources in innovative and creative ways, many teachers struggle to incorporate digital material into their day-to-day literacy instruction (Abrams & Merchant, 2013; Flewitt, Kucirkova, & Messer, 2014). There may be several reasons for this, including lack of confidence in using digital devices in the classroom, extra time needed to explore available digital resources, lack of guidance in how to incorporate digital reading into classroom practice and the common precedence of print reading in already-full curricula (Carrington, 2005; Turbill, 2001). Eliciting wide-scale change in teacher practice, however, is a challenge across countries. While the optimal mechanisms of teacher professional development are still being elucidated, it is clear that effective change in practice is best fostered when pedagogical instruction is accompanied by substantive opportunities to observe, practice, receive feedback and have access to a collaborative professional community of fellow-learners (Garet, Porter, Desimone, Birman, & Yoon, 2001). There is a pressing need in Europe and beyond for effective examples of this model, as applied to digital reading, to help schools keep up with their students’ learning needs.

The above discussion assumes that if the issues of infrastructure and teacher preparation are addressed, then schools can be open gateways to opportunities to
engage with digital text. It is important to note, however, that prominent scholars have persuasively argued that in learning to read children may *actively* need experience with a deeper mode of processing than non-linear text typically engenders (Baron, 2015; Wolf, 2016). Kaakinen et al. (Chapter 6) note that the active decision-making needed for non-linear reading – for example, should a link be followed, which segment of text should be read next? – necessarily reduces the immersive experience of reading. This reduced immersion may impact both children and adult’s ability to engage in ‘deep reading’, i.e. the application of advanced comprehension processes (Wolf, 2016). Wolf and others are careful to note that this concern requires more concrete empirical confirmation, and indeed, there is emerging evidence that when taught strategies to manage the new and distinct demands of non-linear text, individuals can significantly deepen their comprehension of online material (e.g. Ackerman & Goldsmith, 2011). In considering, however, that online reading may require specific strategies to engender comprehension that are not fully established within teaching pedagogy, then, as Walsh (2010) notes (cited in Mifsud & Petrova, Chapter 7), it is important “to consider to what extent digital technologies can be incorporated within classroom literacy programmes without reducing the importance of the rich, imaginative and cultural knowledge that is derived from books” (Walsh, 2010, p. 211). What is the right balance of print and digital text in instruction, and how can we best determine this?

2.2 Implications of learning to read in a digital world: Parents

In relation to educators, parents face overlapping but distinct decisions as their children are exposed to digital reading opportunities. With digital technology typically more available for children at home than at school, whether mobile devices, tablets, or computers (OECD, 2015), the question is not one of *whether* digital devices should be accessed by children, but rather how much and in what manner. Indeed, questions surrounding when and how to introduce digital devices are becoming more and more pressing (e.g. Barzillai, Thomson, & Mangen, 2017; Kucirkova & Radesky, 2017). In their survey of UK parents of children from 0–8 years, Kucirkova and Littleton (2016) found that 31% of the parents surveyed reported feeling confused about how to use e-books with their child to best support learning. More than half of the parents reported that they would like to receive advice on how to use digital media with their children in order to support their child’s learning and to keep them entertained. The popular belief that screens can hurt children’s brains was also articulated by a proportion of respondents. These findings underscore parents’ desire and need for information about how best to manage and support their children’s use of digital devices. Yet, as this volume intimates, the information we have remains nascent.
The beliefs expressed by parents in the Kucirkova & Littleton survey (2016) also highlight the new position text finds itself in debates about how children use their time. As Deszcz-Tryhubczak & Huysmans (Chapter 1) note, when televisions first become widespread, there was considerable fear about the seemingly more positive activities that would be displaced by television viewing, including reading, as well as physical activity and social interaction. The evolution of reading into a screen-based activity has thus moved reading into much larger and emotive debates about ‘screen time’, which potentially adds to the confusion parents face. Progress is being made; for example, the American Academy of Pediatrics has recently amended its recommendations to parents around screen time, from the notable, but rigid ‘2 x 2’ rule, i.e. no screen time for children younger than 2, no more than 2 hours per day for older children, to a more nuanced acknowledgement of the multiple ways in which children use screens, including social interaction, learning, and active play (American Academy of Pediatrics Council on Communications and Media, 2016).

The updated policy statement recommends that media screen exposure is discouraged under the age of 18 months for activities other than video-chatting. For older age-groups, the guidelines still recommend placing certain limits on screen-time, especially around meal times and before going to sleep. In terms of more specific advice around media content choices, however, the recommendations are necessarily limited by the paucity of evidence available. The report advises families to “Avoid fast-paced programmes (young children do not understand them as well), apps with lots of distracting content, and any violent content” (p. 4). Advice is also given to choose “high-quality programming” (p. 3); however, this recommendation pre-supposes that clear information is available on what high quality programming is and where to find it. Both researchers and media producers are making strides in this arena; for example the resources provided by the Joan Ganz Cooney Center at Sesame Workshop (e.g. Guernsey & Levine, 2015), as well as the literacy app guide produced by Natalia Kucirkova in conjunction with the National Literacy Trust of the UK (http://literacyapps.literacytrust.org.uk/). Much more research is needed, however, in order to provide families with specific guidance.

### 2.3 Implications of learning to read in a digital world: Media design

The increased consumption of digital text by young readers also represents a paradigm shift for designers and media creators. The word ‘design’ within a digital reading context covers multiple domains, from text designers working at the level of font choice, letter/line spacing and placing of illustrations, to content and or instructional designers who are generating/curating text, determining the placement of hyperlinks and deciding whether information is presented via the written word, the visual image, audio or video. The digital world also brings
additional design agents – the designers of the hardware/software interfaces on which digital text is presented, as well as individual readers as designers of their own digital reading experience – with the ability to alter how both text and content are presented.

This increase in design complexity, in terms of both the number of design agents and the number of devices on which a piece a text may be presented, fundamentally changes the role of text designers, who in many ways face a loss of control in the wake of text digitisation (Walker et al., Chapter 2). The goal of a text designer is to make the text meaning as clear as possible to the reader, through the type and size of font, the column structure, relative position of illustrations etc. Within the fixed text environment that printed books typify, designer intentions can be delivered directly to the reader without modification; however, with “flowed” text, where the content is fixed but the layout varies depending on the device, the designer has far less control. Pdf format is potentially a middle ground, but this imposition of a fixed text format across a variety of digital devices can bring its own readability challenges in terms of e.g. mismatch between pdf line length and device width.

While text designers may lose control of some elements of design, digital text creation also provides a proliferation of design choices and ease of editing, offering much new opportunity too. This proliferation of choice is equally true for content and instructional designers. Rather than being constrained by the distinct learning affordances of specific media, a digital environment can offer whatever the designer wants in terms of linear versus nonlinear text, inclusion of video or audio and within the more dynamic visual forms of video/audio, these can still be paused, replayed, captioned, annotated etc. As the chapter by Baturay et al. (Chapter 8) intimates, in some respects this puts the current media affordances ahead of learning theory, in terms of knowing how best to present information for a range of individual learners and to allow optimal processing of meaning. The question of knowing how information is best consumed also implicates readers themselves as agents and ‘designers’ of their digital text experience. Studies by Ackerman and colleagues, for example (Ackerman & Goldsmith, 2011; Ackerman & Lauterman, 2012; see Wylie et al., Chapter 3) report that at the undergraduate level, students are often overconfident in their perceived level of comprehension during digital reading as compared to their measured performance, an overconfidence not present in their reading of print material. Thus, research is needed on both the optimal design of digital text environments for the comprehension needs of different readers, as well as on how best to help readers understand their digital reading strengths and challenges. In addition, it is important to realise that although a clear design priority for digital text environments is meaning-making and scaffolding the experiences of young readers, there are other forces at work.
For example, market-share of platforms and compatibility of e-book reading schemes with school digital asset management systems will impact design choices. Supporting children's reading development in the face of such broader economic and societal forces brings us to the final arena for discussion: political and educational policy.

2.4 Implications of learning to read in a digital world: Policy

In national and international level conversations about our 'digital youth', the most pressing agendas currently focus on internet safety, as well as the socio-emotional implications of children's lives being carried out increasingly online (Livingstone & Haddon, 2009). Although the positive contribution of digital media to children's lives are many, there are also risks. Children perceive bullying as a worrying aspect of online life, while adults have additional concerns around the risks of abuse, and potential negative emotional impacts of excessive time spent separated from the 'real', non-digital world. A Lords select committee report from the UK parliament recently stated, “we are concerned that the focus of the Government’s policy is primarily danger and risk. We call on the Government to recognise that [digital] rights, literacy and education are as important in equipping children with the necessary tools to navigate the online world.” (House of Lords Select Committee on Communications, 2017).

Common to both the ‘risk’ agenda and the need to support children in using digital text to learn is the critical reality that while children may be ‘digital natives’, this does not mean they know everything about how to navigate digital sources. Regarding the use of digital text for reading and learning, Salmerón et al. (Chapter 4) remind us that in navigating for information on search engines, younger children tend to rely predominantly on superficial cues to guide their selection choices, e.g. focusing on highlighted words, as opposed to the semantic information provided in the search result descriptions. Equally, learning to differentiate reliable and unreliable sources of information is a skill that students must hone throughout their school careers (Salmerón, Macedo-Rouet, & Rouet, 2016). In a recent UK report (Ofcom, 2016) around half of search engine users aged 8–11 (50%) and 12–15 (56%) reported making some type of critical judgment about search engine results, believing that some of the sites returned could be trusted and some could not, but over 25% of respondents in each age group (28% of 8–11s and 27% of 12–15s) stated that if Google lists information, the results could be trusted.

These observations highlight the pressing need for children to acquire the critical judgment skills to distinguish correct from incorrect information on the internet. This could be achieved by several routes, the most obvious being through
educational programmes that focus on digital reading skills. This brings us back to the crucial role of schools and educators in scaffolding children’s digital reading experience. In the previous section on educational implications we highlighted the relative lack of digital technology access some students experience in the classroom. In these situations, the first policy move needs to be investment in ICT (information and communication technology) infrastructure. Within Europe, specific programmes have been reported in recent years that aim to increase access to technology within schools, for example the 2.0 School Program in Spain (Moreira et al., 2014), the FATIH project in Turkey (Akcaoglu, Gumus, Bellibas, & Boyer, 2014) and a Maltese initiative to provide all 7–8 year olds with tablets in school (Mifsud & Grech, 2016; see also Mifsud and Petrová, Chapter 7). Once infrastructure is in place, attention must turn to curriculum frameworks for integrating both ICT hardware, but also instructional software, into regular classroom practice. Currently the international picture with regard to ICT curricula is very varied. Some countries have nationwide curricula (e.g. Cyprus and Turkey) while in other countries (e.g., Ireland) the development of curricula is the responsibility of individual schools. Where national guidelines or curriculum do exist on the ICT competencies children should have, the level of detail specified can also vary widely. With growing evidence that foundational factors such as the presence of appropriate ICT infrastructure and ICT curriculum framework are certainly necessary (Akbulut, 2009; Gil-Flores, Rodriguez-Santero, & Torres-Gordillo, 2017), these are not sufficient, and teacher-related factors including perceived self-efficacy and ICT competence typically carry most weight in models of classroom ICT use (Akbulut et al., 2007, Lee & Lee, 2014; Tondeur et al., 2008; Valtonen et al., 2015). Thus investment in both initial teacher training as well as continuing professional development is essential. Research suggests that such training should include developing positive attitudes towards the value of ICT in teaching, as well as the building of collaborative peer-communities, both locally as well as online (Akbulut, 2009; Bas, Kubiatsko, & Murat, 2016, Pelgrum & Voogt, 2009).

3. Conclusion

In this chapter, and throughout the edited volume, we have emphasised that learning to read in a digital world is not a single process, but rather a multidimensional problem space of learner, reading goals and digital context. This volume has showcased the recent strides made in our understanding of this problem space, while also highlighting the significant gaps in our knowledge. For example, we have yet to fully understand the complex of interplay of digital text features on the reading preferences and performance of different profiles of readers, or the
optimal approaches to pedagogy. Indeed, for researchers, the ‘digital world’ is a fast-moving target – the hardware, software and text environments that deliver digital text are evolving continually and subject to market forces far removed from the learning sciences.

This is, however, also an unparalleled opportunity for our field. Printed text has strived to provide standardised, optimal readability for the ‘average’ reader and from this paradigm, core knowledge about reading development has been generated. Yet, the increased diversity of digital reading formats, activities, and their changing nature has challenged researchers and practitioners alike to rethink and refine existing conceptualisations of reading. This in turn opens up a parallel opportunity to better understand an equally diverse population of readers; as many fields of human development research progress, e.g. genomics, biology and psychology, we are seeing that being bound to the idea of a statistical average may often obscure important individual differences in behaviour (Molenaar, 2013; Rose, Rouhani & Fischer, 2013). The digitisation of reading thus demands that we develop a far more nuanced understanding of both the reader and the reading material, incisively questioning assumptions built up from the print era. In this way, the ‘disruptive’ innovation offered by the digital world will yield rich dividends.

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With digital screens becoming increasingly ubiquitous in the lives of children, from their homes to their classrooms, understanding the influence of these technologies on the ways children read takes on great importance. The aim of this edited volume is to examine how advances in technology are shaping children’s reading skills and development. The chapters in this volume explore the influence of various aspects of digital texts, the child’s cognitive and motivational skills, and the child’s environment on reading development in digital contexts. Each chapter draws upon the expertise of scientists and researchers across countries and disciplines to review what is currently known about the influence of technology on reading, how it is studied, and to offer new insights and research directions based on recent work.