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The evolution of reading in the age of digitisation: an integrative framework for reading research

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Abstract

In the course of digitisation, the range of substrates for textual reading is being expanded to include a number of screen-based technologies and reading devices, such as e-readers (e.g. Kindle) and tablets (e.g. iPad). These technologies have distinctly different affordances than paper has. Given that textual reading is at the same time likely to remain important as a cultural practice, and is undergoing massive change as digital screens are supplementing paper – with the potential to replace it as the dominant substrate – there is an urgent need to investigate what effects such change might have on the reading of different kinds of texts, for different purposes. This article proposes the need for an integrative, transdisciplinary model of embodied, textual reading accounting for its psychological, ergonomic, technological, social, cultural and evolutionary aspects. The envisaged model aims to be partly explanatory, in the sense that it aligns and integrates existing knowledge, and partly exploratory, in the sense that it points to blank spots in our knowledge where further research is needed. The model will thus serve to guide the planning of such further research, and to make research more compatible and research outcomes more widely useable.

Key words: reading, research methods, comprehension, multimodality, new literacy studies, pedagogy

Introduction: texts, literacies, digitisation and (deep) reading

It is by now a cliché to claim that digital technologies are redefining reading and literacy in education and learning. Digitisation has dislodged reading from its natural place in the constellation of modalities and media. The static, linear modality of written text (including the book) is now supplemented by an increasing complexity of multimodal, dynamic, and interactive representations. The major changes in reading practice over the last few decades have caused a burgeoning interest in reading and literacy research. This interest covers many schools of thought and many new theoretical and methodological approaches. In digital representations, the modality of written text – if present at all – is taking on different meaning-making roles.

When studying new literacy practices such as the use of Flickr, blogs and Twitter, 'old', print-based terms seem inadequate. Changes to the 'mediascape' have prompted a broadening of core concepts such as 'text,' 'reading,' and 'literacy.' Paradigms such as New Literacies Studies (and overlapping frameworks such as Multiliteracies and Digital Literacies) redefine text as "a multimodal intentional representation with purposes and boundaries understood within a given sociocultural domain." (O'Brien and Scharber, 2008, p. 66) The concept of literacy is thus reframed and studied as a plural construct (for instance, Carrington and Robinson, 2009; Coiro et al., 2014; Gillen, 2014; Mills, 2010, and see Rowsell and Pahl, 2015b for a comprehensive overview of key developments in literacy studies overall). The New London Group considers literacy as multiple in nature (Cope and Kalantzis, 2000), and the following definition of digital literacy is exemplary: "We define *digital literacies* as socially situated practices supported by skills, strategies, and stances that enable the representation and understanding of ideas using a range of modalities enabled by digital tools." (O'Brien and Scharber, 2008, p. 67)

These paradigms and schools of literacy research address key questions pertaining to digitisation, for example: how do readers construct meaning from multimodal representations (e.g. Jewitt, 2006; Jewitt et al., 2009)? What are the (novel) literacy demands for successful navigation online compared with in print (e.g. Coiro, 2003; Coiro and Dobler, 2007; Coiro et al., 2014)? How may education practitioners as well as literacy scholars meet the expectations, needs and expertise of digital natives, hence bridging the gap between so-called 'schooled' and more often print-based literacy practices and the increasingly influential and more typically digital "out-of-school" literacy practices (for a study of this potential tension or dissonance, see for instance Dowdall, 2006)?

These and other new reading and literacy research paradigms have been a necessary and welcome response to the transformational nature of recent digital developments. However, the very pluriformity of perspectives and approaches also threatens to obscure the immense potential for collaboration and dialogue across disciplines and paradigms. As Barton (2001)

has pointed out, literacy – and New Literacy – studies, for example, are by now established as a powerful research paradigm. Literacy research projects have revealed the complex interactions between peers involved in meaning construction from different media and modalities, and provided insights into the potential uses of digital technologies in a variety of literacy practices (see for instance Carrington and Robinson, 2009). However welcome this addition to the narrower scope of more traditional reading and literacy studies is, the descriptive ethnographic bent of the sociocultural approach has had as a consequence that the effects over time of digitisation on the process of encoding and decoding of meaning from verbal, written text – that is, 'text' narrowly defined – have remained largely unaddressed.

In an attempt to fill this and similar voids, to create maximal opportunities for interdisciplinarity and to account for the diachronic effects of digitisation on reading, this article aims to present an integrative framework for reading research. This framework suggests the desirability of supplementing existing research paradigms with an empirical theoretical–methodological approach, across substrates and their affordances. Defining reading and literacy as (i) human-technology interaction and (ii) as embodied processes, the framework intends to facilitate interdisciplinary, empirical investigations into aspects and dimensions of reading, some of which have hitherto been largely ignored. More precisely, it invites closer scrutiny of associations between ergonomics (sensorimotor, haptic/tactile feedback), attention, perception, cognitive and emotional processing at different levels, as well as subjective experiential dimensions of reading different kinds of texts for different purposes (e.g. various literary genres, news reading and study reading). Such interdisciplinary, empirical research will enable precise, cross-validated measures of the impact of digitisation, especially in educational contexts in which reading remains central.

The changing nature and circumstances of textual reading

During the past decades, not only have new multimodal forms of reading made their appearance, but reading in the narrow sense, that is, of linear, written texts – has also undergone substantial changes, and is now increasingly performed with digital screen technologies such as laptops, smart phones, tablets (e.g. iPad) and e-readers (e.g. Kindle). As screens are replacing paper as the main reading substrate, digitisation is influencing reading and literacy activities in preschools and kindergartens as well as in elementary schools and in higher education. The current transition from paper to screen substrates invites reconsideration of a number of fundamental questions of an empirical nature, such as the following: What distinguishes (textual) reading from the processing–in multimodal texts–of other modalities, such as (still or moving) images or spoken words? Does the substrate (paper and screens) affect cognitive outcomes such as recall and comprehension? Does our reading experience differ as a function of genre (say, a novel or a poem) or substrate (print or a Kindle screen)? How does the concept of literacy change along with the change of reading substrate, for example, from knowing how to navigate paper-based texts to knowing how to navigate the multiplicity of ever-changing hardware and software configurations involved in screen-based reading? How does the growing digital infrastructure change the social position of books and other texts and that of reading in general?

Especially because of the major implications for education, a great deal of unease may currently be observed about the rapidity and transformativity of changes in reading practice associated with the change from paper to digital substrates, and findings from empirical research are, so far, inconsistent (for an overview of extant empirical research from a range of disciplines, see Baron, 2015). In a matter of a few decades, new reading habits have become widespread. This change has triggered vigorous debates about an assumed deterioration of reading and literacy skills overall, potentially caused, and/or accelerated, by digitisation (e.g. Baron, 2015; Bauerlein, 2008; Carr, 2010; Wolf, 2007). The point made is not so much that people are spending less time reading (if anything, the reverse is probably true), but that they are reading so very differently. The deep reading practices that we had come to take for granted after centuries of book culture (Van der Weel, 2011) are supposedly being replaced by shallower forms of reading (see also Baron, 2015; Carr, 2010).

One effect that has already been observed is that individual and social attitudes to reading (and writing) are changing. Screens are replacing books for leisure reading (as well as for entertainment at large)[1]; digital learning environments replace books for education, even to the extent that in many countries entire iPad schools have been founded; it is suggested from time to time that, thanks to the ubiquity of keyboards, children do not need to learn how to write by hand anymore (Francis, 2008); and both at home and in public the example of parents increasingly shows screen-based behaviour (including the mediatisation of much of their social life). As a result, children are becoming less socialised in a book-based reading culture than they used to be. This may be exacerbated by the fact that the jostle for the consumer's attention involves the full range of modalities converging on the screen.

[1] For example, PwC cites global e-book turnover as having risen from just over $2bn in 2009 to $11bn in 2014, predicting that it will reach $19bn in 2018 (http://www.pwc.com/gx/en/global-entertainment-media-outlook/segment-insights/consumer-and-educational-book-publishing.jhtml).

In this competition, textual reading may be experienced as being intrinsically less immersive and requiring a greater conscious effort at concentration than gaming, listening or viewing. Even if such competition is not in itself new, this perception gains new weight as the competition is played out on a single playing field: that of the digital screen.

In these circumstances, reading research concerning verbal texts takes on fresh urgency. First of all, the effects of the current digital changes are poorly understood. Empirical studies exist (notably, in cognitive and educational psychology and cognitive neuroscience), but differences in textual material, instruments, measures, and in definition of key constructs make it difficult to compare and synthesise findings. It is easy enough to establish that changes in reading practice are taking place, and not even very difficult to determine what it is that is changing. However, it is much less clear if, and if so, how these changes might be causally related to the adoption of digital technology, or, most importantly, what the longer-term sociocultural and cognitive effects of the changes in reading practice might be.

In the meantime, the digital revolution is sparking a greater awareness of the nature and significance of textuality and the extent to which human communication has become mediatised overall. In the mix of modalities, textuality has so far remained central, especially in an educational context. Indeed, while the nature of our reading habits is changing, textual reading will probably continue for the foreseeable future to be an important cultural activity. Text has peculiar strengths that set it apart from many other means of communication. For example, language, spoken as well as written, makes possible communication between different mental faculties; it could be called the lingua franca of modalities (Piper, 2012, pp. 77–78). Reading and writing are as yet indispensable for formal learning in schools as well as for informal and practical knowledge dissemination, and the same goes for self-expression. But reading also remains an important instrument for entertainment. Perhaps most importantly, the linguistic objectification enabled by writing/reading helps us to think (Clark, 2008; Goody and Watt, 1963). Given the importance of reading in the cultural evolution of human civilisation, any changes brought about by the digitisation of reading are likely to have tremendous cognitive, cultural and social implications.

At the same time, there has perhaps never been sufficient awareness of the cultural and social significance of reading. At the turn of the 20th century when almost complete literacy was achieved in the West (Vincent, 1993), and literacy became the norm for successful social participation, we reached the apex of our reading culture. After this, the textual nature of contemporary human culture has in fact tended to be simply taken for granted. To be sure, reading has been understood to be important in the sense that it enables participation in a literate society. However, the importance of reading to the nature of contemporary society clearly needs to be reviewed. This necessitates a better understanding of what reading is and does, of the cognitive and emotional effects of reading on the individual reader as well as how reading and changes in reading practice affect our functioning as a society. For example, that an understanding of the significance of long-form reading is only emerging as it is no longer self-evidently the norm needs to be taken as an indication that we have not been sufficiently aware of major changes as they are taking place.

The need for an integrative, transdisciplinary framework

Due in large measure to digitisation, there has been increasing attention for reading research recently. To begin with, reading is studied from many practical and disciplinary perspectives, for example, as a historical practice (Cavallo and Chartier, 1999; Piper, 2012), as a sociocultural practice (Barton et al., 2000; Street, 2005), as a phenomenological experience (Heap, 1977; Rose, 2011; Rowsell, 2014), as a cognitive process (Duffy and Israel, 2009; Kintsch, 1998; Tapiero, 2007) and as a neuropsychological process (Dehaene, 2009; Wolf, 2007). Additionally, an increasing amount of research is comparing textual reading in print and on screen, focusing on, for example, effects of display technologies on visual ergonomics (Benedetto et al., 2013; Siegenthaler et al., 2011; Siegenthaler et al., 2012), effects of the interface on (meta)cognitive (Ackerman and Goldsmith, 2011; Ackerman and Lauterman, 2012; Kretzschmar et al., 2013; Mangen et al., 2013; Margolin et al., 2013) and emotional (Mangen and Kuiken, 2014) aspects of reading and exploring the new demands of online reading and digital literacy as mentioned earlier (Leu et al., 2013).

Hence, by nature, reading research is inherently multidisciplinary. However, the extensive multidisciplinarity has also had the natural effect of not fostering optimal coherence. There has not been much collaboration and dialogue across disciplines and paradigms. Despite calls for increasing interdisciplinary research and multi-method approaches (particularly bridging the humanities – natural sciences divide), scientists doing experiment-based research (e.g. psychology and neuroscience) tend to shy away from predominantly qualitative research domains (e.g. media/reading history, pedagogy, literary studies and sociology), and reading research in domains such as cognitive and perceptual psychology continue to map the psychological processes involved in reading without reference to the larger, contextual dimensions. Most research in literacy studies now focuses primarily on sociocultural aspects of reading and literacy while downplaying lower-level psychological aspects. Rarely are psychological (or

neuroscientific) and sociocultural aspects of reading considered under the same aegis.

The current digitisation adds urgency to the need to promote greater coherence between research efforts. The transition of reading from paper to screens may enable transforming a dispersed multidisciplinary field with disciplinary and sub-disciplinary paradigms existing side by side into a truly transdisciplinary one (Østreng, 2009; Samuels, 2009), in which theoretical perspectives and models from different disciplines are applied, bottom-up, to shared research questions. It was this felt need for a more coherent approach to reading research that led to the instigation of the E-READ (Evolution of Reading in the Age of Digitisation) initiative, awarded a COST[2] network subsidy in 2014, chaired and co-chaired, respectively, by the authors of the current article. A main objective of E-READ is to bring about crucial synergies between the science and scholarship of reading, and actors, sectors and stakeholders outside of academia (e.g. practitioners, educators, the book trade, librarians, engineering and design and literacy promoters). An innovative, transdisciplinary approach to reading, spanning the natural sciences – social sciences – arts and humanities, will enable a bottom-up mapping of the effects of digitisation by means of multimethod empirical research. By involving educational practitioners (teachers and educators) as stakeholders in scientific development, we ensure that research projects are informed both by their needs and by their expertise. Practitioners provide ongoing input to the research agenda by identifying knowledge gaps in their field, for example, urgent questions such as whether it makes a difference if students read different types of material in print or on computers, or whether it makes a difference for children's story engagement if they read them in print picture books or as iPad apps (Flewitt et al., 2014; Kucirkova, 2014; Kucirkova et al., 2014; Merchant, 2015).

As initiators of E-READ, we propose the need for a transdisciplinary model of reading in order to facilitate the more coherent approach to research that we advocate. This model would serve as a common frame of reference, both for interpreting existing research and for embarking on future research. Rather than to replace existing models, it is intended to serve as an overarching integrative framework capable of encompassing existing models that already successfully capture specific aspects of reading. The framework must be technologically and culturally agnostic, in the sense that it should be able to accommodate different technologies and sociocultural circumstances diachronically and synchronically. So in asking what reading is fundamentally, the framework can at the same time abstract from and account for technological and cultural variation.

Reading is a historically and culturally contingent practice. It has taken centuries for our current textual literacy to evolve. That is to say that the social significance of reading is culturally dependent. Indeed, the digital developments are once again drawing attention to its contingent nature over time. Deep reading may have become the implicit norm that education strives to attain, but it is increasingly clear that this is not a natural, given norm: "My concern," says Baron, "is that deep reading and rereading, uninterrupted reading, and tackling longer texts are seen by fewer and fewer people as part of what it means to read." (Baron, 2015, pp. 230–231) We need to understand how such norms evolve in order to improve our understanding of the significance of the move from paper to screen, and of the significance of reading in today's society. Even if reading is an evolving, historically and culturally contingent practice, it may be that certain characteristics of the type of reading that we have evolved (but which may be at risk of being lost in reading's further evolution) are thought to be worth keeping.

The proposed framework sketched below is intended to provide an integrative conceptual point of departure from which to engage in empirical research on the digitisation of text reading. As such, it should enable the development of transdisciplinary paradigms in which hypotheses can be tested and effects of digitisation on text reading can be measured. Devised from a bottom-up approach to reading as human–technology interaction, the framework would need to facilitate empirical research combining experimental paradigms from, for example, psychology and neuroscience, with historically and socioculturally oriented approaches presently more common in literacy studies. The framework should also be dynamic, to be improved iteratively on the basis of empirical research.

Importantly, apart from the recognition that reading is a vital sociocultural (and thus historically contingent) practice, the framework is based on two theoretical assumptions: (a) Reading is interaction with a technology/device with specific interface affordances and (b) Cognition, hence reading, is embodied – it entails physical (in particular, manual/haptic) interaction with a device (e.g. tablet; e-reader; book). These assumptions provide a theoretical backdrop and a minimal common denominator across the levels and dimensions of the framework. This ensures a degree of internally coherent and consistent epistemology resting on empirically testable claims and enables, in turn, coherent and accumulative scientific progress based on empirical research findings. The proposed framework should point the way to interdisciplinary empirical research and support the development and ongoing refinement of a number of metrics to assess the effect of digitisation on reading. It is thus intended

[2] COST (European Cooperation in Science and Technology) is the longest-running European framework supporting international cooperation among researchers, engineers and scholars across Europe (http://www.cost.eu/about_cost).

to stimulate and facilitate correlational studies as well as experimental and longitudinal research allowing stronger causal inference.

a. Reading is human–technology interaction

It is the merit of historians such as Goody and Watt (1963), Havelock (1981, 1986) and Ong (1982) to have emphasised the technological nature of written language. Entailed in the present conceptualisation of "what we read" is therefore not only the text itself but also the material and technical features of the device or technology presenting or displaying the text. When new technologies appear and begin to replace older ones, the transition to novel interfaces may make us aware of the particularities of the old ones because different technologies, according to Haas (1996), are "materially configured in profoundly different ways" (p. 226). Screens have different inherent properties and affordances than print on paper (for the concept of affordances, see Gibson, 1977; Van der Weel, 2011).

The shift from paper-based to screen-based reading entails, for example, new multimodal capabilities, a loss of fixity and material integrity and a replacement of the sensorimotor, ergonomic and audiovisual affordances of paper with those of different kinds of screen interfaces. To what extent and in what ways such changes may affect (study as well as leisure) reading are empirical questions suggested and accommodated by the present framework.

b. Reading is embodied

In the aptly titled book *Reading and the Body*, McLaughlin observes how reading is typically considered an act of consciousness and that: "literary theory has tacitly framed the act of reading within a simple body/mind dualism, ignoring the eyes and hands, the postures and habits of reading, and denying any connection between the transcendent life of the reading mind and the immanent life of the body." (Mc Laughlin, 2015, p. 1) Whereas literary scholars – with a few exceptions[3] – may have largely ignored the embodied nature of reading, literacy scholars have acknowledged the role of the body in literacy practices. The editors of the *Routledge Handbook of Literacy Studies* state in the introduction that literacy practices are "vernacular, networked and embodied" (Rowsell and Pahl, 2015a, p. 3). Kress has called for increased awareness of the bodily nature of meaning making:

> Forms of imagination are inseparable from the material characteristics of modes, from their shaping in a society's history and from their consequent interaction with the sensoriness, the sensuousness, of our bodies. Introducing a concern with *materiality and the senses* into representation brings the longstanding separation in Western thinking of mind and body into severe question, and therefore challenges the reification and consequent separation of *cognition, affect and emotion*. (Kress, 2003, p. 171; emphases added)

The added emphases are meant to indicate the necessity of teaming up with psychologists and neuroscientists studying the close associations between the human sensory modalities and the surrounding material world. The transition from reading on paper to reading on screens reveals the role of the body in reading and literacy as a common research interest.

Studying young readers' engagement with narratives on paper and screen, Mackey has a section in her book titled "Hands" (Mackey, 2002). With many of the new media, she observes, we are changing the role of hands:

> Hands assist, direct and sustain attention, that vital yet often fragile element of reading. […] We need to ask whether the activity of the hands is simply a superficial accompaniment of our current arrangements of reading, whether the role of the hands is confined to the aesthetics of the tactile elements of reading, or *whether the use of the hands engages the brain in ways that play a constitutive role in the reading process*. (Mackey, 2002, p. 112; emphasis added)

In a recent study of iPad apps in kindergarten, Merchant (2015) finds that the body and, in particular, the hands are fundamental when using iPad apps for story-reading with young children, and that the haptics of the iPad interface makes a crucial difference for meaning making, the experience of the stories, for navigation through the text, and for how the texts are shared overall. (Merchant, 2015) Nevertheless, according to Rowsell, the balance is still in favour of studying aspects of literacy at a far remove from the actual bodily reader: "there has been significant research and writings on literacy and the everyday and literacy as a social, lived practice […], but there is much less research on how literacy is experienced perceptually or as an embodied experience." (Rowsell, 2014, p. 118)

These observations from literacy studies motivate our suggestion that the changing role of the body in digital reading may serve as a catalyst bringing together socioculturally-oriented literacy research with paradigms from natural science disciplines, most obviously addressing the physiological and ergonomic aspects of reading. Mackey's apt conjecture about the role of haptics in cognition is evidenced

[3] For example, Littau (2006) *Theories of Reading: Books, Bodies and Bibliomania*, Malden, MA, Polity Press, and Dames (2007) *The Physiology of the Novel: Reading, Neural Science, and the Form of Victorian Fiction*, Oxford University Press.

by empirical, experiment-based research in cognitive neuroscience, particularly in the paradigm called embodied cognition.[4]

Print books and the substrate of paper lend an obvious physicality to individual texts, while e-books are not tangible volumes and are differently touched, held, carried and navigated. The haptic feedback of a touch screen is different from a paper book, and the implications of such interactions warrant empirical investigations. Studies in experimental psychology and neuroscience show that object manipulation provides spatial information which is crucial for building coherent mental representations of the manipulated object. Such findings motivate a theoretical reorientation allowing more precise and in-depth empirical investigations of associations between sensory modalities in reading as well as in other skills (notably, writing) (Mangen and Velay, 2010; Velay and Longcamp, 2013) than before.

Towards a multidimensional framework for reading research

Building on these two fundamental tenets – that reading is a human–technology interaction, and that reading is an embodied act – the proposed framework should capture the multidimensionality of reading, and allow focused, in-depth exploration. The framework defines reading along the following dimensions:

- Ergonomic dimension: reading is a physical, multisensory engagement with a device;
- Attentional/perceptual dimension: reading is allocation of attentional resources; perceptual processing;
- Cognitive dimension: reading is cognitive, linguistic processing;
- Emotional dimension: reading is, potentially, an emotionally impactful experience;
- Phenomenological dimension: reading is a personally meaningful activity;
- Sociocultural dimension: reading is a socioculturally (and ideologically) appraised and historically contingent activity with sociocultural implications;
- Cultural–evolutionary dimension: reading is an exocerebral extension of the brain (Bartra, 2014) developed under pressure of the increasing informational demands of an ever more sophisticated cultural habitat.

[4] Research in the embodied cognition paradigm has shown that the neurophysiological and neuropsychological processes involved in perception, sensorimotor action, and cognition are more closely related than hitherto acknowledged (Calvo and Gomila, 2008; Chemero, 2009; Shapiro, 2010). Cognition takes place not only in a representation-processing or symbol-processing unit (Clark, 1997, 2008), but fundamentally in the perceptual and motor systems (Calvo and Gomila, 2008). Theories of embodiment have received increasing empirical support from behavioural and neuroscientific studies (for an overview, see Kiefer and Barsalou, 2011).

Together these dimensions provide an integrative conceptual and theoretical framework for the study of reading. This framework can then be used for the empirical testing of hypotheses about the effects of digitisation on reading across these dimensions. For instance, for studying literary reading on e-readers and tablets, the framework should enable a combination of qualitative measures of subjective, first-person experiences with objective and quantitative measures from a third-person perspective. The framework would thus facilitate combining paradigms from, for example, neurophysiology and neuropsychology with historically and culturally oriented approaches more typical of the arts and humanities, allowing in-depth studies of how reading, for emotional engagement as well as for information and learning, is transformed by digitisation.

This proposed framework should enable fine-tuned measures of a number of potentially mediating variables pertaining to, for example, the following:

- Substrate: paper vs screen-based reading devices (e.g. e-readers, tablets, computer screens and smart phones), audio–visual features and haptic/tactile feedback;
- Interface characteristics (e.g. one or two-page display, page turning, thickness, weight and bendable/flexible screens);
- Text: length, type of text (e.g. genre and complexity: narrative, expository), layout and structuring;
- Levels of comprehension: from surface (word and sentence) to deep inferential comprehension;
- Time of recall: short-term vs long-term memory;
- Readers: age, socio-cultural background, gender, expert level (e.g. students, children vs adults, women vs men, beginning vs advanced and 'digital native' vs 'digital immigrant');
- Motivation and purpose of reading (e.g. study, leisure, contemplation, light entertainment and news).

The accompanying diagrams (Figures 1–3) aim to visualise the conceptual framework as described earlier, taking into account all of the dimensions and variables mentioned. Pragmatically, the visualisation recognises three stages in the reading process: (1) preparation, (2) the act of reading itself and (3) the effects of reading. We emphatically intend both the framework and its visualisation as working concepts to be improved iteratively on the basis of empirical research.

The framework as outlined earlier should aid research in a variety of ways. In the first place, it should improve our understanding of what reading is fundamentally, how it actually works as a process and which human faculties are involved. Secondly, it should help explain better the effect of reading on the individual brain. For as we have seen, it is not just reading per se that changes the way we think; so does the substrate

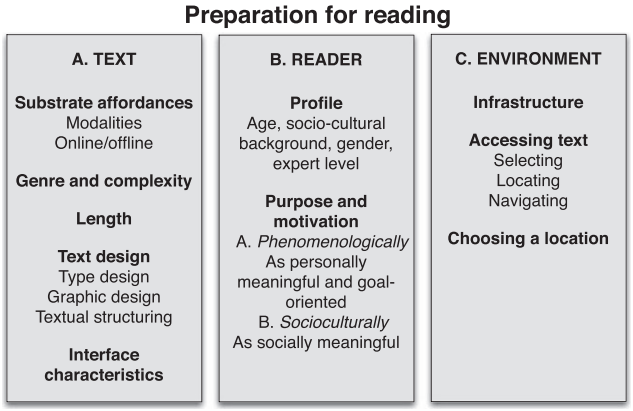

Figure 1: Preparation for reading

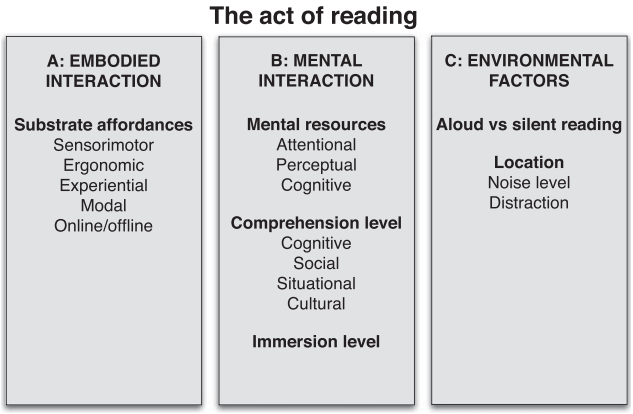

Figure 2: The act of reading

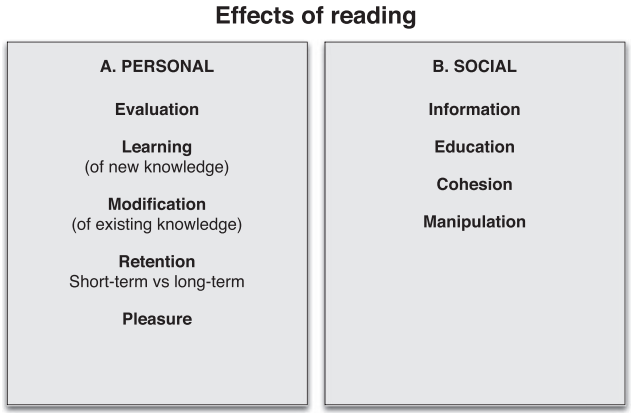

Figure 3: Effects of reading

from which we read. Examples of questions to be addressed are as follows: Do the permanence and physicality of the print book facilitate readers' awareness of where they are within the book and, by extension, within the text? Does this impact more general reading comprehension? What are the educational implications of replacing paper with screens for the reading of different kinds of texts in different literacy contexts (e.g. multiple text reading, literary text reading, reading long vs short texts, reading and note-taking, hypertext reading vs linear text reading and computer/laptop reading vs tablet reading)?

Next, the framework should help explain better the relationship between technology and culture at large. How do technologies shape our reading practices? What is the role of the substrate? Does a digital reading environment differ fundamentally from a paper one? Which are likely social effects of the current transition from paper to screen reading? Following on from this, the framework's historical awareness (implied in its sociocultural dimension) should help explain better the effect of a change of reading technology on society. In her book *Proust and the Squid*, Maryanne Wolf (2007, p. 26) points out that "understanding the origins of a new process [i.e., reading] helps us see […] 'how it works'. Understanding how it works, in turn, helps us know what we possess and what we need to preserve". Now that we are coming to the end of the "Order of the Book" (Van der Weel, 2011), precisely the same goes for the digitisation of that process. The historical dimension, by indeed "help(ing) us know what we possess and what we need to preserve" should offer guidance in underpinning government literacy policies, reading education and so on. On a meta level, finally, the framework should help improve the coherence between disciplinary perspectives; it should help improve the coherence between individual research projects; it should help to harmonise (international) research agendas and so improve the efficient use of research resources. It is also likely to serve as a basis for further research by drawing attention to the white spots in our current knowledge. Lastly, it should help evaluate research proposals.

Concluding perspective

The transition of reading from paper-based to screen-based devices provides an urgent occasion as well as an excellent opportunity to conceptualise reading, bottom-up, accommodating the full range of complexities of texts, substrates, technologies and reading processes and outcomes. Such a reconceptualisation also has important implications for teachers and teacher educators. The integrative framework is fundamentally informed by their input in the form of identification of knowledge gaps and new research questions emerging with technological developments. The scientific progress of E-READ, which is continually fed by ongoing reciprocal consultation with all stakeholders, in turn leads to research outcomes that are made available to all categories of end users, including educational practitioners. The wide spectrum of disciplinary contributions this demands mandates a radical kind of transdisciplinarity, entailing in particular increased theoretical–methodological collaboration between scientists doing experiment-based research and scholars from the arts & humanities. The multidimensional framework of reading proposed here

should facilitate such transdisciplinary collaboration. Last, but far from least, we hope that the framework will foster recognition of the importance of reading as an activity that–so far–remains uniquely human and has been more deeply constitutive of our culture than we generally recognise.

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