The Web-Extended Mind

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Abstract

The rapid growth and penetration of the Web raises important questions about its effects, not just on our social activities, but also on the nature of our cognitive and epistemic profiles. The extended mind hypothesis may be particularly well-suited to addressing these questions because it encourages us to think about the way in which much of our cognitive success is grounded in processing loops that factor in the contributions of our extra-neural social and technological environments. When applied to the specific socio-technical context of the Web, the extended mind hypothesis gives us the notion of the 'Web-extended mind', or the idea that the technological and informational elements of the Web can (at least sometimes) serve as part of the mechanistic substrate that realizes human mental states and processes. This paper attempts to explore the notion of the Web-extended mind. It first provides an overview of cognitive extension and the extended mind hypothesis, and it then goes on to discuss the possibility of Web-based forms of cognitive extension involving current or near-future technologies. It is argued that while current forms of the Web may not be particularly suited to the realization of Web-extended minds, new forms of user interaction technology as well as new approaches to information representation on the Web do provide promising new opportunities for Web-based forms of cognitive extension. Extended minds, however, are not solely the product of technological innovation. Cognitively-empowering forms of bio-technological union sometimes rely on the emergence of social practices and conventions that shape how a technology is used, as well as the specific (bio-)cognitive mechanisms that are available to support its effective exploitation. In particular, it is suggested that Web-extended minds may depend on forms of socio-technical co-evolution in which social forces and factors play just as an important role as do the processes of technology design and development.

Introduction

In the few decades since its invention the World Wide Web has exerted a profound influence on practically every sphere of human activity. Online stores have transformed the way we purchase goods, social networking sites have transformed the way we stay in touch with friends, and real-time news feeds have transformed the way we stay abreast of current affairs. For better or worse, it seems, the Web is poised to have a significant influence on the way we live our lives, and perhaps ultimately the web will come to influence the social, political and economic forces that determine how our lives are lived.

The rapid growth and penetration of the Web raises important questions about its effects, not just on our social activities, but also on the nature of our cognitive and epistemic profiles. The Web is a transformative technology, but its transformative influence does not necessarily stop at the social processes that govern our everyday interactions with one another. Many technologies that have transformed society (for example, the clock, the map and systems of writing) have also exerted subtle (and sometimes not so subtle) effects on our cognitive and intellectual capabilities. The Web provides new opportunities for interaction and engagement with a global space of information, and, in some cases, such interactive opportunities may contribute to profound shifts in the way we see ourselves and the nature of our cognitive processing. But what exactly is the nature of this transformative influence, and by what mechanisms does the Web stand poised to transform our cognitive and epistemic capabilities?

One answer to this question comes in the form of the extended mind hypothesis (Clark and Chalmers 1998), which has been the focus of much recent philosophical debate (Menary 2010; Rowlands 2010; Rupert 2009; Smart 2010; Smart et al. 2010; Adams and Aizawa 2008; Clark 2008). The basic idea of the extended mind is that human cognition is sometimes constituted by information processing loops that extend beyond the biological brain. It maintains that the machinery of human cognition can sometimes extend beyond the neural realm to include elements of our social and technological environments. When applied to the specific socio-technical context of the Web, the extended mind hypothesis gives us the notion of the 'Web-extended mind', or the idea that the technological and informational elements of the Web can (at least sometimes) serve as part of the mechanistic substrate that realizes human mental states and processes (Halpin, Clark, and Wheeler 2010; Smart et al. 2010; Smart et al. 2009).

This paper attempts to explore the notion of the Web-extended mind. It first provides an overview of cognitive extension and the extended mind hypothesis, and it then goes on to discuss the possibility of Web-based forms of cognitive extension involving current or near-future technologies. It is argued that while current forms of the Web may not be particularly suited to the realization of Web-extended minds, new forms of user interaction technology as well as new approaches to information representation on the Web do provide promising new opportunities for Web-based forms of cognitive extension.

Cognitive Extension and the Extended Mind

The traditional view in the sciences of the mind sees the human brain as occupying a rather special place in the material fabric associated with the realization of human mental states and processes. The view claims that the machinery of the mind is housed largely within the head, and that to understand more about our cognitive profiles we need to understand more about the machinations of the biological brain. Eventually, it is claimed, we will have a complete theory of human cognition, and within this theory the human brain will occupy centre-stage.

The validity of this neurocentric, or intra-cranial, perspective has recently been challenged by those who embrace situated, embodied or distributed approaches to cognition (Hutchins 1995; Robbins and Ayded 2009; Clark 1999; Haugeland 1998; Pfeifer and Bongard 2007). Such approaches challenge the notion that mind and cognition are solely internal (neural) phenomena by emphasizing the role played by extra-neural and extra-bodily factors in shaping the profile of much real-world cognitive processing. One view that is perhaps maximally opposed to the traditional view of the human mind is the thesis of the extended mind (Clark and Chalmers 1998). This view actually goes by a variety of names, including locational externalism (Wilson 2000, 2004), active externalism (Clark and Chalmers 1998), vehicle externalism (Hurley 1998; Rowlands 2006), environmentalism (Rowlands, 1999), cognitive extension (Clark 2008) and the extended mind (Clark and Chalmers 1998); however, what all of these locutions have in common is a commitment to the idea that aspects of the external, extra-neural environment can play a constitutive role in the material realization of human mental states and processes.

As an example of extended mind theorizing, consider the case of multiplying two three-digit numbers. One account of how we are able to multiply the two numbers might emphasize how we first derive some symbolic encoding of the visual (or auditory) input corresponding to the two numbers. It would then invoke a computational account according to which the inner symbols are manipulated in some way so as to achieve the correct mathematical outcome. Now contrast this with what is surely a more accurate (and ecologically-realistic) picture of how we implement long multiplication in the real world. This alternative picture involves the active manipulation of external symbols in such a way that the problem confronting the biological brain is profoundly simplified. In place of purely inner, environmentally-decoupled, computational operations we see a pattern of real world-involving perception-action cycles – ones in which single digit numbers are compared and intermediate computational results are stored in an external medium using (e.g.) pen and paper. This example, described in Wilson and Clark (2009), is a case of what we might call environmentally-extended cognition or cognitive extension (see also Clark 2008). It takes what is, ostensibly, an inner cognitive capability (an ability to do long multiplication) and shows how crucial aspects of the problem-solving process can be (and usually are) delegated to aspects of the external world.

In their original formulation of the extended mind hypothesis, Clark and Chalmers (1998) attempted to go beyond the simple case of cognitive extension, as exemplified by long multiplication. In particular, they wished to show that extended mind theorizing could also be applied to cases involving the ascription of intentional mental states such as states of belief and desire. In order to make this case, Clark and Chalmers (1998) asked us to imagine two individuals: Inga and Otto, both of whom are situated in New York City. Inga is a normal human agent with all the usual cognitive competences, but Otto suffers from a mild form of dementia and is thus impaired when it comes to certain acts of information storage and recall. To attenuate the impact of his impairment on his daily behaviour, Otto relies on a conventional notebook which he uses to store important pieces of information. Otto is so reliant on the notebook and so accustomed to using it that he carries the notebook with him wherever he goes and accesses the notebook fluently and automatically whenever he needs to do so. Having thus set the stage, Clark and Chalmers (1998) ask us to imagine a case where both Otto and Inga wish to visit the Museum of Modern Art to see a particular exhibition. Inga thinks for a moment, recalls that the museum is on 53rd street and then walks to the museum. It is clear that in making this episode of behaviour intelligible (or psychologically transparent) to us Inga must have *desired* to enter the museum, and it is clear that she walked to 53rd street because she *believed* that that was where the museum was located. Obviously, Inga did not believe that the museum was on 53rd street in an occurrent sense (i.e., she has not spent her entire life consciously thinking about the museum's location); rather, she entertained the belief in a dispositional sense. Inga's belief, like perhaps many of her beliefs, was sitting in memory, waiting to be accessed as and when needed.

Now consider the case of Otto. Otto hears about the exhibition, decides to visit the museum, and then consults his notebook to retrieve the museum's location. The notebook says the museum is on 53rd street, and so that is where Otto goes. Now, in accounting for Otto's actions we conclude, pretty much as we did for Inga, that Otto *desired* to go to the museum and that he walked to 53rd street because that is where he *believed* the museum was located. Obviously, Otto did not believe that the museum was on 53rd street in an occurrent sense (Otto has not spent much of his life constantly looking at the particular page in his notebook containing museum-related facts); rather, he entertained the belief in a dispositional sense. Otto's belief, like perhaps many of his beliefs, was sitting in the notebook, waiting to be accessed as and when needed.

Clark and Chalmers (1998) thus argue that the case of Otto establishes the case for a form of externalism about Otto's states of dispositional believing. The notebook, they argue, plays a role that is functionally akin to the role played by Inga's onboard bio-memory. If this is indeed the case, then it seems to make sense to see the notebook as part of the material supervenience base for some of Otto's mental states, specifically his states of dispositional belief (such as those involving museum locations). The main point of the argument is to establish a (potential) role for external artefacts in constituting the physical machinery of at least some of our mental states and processes. If, as Clark and Chalmers (1998) argue, the functional contribution of an external device is the same as that provided by some inner resource, then it seems unreasonable to restrict the material mechanisms of the mind to the inner, neural realm. It seems possible, at least in principle, for the human mind to occasionally extend beyond the head and into the external world.

Such claims are, understandably, disconcerting, and it is important that we understand the precise nature of the claim that is being made. One immediate cause for concern relates to the notion of functional equivalence between the inner (e.g., bio-memory) and outer (e.g., notebook) contributions. If we allow any form of externally-derived influence to count as part of the mechanistic substrate of the mind, then doesn't this cast the mechanistic net too widely? Don't we end up confronting cases that are so blatantly counter-intuitive that they undermine the very notion of the mind as a proper locus of scientific and philosophical enquiry? Clearly, not all of the technologies or external resources that we encounter are apt to engage in the kind of bio-technological hybridization envisioned by the extended mind hypothesis. As Clark (1997) argues:

> *"There would be little value in an analysis that credited me with knowing all the facts in the Encyclopaedia Britannica just because I paid the monthly installments and found space for it my garage" (pg. 217).*

Similarly, it would be foolish to equate my personal body of knowledge and beliefs as co-extensive with the informational contents of the Web simply because I own an iPhone. What, then, are the conditions under which we count a set of external resources as constituting part of an environmentally-extended mind? In answering this question, Clark and Chalmers (1998) embrace a particular set of criteria, ones that appeal to the accessibility, portability, reliability and trustworthiness of the external resource. The criteria are that:

1. "…the resource must be available and typically invoked" (Clark 2010). **[Availability Criterion]**
2. "…any information…retrieved from [the non-biological resource must] be more-or-less automatically endorsed. It should not usually be subject to critical scrutiny (unlike the opinions of other people, for example). It should be deemed about as trustworthy as something retrieved clearly from biological memory" (Clark 2010). **[Trust Criterion]**
3. "…information contained in the resource should be easily accessible as and when required". (Clark 2010) **[Accessibility Criterion]**

Clearly, such criteria serve to guide and constrain our intuitions about the kind of bio-artifactual and bio-technological couplings that are relevant to the formation of an extended mind. And they do so precisely because they delimit the range of situations under which we recognize the capabilities engendered by an external resource as being (most plausibly) that of a specific individual human agent (or perhaps a collection thereof (Tollefsen 2006; Theiner, Allen, and Goldstone 2010)).

Extending the Mind: Cognitive Extension and the Current Web

The extended mind hypothesis encourages us to think about the way in which much of our cognitive success is grounded in processing loops that factor in the contributions of our extra-neural social and technological environments. In this sense, it is an hypothesis that is highly applicable to discussions about the potential impact of the Web on the human mind. When we apply the concept of the extended mind to the specific socio-technical context of the Web, we end up with the idea of the 'Web-extended mind' (Halpin, Clark, and Wheeler 2010; Smart et al. 2010), or the idea that the informational and technological elements of the Web can, at least on occasion, constitute part of the material supervenience base for (at least some of) a human agent's mental states and processes.

Of course, just because we can conceive of something like a Web-extended mind this does make the realization of Web-based forms of cognitive extension a practical possibility. We need to consider the specific features of the Web and ask whether it constitutes a suitable target for cognitively-relevant bio-technological mergers; in particular, whether it meets the kind of criteria encountered in the previous section. At first blush, the answer to this question seems straightforward: given the thought experiment used by Clark and Chalmers (1998) – the one involving Otto, Inga and the notebook – we can easily imagine a scenario in which the notebook is supplanted with a more technologically-sophisticated resource, such as a Web-enabled portable device (see the example scenario discussed in Smart et al. 2010). Such a device would seem to provide much of the same functionality as a notebook, and, in some cases, it might even provide additional functionalities that obviate some of the philosophical criticisms of the extended mind hypothesis[1]. Weiskopf (2008), for example, has criticized the extended mind hypothesis on the grounds that a conventional notebook

[1] One concern that is sometimes raised about the proposed substitution of Otto's notebook with a Web-enabled device is that the Web does not support the same kind of content editing capabilities that are seen in the case of a conventional notebook. While this was true of earlier versions of the Web, the advent of Web 2.0 has essentially taken us a step closer to the era of the read-write Web, and is fair to say that most of the content available on the Web today is generated by users posting and uploading content.

fails to deliver the kind of informational updating capabilities that we normally expect in the case of biologically-based belief states. However, while Weiskopf may be right about the shortcomings of a paper notebook, it is not clear that such criticisms have the same leverage when we think about more sophisticated technological resources (see Smart 2010).

Another advantage of Web-based access is, of course, that we are put in touch with a vast repository of information and knowledge – one much larger than anything we could hope to accumulate in a conventional notebook. The implications of this informational access from an extended mind perspective are potentially profound. For example, if we are enabled to have more-or-less immediate, reliable, and easy access to bodies of information on the Web, and if such information is indeed poised to count as part of own body of knowledge and beliefs about the world – in the same way, perhaps, as the content of our biologically-based (semantic) memories – then we may be only a few technological steps away from an era in which the limits of our personal knowledge are defined by the extent of the Web's reach!

The problem with this upbeat vision, however, is that it is presently unclear to what extent the Web (as currently constituted) possesses the kind of features that would support the emergence of Web-extended minds. The primary problem is that most forms of cognitive extension depend on a particular form of information flow and influence in which there is a close temporal coupling between the various elements that comprise the extended system. In the case of the extended mind, for example, it seems reasonable to insist that there should be some functional similarity in the influence exerted by both bio-external and bio-internal information sources. If external information should exert an influence on our thoughts and actions that is profoundly unlike that seen in the case of (for example) bio-memory, then it seems unlikely that we approach the kind of conditions under which genuine forms of mind-extending bio-technological integration take place. And if we think about the kind of informational contact we have with the conventional Web (the Web of HTML documents), then it seems unlikely that we will ever have a form of contact in which information can be accessed in a way that resembles the contents of our long-term memories (see Smart et al. 2009). One area of concern in this respect is the current reliance on document-centric forms of information representation. Thus, ever since the invention of the Web, the dominant way of representing information content has been via the use of HTML. Traditionally, information has been delivered in the form of HTML documents, which are accessed by browser technologies and then presented to human users in the form of Web pages. This page, or document-centric, mode of representation has significant implications for how we access information content, and it affects the kinds of influence that Web-based information can exert over our thoughts and actions. If we want to enable the kinds of information flow and influence that support the emergence of extended minds, then we need to ensure that our contact with the Web fulfils the kind of criteria outlined by Clark (i.e., the criteria of accessibility, availability and trust). It is by no means clear, however, that our current reliance on document-centric modes of information delivery really do enable us to meet these criteria. As an example of the shortcomings of document-centric modes of information representation, think about the problem of accessing factual information from a Web-accessible resource, such as Wikipedia. Even if the delays associated with document retrieval and presentation are resolved, the user is still confronted with the onerous task of surveying the document for relevant information content. In most cases, this requires the user to scroll through the Web page and process large amounts of largely irrelevant content in order to identify the small amount of information that is actually needed. This is a very inefficient means of information access. Even if the user tries to isolate specific information items for use on multiple occasions, he or she cannot do this without reliably fixing the physical location of the information (perhaps by copying the required information to a local resource). Ideally, what is required in order for Web-based content to count as part of an extended mind is that the relevant factual content should be available to guide thought and action in the ways we have come to expect our thoughts and actions to be guided by information retrieved from bio-memory. The problem with the conventional, document-centric Web – the Web of Documents – is that the relevant pieces of information that are required to guide, scaffold and constrain our thinking are usually embedded in a mass of other distracting information. This makes it difficult to see how current forms of Web-based content could have the kind of functional poise sufficient to count as part of our personal body of knowledge and beliefs about the World.

This is not to say, of course, that the Web does not have the *potential* to serve as the target of cognitively-significant biotechnological mergers. The Web is something of a protean beast when it comes to user interaction and information access capabilities. New forms of information representation, new forms of user interaction technology, and new forms of application development all contribute to an ever-changing landscape against which our notions of the Web's capacity to support cognitive extension are always likely to be somewhat ephemeral. In addition to this, we also need to consider the possibility that cognitive extension may depend on the emergence of specific social conventions and practices that determine how the *social* use of a technology is optimized to support cognition at both the individual and collective levels. The Web is a relatively recent technology, and it is still undergoing rapid development and change. In the next section, I will argue that cognitively-potent forms of biotechnological merger do not necessarily come for free. They are often the end product of a complex, often co-dependent, process of technological innovation, social change and even neurological configuration. The relatively recent emergence of the Web means that we should not expect it to immediately fulfil all of our requirements in terms of its capacity for cognitive extension. It sometimes takes time for the true transformative potential of a technology to be fully realized.

Socio-Technical Evolution and the Making of an Extended Mind

In the introduction to his book on cognitive extension entitled 'Supersizing the Mind: Embodiment, Action and Cognitive Extension', Andy Clark (2008) recounts an exchange between the Nobel Prize-winning physicist Richard Feynman and the historian Charles Weiner in which Feynman argues for the importance of his notes in contributing to his thoughts. Rather than representing a mere record of his internal cogitation, Feynman seems to be arguing that the process of creating the notes and sketches is part of the cognitive work itself. Clark agrees. He argues that the cycle of information flow and influence established by Feynman and his notepad plays a crucial role in the realization of Feynman's thinking:

> *"...I would like to go further and suggest that Feynman was actually thinking on the paper. The loop through pen and paper is part of the physical machinery responsible for the shape and flow of thoughts and ideas that we take, nonetheless, to be distinctively those of Richard Feynman." (pg. xxv)*

What Clark is basically suggesting here is that writing is constitutive of thinking: that writing plays an active role in the realization of our thoughts, and that the machinery of cognition extends to include not just the biological brain, but also the elements of the bio-external environment that make the creation of symbolic artefacts (written words) possible.

The cognitive virtues of writing are a common focus of attention for those interested in technology-mediated cognitive enhancement (e.g., Dix 2008). Clark (1997), for example, suggests that the process of writing an academic paper is one that involves the integration of a variety of props, aids and artefacts into complex nexuses of environmentally-extended information processing. "Extended intellectual arguments and theses," Clark argues, "are almost always the products of brains acting in concert with multiple external resources" (Clark 1997; pg.207).

Writing therefore emerges as a compelling example of technology-mediated cognitive empowerment. Such empowerment, however, does not come for free. The fact is that almost all forms of technologically-based cognitive extension require a prolonged period of technological, sociological and even neurological adaptation. In the case of writing, the features that make writing technologies so apt to participate in extended cognitive systems have come at the end of a long process of technological innovation and social change. The widespread availability of pen and paper, for example, did not happen overnight. It took many years before these resources were available in sufficient quantity for them to become a standard part of our everyday lives – part of the persisting backdrop against which our current set of cognitive capabilities emerged. And although technological innovation and adoption are clearly a major part of the story, they are not the only things that need to be considered. We are not born skilled writers, capable of wielding a pen or working a keyboard. Rather, our writing abilities emerge over the course of many years of instruction and training, often undertaken as part of a formal education. Pen and paper may be simple technologies, but their proper use and exploitation comes only at the end of a rather prolonged period of socially-scaffolded neurological adaptation and configuration. Biotechnological bonding does not necessarily come for free: we often need to teach our brains how to press maximal cognitive benefit from the technologies we use.

The history of writing also teaches us about the importance of social practices and conventions in enabling a technology to realize its full potential. In using writing technology, we follow a socially-accepted set of principles and guidelines governing the proper use of those technologies, and, over time, those principles have evolved to enable the technology to meet its designed purpose. The importance of these social conventions is apparent when we look at early forms of writing. These were not necessarily conducive to cognitive enhancement in the way that later forms were. In fact, early forms of writing were heavily influenced by the traditions and practices of the preceding era, within which information was communicated by purely oral means. Writing initially assumed the form of a continuous stream of text (known as scriptura continua), which was devoid of any of the conventional orthographic features (such as word spacing and punctuation) that we now accept as standard features of a written text. The reason for this particular form of writing seems to be based on the fact that writing was initially seen as a means to record and re-present orally communicated information. It simply never occurred to the early writers that the new system of recording thoughts and ideas could be used independently of the spoken word:

> *"It's hard for us to imagine today, but no spaces separated the words in early writing. In the books inked by scribes, words ran together without any break across every line on every page, in what's now referred to as scriptura continua.*

> *The lack of word separation reflected language's origins in speech. When we talk, we don't insert pauses between each word – long stretches of syllables flow unbroken from our lips. It would never have crossed the minds of the first writers to put blank spaces between words. They were simply transcribing speech, writing what their ears told them to write." (Carr 2010; pg. 61)*

Scriptura continua therefore seems to reflect an intermediate stage in the transition from oral to written culture. It was a form of writing that was heavily influenced by previous forms of information communication, and, like many innovations, it took time for it to become optimally suited to its target audience.

This history of writing serves as a fitting backdrop to the present discussion on Web-extended minds because it helps us understand why current incarnations of the Web may lack the kinds of features that support cognitive extension. We saw that early forms of writing, like the use of scriptura continua, were heavily influenced by the preceding oral tradition. It took some time before the social practices and conventions associated with writing were optimized to take account of its new cognitive role. Like early forms of writing, I suggest that the current form of the Web (the Web of HTML documents) is heavily influenced and informed by the practices and conventions of the era that preceded it: the era of the written and printed word. When information is published on the Web, it is typically done so in the form of 'pages' that communicate information in much the same form as we would expect to see in a printed document. This mode of information presentation is, like early forms of writing, not necessarily best suited to the emergence of extended cognitive systems. Perhaps the current version of the Web is, like scriptura continua, an initial form of a technology that is attempting to free itself of the metaphors of a previous era and evolve into something that is far more suited to the realization of its true cognitive potential. What the history of writing teaches us is that we should not mistake the early forms of a technology as constituting the final word in terms of that technology's ability to transform our cognitive and epistemic potential. The making of an extended mind is not something that is necessarily rapid or straightforward: it sometimes takes a long time for a technology to be available in the right form, and we sometimes need to engage in extensive training before we can derive maximum cognitive benefit from the use of a technology. In addition to this, the use of a technology is often guided by social conventions, and these need to be carefully aligned with both the form of the technology and our ability to use it (or our ability to learn how to use it).

Extending the Mind: Cognitive Extension and the Future Web

The transition to a Web that is capable of supporting the emergence of Web-extended minds arguably requires a number of innovations, and together these innovations provide us with an alternative vision of the Web and the kind of interactive opportunities it affords. In this section, I describe two areas of technology development that are already beginning to change our relationship to Web-based information content. The first of these areas concerns the use of linked data formats to change the way information content is represented on the Web (Bizer, Heath, and Berners-Lee 2009). Such formats improve both the accessibility (in terms of the retrieval of specific pieces of relevant information) and versatility (in terms of flexible modes of presentation) of information content. The second area of technology development concerns the use of new kinds of display device and augmented reality capabilities. These change the nature of our relationship to information on the Web by making that information more accessible and more suitably poised to influence our everyday thoughts and actions.

The Missing Link: Towards the Web of Data

We have seen that the conventional Web – the Web of HTML documents, or Web of Documents – presents a number of problems for Web-based forms of cognitive extension (for example, the difficulties of accessing relevant information that is embedded in a mass of other, semantically-irrelevant, content). Fortunately, an alternative approach to the representation of online content is emerging alongside the conventional Web of Documents. This is the Web of Data (Bizer, Heath, and Berners-Lee 2009), which is based on the idea that the Web should serve as a globally-distributed database in which data linkages are established by dereferenceable URIs. The transition from document-centric to data-centric modes of information representation is, I think, an important step in the technological evolution of the Web, particularly when it comes to the notion of the Web-extended mind[2]. What is important for Web-based forms of cognitive extension are flexible modes of data integration, aggregation, filtering and presentation, in conjunction with an ability to gear information retrieval operations to suit the task-specific needs and requirements of particular problem-solving contexts. The Web of Data supports these capabilities in a number of ways. In particular, it countenances representational formats that are:

1. largely independent of specific presentational formats or usage contexts (this supports flexibility in the way information content is presented; it also enables data to be used in different ways in different application contexts),
2. centred on the representation of limited sets of data or data items (this supports the rapid retrieval and presentation of specific pieces of information), and
3. semantically-enriched (this supports the retrieval of relevant information).

This mix of features brings us a step closer to establishing the kind of conditions under which the emergence of Web-extended minds is a realistic possibility. The Web of Data is not necessarily the final step in this process, but it does provide an important step, I think, towards more potent (and empowering) forms of cognitive engagement with the Web.

The Real World Web

The gradual transition from document-centric to data-centric modes of information representation is one of the ways in which the Web is evolving to provide new opportunities for cognitive augmentation and enhancement. Without the correlative development of suitable interaction mechanisms, however, the potential for the new representational formats to genuinely transform our cognitive and epistemic potential is still somewhat limited. Although there are new types of browsers that enable human users to browse the Web of Data, it is unlikely, I think, that these browsers will introduce any radically different forms of informational contact, at least relative to the kind of contact already afforded by conventional Web browsers. Rather than focus on the development of browser interfaces that simply take existing functionality and adapt it for the Web of Data, I suggest that we need to think about radically new forms of information display and user

[2] Paradoxically, although the aim of the linked data initiative is to provide content that is primarily suited for machine-based processing, while the aim of the conventional Web (the Web of Documents) is to provide content that is primarily suited for human consumption, it is the Web of Data that, I suggest, provides the better opportunity for human-centred cognitive transformation.

interaction. We need to move beyond the browser interface, which for too long has dominated our notions of informational contact with Web-accessible information resources. Instead, I suggest that we need to entertain a new vision of the Web: one which makes bio-external information resources suitably poised to participate in the emergence of Web-extended minds. Let us refer to this new vision of the Web as the 'Real World Web'.

As is suggested by its name, real world environments are at the heart of the concept of the Real World Web. The basic idea is that Web-based information should, wherever possible, be embedded in the real world and easily accessed as part of our everyday interaction with that world. Information about everyday objects should be associated with those objects, information about locations should be accessible in those locations, and information about people should be 'attached' to those people. In all cases, the information should be immediately accessible and easily processed. It must be able to guide thought and action in the way in which our everyday cognition is supported by the information retrieval operations of our own biological brain. What this means, in effect, is that information should be immediately accessible to our perceptual systems. It should require little or no effort to make the information available for perception, and, in most cases, the information should be delivered automatically, with little or no conscious effort required to make that information available.

This vision is one which modifies our traditional modes of interaction with the Web in a number of ways. Instead of the retrieval of relevant information being entirely the responsibility of the human agent, the notion of the Real World Web advocates a more intelligent and proactive Web: a Web which is capable of anticipating users' information requirements and making that information available in ways that support cognitive activity. It is also a vision that places the Web at the heart of our everyday embedded interactions with the world. Rather than information access requiring perceptual detachment and disengagement from our immediate surroundings (something that is required even with the most portable of mobile devices) the notion of the Real World Web seeks to make Web-based information access a standard feature of our everyday sensorimotor engagements with the world – it seeks to make the Web part of the perceptual backdrop against which our everyday thoughts and actions takes shape. Finally, the notion of the Real World Web emphasizes a shift away from traditional browser-based modes of Web access, featuring the use of screen-based displays, keyboard-based interaction mechanisms and document-centred representational schemes. In place of conventional screen-based modes of information access, the Real World Web emphasizes the importance of more perceptually-direct forms of information access (e.g., the use of augmented reality devices to overlay Web-based information onto real-world objects and scenes); in place of conventional user interaction devices, such as mice and keyboards, the Real World Web advocates the use of alternative interaction mechanisms (more on which below); and in place of conventional document-centric modes of information representation, the Real World Web countenances a transition to more data-centric modes of information representation (see above). The main implication of this shift away from conventional browser-based modes of Web access is that we are enabled to see the Web in a new light: as something more than a passive set of information resources that need to be coaxed into useful cognitive service by our deliberate search and retrieval efforts. Our traditional modes of access with the Web encourage us to see the Web as something that is:

1. **passive:** we need to engage with the Web in a deliberate manner in order to retrieve relevant information. Information needs to be discovered, retrieved, filtered and interpreted; seldom does the Web support us in a proactive manner – providing the right information just when we need it.
2. **distinct from our everyday interaction with the world:** the Web may support our everyday decision-making and problem-solving behaviours, but, in general, this support comes at the cost of us having to divert our attention away from the problem at hand. Instead of information being immediately available to support our thoughts and actions, we are often required to suspend what we are doing in order to 'look things up' on the Web.
3. **impersonal:** the information content of the Web is, in general, not geared to specifically suit our idiosyncratic problem-solving needs and concerns; often we have to access information from several sources and adapt it for our own ends.

In place of this vision, the Real World Web gives us a vision of the Web as something that is proactive, personal and perceptually-immediate. Once we are afforded immediate perceptual access to Web-based information, and once such information becomes available at just the right time to support our goals, interests and concerns, then such information becomes, I suggest, far more capable of fulfilling the kind of conditions that merit the emergence of Web-extended minds.

The Real World Web, it should be clear, relies on a rich range of sophisticated technical capabilities, most of which are, as yet, either unavailable or not in widespread use. This might be perceived as grounds for pessimism about the tenability of the Real World Web vision. However, for the most part, the kind of technological innovations required to make the Real World Web a reality are not beyond the reach of our current engineering capabilities, and, in some cases, early forms of the technologies are already starting to appear. One of the most interesting and relevant areas of recent technological innovation concerns the development of a range of highly portable augmented reality or mixed reality solutions. These are available in a variety of forms, from handheld mobile devices that overlay information onto a real-world scene via a camera and screen display, through to wearable-computing solutions, such as head-mounted displays and retinal projection systems. One such system, which is being developed by researchers at the University of Washington, uses a set of microfabrication techniques to incorporate display micro-devices into a contact lens (Lingley et al. 2011). The contact lens is worn like any other contact lens, and it provides a see-through display that is both remotely powered and controlled via a wireless link. The ultimate promise of such devices is that they enable network-accessible information to be superimposed on real world objects and scenes, enhancing the kind of informational contact we have with our online world, and significantly enriching the range of perceptual cues, prompts and affordances that guide our everyday thoughts and actions.

Conclusion

Throughout history, technologies have exerted a significant influence on humanity. Some technologies have contributed to profound forms of socio-economic change, fundamentally transforming the nature of our social activities and modifying the structure of our social engagements. Others have contributed to a profound change in our cognitive profiles, fundamentally transforming the way we think about the world and modifying the basic character of our cognition. Like the transformative technologies that preceded it, the Web is a technology that is potentially poised to influence both society and ourselves. At present, much of the research related to the Web has focused on its social and societal impact: the effect the Web is having on social, political and cultural processes. However, the cognitive impacts of the Web are also an important focus of scientific and philosophical attention. The current paper explored the notion of the Web-extended mind – the idea that the informational and technological elements of the Web may support environmentally-extended cognition in the manner suggested by the extended mind hypothesis (Clark and Chalmers 1998). Following a consideration of the Web's features in relation to a number of criteria outlined to discriminate genuine cases of cognitive extension from more ersatz varieties, it was concluded that the Web is not particularly well-suited to the formation of extended cognitive systems.

We should not, however, be overly surprised or downcast by this conclusion. When thinking about the cognitive impact of the Web it is always important to be clear that the Web is a relatively recent technology, and it is still undergoing rapid development and change. This means that our conception of what the Web is is a highly dynamic one. Current modes of interaction with the Web do not necessarily limit (or even limn) the space of interactive opportunities that could be created by future forms of technological innovation, and we thus need to be very wary of blanket statements about the Web's ability to help or hinder cognitive processing. In addition to this, we saw in the case of writing that some technologies take time to become ideally suited to supporting cognitive extension. Perhaps something similar is true of the Web. As was the case with writing, our ability to gain maximal cognitive benefit from the Web will depend on a progressive optimization of the technologies we use and the social conventions that dictate how we use them. The current Web is surely an important point in our cultural and intellectual history, but it need not be the final word in terms of our cognitive and epistemic transformation. Perhaps, with time, we will come to see the current Web as laying the groundwork for more potent and profound forms of cognitive enhancement – an important, albeit temporary, milestone en route to our Web-extended cognitive destiny.

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