Characteristics of Human Perception and their Relevance When Studying Information Behaviour

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Abstract

Research in allied disciplines suggests that failing to notice information that is actually present in the environment is not an exception but rather to be expected. The specific characteristics of human bodies along with the cognitive and perceptual systems that have co-evolved with these bodies are such that humans perceive only a fraction of the information that is potentially perceivable. There are many reasons for that including, but not limited to, the body's "being in the world" and the physical movements that are involved in any kind of information behavior and that both enable and constrain what one can perceive. The information that is perceived may or may not include information that is relevant to a task at hand. In this article, we summarize some of the relevant research conducted in allied disciplines and argue that information behaviour research needs to find ways to address the human characteristics that imply that a) subjects are likely to fail to recognize information that is present in an environment and potentially relevant to a task at hand and b) subjects would not be able to report on the fact that they failed to recognize the information. We also discuss as to how information behaviour research can address the aforementioned challenges resulting from human movement and perception.

Introduction

"Information" is a phenomenon that is of particular interest to a range of disciplines including Computer Science, Information Systems, and Library and Information Science. Depending on the context, the term information can refer to physical matters that can be measured (see e.g., Shannon, 1948) or largely cognitive phenomena that would be extremely hard if not impossible to measure. In the context of this paper, information is seen as a matter of perception that
requires a human subject for the information to be perceived. From this point of view, more or less anything can be used to generate information: "[...] we are unable to say confidently of anything that it could not be information." (Buckland, 1991, p. 50).

Having a physical body is essential for perception (e.g., Gibson, 1986). "Embodiment", however, is not only required for perceiving the world and interacting with it. Over the past few decades, having a body has also been recognized as being essential for enabling human-level intelligent behaviour (e.g., Clark, 1997; Pfeifer and Scheier, 1999; Wilson, 2002; Gallagher, 2005; Pfeifer and Bongard, 2007).

The ‘embodied cognition’ perspective (Clark, 2008) states that cognitive systems and their bodies cannot be understood independently of each other as they are adapted to each other in very profound ways: physical characteristics of the body, including its morphology, help enable and support the cognitive system by simplifying essential activities. Clark's (1997) "scaffolding minds" perspective suggests that human intelligent behaviour depends to a large extent on structuring and exploiting the physical as well as the social environment. Following Clark (ibid.), human cognitive capabilities cannot be explained properly without considering a) embodiment and b) the embedding within well-structured (‘scaffolded’) environments created and sustained by (other) human minds. Examples of corresponding external structures are physical, symbolic and socio-institutional structures (see e.g., Hutchins, 1995). A popular example of a scaffolded environment is using one's desk to "outsource" memory by representing information in documents, to prioritize tasks by arranging documents according to their importance, or to off-load the need to remember tasks by creating physical reminders, e.g., by placing a letter to post by the front door. The relatively safe environments that parents create for small children, e.g., by keeping unsuitable food and sharp items out of reach and blocking off stairs, would be an example of scaffolding aimed at reducing the complexity of the baby's interaction with the environment.

Section 1 Perception: what we see, what we think we see, and what we do not see

This paper explores some of the implications of the specific characteristics of the human body and the cognitive and perceptual systems that co-evolved with it to the extent that they are
relevant for human information behaviour and the scientific study thereof. In this section we discuss those characteristics and potential impacts of those characteristics on what we "see". Implications for research in information behaviour research will be discussed in subsequent sections.

The physical location of one's body and its physical orientation are issues we all know too well from travel which is literally about moving our body over a distance. If our bodies were not orientated roughly towards the announcement panel at the airport we would physically be unable to see the panel and the information that it provides. Unlike cockroaches and dragonflies that are equipped with large compound eyes delivering a wide field of view of 360 degrees, humans feature a comparatively narrow field of view of approx. 180 degrees horizontally and 120 degrees vertically with only about 1.5 degrees in focus at any time.

If we cannot "see" the panel we cannot perceive the information provided by the panel either. In some situations we may be able to spot the flight announcement panel from a distance but we need to move our bodies close enough such that we are physically able to obtain vital information, including boarding time and departure gate. A similar behaviour is required when spotting an interesting looking shelf in libraries or bookstores and moving closer such that we would be physically able to read the spines of the books on the shelf.

The examples points to some of the more obvious challenges that come with having bodies and their specific perceptual systems. Even in badly designed airports we would know from experience that there must be announcement panels somewhere, and would search for them. In environments of particular interest to information behaviour research including libraries and museums, we may miss information though because there are so many other information displays competing for our attention that we may not even become aware of potentially relevant material that we are going to miss. We may miss information because we are too far away to be able to read, and because we decide against moving our bodies closer such that we would be able to read the information.

Age, eyesight, mobility and perspective are among the factors to consider when investigating information behaviour from a perspective that takes perception seriously. In the case of traffic signs, for example, it has been established that age is a factor influencing the capacity to read
from a distance (e.g., Sagawa, 2002). Saumure and Given (2002) investigated visually impaired students, noting that they are "marginalized groups [that have shown] to exhibit different information behaviours from those that have typically been viewed as 'normal'" (p. 151); see also related research by Williamson (1996), Williamson and Asla (2009). Beverley et al. (2007) report on effects of visual impairment on information behaviour. Bidwell and Lueg (2004) report relevant findings from a study of navigating an unfamiliar environment. The set task was to navigate an unknown university campus using a number of photographs taken from an ego-centric perspective i.e. from the point of view of the person navigating the environment. A tablet PC was used to present series of images of landmarks each preceded by a textual route instruction. The experiments were conducted in very hot and humid tropical conditions and these conditions had a profound influence on the outcome of the experiments in ways that make them relevant to this paper. In particular, the authors were facing issues such that certain landmarks to be used for ego-centric navigation were 'there' i.e., they were physically present, but they were 'unavailable' for navigation purposes, because of the physiological and environmental conditions. For example, hopping from shade to shade to escape the tropical heat caused a subject to not actually see certain landmarks because of the resulting physical position; another subject was irritated by colour shifts because of wearing sunglasses protecting the eyes from harsh tropical light. An example of certain characteristics of the human vision system impacting on a person's information behavior, or, more precisely, his or her capacity for information behavior, is a study by Baker (2004) of police involved in undercover prostitution operations. Baker (ibid.) reports that "[...] headlights from on-coming cars blocked the vision of the eye [car with officers watching the decoy] with whom she was parked on the side street; however, the eye parked on the main street had the decoy in his view." From the perspective developed in this paper, Baker (ibid.) reports significant findings regarding location, body orientation, and the physiology of vision, and how they may impact on information behavior.

Determining what humans actually perceive, rather than what they would potentially be able to perceive, is even more difficult since there are not only "obvious", physiology or body orientation related aspects that influence what humans perceive. First of all, the task at hand literally influences the way humans look at the world: "Our eye movements are not driven by
what is biggest, brightest, or flashiest in a visual scene. They reflect the purpose of our looking." (Ellard, 2009). This is also stressed by Rothkopf et al. (2007): "[...] in the execution of extended natural tasks, human gaze is directed toward regions of the visual scene that are determined primarily by the task requirements."

There are also a number of cognitive biases that influence what we "see". In the social sciences it has been determined that stereotypic beliefs influence how humans perceive and interpret the world (e.g., Peeters, 1983; Case 2012). Heuer (1999) discusses cognitive biases in the context of intelligence analyses. Dunham and Banaji (2010) point out that "objects out in the world are not perceived 'as they are,' and evaluations of objects are not stable values that can be exactly measured. Rather, perceptions and attitudes are partially constructed and interpreted out of what is already inside our heads" (p. 206). In the context of information behaviour this means that potential information sources, including people to ask, may be considered less relevant to the task at hand because of stereotypic beliefs or platonic blindness; Case (2012) discusses related work as related to avoiding information.

Furthermore there is also evidence that being oriented towards something does not necessarily mean that we recognize what is in front of us. Humans often miss information that they do not expect to see. The 'invisible gorilla' experiments by Simons and Chabris (1999), based on earlier experiments reported by Neisser (1979), is a particularly well-known example of what is called inattentional blindness (Mack and Rock, 1998). In the invisible gorilla experiments about 50% of people will not "see" the additional information that is presented to them, in that case a black gorilla walking among two teams of ball players observed by the subjects.

Hyman et al. (2010) demonstrated that inattentional blindness may also happen while walking around if people get distracted, e.g., by talking on a mobile phone. Not spotting a nearby unicycling clown as in the experiments is not the same as failing to notice stationary information sources but may be very similar to not spotting a colleague that could provide relevant information. "Talking to colleagues" is a preferred way of gathering information which makes such blindness effects relevant to information behaviour research.
Apart from information that is "there" but not (consciously) perceived there is also information that is "perceived" even though it is not actually there. When investigating how certain magical tricks are performed Kuhn et al. (2008) found that subjects may "see" objects even though they clearly were not there, most likely because they expected to see it that way. Interestingly, Kuhn et al. (2008) also demonstrate that while the magician manages to trick the 'mind' of a subject, the perceptual system ('the eyes') isn't tricked. It seems to be the case that the mind 'overrides' the visual information that is coming from the eyes. Overriding sensory information also occurs in the so-called McGurk effect which denotes an illusion causing people to hear something different because of what they see (e.g., Rosenblum, 2010).

To sum up, having (human) bodies and corresponding perception systems means that we are likely to miss some of the information that may be relevant to a task at hand. Depending on the conditions, humans may not "see" potentially relevant information or may see information that does not actually exist. We may also interpret information differently depending on the specific circumstances.

Figure 1 below depicts, albeit not to scale, the information environment in which human information behaviour is situated. The figure does not refer to any particular information behaviour model since current models are typically based on the assumption that we manage to perceive the information that is relevant. Neither does the model incorporate already established effects such as situational factors (e.g., Barry 1994) or factors such as "anxiety, desire, leisure, pleasure, boredom, frustration, uncertainty, curiosity, serendipity, surprise, anticipation, immersion, sense-making or cognition, habits, and memory, among others" (Keilty 2012) that may interact in complex ways with what we perceive. Because of the scope of the paper the model does not cover how different sensor modalities contribute to establishing the information environment in which people engage. Readers interested in relevant communication aspects are referred to Schramm's (1973) concept of selective exposure and the related discussion of avoiding information in Case (2012, p. 109ff).
Figure 1: Grounding "information" in human perception

Section 2 Human Information Behaviour

Human information behaviour is a research area of particular interest to scholars and practitioners in Library and Information Science (LIS). Traditionally, the focus of information behaviour research is on "how people need, seek, manage, give and use information in different contexts" (Savolainen 2007, p. 112) but also includes speciality domains such as serendipitous information discovery (see e.g., Rubin et al. 2011).

Wilson's (1999) popular article defines a hierarchy of four core information behaviour terms and their relationship with each other: information behaviour, information seeking behaviour, information searching behaviour and information use behaviour. Information behaviour is the most general term, denoting "the totality of human behaviour in relation to sources and
channels of information, including both active and passive information seeking, and information use. Information seeking behaviour is "the purposive seeking for information as a consequence of a need to satisfy some goal"; it may consist of information search behaviours which are the "'micro-level’ of behaviour employed by the searcher in interacting with information systems of all kinds". Finally, information use behaviour "consists of the physical and mental acts involved in incorporating the information found into the person's existing knowledge base." As an example of physical acts Wilson lists "marking sections in a text to note their importance or significance"; an example of mental acts would be comparing new information with existing knowledge. In the preface to a widely referenced collection of theories of information behaviour, Fisher et al. (2005) build upon Wilson's definition and conceptualize information behaviour as "including how people need, seek, manage, give, and use information in different contexts."

In the context of this paper, it is worth noting that even though certain models including Wilson's are widely adopted "there is no generally accepted detailed theoretical framework for explaining and predicting the variety of such behaviour. Indeed, the only genuinely fundamental models which we have are so general as to be of limited value in explaining specific aspects of behaviour—most notably Zipf's principle of least effort." (Bawden and Robinson, 2009, p. 188). Spink's (2010) information behaviour framework, for example, goes beyond the scope of traditional information behaviour models in that the framework tries to explain how information behaviour has evolved as a human capacity and is also an attempt to unify a diverse range of approaches focusing on specific aspects of information behaviour, such as information grounds of multi-tasking; see also Bates (2005) for another take on evolutionary aspects in information and knowledge.

Information behaviour theory has been interested in what is commonly referred to as situational aspects in information behaviour for decades. Barry (1994), for example, points out that "[...] situational factors other than the inherent topical content of documents influence the relevance judgment process; that the situation encompasses any factors that the user brings into the situation, such as experience, background, knowledge level, beliefs, and personal preferences; and that evaluations of individual documents take place within the larger context
of the information environment." Sadler and Given (2007) build on Gibson's affordance theory to understand how students perceive and use the various "opportunities for action" (books, databases, instructional sessions, librarians, physical space, etc.) offered by the local library and how these perceived affordances matched librarians' intentions and expectations. Hepworth (2007) discusses the need to understand cultural, environmental, social and individual factors. More recently, Keilty's (2012) work added a body-centred perspective that helps explain the relevance of topics of interest including "anxiety, desire, leisure, pleasure, boredom, frustration, uncertainty, curiosity, serendipity, surprise, anticipation, immersion, sense-making or cognition, habits, and memory, among others".

Of particular interest to this paper is that while there is an impressive information behaviour literature exploring what information sources subjects use while seeking for information and what situational factors may influence that behaviour (e.g., Barry's aforementioned work), little attention has been paid to the fact that humans may fail to recognize the very existence of relevant information sources, and that this failure may not the exception but, as discussed in the previous section, to be expected.

A noteworthy exception is Erdelez's (2004) work on the use of eye-tracking technology in information behaviour research. Assuming that eye movements would reveal subtle changes in shifting user's attention, Erdelez (ibid) explored the use of eye-tracking technology when looking for 'positive' evidence of 'noticing' in information seeking. In the context of this paper it is particularly interesting that the experimental setup that allowed to reveal "noticing" also allowed to reveal "not noticing". As such, the experiments could be interpreted as early information behaviour research looking for evidence that subjects may fail to notice information that was on the screen right in front of them. At the same time the experimental setup demonstrates that movements as tiny as eye movements are in fact aspects to be considered in information behaviour (see Kelder and Lueg, 2011 for an extended version of the argument).

Limitations of human perception raise important questions about the grounding of information behaviour research in the real world. Current research in information behaviour excels at one side of the (perception) coin while largely disregarding the other. One of the challenges is recognizing that popular data collection methods including questionnaires, interviews and
"thinking aloud" sessions offer limited insights into what information a subject failed to notice, and typically no insights into why they failed to do so. Complementing those data collection methods with ethnographic methods, such as participant observation combined with third party "ideal observer" analyses of the information situation at hand, would address some of the data collection issues but the additional effort is high and accuracy typically low (e.g., gaze direction). Furthermore, inattentional blindness and other cognitive characteristics discussed earlier in this article suggest even if a subject looks into a certain direction that does not mean that the information is consciously perceived.

Research in situation awareness (SA) looking at high risk combat and emergency situations in particular has been working for decades on understanding, quantifying and preventing the failure to notice relevant information but has had limited influence on LIS information behaviour research. SA has been defined as "...the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (Endsley, 1988). Von Thaden (2007) explored SA perspectives in the context of distributed information behaviour in aviation security.

A valid question is whether the aims pursued in LIS information behaviour research demand achieving the same level of rigour and accuracy as in high risk research and what the field would lose in terms of expressiveness and validity of results if there was a conscious decision not to pursue on the same level. A major hurdle to paying more attention to embodiment might be the effort required to analyse moment-to-moment, embodied interaction (Lueg and Bidwell, 2005). This is a challenge in high risk combat and emergency situations but also in what has been identified as micro-information seeking (Kelder and Lueg, 2011) where behavioural details such as gestures, bodily movements and visual impressions matter, as these may provide vital cues regarding people's willingness to engage in further communication, in this particular case information about invasive screenings for breast cancer.

Section 3 Is Information Overload a Problem?

There is an argument put forward in particular by technologists that new media including the internet cause "information overload" and that new technologies are needed to cope with this
information overload (e.g., Maes, 1994). Case (2012) defines information overload as "a state in which too much information leads to a generalized state of anxiety and/or confusion, or an inability to make a decision regarding a specific problem." A different view, grounded in the physiology of perception, is to argue that humans are subject to continuous "overload", and always have been, simply because they are situated in a constantly changing, intrinsically unpredictable, and infinitely rich world (Lueg and Pfeifer, 1997). Following that argument, recorded information which is the focus of library and information science research (Bates, 1999) merely adds to an already existing phenomenon; see Bawden and Robinson (2009) for a broad discussion of information overload and related issues, including a warning that "there is some danger that information specialists may promote solutions to problems which are largely recognized only by themselves" (p. 181) which arguably was the case when computing researchers focused on addressing internet information overload at the expense of other types of information overload.

Lueg and Pfeifer's (1997) point that "[t]he information overload problem in its generic form exists independently from the advent of the Internet and its services[…] it seems to be a social and societal phenomenon caused by expectations such as always being informed about politics, business, latest trends, etc." resonates with Bawden and Robinson (2009) pointing out that "what is perceived as information overload may, more fundamentally, be work overload" (p. 187) or Janssen and de Poot (2006) reporting that "the extent to which people suffer from information overload is closely related to the strategies they use to deal with it."

Humans have evolved to cope with information overload. In fact, human cognitive characteristics, such as inattentive blindness, need to be seen as a strength and a weakness at the same time. While inattentive blindness may cause humans to miss important information it also enables them to cope with continuous information overload: "It is the price we pay for the gift of attention." (Green, 2011).

Carefully designed technologies may help ease what is often perceived as weaknesses of human perception. Awareness supporting systems ranging from early 'edit wear' and 'read wear' systems (Hill et al., 1992) to 'nudges' (e.g., Kalnikaite et al., 2011) demonstrate that it is possible to design interfaces such that they add useful information without contributing to
"information overload". Dostal et al.'s (2013) work exploring gaze-dependent techniques for visualising display changes in multi-display environments may help ease change blindness (McConkie and Currie, 1996) by helping people recognize change on computer displays that they might otherwise fail to notice. Other types of context-aware systems may include in-car technologies alerting drivers to workers by the roadside or fighter cockpits that reveal suspected enemy combatants. CrossingGuards (Guy et al. 2012) is an example where researchers pay attention to the fact that boosting one sense may come at an expense to the others.

A different approach to working with characteristics of human perception is pursued in military research aiming to exploit the observation that the electrical activity in the brain's visual cortex has already 'spiked', which can be measured, even before a person is consciously aware of what he or she is seeing. In their case the aim is to reduce the time it takes human observers to consciously recognize specific information in visual representations, such as aerial photographs (Peck, 2008). Haynes (2011) reports that "the specific outcome of free choices between different plans can be interpreted from brain activity [...] several seconds before it is made."

The fact that humans cannot halt 'perceiving' unless unconscious or in a state of deep meditation is exploited by marketing where absorption of information may not be overtly intentional (Case 2012). Neuromarketing which a special branch of advertising investigates 'subliminal messages' which are advertising messages that are not consciously recognized but that are said to trigger purchasing behaviours regardless (e.g., Lindstrom, 2010). Exposure to regular food advertising shown on television has in fact shown to prime automatic eating behaviors (Harris et al., 2009).

Section 4

Discussion and future research

"the idea that we miss a substantial amount of the visual world at any given time is startling [...]" (Mack, 2003).
Referring to inattentional blindness, Nardi and O'Day (1999) alerted researchers interested in collaborative practices that "some of what goes on in any setting is invisible unless [one] is open to seeing it". Considering the evidence put forward in this paper we probably need to accept that failing to notice information that could be relevant to a task at hand is not an exception but rather to be expected, and take this into account when researching information behaviour.

The major contribution of this paper is in putting the human body and the specific characteristics of the cognitive and perceptual systems that co-evolved with ('embodiment') at the centre of attention in information behaviour research. Perception is intrinsically related to moving around which means we need to find ways to determine how moving around influences what we see since this in turn influences the outcome of any information behaviour. As a matter of fact, embodiment-related references are scattered throughout the information seeking and information behaviour literature, and as early as in the work that introduced the term information seeking (Taylor, 1962). Bates's (1989) berrypicking metaphor is an early example that certainly evokes the idea that moving around in a physical space is an aspect of information behaviour; Kwasnik (1992), referenced in Bates (2006), noted that subjects focused in their study "on the movement of people's attention from item to item or from representation to representation. Movement was signalled by physical movement (walking, page-turning, finger pointing and so forth) and by verbalizations that showed evidence of a shift in focus".

One of the challenges that come with recognizing the importance of embodiment is acknowledging that popular data collection methods including questionnaires, interviews and "thinking aloud" sessions offer limited insights into what information a subject fails to notice (and the reasons for not noticing), unless there is considerable additional effort on behalf of the researcher to complement those data collection methods with ethnographic methods, such as participant observation. This may ease some of the problems but the additional effort is very high and accuracy low (e.g., gaze direction). Furthermore, inattentional blindness and other cognitive characteristics suggest that even if a subject looks into a certain direction this does not mean that information within visual range is consciously perceived.
Compared to the limited technological support that was available when Barry (1994) and others researched situational factors in information behaviour, we now have a range of technologies available that allow fairly accurate gaze tracking and therefore also a certain level of attention tracking. Balatsoukas and Ruthven (2012), for example, used eye tracking for evaluating relevance assessments and Bulling et al. (2011) identified characteristic patterns in eye movements that can be used to identify certain types of tasks, such as reading, that subjects are working on. Gaze tracking is frequently used in studies of consumer behaviour (e.g., The Economist 2012) which is an area closely related to information behaviour research. Knowing in greater detail as to what people pay attention to, what information sources they look at (and potentially perceive) and what information they miss will allow to ground information behaviour models in richer data than is currently available in regards to data collection, conceptual modeling and also in evaluating models.

When using the data to design perception enhancing technologies we must assume, however, that there is no free lunch since engaging in multi-tasking behaviours does not lead to an increase in the total amount of attention that is available (see e.g., Lin, 2009 for a discussion of some of the challenges in multi-tasking behaviors). This means we will need to carefully balance the opportunities offered by technologies enabling "perception beyond the Here and Now" (Schmidt et al., 2011) and the capabilities of human perception and cognition that have evolved for surviving in a world that was rather different to the one that is familiar to us (Buonomano 2011).

**Acknowledgments**
The author would like to thank the anonymous reviewers for their insightful and thought-provoking comments and colleagues, students and friends for their feedback and their patience when commenting on early versions of the manuscript. Early aspects of the embodied information behaviour perspective were developed some 15 years ago while the author was with the AI Lab at the University of Zurich, Switzerland. Participating for several years in the Global ShanghAI Lectures on Natural and Artificial Intelligence (shanghailectures.org) provided a constant reminder that there was still an article waiting to be written.
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