The connected brain

Gaby Pfeifer looks at reading and memorising in the internet era

Using the internet or other information communication technology to acquire information has become common practice. However, reading online changes the way we process and memorise the unbounded information available on the web, compared to reading traditional closed print text. How do we prepare present and future generations for the new and more complex 'digital literacies'? Are our changing online reading behaviours merely negative for knowledge acquisition, or do they perhaps represent the cognitive mechanisms of the future to successfully deal with information abundance on the internet?

questions

How can we teach and guide school children to extract and acquire relevant information from the internet?

Which cognitive processes will emerge as most useful in the future to enjoy and successfully utilise information communication technologies? Multitasking?

resources

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www.jisc.ac.uk (information about the 'Developing Digital Literacies Programme' in the UK)

Is today's 24/7 internet availability turning us into impatient, superficial data hunters and gatherers, urged to rush through an ever-growing and changing amount of information? Does the hyperlinked World Wide Web interfere with our muse to read long articles and books? Is the sensory bombardment of blinking ads and e-mail alerts distracting us from deep reading and knowledge acquisition? And how does the ubiquitous information 'stored out there' affect our own memory storage?

Media articles stir up unsettling ideas, with headlines such as 'Is Google making us stupid?' (Carr, 2008), 'Your outboard brain knows all' (Thompson, 2007), and 'Online, R U Really Reading?' (Rich, 2008). The polemic tone of these concerns suggests a doomed future for all those avidly engaging with the internet and other information communication technology (ICT). However, psychological evidence has recently accumulated to clarify some of the mysteries about the impact of modern information resources on reading, multitasking, memory and the hard-wiring of our brains, leaving us with a refreshingly more balanced, if not positive, perspective for the future.

Online reading behaviours

One of the internet's undeniable benefits is its efficiency in providing unbounded information within a matter of milliseconds. The latest Oxford Internet Survey (Dutton & Blank, 2011) reports that 71 per cent of respondents now use the internet as their first source to acquire information about professional, school and personal projects, compared to 5 per cent who first turn to directories or books for these purposes, make personal visits (16 per cent), or use the telephone (8 per cent). But the internet's generous return may also be our fate: does the unbounded information, often coupled with time constraints, compromise effective reading?

In answering this question, it is critical to distinguish between the reader's aims (Zhang & Duke, 2008). Are they interested in searching for specific information or in general knowledge acquisition? Searching for specific information does indeed take a rigorously selective approach. Eye-tracking studies have shown that search engine result pages or websites are often scanned in an F-shaped fashion (Nielsen, 2006; Shresta & Lenz, 2007). That is, readers pay most attention to the upper horizontal line, make a second, shorter horizontal movement further down the page, and then travel down vertically along the left side, ignoring most of the information to the right. Nevertheless, readers with average competence in searching the internet for facts (i.e. with experience of at least once a week) typically take less than two minutes to be successful. Although search complexity influences performance, accurate information is retrieved within one to two cycles of entering keywords in search engines, visiting websites and evaluating their content (Marcos et al., 2012).

A different finding emerges when we aim to read websites for information. Although readers stay closely engaged with the text once a suitable website is identified (Zhang & Duke, 2008), online reading has changed people's reading strategies (Liu, 2005). Specifically, and much in line with anecdotal beliefs (e.g. Carr, 2008), reading long texts on websites increasingly takes the form of skim-reading, a strategy in which the reader chooses words, paragraphs or pages selectively (Duggan & Payne, 2009, 2011;

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Liu, 2005). But are the effects of skim-reading detrimental to comprehension? Surprisingly, readers who forage for information on websites with limited time do so quite efficiently. In fact, if time is short, skim-reading over the entire text will grant better comprehension than detailed reading of certain parts of the text (Duggan & Payne, 2009). During skim-reading, readers dedicate their gaze to a page, or a paragraph within a page, just long enough to appease their appetite about the information they wanted to acquire before moving on to the next section. Using this strategy, termed 'reading for satisficing', skim-readers not only spend more time on important than on unimportant information, they also show improved memory for important information (Duggan & Payne, 2011). In other words, skim-reading can help us retain more of what is important and less of what is unimportant. Thus, while skim-reading may not be an appropriate reading strategy for acquiring in-depth knowledge (see Duggan & Payne, 2009), it is a means to efficiently extract the gist of long pieces of information and helps decide which parts deserve further dedication.

New digital literacies

Given that online reading for information plays an increasingly important role in academic contexts (Coiro, 2012), it has attracted interest in the light of the changing and potentially more challenging cognitive processes that readers will face. This has led to the definition of several new literacies, such as locating information, critical evaluation, synthesis, and communicating solutions, which constitute online reading skills that are essential for text comprehension in digital format (Leu et al., 2004). Although many of these proficiencies are neither entirely new nor unique to online text comprehension, they were suggested to take new levels of complexity relative to print text reading. For instance, while the comprehension of conventional print text undoubtedly

benefits from critical evaluation skills, readers of online texts must additionally evaluate a website's reliability and accuracy of information content, the potential bias of websites with promotional intent, and the relevance of hyperlinks (Coiro, 2011). Similarly, synthesising and effectively communicating knowledge gathered from various sources on the internet are likely to be more complex than in closed print environments. Support for these new literacy skills comes from a study by (Coiro, 2011), who found that digital literacy skills contributed significantly to students' performance in an online comprehension task over and above print text reading skills and prior topic-specific knowledge. In other words, readers who are adept in these new literacies are able to effectively master online reading for information.

How might these new reading challenges affect the way we process information? Perhaps the best attempt for an answer is to consider the challenges across different 'internet generations'. That is, online reading affects young student populations who started using the internet and other forms of ICT in childhood ('digital natives', following the terminology of Prensky, 2001) differently from 'digital immigrants' (i.e. those who came to use the internet later in life). For example, Eshet-Alkalai and Chajut (2010) compared 17-year-olds ('digital natives') with 30–40-year-olds ('digital immigrants') on several digital literacy skills at two time points within five years of regular internet usage. At time point 1, the adolescents performed better than adults in technological skills (e.g.

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using graphical interfaces, searching through hyperlinked text), whereas the adults showed better critical and creative thinking skills than adolescents (e.g. writing a critical report after reading different news websites on a specific topic). Importantly, five years later at time point 2, there was a trend towards closing the gap between adults and adolescents in the technological skills, due to significant improvements of adults and unchanged performance of adolescents. For the creative and critical thinking skills, however, the gap widened between the two groups: adults tended to improve these skills whilst adolescents showed poorer performance than at time point 1. This finding shows that the technological and cognitive challenges of the internet affect information processing of various 'internet-generations' differently. While 'digital immigrants' are able to develop the technological skills with experience, 'digital natives' appear to require additional training in the cognitive skills to assist in critical evaluation, synthesis and communication.

On the positive side, once the necessary digital literacy skills (technological and cognitive) are in place, adolescents benefit from efficiently compensating a lack of prior topic-specific knowledge when completing online research projects. They achieve comparable results with adolescents with prior knowledge and good digital literacy skills, and perform significantly better than adolescents with little prior knowledge and poor digital literacy skills (Coiro, 2011). Thus, despite the general concerns about the future of reading for information on

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the internet, the internet's competent and scholarly use may largely be improved through systematic teaching of the new digital literacies (Coiro, 2012; Eshet-Alkalai & Chajut, 2010). Once these skills are mastered, they can provide cognitive efficiencies that would otherwise be lacking.

Staying in control

One of the challenges of online reading is the temptation to multitask: as my literature piece downloads on the screen, I log on to my e-mail accounts, then Facebook, then Twitter. These welcome distractions run in the background, signalling new information instantly. In the foreground I begin to read. A tiny window in the bottom right corner plays a video of my favourite TV series and serves as a frequent reward for my reading efforts.

The above scenario may increasingly pervade the online reading scene as 29 per cent of the 16- to 24-year-old generation openly report such multitasking behaviour (Ofcom, 2010). How do these reading habits affect the way we absorb information? Concerns about multitasking during reading are warranted by a vast literature reporting capacity limits of our attentional system as well as working memory (see Marois & Ivanoff, 2005, for review). The limitations of these cognitive systems allow only restricted amounts of information to be consciously perceived, reminding us that reading is best done without distractions to achieve appropriate learning outcomes. Indeed, multitasking has been shown to influence learning directly, leading to less flexible memory retrieval than learning under focused conditions (Foerde et al., 2006).

But can the frequent and concurrent use of multiple technological devices change the way we think? In an intriguing study by Ophir et al. (2009), the authors demonstrated that high media multitaskers (participants who, 'most of the time', used several applicat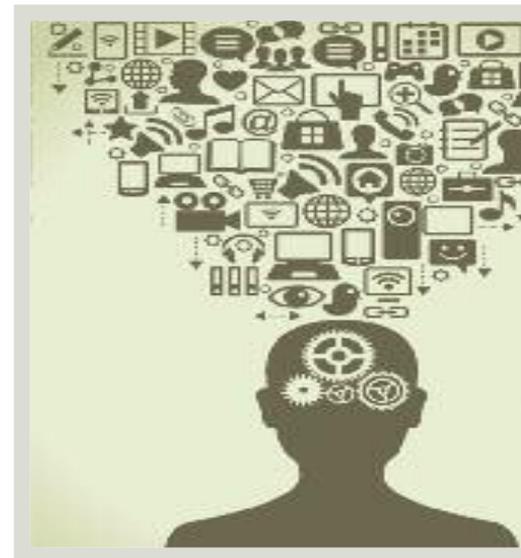ions on the computer and other ICT simultaneously) performed significantly worse than low media multitaskers in filtering out visual and verbal distracters during working memory tasks and were slower to respond during task-switching. This finding suggested that the multitasking behaviour transferred to other cognitive tasks. The breadth-based approach inherent in multitasking may calibrate our cognitive control system over time to embrace a greater breadth of environmental stimuli, with detrimental effects on selective attention and the working memory span. Alternatively however, while multitasking might compromise the cognitive control system in its ability to focus, some unknown positive skills may emerge and, in the view of the authors 'it remains possible that future tests of higher-order cognition will uncover benefits' (Ophir et al., 2009; p.3).

Insights from cognitive neuroscience

With accumulating evidence pointing to reading and thinking changes in response to the pervasive use of the internet and other ICT, we might question the potential manifestation at the level of the brain.

The idea that our brains are 'plastic' and undergo experience-based dynamic changes is not new. Previous computer-based brain training studies have already shown the functional plasticity of brain regions following structured working memory training in young adults (Dahlin et al., 2008), as well as attention training in elderly participants (Erickson et al., 2007), demonstrating that training-induced changes can occur throughout the lifespan after just several weeks of repeated task exposure. The UK population spends about 45 per cent of their daily waking hours interacting with the internet and other ITC (Ofcom, 2010). Might such frequent interactions be sufficient to change the functional organisation of our brains?

Some evidence in support of this assumption comes from a study by Small et al. (2009). Using fMRI, the authors compared the brain activity of a 'net savvy' and a 'net naive' group of older participants (aged 55–78 years) during searching and reading texts on websites versus reading the identical texts laid out in traditional book-style format. The 'net naive' group showed no activation differences between website and book-style text reading. The 'net savvy' group however showed much more widespread activation when searching and reading the websites compared to reading the traditionally laid-out texts. Specifically, reading the internet pages activated regions in the prefrontal cortex involved in higher-level thought processes and decision making, which was not seen in the 'net naive' individuals. This seems to suggest that the brain activity of the 'net savvy' group has adapted to the frequent internet use (up to several times a day) and triggers brain regions that best serve foraging and reading for information in stimulating web environments. Less clear is why the 'net naive' group did not require these brain regions and yet showed comparable text comprehension to the 'net savvy' group. Perhaps the brain of inexperienced web users still treats sporadic website reading and book-style text reading as one and the same. Only when the more complex web-based reading strategies have been learned and

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habituated, does the brain show adaptive activations in regions that facilitate higher-level thought processes and decision making (see Small et al., 2009).

It is worth considering that such adaptive brain changes might take very different forms across different 'internet generations'. Young generations between 16 and 24 years of age ('digital natives') use technology devices for 6.5 hours per day, often squeezing in up to 9.5 hours by using several media simultaneously (Ofcom, 2010). Unlike the adult brain, the brains of adolescents still undergo significant developmental maturation alongside their web consumption. Thus, not surprisingly, this age group is an interesting target population for speculation about the potential effects of frequent and simultaneous media enjoyments on brain development (see Giedd, 2012, for review). The most protracted developmental changes occur in the prefrontal cortex, the region associated with functions such as higher-order cognition, decision making and cognitive control. If this region shows late web-experience-dependent brain changes to compensate the complex demands required in web environments (e.g. Small, et al., 2009), such adaptive changes might be instantiated early in the developing brain to deal with these demands much more efficiently. How this may influence the way in which 'digital natives' will be able to handle the new digital literacies, multitasking and selective attention are exciting new questions for the future.

(R)evolution of human memory?

A slightly different angle takes the concern about the future of our memory (e.g. Thompson, 2007). Consider the following statement by Colin Blakemore, Professor of Neuroscience at the University of Oxford:

When I was at school I learned by heart great swathes of poetry and chunks of the Bible, not to mention page after page of science textbooks. And I spent years at a desk learning how to do long division in pounds, shillings and pence. What a waste of my neurons, all clogged up with knowledge and rules that I can now obtain with the click of a mouse. (Quoted in Naughton, 2010)

This confession makes us gratefully embrace the conveniences of today's online information. However, such benefits may not come without a cost. With information being readily available on the internet, are we gradually losing our declarative memory – that is, memory for facts that were once so onerous to acquire?

Indeed, the results of a recent study by Sparrow et al. (2011) show some support for this concern. Volunteers of the study were able to recall fewer facts when learning information on the computer that was known to be later accessible (as on the internet), compared to learning information which was known to be erased (as on a whiteboard). Thus, with the internet as an external memory source at the back of our mind, we might be inclined to retain less factual knowledge ourselves.

However, the relationship between internet access and memory for facts is more complex: the vast amount of information available on the web places a new emphasis on our memory, namely remembering where to retrieve the details at a later point. To meet these demands it was found that participants, when asked to read, type and save 30 facts into a computer (e.g. 'An ostrich's eye is bigger than its brain'), recalled the location in which the facts were saved more accurately than recalling the actual facts (Sparrow et al., 2011). Thus, it appears that our memory for fact-location may be improved at the expense of our declarative memory. However, an interesting twist in the Sparrow et al. study was that when memory for facts was present, people were less able to remember their saved location. In other words, there seems to be a trade-off between remembering where a piece of information can be found and remembering the actual piece of information.

Can we therefore abandon our concerns of a memory decline in the internet era? Consider that knowledge stored in books at the local library, news received from our neighbours or friends, and expertise obtained from local professional stores are all examples of relying on resources outside of our brains that were used well before the inception of the internet. In this sense, the tendency to 'outsource' memory for facts and rely on the internet for retrieval can be viewed as the modern form of efficient acquisition, storage and transfer of vast amounts of information. Perhaps a more positive outlook is to appreciate the new form of memory storage as one taking place at a larger spatial and temporal scale. By relying on the internet we connect to world knowledge in milliseconds, while local networks only cover the immediate environment and often take days to access.

Conclusion

The internet has profoundly changed the availability of information: it is unbounded, ever-present, fast and incredibly diverse. Not surprisingly, anecdotal reports express concerns about new online reading approaches that are ill-suited to meet conventional ways of knowledge acquisition and memorising. Online, we skim-read, multitask and remember fact-locations over facts. Yet, psychologists increasingly acknowledge that these new forms of reading may be well-suited to manage information abundance in online environments. Interacting with the internet does change the way we think towards embracing information more inclusively, complexly and efficiently. To help facilitate the changes, teaching digital literacy skills is one way of nurturing these proficiencies. In addition, these skills may be honed incrementally through developmental and evolutionary brain changes for all those who will stay or get connected in the future.

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