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Information discernment and online reading behaviour: An experiment

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Information discernment and online reading behaviour: An experiment

Author(s)

Abstract

Purpose. To explore the relationship between participants' eye fixations (a measure of attention) and durations (a measure of concentration) on Areas of Interest within a range of online articles and their levels of information discernment (a sub-process of information literacy characterising how participants make judgements about information).

Methodology. Eye-tracking equipment was used as a proxy measure for reading behaviour by recording eye-fixations, dwell times and regressions in males aged 18-24 (n=48). Participants' level of information discernment was determined using a quantitative questionnaire.

Findings. Data indicates a relationship between participants' level of information discernment and their viewing behaviours within the articles' Area of Interest. Those who scored highly on an information discernment questionnaire tended to interrogate the online article in a structured and linear way. Those with high-level information discernment are more likely to pay attention to textual and graphical information than those exhibiting low-level information discernment. Conversely, participants with low-level information discernment indicated a lack of curiosity by not interrogating all of the article. They were unsystematic in their saccadic movements spending significantly longer viewing irrelevant areas.

Social implications. The most profound consequence is that those with low-level information discernment, through a lack of curiosity in particular, could base health, workplace, political or everyday decisions on sub-optimal engagement with, and comprehension of information or misinformation (such as fake news).

Originality/value. Ground-breaking analysis of the relationship between a persons' self-reported level of information literacy (information discernment specifically) and objective measures of reading behaviour.

Keywords: Information literacy, information discernment, eye-tracking, misinformation, seductive text

Article classification: Research paper

Introduction

Whilst young people (16-24 year olds in the UK) rely predominantly on digital resources for their information and news (Ofcom, 2018), research confirms that young people are not as naturally information literate as might be commonly believed (Pickard 2002; Elliot, 2006; Rowlands *et al.*, 2008; Pickard, *et.al.* 2013; Pickard *et.al.* 2014) and fall victim to the dubious claims of misinformation (Guess, Lerner and Lyons *et al.*, 2020). Shenton and Pickard (2014) observe that the raw information exists for learners to succeed - at home, in school and throughout their lives. However, lack of information literacy capabilities creates 'cognitive roadblocks' (Pickard, 2002). This, can lead young people into approaching the evaluation of information 'sub-optimally' although this can improve to a certain extent with age (Metzger *et al.*, 2015, p325).

It has been argued for some time that high levels of information literacy (IL) are regarded as an important part of a successful learning journey in higher education (Secker and Coonan, 2011), every-day life (Whitworth, 2014), work (Crawford and Irving, 2012) and, therefore, a

solution to the issue of poor information literacy capabilities in young people. The sub-set of cognitive, metacognitive and affective (emotional) capabilities which enable people to make sound judgements about information (known as information discernment) are critical components of information literacy (Walton and Cleland, 2017; Walton, 2017; Walton *et al.*, 2018a, Wong *et al.*, 2020). These capabilities may hold the key to addressing the issue of misinformation for example fake-news (including artificially generated fake text – see Schwartz, 2019), “counter-knowledge” (Sanchez-Casado, Cegarra-Navarro and Tomasetti-Solano, (2015) and ‘post-truth’ at a time when these issues are becoming ever more prevalent and harder to discern in the information landscape (Lewandowsky *et al.*, 2012; 2017). However, whilst the cognitive and metacognitive aspects of information discernment are understood, what has not been measured hitherto is the relationship between information discernment and reading behaviour. By examining this relationship, it is envisaged that a deeper insight into how people engage with information will be gained.

Our research question and hypothesis;

- What is the relationship between a participant’s reading behaviour (i.e., eye fixation, saccade movements, dwell/visit duration and regression) and their level of information discernment?
- It is hypothesised that those with high-level information discernment (as measured by a questionnaire) engage more readily in reading behaviours such as, intentional reading and visual attention (i.e., where they fixate on a page, dwell on areas of interest and regress to aspects of the page to support their understanding of the information.

Information literacy and the specific sub-process of information discernment

It is recognised that Paul Zirkowski in 1974 was the first to mention the concept of Information literacy (Whitworth, 2020). Information literacy has moved beyond a set of normative skills which enable finding, evaluating and using information, to a diverse set of concepts which involve higher order thinking within a social context. Information literacy has evolved from individualised practice-based models such as ACRL new framework (2016), the SCONUL Seven Pillars Model (2013), ANZIIL (Bundy, 2004), to research-based models which have a socio-cultural focus such as Lloyd (2017) and other complex educational frameworks such as ANCIL (Secker and Coonan, 2013) and interdisciplinary frameworks such as information discernment (Wong *et al.*, 2021). Information literacy is characterised as a set of capabilities which ‘*ascends towards high-level intellectual and metacognitive behaviours and approaches*’ (Secker and Coonan, 2011, p20) that may possibly employ heuristics (Metzger *et al.*, 2015) to navigate the information landscape (Lloyd, 2010) and ultimately constructively question our relationship with the world (Head, 2017).

The value of information literacy training is recognised by for example, Jacobson and Mackey (2013), Jacobson *et al.* (2018) and Mackey (2020); Shenton and Pickard (2012; 2014a; 2014b); Walton and Hepworth (2011; 2013); Walton *et al.* (2018).

Lloyd’s information literacy theory (Lloyd, 2017) based on Schatzki (2000) and developed in Lloyd and Williamson (2008) and Lloyd (2010; 2017) offers a fresh perspective by re-imagining the multitude of literacies foregrounded by Mackey and Jacobson (2014) such as digital, media, science and carbon literacy into a new mid-range theory known as ‘literacies of information’. This situates information literacy as a socio-cultural practice which is “enacted in a social setting. It is composed of a suite of activities and skills that reference structured and embodied knowledges and ways of knowing relevant to the context” (Lloyd, 2017, p.94). Lloyd (2010, p.252) argues that information literacy is an information practice (its sayings, doings and relatings) enacted through the social setting and is not “reified and decontextualised skills, cast adrift and remote from the discourse and practices that drive human activity”. In sum, “information literacy is a contextual way of understanding a situation which involving mobilisation of information of any kind from the codified (for example text or image) to the tacit (unwritten or even unspoken but nevertheless embodied and enacted)” (Walton *et al.* 2021).

The specific capability within information literacy, and which forms the focus of this research, is information discernment, defined as ‘*the ways in which social, psychological, behavioural and information source factors influence peoples’ judgements about information*’ (Walton, 2017, p151). It is argued that information discernment directly informs the ACRL (2016) threshold concept that *authority is constructed and contextual*. The notion of information discernment is based on information behaviour research (Kuhlthau, 1991; Wilson, 1999; Heinstrom, 2003; Ford, 2004; Hepworth, 2004; Belkin, 2005; Fisher, Erdelez and McKeachie, 2005), learning theory (Bloom et al, 1956 and Mosley et al, 2004) and originally articulated in Walton and Hepworth (2011 and 2013). Further theorising (Walton, 2017) has illustrated that ‘knowledge state’ may include a number of additional cognitive processes associated with prior knowledge which have a bearing on how people make judgements about information such as worldview (Lewandowsky et al, 2012) confirmation bias (Campbell et al, 1960; Frimer, Skitka and Motyl, 2017), epistemic beliefs including curiosity (Trevors et al, 2017) and motivated reasoning (Kahan et al, 2012; Jones 2017). Hepworth and Walton (2009), Walton and Hepworth (2011; 2013) and Walton (2017) argue that becoming information literate is highly depended on the four areas: sociological data such as person-in-context (Wilson, 1999); psychological data such as, cognitive processes of knowledge (including prior knowledge), comprehension, analysis, application, synthesis, evaluation (Bloom et al, 1956) and the affective state such the degree of uncertainty people feel about looking for information for a topic they need to research (Kuhlthau, 1991); behavioural data such as, how someone sets about engaging with information and source data such as its category and how it responds to a user (Hepworth, 2004).

It is known that people present with a range of information discernment levels – high-level information discernment is characterised by people considering both sides of an argument and employing various evaluation criteria such as authority (Lankes, 2007) and reliability (Walton, 2017). Conversely low-level information discernment is exemplified by not reading the information completely or not using any criteria at all to judge information (Walton and Cleland, 2017). There is also a range of research which demonstrates how IL models and approaches can be employed to increase young peoples’ levels of information discernment for example, Pickard *et al.* (2010; 2012; 2013); Shenton and Pickard (2012; 2014a; 2014b); Walton and Hepworth (2011; 2013). Recent research (Walton *et al.*, 2018b; 2021) indicates that the differences between those that possess high levels of information discernment and those with low levels are statistically significant in several ways. It appears that those with high levels of information discernment tend to report the following thought processes and behaviours when engaging with information:

- are more curious about the world;
- tend to use multiple sources to verify information;
- are more likely to be sceptical about information on popular search engines;
- do not regard the first results page as the most trustworthy information;
- are cognisant of the importance of authority;
- regard knowledge as not fixed but changing
- recognise that knowledge can be contradictory at times.
- tend not to ignore information that contradicts their view (Walton et al, 2018b; Walton et al, 2021).

It is logical to extrapolate that higher levels of curiosity and regard for the importance of authority exhibited by those with high levels of information discernment, may reveal themselves through eye-movements as they read an article, given that gaze behaviours and regressions indicate level of engagement (Gere et al, 2017 – see next section below for more detail). Related research carried out by Walton et al (2018b; 2021) also revealed that emotion (affective factors) play a part in information discernment. Additionally, they found that when

participants were exposed to misinformation during a stressful task, higher information discerning individuals responded with more positive emotions before and after the stressful task, in comparison to lower information discerning individuals. It is known that mood (i.e. emotion) affects attention (Isaacowitz *et al.*, 2008), and so it would be expected that there may be a relationship between a person's level of information discernment and their eye-tracking data gleaned from a reading task.

In summary, the assumption made here is that those with high-level information discernment readily engage in reading behaviours such as, intentional reading and visual attention (i.e., where they fixate on a page and begin reading, the duration of that fixation and the time spent on areas on the page).

Eye-tracking and reading behaviour

Eye-tracking is an objective technique that can afford advantages for in-depth analysis and provides a proxy method for measuring cognitive and affective states (Poole and Ball, 2006). Moment-to-moment behavioural index generated registers eye-positions and movements (Nielsen and Pernice, 2010) capturing data regarding the acquisition and processing of information (Holmqvist *et al.*, 2011). This data providing insights into a users' behaviour e.g., perceptual speed, working memory, cognition, reading behaviour (Toker *et al.*, 2018; Lalle *et al.*, 2019) and so can indicate information discernment level (Walton *et al.*, 2018b; Walton *et al.*, 2021).

To track eye-movements, several variables on pre-defined areas of interests (AOIs) can determine whether reading behaviour is intentional (i.e., reading that follows the logical sequence of fixations and saccades throughout the source), or unintentional (i.e., presented as a range of fragmented fixation stimuli and saccades order) (Gere *et al.*, 2017). The latter typically seen as unordered saccade movements where a person scans the page looking for options or hooks (i.e., linguistic signs or metaphors) to meet a need (such as task fulfilment) within a given context (Schmar-Dobler, 2003; Liu, 2005; Duggan and Payne, 2011).

Research notes a range of factors influencing reading behaviour and how readers process textual information and embedded visualizations (Toker *et al.*, 2018; Toker *et al.*, 2019). Unique to reading research is the stimulus layout which has an inherent order of processing; one word comes after another in a sequence (Holmqvist *et al.*, 2011). Two common indices assist in the evaluation of how information is processed; first-pass fixation time and second-pass fixation time or look-back fixation time (Hornof and Halverson, 2003; Kaakinen *et al.*, 2015; Macatee *et al.*, 2017). These indices measure reading gaze, dwell times and regression/look-back retuning to areas on a page which help to determine intentional and unintentional reading behaviours.

Seductive text

Seductive details are vivid & emotionally interesting text, image, video, or sound that raise reader interest by being attention-grabbing (Chang and Choi, 2014; Sanchez and Wiley, 2006; Garner *et al.*, 1992; Lehman *et al.*, 2007; Rey, 2012). Their purpose is to increase the readers' enjoyment rather than inform or explain (Harp and Mayer, 1997; Wang and Adesope, 2016) so that the reader applies more energy to the text and comprehend the main ideas quicker (Chang and Choi, 2014; Hidi, 1990; Schraw, 1998). This is useful because high and low-level information discerners show different approaches to information gathering (Walton *et al.*, 2021), they may exhibit different behaviours around seductive details within an information source.

Seductive details are heavily used in soft-news (Prior, 2003) which is typically a more sensationalised and personality-centred news format (Patterson, 2000). It is produced for its entertainment value, ability to shock, or focus on scandalous aspects of politics which cater for consumers who normally favour entertainment over news content (Prior, 2003; Baum, 2002) but may be considered a type of **misinformation, or a manipulated source of information.**

Previous research has shown high interest levels facilitate an increased ability to recall information by as much as 12% (Schraw *et al.*, 1995). Interest **can** motivate readers to focus on the main ideas of a text and its fundamental meaning (Krapp, 1999).

There are different types of interest, such as situational, individual and emotional. Situational interest refers to a person's reaction to something in their environment and may only have a short-term effect (Murphy and Alexander, 2000). Individual interest involves inherent knowledge and values, which develop slowly over time and tend to be long lasting (Renninger, 2000).

Emotional interest is considered a subtype of situational interest (Schraw *et al.*, 1995; Hidi, 2001), a state of heightened emotional arousal which increases interest levels. Within written articles, heightened emotional states can be elicited using adjunct text or images, known as seductive details (Harp and Mayer, 1997). Concepts such as death, danger, power, violence, and sex, are thought to be universally interesting (Schank, 1979) and are used to elicit emotional interest (Kintsch, 1980).

Whilst reader attention has been shown to increase attention, it is thought to contribute to poor recall and comprehension (Chang and Choi, 2014; Garner *et al.*, 1989). Seductive details have been found to reduce time spent reading base sentences, which hinders recall and processing of the main ideas (Lehman *et al.*, 2007). Similar reading behaviours such as quick sentence scanning, have been exhibited by low information discerners who are more likely to scan pages in an unordered manner (Walton *et al.*, 2021).

Overall, seductive details have shown to be ineffective for learning (Prior, 2003) especially when used in written sources such as textbooks, where information exchange and learning are a priority (Garner *et al.*, 1989; Garner *et al.*, 1992; Lehman *et al.*, 2007; Sanchez and Wiley, 2006; Chang and Choi, 2014). **The rise in popularity of** social media to gather information (BBC, 2019) may increase exposure to soft-news and seductive details. As high and low-level information discerners show different approaches to information gathering (Walton *et al.*, 2021), they may exhibit different behaviours around seductive details **within information sources**.

User Gaze and Duration

A reader's gaze is seen as a dependent behaviour and a powerful technique for investigating the relationship between a reading task and level of engagement (Holmqvist *et al.*, 2011; Barral *et al.*, 2020). Past research examined gaze behaviours across visual elements within a document and the effect this has is based upon a participant's level of visualization literacy (Barral *et al.*, 2020). Mason *et al.* (2014) investigated visual attention distributions noting gaze time significantly increased on related and understood information sources. Both studies indicate that a user's attention is guided to the salient components of the documents narrative, especially when a transition between a key visual component is used i.e., datapoints, labels and legends (Mason *et al.*, 2014; Barral *et al.*, 2020). These examples suggest a need to create meaningful interventions for future evaluation, points which resonate with reading behaviour and a user's information discernment.

Duration (or time spent) within an area is a perceived depth of attention or a reading measurement which can be quantified (i.e., fixation duration or dwell time and number of fixations per-word in an AOI). These can determine how much of the text has been read, quantifying reading depth (Holmqvist *et al.* 2011). Wiley *et al.* (2014) identified that working memory capacity (WMC – a measure of one's ability to use one's working memory system) can predict learning from text. WMC is encoded quickly into memory without extra processing time (Kaakinen *et al.*, 2015) – aligning with Walton's notion of prior knowledge (2017). The duration within an area can be envisaged as an indication of topic-specific epistemic belief, or participant's prior knowledge by increased dwell times as they moderate processing with more availing conviction (Van Berkum *et al.*, 2005; Kaakinen *et al.*, 2015).

Wiley *et al.* found lower WMC reduced a reader's ability to select specific information in each modality and integrate it to develop overall understanding, echoed by Hannus and Hyönä (1999), lower WMC participants (lacking in literacy skills) spent more time gazing at irrelevant blank spaces between and around text and illustrations. This could be deemed as lack of engagement and, therefore, be a further indication of low-level information discernment.

Reading delay, regression and look-back

A refixation on a word or area within a document is a regressive behaviour and calculated by the duration of all fixations on returning to the target region (Duchowski, 2003). The information has been initially processed (or skimmed) and where there is a need for clarification - there maybe level of uncertainty or doubt. This is less automatic and more intentional behaviour delaying processing time during reading to reflect on the information source. Poorer readers pay less attention to pertinent segments, rarely re-read the text, make fewer connections between text and illustrations (Hannus and Hyönä 1999; Kaakinen *et al.* 2015;). This measure of reading behaviour may act as a further indicator of information discernment level.

Time delays and gazing behaviour have been indicators of disengagement and consistently linked to anxiety. Cisler and Koster (2010) placed fragments of bias within information to distinguish engagement from threat **to assess** the delays in engagement. Levels of anxiety specifically related to delays as perceived disengagement (Macatee *et al.*, 2007) mirrors research which found that uncertainty (i.e., heightened anxiety) can lower a person's information discernment level (Walton and Hepworth, 2011). Reoccurring fixations potentially demonstrate perceived levels of anxiety as attempts to interpret text are made even at the expense of making guesses that possibly turn out to be incorrect (Just and Carpenter, 1980). This could be lack of subject knowledge or a misunderstanding of the information. **This provides** another demonstrable link to a person's level of information discernment.

Methods

User Study – Methodology and experimental design

Participant levels of information discernment data and their patterns of reading behaviours across a range of news articles **were collected**. This involved forty-eight 18-24 year old males (M = 19.73 years, SD = 2.04 years). This age group was chosen because, according to the ONS (2015), people aged 18-24 are the most likely users of the Internet. Males were selected to control for the variability in the ways that males and females engage with ICT (Ford, 2004; Siddiq and Scherer, 2019). Recent research also indicates that males are more likely to seek out misinformation than females (OfCom, 2021). Additionally, as part of a larger study (see Walton *et al.* 2021 for a full account), the experiment was also designed to assess Cardio-Vascular (CV) responses continuously, while participants were also reading the articles. There is evidence of sex differences between hypothalamic-pituitary-adrenal (HPA) axis responses to stress (Kudielka and Kirschbaum, 2005) and physiological responses (Krantz *et al.*, 2004). Furthermore, arousal and attentional responses can differ (Bangasser *et al.*, 2019). These considerations meant it was necessary to control for gender. Participants were screened for religious beliefs. The online articles (source behaviour) used in this study had a religious theme (source character) and so it was deemed important to do this to ensure none taking part exhibited extreme beliefs. Each article had the same boundaries and layout, this consisted of - publisher, title, author, and source. The main content areas followed a traditional journalistic format with information and illustrations (images and/or graphs).

The experiment was conducted within a laboratory setting which enabled the controlling of sociological factors identified by Hepworth (2004) such as norms (university setting), roles (students) and tasks (reading news articles). The Tobii X2-30 eye-tracker was chosen for this

study due to the size, portability and unobtrusiveness, this remote eye-tracker attached to the laptop in a display of 1280x1024 pixels, with a sampling rate of 30 Hertz. The speed threshold recognition (I-VT) gaze classification algorithm was used to compare fixation filter data with participants perceived impression on the position and duration of the fixations as they were exposed to the PDF's. Participants were seated to enable consistent calibration of the eye-tracker.

Experimental procedure

This approach was based around commonly adopted methods applied in tracking user studies (Kaakinen et al., 2015; Toker et al., 2019; Lalle et al. 2019). Participants were invited into the lab and asked to complete a consent form and the first data capture instrument the information discernment questionnaire (Walton et al, 2018b; 2021), which provided a quantitative measure of information discernment (see Note at the end of this article for a link to the questionnaire and Appendix A for scoring method).

Participants were then asked to sit in front of the laptop and their eye movements were calibrated. Based upon the calibration test on all participants (n=48) there were 8 outliers due to calibration problems. A detailed analysis took place on a purposive sample of high and low-level information discerners (n=20 high and n=20 low-level information discerners). The recorded reading behaviour and results provided insights into gaze behaviour, fixations and visit durations based upon the AOI's for participants (n=40).

Once the calibration was complete, participants were introduced to the experiment and began to read the articles, once they finished an article, they used the spacebar to proceed until the end. Participants were not given a time limit however they were told that their performance would help a fellow student to win a prize. Participants were then asked to complete a competitive word search task (which was impossible to accomplish in the time allocated) to provide them with additional motivation. The function of this is part of the experiment was to create mild stress to generate meaningful CV data (see Walton *et al.*, 2021 for the full account).

The online reading task consisted of 5 religion-based news articles. Participants were asked to read factual articles gleaned from high quality and credible news sources with a religious theme on a variety of topics such as:

- Israeli settlement building may not help peace
- Football and religion
- Religious extremism as a cause of terrorism
- Norway shooting, quotes from Anders Breivik's online manifesto
- French soldier shoots, wounds machete-wielding attacker at Paris Louvre

The religious theme was chosen to generate interest as it was topical at the time.

Analysis of Information Discernment on Reading Behaviour

Eye-tracking results for this paper are based upon the 5 articles to assess. the impact different levels of information discernment have on patterns of reading behaviour. Firstly, eye-tracking measures were identified to support the data capture, these include fixation counts, visit counts, durations, and sequence data such as scan paths. The matrices selected are listed in Table 1.

[Table 1. Set of eye tracking matrices generated based upon the defined AOIs - HERE]

The recorded data was analysed within a Tobii Pro Studio project. AOI's were created for each article, Figure 1, and listed under six different coloured groups:

1. General article identifiers (Green): identifiers include the author, publisher, source, title, and first paragraph for each article.
- Point 2,3 and 4 also relate to the seductive elements within the articles.
2. Engagement sections (Pink): identified as three lines of text at the start, middle, and end of every article.
3. Image(s) (Dark Blue): showed as a used to support the narrative within the articles.
4. Paragraphs (Purple): Paragraphs and sentences support the engagement level
5. Sentences (Yellow).
6. Whole text (Light Blue): providing a holistic view of reading behaviour.

[Figure 1. Example of Areas of Interest – Article “Matches Made in Heaven” – HERE]

Once the data was created, it was exported and calculated inferences could be made regarding the n-count, means and sum values. T-tests utilised mean scores to calculate statistically significant behavioural differences between each information discernment group (high and low). Mean score comparisons are common practice in studies that use eye tracking and reading behaviour metrics (Lehman et al, 2007; Isaacowitz et al, 2008; Kaakinen et al, 2015; Franěk et al, 2018). Similarly, t-test significance testing is also common practice in this type of study (Sargezeh et al, 2019; Gottschling & Kammerer, 2020).

Results

Consistent AOI's within each article were set and data gathered was compared against eye tracking metrics; fixation count, fixation duration, visit count, and total visit duration. **Mean scores were analysed using two t-tests to determine statistical significance. When analysing the same discernment group against different test types, the Paired Sample T-test was selected. Otherwise, a Two Sample T-test was used to analyse the two discernment groups within the same test. T-tests produced a t-value (t:) and p-value (p:), all p-values are significant at $p < 0.05$. Additionally, where paired sample t-tests were used, family-wise error correction was implemented using a Bonferroni Correction. This reduced p-value significance to $p < 0.025$.**

Appendix B details standard deviation (Stdev), confidence interval (CI), significance, sample size and variance. Variance was used to determine the use of equal or unequal two sample t-tests. As none of the selected variances matched, unequal two sample t-tests were used throughout.

Reader Engagement

Engagement measures were captured by placing three equally sized AOI's (approximately three lines of text) at the start, middle, and end of each article (Table 2). **Mean scores were collected for each text within each article, these were grouped by the sample respectively based upon the information discernment scores (high & low).** Results found that high-level information discerners fixation counts **consistently showed a greater number of n-counts compared to low-level information discerners most notable at the end of each article.** Low level information discerners demonstrated reduced fixation counts at the middle and end AOI's, when compared **with** mean fixations within AOI's at the start of each article. The middle AOI (t: 4.4934 & p: 0.0064) and end AOI (t: 3.8703 & p: 0.0118) show considerable reductions.

Longer fixation durations for high information discerners were present at all three engagement AOI's. Values at start and middle engagement AOI's showed significant differences. Low-level information discerners demonstrated reduced total fixation durations between the start (473 seconds) and end (295 seconds) AOI's, but the t-test mean scores did not show a significant difference (t: -1.9462 & p: 0.109). When comparing visit counts to low-level information discerners, high-level information discerners recorded greater counts at each end of article engagement AOI, t-value of 2.5872 and p-value of 0.0361. Low-level information discerners demonstrated lower visit counts at the end of article AOI when compared with the start AOI (t: 3.8471 & p: 0.012). The high-level information discerners revealed lengthier total visit durations at all three engagement AOI's. The start, middle, and end all show a significant difference. Low-level information discerners (1200sec) recorded a difference of -465 seconds in total visit duration, demonstrating that high-level information discerners (1666 seconds) spent almost eight minutes longer reading the engagement sections.

[Table 2. Significant results from our assessment of Reader Engagement based upon AOI's on two sample and paired sample t-tests. – HERE]

Graphical Images

Article images were categorised as either seductive or informative. In total, there were five images across the articles and mean scores were compared for the sample groups (Table 3). High-level information discerners recorded significantly more fixations on informative images than seductive images (t: 4.4439 & p: 0.0113). Low-level information discerners also indicated a similar tendency to fixate on informative images, with 296 less recorded fixations on seductive images, but this difference was not significant when analysing for t-test fixation means.

Comparing fixation durations, informative images showed increased duration times across both groups compared to seductive image durations. Although the difference were not significant. For example, when looking at informative images, high-level information discerners recorded a total of 498 seconds and low-level information discerners recorded a total of 164 seconds. Visit counts showed on average, higher counts for informative images than seductive images for the high-level information discerners (t: 3.1263 & p: 0.0353). Low-level information discerners recorded similar scores for informative images, although not statistically significant, showing that the same level of cognitive processing, concerned with regressions, applied to both image types for the low-level discernment group.

High-level information discerners spent an average of more than 3.5 minutes looking at informative images when compared with low-level information discerners. A total visit duration of 508.6 seconds, with a difference of 217.63 seconds (3.627 minutes) was recorded for high-level information discerners. A t-test noted a significance at t-value 3.9954 and p-value 0.0162.

[Table 3. Significant results from our assessment of Graphical Media based upon AOI's on two sample and paired sample t-tests. – HERE]

Paragraphs

These AOI's were categorised as seductive or informative; seductive paragraphs contain emotive and attention-grabbing text; informative paragraphs contain factual and important text. Four paragraphs were selected for each designation, the paragraphs within each group had similar word counts in total.

As we compared sample groups, high-level information discerners had longer fixation durations within informative paragraphs. T-tests confirmed significance with at $t: 4.3016$ & $p: 0.0051$ for fixation duration. Both groups record insignificant differences in fixation counts when contrasting informative or seductive paragraphs, with a minimal difference of n-counts of 76 and 118 for the high and low groups respectively.

High-level information discerners had significantly longer average fixation durations for both informative and seductive paragraphs. There were no significant differences in mean fixation durations for either sample groups and similar visit counts were recorded for both paragraph types and discernment groups. The t-test values were not significant. High-level information discerners had revealed significantly longer total visit durations on informative ($t: 2.7177$ & $p: 0.0419$) paragraphs when compared to low-level information discerners. Minor increases in total visit durations were recorded when reading seductive paragraphs for both groups, but the differences was not significant.

[Table 4. Significant results from our assessment of Paragraphs based upon AOI's on a two paired sample. – Here]

Discussion

The results presented perceived reading behaviours across $n=40$ participants, with an assessment comparing these behaviours against levels of information discernment ($n=20$ Low ID and $n=20$ High ID). Results showed relationships between eye tracking metrics and information discernment levels across the AOI's, demonstrating that high-level information discerners showed increased engagement and perceived reading across all articles much more than low-level information discerners. High-level information discerners have stronger levels of engagement across all the eye-tracking matrices, with increased visits and more than 3.5 minutes of total visit duration times within the image based AOI's.

High-level information discerners exhibited statistically consistent engagement levels across all engagement AOI's. Whereas low-level information discerners recorded a statistically significant tapered reduction across the start, middle and end engagement AOI's, which demonstrates potential reductions in engagement levels, echoed by Macatee *et al.* (2017). This decreased attention and perceived engagement levels for low-level information discerners continued as they read through the articles. Gere *et al.*, (2017) highlighted shifts and changes in saccade order and dwell reduction times within an article as a change in engagement something which can be seen across this sample group. Also comparing these results against the sample low-level information discerners could have lacked curiosity (Trevors *et al.*, 2017; Walton *et al.*, 2018b) and interest (or knowledge on the subject) something Mason *et al.* (2014) mention as a factor in attention and engagement.

However, it should be noted that it was observed that high-level information discerners also demonstrated some reduction in engagement (even though the resulting t-test did not produce a statistically significant p-value). This reduction, particularly at the end of an article is not uncommon and can be seen in studies where reading fatigue plays a role (Nielsen and Pernice, 2010; Holmqvist *et al.*, 2011; Gere *et al.*, 2017). The heat map (Figure 2) presents general gaze behaviour and perceived concentration levels forming an "F-shaped pattern", an expected behavioural pattern (Nielsen and Pernice, 2010). This pattern highlights perceived intentional and unintentional reading; concentration levels are strong at the beginning of paragraphs but a clear lapse forms, demonstrating possible levels of disengagement, unintentional or reading fatigue. As we separate the participants by sample, we do note additional behavioural changes. High-level information discerners are dwelling longer on the

text and graphs and process informative images more thoroughly than seductive images. Most likely, this extra effort was spent internalising the graphical content which contained important information relevant to the article. These patterns could also be determined by their level of visualization literacy something that Barral *et al.* (2020) explain can affect user cognition.

[Figure 2 – High ID and Low ID Heat Map – HERE]

Conversely, high information discerners demonstrated greater cognitive processing of informative images through higher recorded fixation counts, visit counts, and total visit durations when compared to seductive images, again something found within past visualization literacy research (Toker *et al.*, 2018; Lalle *et al.*, 2019). Low-level information discerners did not show any statistically significant results when comparing seductive and informative image metric values.

Assessing the textual information within the high information discerners recorded more fixations within seductive paragraphs, rather than informative paragraphs. Low information discerners showed no significant differences when comparing informative and seductive paragraph metric values. Seductive details are not always directly relevant to the main content of an article. Whilst they are designed to excite and hook a reader, their meaning might not be as well understood as a simple numerical fact, for example. These findings correspond to Walton and Hepworth (2011 and 2013), those with low-level information discernment tend to engage with information in a superficial way indicating a lack of curiosity (Trevors *et al.*, 2017; Walton *et al.*, 2018b; Walton *et al.*, 2021). High-level information discerners could be fixating more on seductive paragraph syntax to better understand the article content and its meaning. This seen as a characteristic of WMC, high-level information discerners seem to be reading and learning from the text (Kaakinen *et al.*, 2015; Wiley *et al.*, 2014).

The results found that High-level information discerners had significantly longer average fixation durations for both informative and seductive paragraphs. Low-level information discerners have increased concentration levels in “white space” areas between the AOI’s (figure 2). This could be lack of engagement, understanding, boredom or even behavioural patterns relating to changing levels of anxiety (Just and Carpenter, 1980; Macatee *et al.*, 2017), as they pay less attention to pertinent segments and possibly not making sense or connecting text and illustrations supporting the articles context (Kaakinen *et al.*, 2015; Lalle *et al.*, 2019). This is seen as a process of information integration and indicates that those with low-level information discernment are not interrogating the whole text (Walton and Hepworth, 2013), and possibly lose interest and focus on the salient paragraphs within the article. A fixation duration is seen as a precursor to reading (Hannus and Hyönä 1999; Holmqvist *et al.*, 2011) and the results provide insights into behaviour based upon their perceptual speed and cognition informing reading behaviour (Toker *et al.*, 2018; Lalle *et al.*, 2019), which is seen as an influence on information discernment levels (Walton *et al.*, 2018b; Walton *et al.*, 2021).

Finally, analysing the sequence or saccadic movements across the groups, high information discerners read in a more methodical and structured manor, and the recorded fixations are tightly grouped together tying with work by Cutrell and Guan (2007) assessment of search and snippet results. When compared, the low-level information discerners gaze sequence seems to be more random and less purposeful. This shift and change in behavioural movement to a more unintentional reading behaviour, the low-level information discerners eye movements scan looking for keywords increasing the fixation counts, perhaps used as a “satisficing strategy” focusing on important areas (Duggan and Payne, 2011) not actually reading. This perceived reading behaviour may be due to loss of interest or perhaps a coping strategy as they problem-solve more complex information. Hannus and Hyönä (1999) found

poor readers, spent more time gazing at irrelevant space and pay less attention to pertinent segments. This is clearly apparent with the low-level information discerners with their increased gaze concentration within the centre of the article. The differences in gaze behaviour and fixation delays are indicators of perceived disengagement linked to anxiety or lack of knowledge (Just and Carpenter, 1980; Cisler and Koster, 2010; Gere *et al.*, 2017). This indicates that low-level information discerners are less likely to approach a reading task with a specific plan, they seem to be more likely to look around at elements that grab their attention. Whereas high-level information discerners attend to specific elements, such as an image and a title, before focusing completely on the initial paragraph and beginning their read-through of the article.

Conclusion

The aim of this research was to assess the relationships between reading behaviours and levels of information discernment in males aged 18-24. Clearly, this implies that the results cannot be fully generalised, nevertheless they have implications for approximately 50% of the population. There appears to be a relationship between eye movements and fixations (i.e., a measure of perceived attention) and participants' level of information discernment. In short, high-level information discernment tends to correspond with high attention and low-level information discernment corresponds with low attention, supporting the research hypothesis. The data here has mapped participants behaviour, primarily upon a sample. These examples vividly display how low-levels of information discernment affect reading behaviour, specifically the number of fixations and visit durations within AOI's. There appears to be a level of disengagement and lack of curiosity in the content, particularly for participants with low-level information discernment. Eye-tracking data indicated that participants with low-levels of information discernment tended not show a high level of fixation or concentration (measured by duration) which supports the hypothesis. It was also apparent that low-level information discerners, in the main, ignored factual information such as graphs and tables. Conversely, high-level information discerners tended to interrogate the text, graphs and images in a structured way, a process of information behaviour resonating with "working memory capacity" (Wiley *et al.*, 2014; Gere *et al.*, 2017) where working time was applied to the more complex areas of the article.

These findings are significant because they demonstrate behavioural differences between the two discernment groups. Firstly, reading behaviours differ in the way that high-level information discerners demonstrate more overall engagement, statistically consistent engagement levels, as well as more methodical and structured gaze patterns. Whereas low-level information discerners demonstrated tapered engagement levels, and uneven or less purposeful gaze patterns. Secondly, behavioural differences around seductive details were observed. High-level information discerners recorded increased engagement within informative image and seductive paragraph AOI's, whereas low-level information discerners showed no significantly increased engagement within either element type.

It is recognised that a using fixation and durations metrics is a limitation. Additional metrics could be explored to support the assessment of reading behaviours within this context. It is recommended that further research should use dwell time and saccadic measures to triangulate the findings from the fixation measures and any other metrics to confirm reading engagement levels (see Toker *et al.*, 2019). More obvious limitation are in terms of sample size and the need to control for gender. However, this suggests interesting avenues for future exploration. The next step is to work with female participants aged 18-24 years to analyse whether their reading behaviour corresponds with their level of information discernment as shown in our male participants. Further research will aim to assess all participants' information discernment levels, patterns of reading behaviour, religiosity and physiological response. This will focus upon keywords and an extension of the AOI's within the articles to see if this matches with emotions using cardiovascular measurement data. The research will also look at the effect of fatigue on reading behaviour. The articles follow recognised design

and layout patterns and there has been significant work based upon print versus electronic resources. An assessment of reading behaviour throughout the experimental process will provide an insight into effective page layouts to support online reading behaviour.

The research offers three conclusions. Firstly, the ways in which people read news and how low-level information discerners pay less attention to textual detail, fact and graphical information. This indicates the need for the implementation of effective training interventions (for example Walton *et al.*, 2018a; Walton *et al.*, 2021) to enable those with low-levels of information discernment to increase their capabilities which may, in turn, enable them to improve their reading behaviour helping them engage more fully with information sources. Secondly, low-levels of information discernment with its accompanying low levels of comprehension of information encountered could initiate sub-optimal engagement resulting in poor health, workplace, political or everyday decisions. This has profound implications for those with low-levels of information discernment especially when they encounter misinformation. In turn, this lowering of comprehension through a lack of attention to the text and images may lead to the tendency to make sub-optimal judgements and contribute in part, to the explanation for the acceptance, by some, of pseudo-scientific reporting such as vaccination and climate change denial. Thirdly, there is a clear theoretical implication in that eye-tracking can be employed as a means for informing the ways in which the cognitive aspects of information behaviour, especially attention, could be more accurately measured. This may provide new and more robust ways of identifying those particularly susceptible to the seductive nature of mis-information.

Note: The information discernment questionnaire is in the *Pre-screening booklet* at:

<https://www.informationliteracywellbeing.org.uk/project/>

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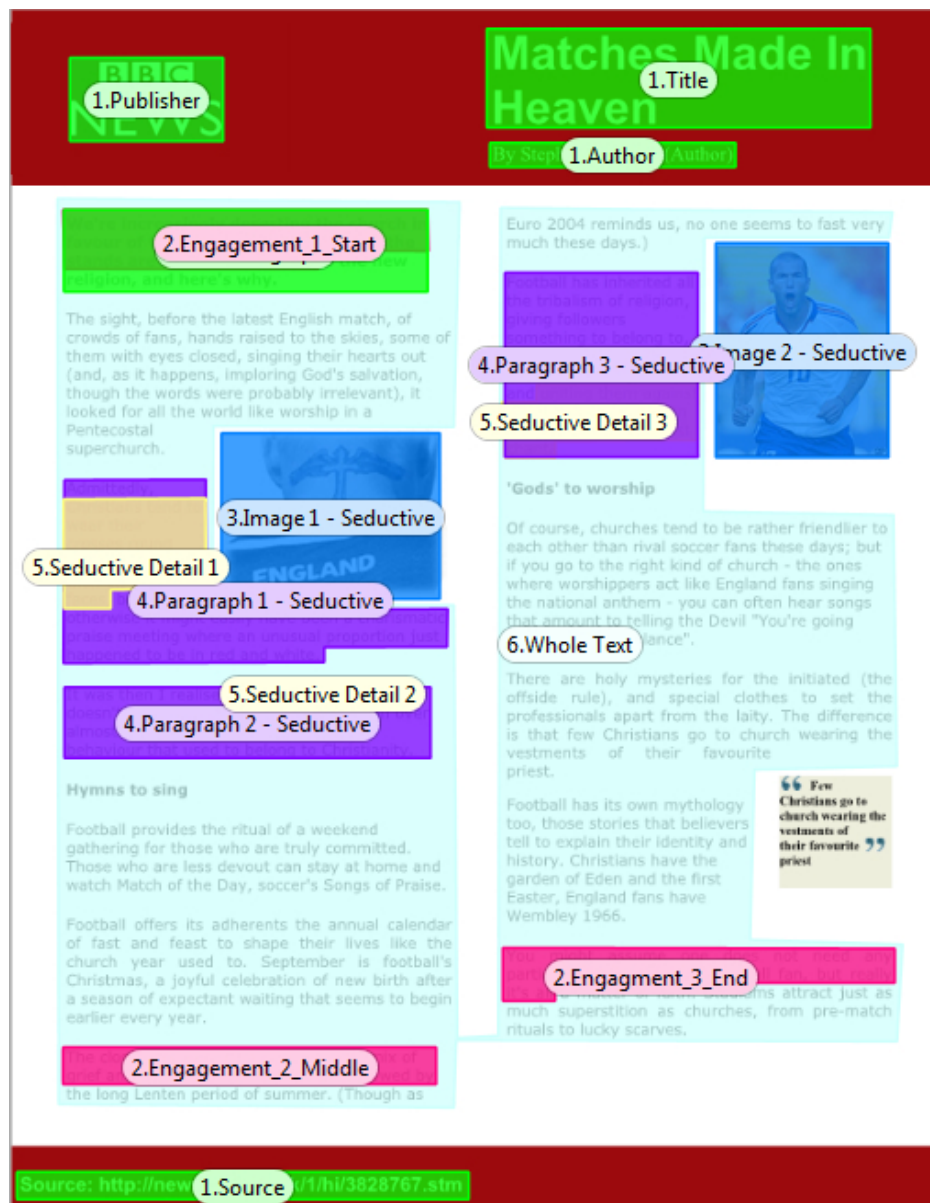


Figure 1 Mathces made in heaven AOIs

338x436mm (38 x 38 DPI)

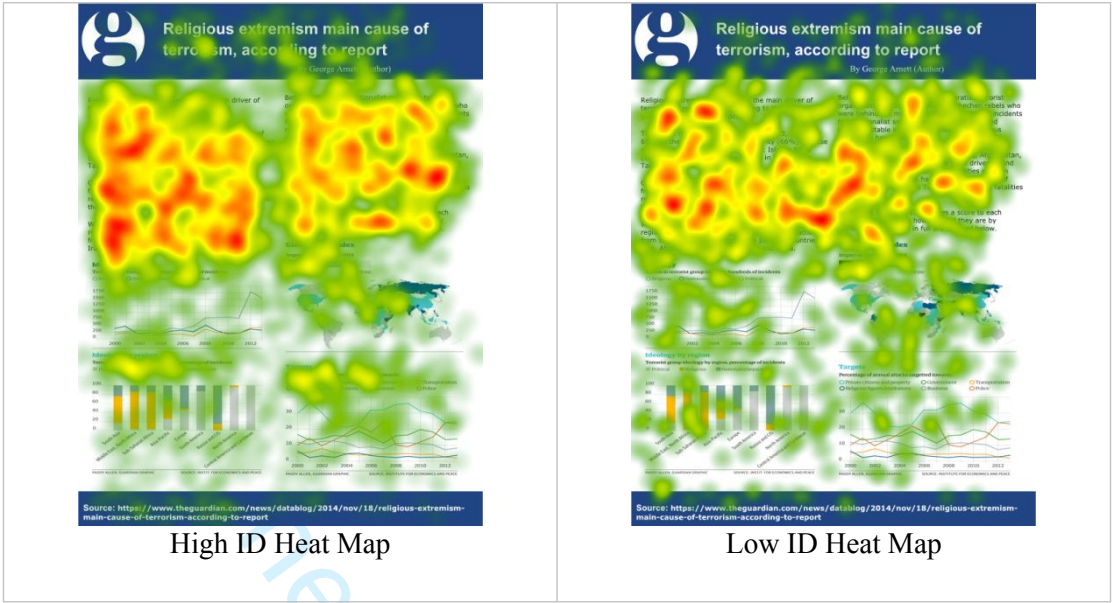


Figure 2. High ID and Low ID Heat Map

No.	Eye Tracking Metric	Description
1	Time to first fixation	Time taken from start of the task to the first fixation within an AOI, e.g., where do participants/groups look first?
2	Percentage Fixated:	Percentage that fixates within an AOI, e.g., how many participants/groups looked at the AOI?
3	Fixation Count:	Number of fixations within a set time and/or within an AOI, e.g., how many times did participants/groups fixate on the AOI?
4	Fixation Duration:	Elapsed time within a sequence of gaze points that make up a fixation, e.g., how long did fixations generally last within the AOI?
5	Visit Counts	Gaze transitions based upon visits within a set time and/or within an AOI, e.g., how many times did participants revisit the AOI?
6	Total Visit Duration:	Total elapsed time of every first and last fixation within an AOI, e.g., in total, how long did participants/groups spend visiting the AOI?

[Table 1. Set of eye tracking matrices generated based upon the defined AOIs]

Reader Engagement						
Target Group	Test Type	Output Value	Fixation Count	Fixation Duration	Visit Count	Total Visit Duration
Start AOI	High ID / Low ID	T-value	-	6.467525446	-	-
		P-value	-	0.000194665	-	-
		Stdev - High	-	0.040331956	-	-
		Stdev - Low	-	0.02228602	-	-
Middle AOI	High ID / Low ID	T-value	-	5.52972079	-	-
		P-value	-	0.000878494	-	-
		Stdev - High	-	0.041311822	-	-
		Stdev - Low	-	0.021369761	-	-
End AOI	High ID / Low ID	T-value	3.649706713	-	2.587209678	3.275277804
		P-value	0.004464467	-	0.036091182	0.013575147
		Stdev - High	0.624563848	-	0.498052875	0.828526805
		Stdev - Low	0.677839706	-	0.211849003	0.331707703
High ID	Start AOI / Middle AOI	T-value	-	-	4.569593642	-
		P-value	-	-	0.006004125	-
		Stdev - Start	-	-	0.731375417	-
		Stdev - Mid	-	-	0.446829572	-
Low ID	Start AOI / End AOI	T-value	3.870263842	-	3.847149896	3.69014825
		P-value	0.011757123	-	0.012035917	0.014143454
		Stdev - Start	2.060851766	-	0.630290938	1.064192965
		Stdev - End	0.677839706	-	0.211849003	0.331707703
Low ID	Start AOI / Middle AOI	T-value	4.493448504	-	-	2.905995571
		P-value	0.006438294	-	-	0.033555671
		Stdev - Start	2.060851766	-	-	1.064192965
		Stdev - Mid	1.575863784	-	-	0.889216884

Table 2. Significant results from our assessment of Reader Engagement based upon AOI’s on two sample and paired sample t-tests.

Graphical Images						
Target Group	Test Type	Output Value	Fixation Count	Fixation Duration	Visit Count	Total Visit Duration
High ID	Informative / Seductive	T-value	4.44388742	-	3.1263048	3.99537072
		P-value	0.01129995	-	0.03531095	0.01619234
		Stdev - Inform	4.17054793	-	0.70181907	2.59309082
		Stdev - Seduct	1.58736259	-	0.79153648	0.79954362

Table 3. Significant results from our assessment of Graphical Media based upon AOI's on two sample and paired sample t-tests.

Paragraphs						
Target Group	Test Type	Output Value	Fixation Count	Fixation Duration	Visit Count	Total Visit Duration
Informative Elements	High ID / Low ID	T-value	-	4.30156907	-	2.71772824
		P-value	-	0.00508406	-	0.04188824
		Stdev - High	-	0.0386221	-	1.6559061
		Stdev - Low	-	0.02986079	-	0.94383526

Table 4. Significant results from our assessment of Paragraphs based upon AOI's on a two paired sample.

Appendix A

How you consume news

How strongly or otherwise do you agree with the following statements about the ways regarding how you consume news on the Internet?

1. When I look for news I go to my favourite news site(s).

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1	2	3	4	5

2. When there is a news story I always check news sites which have opposing views.

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
5	4	3	2	1

Your views about knowledge

How strongly or otherwise do you agree with the following statements about knowledge?

3. Knowledge is fixed for all time

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1	2	3	4	5

4. There are facts to be learnt which don't change

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1	2	3	4	5

5. The job of scientists and experts is to find out the truth about things

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1	2	3	4	5

6. Knowledge keeps changing and developing

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
5	4	3	2	1

7. We gain knowledge by weighing up the evidence for and against something

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
5	4	3	2	1

8. Knowledge can be contradictory sometimes

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
5	4	3	2	1

How you use information

How strongly or otherwise do you agree with the following statements about the ways you use information from the Internet?

9. Before I use any information from the Internet I always check who has written it first.

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
5	4	3	2	1

10. Information that is found by search engines (e.g. Google) is always true.

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1	2	3	4	5

11. The most trustworthy results from a search engine are those found on the first page of a set of search results.

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1	2	3	4	5

12. When looking for information on the Internet I always use more than one source.

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
5	4	3	2	1

13. I always ignore information that contradicts something I already know about.

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1	2	3	4	5

14. I like to find out new things to expand my knowledge of the world

Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
5	4	3	2	1

Appendix B

Engagement values by metric and AOI type

Engagement		Start AOI		Middle AOI		End AOI	
		High ID	Low ID	High ID	Low ID	High ID	Low ID
Fixation Count	Mean	9.955	9.705	8.22	7.716667	7.46	6.086667
	Variance	9.26815	4.24711	4.55528	2.483347	0.39008	0.459467
	Significance	0.05	0.05	0.05	0.05	0.05	0.05
	Stdev	3.0443636	2.060852	2.13431	1.575864	0.624564	0.67784
	Sample	20	20	20	20	20	20
	CI	1.3342267	0.903192	0.935385	0.69064	0.273722	0.297071
Fixation Duration	Mean	0.5533333	0.431667	0.576667	0.471667	0.523333	0.456667
	Variance	0.0016267	0.000497	0.001707	0.000457	0.006467	0.001907
	Significance	0.05	0.05	0.05	0.05	0.05	0.05
	Stdev	0.040332	0.022286	0.041312	0.02137	0.080416	0.043665
	Sample	20	20	20	20	20	20
	CI	0.0176759	0.009767	0.018105	0.009366	0.035243	0.019137
Visit Count	Mean	3.365	3.476667	2.698333	2.636667	3.111667	2.54
	Variance	0.53491	0.397267	0.199657	0.115587	0.248057	0.04488
	Significance	0.05	0.05	0.05	0.05	0.05	0.05
	Stdev	0.7313754	0.630291	0.44683	0.33998	0.498053	0.211849
	Sample	20	20	20	20	20	20
	CI	0.3205335	0.276232	0.195828	0.149	0.218277	0.092845
Visit Duration	Mean	5.5433333	4.243333	4.83	3.673333	3.968333	2.775
	Variance	2.6098667	1.132507	1.78916	0.790707	0.686457	0.11003
	Significance	0.05	0.05	0.05	0.05	0.05	0.05
	Stdev	1.6155082	1.064193	1.337595	0.889217	0.828527	0.331708
	Sample	20	20	20	20	20	20
	CI	0.7080147	0.466395	0.586216	0.389709	0.363111	0.145375

Image values by metric and type

Image		Informative		Seductive	
		High ID	Low ID	High ID	Low ID
Fixation Count	Mean	10.322	6.814	4.022	3.774
	Variance	17.39347	9.30788	2.51972	1.82653
	Significance	0.05	0.05	0.05	0.05
	Stdev	4.1705479	3.050882	1.587363	1.351492
	Sample	20	20	20	20
	CI	1.8277896	1.337083	0.69568	0.592306
Fixation Duration	Mean	0.468	0.416	0.444	0.408
	Variance	0.01052	0.00968	0.01253	0.00382
	Significance	0.05	0.05	0.05	0.05
	Stdev	0.1025671	0.098387	0.111937	0.061806
	Sample	20	20	20	20
	CI	0.0449512	0.043119	0.049058	0.027087
Visit Count	Mean	3.79	2.982	2.784	2.87
	Variance	0.49255	0.29707	0.62653	0.54915
	Significance	0.05	0.05	0.05	0.05
	Stdev	0.7018191	0.545041	0.791536	0.741047
	Sample	20	20	20	20
	CI	0.3075801	0.23887	0.3469	0.324772
Visit Duration	Mean	5.242	3.096	1.822	1.528
	Variance	6.72412	3.38888	0.63927	0.22927
	Significance	0.05	0.05	0.05	0.05
	Stdev	2.5930908	1.840891	0.799544	0.478821
	Sample	20	20	20	20
	CI	1.1364513	0.806791	0.350409	0.209849

Paragraph values by metric and type

Paragraph		Informative		Seductive	
		High ID	Low ID	High ID	Low ID
Fixation Count	Mean	14.3425	12.2825	13.3825	10.6425
	Variance	8.107225	3.715492	3.869892	2.726892
	Significance	0.05	0.05	0.05	0.05
	Stdev	2.8473189	1.927561	1.967204	1.65133
	Sample	20	20	20	20
	CI	1.2478696	0.844775	0.862149	0.723714
Fixation Duration	Mean	0.5675	0.4625	0.6575	0.5375
	Variance	0.0014917	0.000892	0.024692	0.013492
	Significance	0.05	0.05	0.05	0.05
	Stdev	0.0386221	0.029861	0.157136	0.116154
	Sample	20	20	20	20
	CI	0.0169266	0.013087	0.068867	0.050906
Visit Count	Mean	3.3775	3.2	3.7075	3.4625
	Variance	1.0063583	0.4274	0.102225	0.207292
	Significance	0.05	0.05	0.05	0.05
	Stdev	1.0031741	0.653758	0.319726	0.455293
	Sample	20	20	20	20
	CI	0.4396524	0.286517	0.140124	0.199537
Visit Duration	Mean	8.2575	5.6675	8.985	5.8575
	Variance	2.742025	0.890825	7.4503	3.700092
	Significance	0.05	0.05	0.05	0.05
	Stdev	1.6559061	0.943835	2.729524	1.923562
	Sample	20	20	20	20
	CI	0.7257195	0.413646	1.196245	0.843023