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"Attention! It's the News." Cognitive Load and News Posts on Facebook: An Eye-tracking Study

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Abstract

Individuals get much of their news and information through social media. Thus, it has become crucial to evaluate how they are paying attention to and processing news content in this saturated space. The present study investigates users' visual engagement with news posts on Facebook using cognitive load theory of attention. An eye-tracking device was used to track visual attention of N = 152 participants. Following a 3 x 2 between-subjects factorial design, we manipulated intrinsic cognitive load by varying the story topic (either health or science) and the extraneous load by varying the presentation type (text only, video only, or video with text). Cognitive load does impact attention, such that those who viewed the video with text story (high cognitive load) exhibited higher visual attention to the content. We conclude that content higher in complexity elicits more attention compared to less complex content on Facebook.

Keywords: Facebook news, cognitive load, eye-tracking, modality, issue salience

Introduction

Social and mobile media have become ubiquitous sources of news consumption for young adults aged 18-25 across the world (Nic et al., 2019), prompting a discussion on the presentation of news content on these platforms. Most popular news outlets such as CNN, Fox, BBC, and *The New York Times* have a social media presence, essentially widening their reach. Since audiences for news posts are diversifying, it has become increasingly challenging to cater to these changing needs of users to make the content more interactive, appealing, efficient, and to relay an optimal user-experience. Furthermore, social media are taking over as a primary news source, and it has thus become important to evaluate best practices for presentation of news content that evoke maximum user engagement and satisfaction. Due to an abundance of information on social media, selective attention mechanisms are at play, wherein users filter out redundant information to cope with this influx of information. For example, users direct more attention towards posts that are attitude consistent, and have more social endorsements on them (Vraga et al., 2016).

This present study explores how varying news presentation formats and story topics on Facebook affect young adults' attention using eye-tracking. The presence or absence of graphical elements on an interface can significantly affect attention to such interfaces (Lin et al., 2013). Measuring how users pay attention to news content on social media, such as Facebook, can yield important considerations for improving the presentation of news content found on such platforms. We ground our research in cognitive load theory (CLT) (Sweller, 2010), which explains how varying modalities of presentation and the difficulty of the contents can affect attention paid to stimuli. Several studies have applied this theory to the context of online media and have operationalized cognitive load as the presence of hyperlinks, graphics, and other interactive web elements on the interface (Cárcamo Ulloa et al., 2015; Gerjets et al., 2006). To test the effects of cognitive load on attention, we used an eye-tracking instrument. Eye-tracking involves tracing the pattern of a person's eye while they engage with content and provides a measure of visual attention. The movements of the eye are measured in terms of fixations (when the eye is resting on something) and saccades (the rapid movement between one fixation to the other). Eye-tracking often relies on the mind-eye hypothesis that posits that there is a consistency between what people are looking at and what they are thinking about (Nielsen & Pernice, 2009).

Goldberg & Wichansky (2003) elucidate eye-tracking's application to understanding cognitive load. As cognitive load increases, attention represented by saccadic events or the fixation count reduces (Ehmke & Wilson, 2007). This was further validated in a lab study where attention patterns wavered when users engaged in complex tasks (Leuthold et al., 2011). In the social media news space, Adam, Quinn & Edmonds (2007) carried out an eye-tracking study to understand how people navigate homepage designs of 25 popular news websites, providing implications for how users engage with them.

Some researchers have also examined the effects of modality on attention. Users tend to fixate more on text compared to visuals or graphics (Yang & Shen, 2018). Previous studies (Kruikemeier et al., 2018) consider only fixation duration/time spent on the story as measures of visual attention. This study includes fixation count in addition to fixation duration as a measure of visual attention. Fixation count can provide additional data about the importance of an element on the interface such that more important elements will elicit greater number of fixations. We use eye-tracking as a means of obtaining unbiased data about users' visual attention to mitigate issues with self-report data (Wang et al., 2014).

For this study, we manipulate intrinsic cognitive load by varying Facebook news story topics and extraneous cognitive load through news presentation modality. We are interested in examining unique interest areas of these news story posts, as generated by the platform itself (See Figures 1, 2, 3.1, and 3.2 for more details on specific interest areas). An interest area represents the unique objects presented to users while engaging with an interface (Orquin et al., 2016). Interest areas as depicted in Figures 1-3 were drawn for each participant. Since news content on social media is embedded within the platform's features, fixation count and fixation duration were isolated for the main story area versus other elements on the interface. For the video with text condition (Figure 1), fixation metrics for the video frame, headline, organization logo, engagements, and subtitles were isolated from the notifications bar, messenger chats, and other stories. For the video-only condition (Figure 2), fixation metrics for headline, video frame, organization logo, and engagements were isolated from messenger chats, the notifications bar, and other stories. For the text condition (Figures 3.1 and 3.2), fixation metrics for headline, image, story text, and news organization logo were isolated from messenger chats, the notifications bar, and side bar.

Figure 1. Interest areas for video with text condition.

Figure 2. Interest areas for video-only condition.

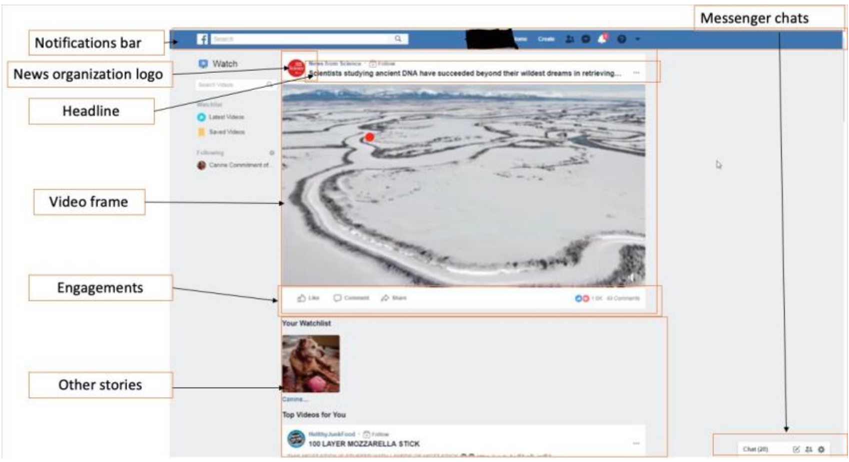


Figure 3.1. Interest areas for text-only condition.

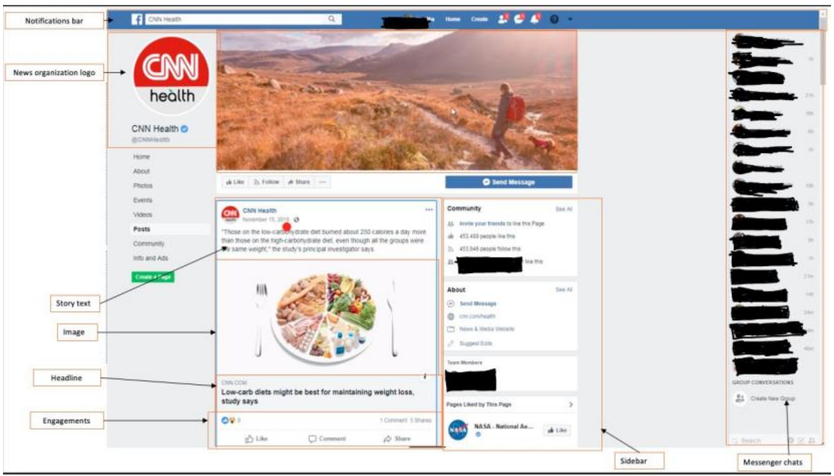


Figure 3.2. Interest areas for text-only condition.

Eye-tracking lends data in the form of both fixations (unique resting of the eye on a point) and saccades (the rapid movements of the eye between two points). Fixations can quantify visual attention, while saccades denote the shift of attention between different points on an interface. The focus of the present study is to quantify users' visual attention to elements on an interface, rather than measure a shift in their attention from one interface element to the other (Beymer et al., 2007). Hence, fixation counts and duration were chosen as appropriate eye-tracking measures for this study. We measure the user's visual fixation on these elements, both in terms of time (fixation duration) and number of times they look at them (fixation count) (Antonenko & Niederhauser, 2010). While fixation count is suggestive of the concentration of fixations on the interface, fixation duration provides a sum total of the time of these fixations. Hence, both fixation count and fixation duration can provide rich and descriptive data about how much and how long a user lends visual attention to a story. Furthermore, an analysis of studies employing eye-tracking, suggested that fixation counts and fixation duration were the most widely used metrics to measure visual attention to content, underscoring their relevance thereof (Jacob & Karn, 2003).

Facebook continues to be the most popular social website for news in key markets across the world. It is the first point of contact for 28% of young adults across the world, compared to Twitter (12%), and Instagram 9% (Nic et al., 2019); hence making it important to study news presentation on these sites. Additionally, the complexity of Facebook as a platform for news can lead to split-attention effects (Ayres & Sweller, 2014; Liu, Lai, & Chuang, 2011), causing users to pay more or less attention to other features or distractors embedded within the interface that are often multimodal (Chandler & Sweller, 1992; Mayer et al., 2001). In this study, we focus on understanding differing attention to content when the presentation type and story topic are varied.

It remains disputed in current research whether interactive content is more effective than less interactive content for prompting attention and other memory outcomes. While interactive content is rated to be more appealing, increases enjoyment, and generates overall positive attitudes (Yang & Shen, 2018), its effects on cognitive outcomes such as attention, retention, and learning is largely mixed (Mayer et al., 2001; Pincus et al., 2017; She & Chen, 2009; Sundar, Kang et al., 2017). We seek to address this gap in the literature, contribute to better understanding the impacts of news modality on attentional processes, and provide actionable insights for news content creators for platforms such as Facebook specifically, to maximize attention to these posts. Previous research in this domain has looked at attention to different types of posts on Facebook (social, political, and news) and concludes that richer content containing videos and pictures elicits more attention (Vraga et al., 2016). In our study, we consider only news posts on Facebook and seek to understand how different presentation formats and topics garner more or less attention from the user. In addition to looking at how much attention users allocate to posts on Facebook, we go a step further by aiming to understand optimum ways to present news to young adult audiences.

Literature Review

Cognitive Load Theory and Hypotheses

Attention is largely dependent on the amount and type of load involved (Lavie, 2010). Cognitive load can be defined as the constraints imposed on working memory when trying to hold certain items in the short-term memory (Sweller, 2010). Cognitive load is influenced by the number of cognitive resources available and required to complete a particular task, which is itself dependent on factors such as topic relevance and mental effort required to process information (Chandler & Sweller, 1991). Under conditions of high cognitive load, individuals might be unable to maintain task priority, directing more attention towards irrelevant aspects of the stimuli (Wang & Duff, 2016). While the load theory has found several applications within the media studies literature (e.g., video games), little has been said about it in the context of social media.

Cognitive load theory (CLT) is based on the constraints imposed on working memory, and its capacity to process several pieces of information at the same time (Paas et al., 2003). Given this, the theory posits that information should be presented in such a way as to minimize any load experienced by the individual. However, load experienced may also further be a function of the complexity of material, wherein processing is dependent on an individual’s ability to recall previously stored knowledge schemata to process information. However, when such schemata are not available, cognitive load experienced is high (Leahy & Sweller, 2011).

Research on CLT proposes two channels of information processing: visual and auditory. The combination of these two channels can be used for optimum information presentation, however, presenting information using different sources in the same stimulus may result in cognitive overload (Mayer & Moreno, 2003). For example, combining text with video that has audio may impose additional load on participants because the text reiterates audio, and is thus considered redundant. Furthermore, the relationship between attention to content and cognitive load may not be linear; in fact, it may follow an inverted U-shaped pattern, such that attention seems to increase first as cognitive load increases and decreases once it reaches an optimum level (Ahmed & de Fockert, 2012; Wang et al., 2014). In other words, attention is highest for content with medium complexity.

CLT classifies cognitive load into three types: intrinsic, extraneous, and germane. Intrinsic cognitive load refers to the content of the material to be processed. Extraneous cognitive load pertains to the complexity of the modality. Lastly, germane cognitive load refers to the number of heuristics required and allocated by the individual to process the information. Germane load is largely dependent on individuals' motivation and effort. We consider intrinsic and extraneous cognitive load for the purposes of this study while omitting germane cognitive load, as the former two can be experimentally manipulated but germane load cannot since it depends on pre-existing schemata of the user (Anderson et al., 2011).

Extraneous Cognitive Load

Extraneous cognitive load refers to the number of elements in a stimulus and is affected by the format it is presented in. DeLeeuw & Mayer (2008) explain that the presentation of redundant information can impose additional constraints on processing. For example, the presentation of audio in combination with video might impose lesser cognitive constraints compared to only presenting information in either audio or video, since both audio and video are essential to understanding the contents of the message. However, when on-screen text is presented in addition to video and audio, text is redundant because it is merely repeating the information that is provided in the audio, thus imposing additional constraints on the working memory. Extraneous load can impose the need for cognitive resources beyond what is available to a user, thus impacting attention (Harper et al., 2009; Huang, 2003).

The complexity of the page depends on various elements such as homepage length, number of hyperlinks, and the number of pictures on a particular interface (Geissler et al., 2001). Different studies have manipulated this by varying the number of elements (e.g., graphics, hyperlinks; Gerjets et al., 2006), or by varying the presentation format of content by including more or less elements (Liu et al., 2011; Sweller, 2010; Wang et al., 2014). These studies find that on-screen text orients users' attention towards the text compared to other elements. This leads to an inverted U-shaped pattern of attention such that visual attention is most for websites with low intrinsic load and high extraneous load.

Element interactivity is also an important factor affecting extraneous cognitive load. Interactivity refers to the number of elements that the user needs to process simultaneously. The higher the number of elements interacting on an interface, the higher the extraneous cognitive load imposed (Sweller, 2010). Information on social media is often multimodal and can include pictures, text, graphics, videos, and any combination of the above; although, this presentation of multimodal information may impose cognitive constraints on the user, impacting attentional processes (Sweller, 1994). For example, users might fixate longer on larger images compared to smaller images (Cárcamo Ulloa et al., 2015). However, whether or not multimodal information is perceived to impose additional cognitive load is debatable. Some studies find the presence of text in videos has been linked to an increase in extraneous cognitive load (Mayer, 2002; Mayer et al., 2001), thereby reducing memory functions. However, other studies find that text accompanied with video decreases cognitive load, and increase outcomes such as attention (Kruger et al., 2013).

For this study, extraneous cognitive load is operationalized as the presentation format of a social media news story post: text only (low extraneous load), video only (medium extraneous load), and video with text (high extraneous load). This is based on previous research that manipulated extraneous load by varying the number of interface elements (Geissler et al., 2001; Cárcamo Ulloa et al., 2015). Text-only stories have fewer elements to process (static text, static images) compared to videos that incorporate motion pictures and audio, and video with text that combines motion pictures and audio with text. We thus pose the following research question to understand the impacts of extraneous cognitive load on perceptions of cognitive load and attention, which is measured using fixation counts and fixation duration:

RQ1: How does extraneous load affect a) fixation duration, and b) fixation count?

Intrinsic Cognitive Load

Intrinsic load refers to the complexity of the content presented, which can itself have an impact on attentional patterns (Sweller, 2010).

Intrinsic load can hamper the information processing route by causing the user to expend more cognitive resources when the perceived difficulty of the content presented is high (Little, 2010). Intrinsic load is often influenced by prior knowledge and familiarity with the topic, as this reduces the need to learn new information, making cognitive resources available to process other elements in the story. When a user encounters some new information, they generally link it to available schemata, which helps reduce the load on information processing. If no existing schemata can be linked to this new information, this imposes a greater intrinsic cognitive load on the user since they now have to familiarize themselves with something that is completely unfamiliar. Increases in intrinsic cognitive load is associated with a decrease in attention (Susac et al., 2019). For a Facebook news post, intrinsic load should vary by the complexity of the topic presented.

Element interactivity can also be used to explain intrinsic cognitive load. An element refers to a pre-existing schema that has been or needs to be learned. Low element interactivity refers to stimuli that can be interpreted by the user with minimal reliance on other elements requiring less effort and imposes less cognitive load on the user (Sweller, 2010). However, when users are exposed to stimuli with a lot of interdependent elements, it can impose higher cognitive load. For example, learning the alphabet (a, b, c, and so on) has low element interactivity since users learn each letter in isolation. However, when the same letters are used in a mathematical equation ($ab + bc^2 = 3ab + c$), the individual elements have high element interactivity since the equation needs to be interpreted as a whole, imposing heavier intrinsic cognitive load.

For this study, intrinsic cognitive load is operationalized as the story topic presented: health (low intrinsic load) or science (high intrinsic load). The content of science stories can be unfamiliar to participants, requiring additional cognitive resources to process the material (Gerjets et al., 2006; Klepsch et al., 2017). Furthermore, intrinsic cognitive load also tends to depend on the number of new elements to be learned and the number of elements to be kept in working memory; both of which tend to be higher in science stories than stories about health (Chang & Yang, 2010; Galy et al., 2012). Science stories are also higher on element interactivity since users need to not only learn scientific terminology but also relate this to the contents of the article. Thus, the following hypothesis is posed:

H1: High intrinsic load stories will lead to lower a) fixation duration, and lower b) fixation count than low intrinsic load stories.

Intrinsic cognitive load tends to interact with extraneous cognitive load such that when intrinsic load is low, stimuli with greater extraneous cognitive load will elicit higher attention (Lambert et al., 2009). This is so because lesser number of resources are required to process content with low intrinsic load, making additional resources available to process interactive (more complex) elements. An inverse effect is observed when the intrinsic load increases and there are fewer cognitive resources available to users as they expend their resources processing the contents of the information (Lavie et al., 2004). Although, a level of optimum complexity elicits higher attention, beyond which fixation counts begin to lower (Geissler et al., 2001). Thus, medium complexity content tends to elicit higher fixation counts when intrinsic load is high.

Based on this, the following hypotheses are posed:

H2: Intrinsic cognitive load will moderate the relationship between extraneous cognitive load and a) fixation duration, and b) fixation count.

H3: An inverted-U shaped pattern of attention will be observed such that for the science stories, those in the video-only (medium complexity) condition will exhibit highest a) fixation duration, and highest b) fixation count.

Issue Salience

Issue salience pertains to the level of interest in a particular topic (Vreese & Boomgaarden, 2006) and is another important variable affecting attention to news content (Weeks & Southwell, 2010). For example, users are more likely to engage with stories that are personally relevant, happening in close proximity to them, or have catchy headlines (Reuters, 2019). Topics of perceived salience garner greater attention (O'Brien et al., 2014). Particularly, Vraga, Bode & Troller-Renfree, (2016) find that users are more likely to pay attention to news and social posts over political posts as the former is more salient, and that more interactive posts elicited elevated attention. Although, a more recent study by Vraga et al. (2019) finds that visual attention to social media posts is not affected by interest to that topic. Based on this discussion, issue salience is proposed as a control variable in this study.

We also incorporate self-reported attention as a second control measure in this study. There is often a difference between what people say they do (self-report) and what they actually do (behaviour). Self-reported attention is intended to measure user's perception of attention to news stories. The measure looks at how aware the user is of their own news consumption practices and the importance of consuming news to the user.

Methods

Design

This study employed a 3 (extraneous load: text-only vs. video-only vs. video with text) x 2 (intrinsic load: health vs. science) between-subjects experiment to test the effects of extraneous and intrinsic cognitive load on attention. Extraneous load is operationalized as the story presentation format, with low being text-only, medium being video-only, and high being video with text. Story topic serves as the operationalization for intrinsic load, with health representing low and science representing high intrinsic cognitive load. The data for this experiment were collected as part of a larger project.

Participants and Screening

A convenience sample of *N* = 172 was recruited from an undergraduate class at a large North-eastern U.S. university by means of an online posting. The sample ranges in age 18-24 (*M* = 19.37, *SD* = 2.15), comprising of 62.7% females. Statistics indicate that Facebook still remains a popular platform for seeking news and information for young adults aged between 18-25, making this age group an appropriate sample for this study. Participants received course credit in exchange for participating in this study. Half of the participants indicated that they get news from Facebook multiple times a day. A pre-test was used to screen participants for the study using the following two criteria:

(1) They must use Facebook (have an active account and use the app regularly). Participants were also asked to indicate how frequently they used the app. The options were never, almost never, sometimes, once in a month, once in a week, once in a day, and several times per day. Participants who chose “never,” and “almost never” were excluded from the study.

(2) They must have normal or corrected-to-normal vision and/or with contact lenses. Glare associated with glasses can lead to measurement errors in eye-trackers; hence, we were unable to include participants who wear glasses.

Procedures

Participants signed up for a time slot to complete the study. Upon arrival at the lab, a researcher or a lab assistant guided the participant through the study. They were told that their eye movements would be tracked using an unintrusive device during one part of the study. They first completed a set of questionnaires that assessed their news consumption patterns, their trustworthiness of different news sources, and self-reported attention to the news. They were then asked to sign in to Facebook with their account. We randomized the order of the news stories, and each participant was shown one of six stories on Facebook. At this point, we also calibrated the eye-tracking device. Once the eye-tracking device was ready, the researcher/lab assistant opened the story on Facebook and participants were free to engage with the story. For video stories, the researcher/lab assistant navigated to the video on Facebook and ensured that the audio volume was turned up. They were then free to take as long as they want to interact with the story. For the text stories, the lab assistant navigated to the relevant page. Participants also had the choice to not view the story or stop viewing the story at any time point. After viewing the story, the eye-tracker was switched off. An attention check was presented at this stage to control for participants who did not pay attention to the study. They were presented with a multiple-choice question to name the news outlet of the story that they just viewed. They then completed the rest of the questionnaire measuring perceived cognitive load and issue salience. Other measures that were part of the larger study such as elaboration, imagined audience, recognition, recall, and knowledge are not included here.

Stimuli

We selected news stories from popular news outlets on Facebook, namely CNN, Buzzfeed, BBC, and AAS science news, as they continue to be rated highly in terms of news source preference by users (Pomeroy, 2019). We selected six stories varied by story topic and presentation format. The lengths of the video conditions were equal to maintain parity across the conditions.

Eye-tracking Device

Eye movements were collected using an Eyelink 1000 Plus (SR Research, Toronto, ON, Canada) desktop in remote mode, which sampled at 250Hz from the right eye. The device has an average accuracy of ~0.5 degrees. Participants were seated approximately 60 cm from the display screen. Prior to presenting the news story, a five-point calibration procedure was performed for each participant, followed by a validation of the calibration. Any deviations above one degree were flagged by the system as “fair” or “poor.” In this case, the calibrations were redone to ensure quality of data. Further, the threshold for accepting a fixation was set to 150 milliseconds (Blignaut, 2009; Manor & Gordon, 2003); therefore, any fixations lower than 150 ms were not registered by the device. Screen Recorder software (SR Research, Toronto, ON, Canada) was used to record participant eye movements as they viewed their assigned news story on Facebook.

Measures

Eye-tracking Measures

(1) *Fixation count* refers to the total number of fixations falling within a certain interest area. Fixations refer to each unique resting of the eye when engaging with the news story (*M* = 349.99, *SD* = 183.22).

(2) *Fixation duration* pertains to the sum of the time of all fixations in a particular interest area. This was measured in milliseconds and was converted to seconds for further analysis (*M* = 142.65, *SD* = 106.99).

Perceived Cognitive Load

We asked participants to report their perception of cognitive load after viewing the story they were exposed to with two items borrowed from Schmeck et al. (2015). "How much mental effort did you invest while viewing the story?" and "How difficult were the contents of the story you viewed?" (*r* = .15, *p* < .05, *M* = 2.81, *SD* = .99). We performed a *t*-test to understand whether users did indeed perceive a difference between the two intrinsic load conditions. Results from a *t*-test analysis of perceived cognitive load reveal significant differences between the two groups, *t*(167) = -2.693, *p* < .05, with those exposed to the science story (*M* = 3.00, *SD* = .95) reporting higher perception of cognitive load than those exposed to the health story (*M* = 2.54, *SD* = 1.07).

Control Measures

Self-reported attention was borrowed from a past research study (Oeldorf-Hirsch & Srinivasan, 2018), measured using six items on a 7-point Likert scale ranging from 1 = Strongly Disagree to 7 = Strongly Agree. The six items were averaged to create a composite measure of self-reported attention (α= .91, *M* = 5.18, *SD* = .95). The scale consisted of the following items: I pay attention to the news, I keep up with current events, I like to know about what is going on in the world, I am interested in current events, I take time to follow the latest news, it is important for me to follow what is happening in this world.

Issue salience was adapted from Paek et al. (2012) and was measured using four items using a 7-point semantic differential scale (α= .90, *M* = 5.22, *SD* = 1.20). Items include: Was the news story: Trivial - Serious, Unimportant – Important, Not much concern – Worth a lot of concern, Irrelevant – Relevant.

Additional measures collected as part of a larger project are not included in this study.

Analysis

Firstly, we eliminated eight participants due to a malfunction with the eye-tracking equipment. Additionally, 12 failed the attention check and were excluded from further analysis. Thus, our final sample size for the study is *N* = 152. We isolated fixations on all other elements from the fixations on the news story since we were interested in comparing attention across the different story formats (Vraga et al., 2016). We used interest area reports to proceed with our analysis to calculate the unique fixations in particular areas of interest within each condition. The type of interest area in each condition is uniform, though the exact number varies based on the number of elements in the story itself. Figures 1, 2, 3.1, and 3.2 describe the types of interest areas for the various conditions. On average, the four video conditions were 174 seconds (2 minutes, 54 seconds), and the text articles contained 610 words. The video with text conditions had an average of 457 words (text in subtitles).

Results

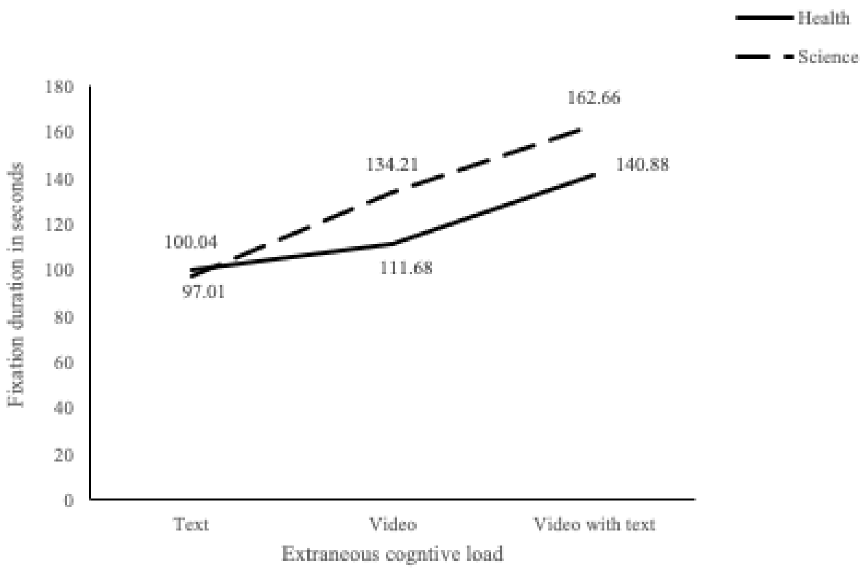
Interaction Effects

RQ1 asked how extraneous load affects a) fixation duration, and b) fixation count. We were interested in looking at the differences between presentation formats (extraneous load) on attention (fixation duration and fixation count). H1 predicted that high intrinsic load stories will lead to lower a) fixation duration, and b) fixation count than low intrinsic load stories. H2 predicted that intrinsic cognitive load will moderate the relationship between extraneous cognitive load and a) fixation duration, and b) fixation count. To test RQ1, H1, and H2, we conducted two separate univariate ANOVAs with presentation type (extraneous load) and story topic (intrinsic load) as predictors, and fixation duration and fixation count as dependent variables. Issue salience and self-reported attention were added as control variables in the model. All assumptions for ANOVA were met.

Fixation Duration

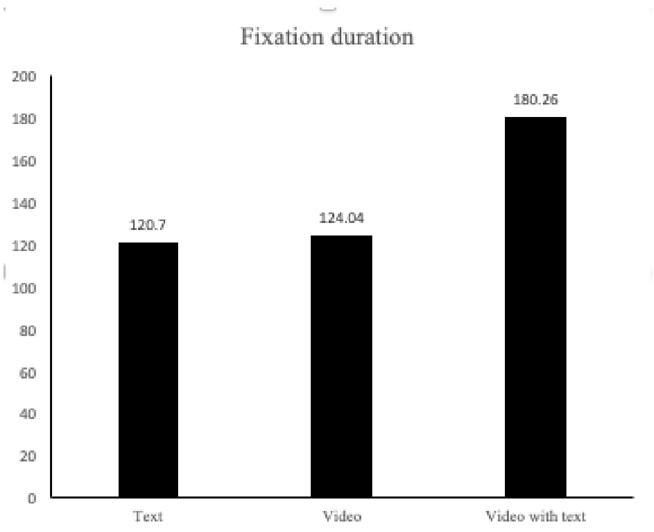
For fixation duration, the main effect for extraneous cognitive load $F(2, 142) = 9.99$, $p < .001$, is significant. However, the main effect for intrinsic load, $F(1, 142) = 1.15$, $p = .28$, and the interaction of intrinsic and extraneous load, $F(2, 142) = .61$, $p = .55$, are not significant (Figure 4). Issue salience, $F(1, 142) = 1.20$, $p = .27$, does not emerge as a significant predictor in the model, but self-reported attention, $F(1, 142) = 4.62$, $p < .05$), does.

Figure 4. Interaction effect of intrinsic and extraneous cognitive load on fixation duration.



We further examined the post-hoc tests to see which of the extraneous load conditions significantly differed. The Tukey's test revealed a significant difference between text and video with text (Mean difference = 53.70, p < .001), and video-only and video with text conditions (Mean difference = 28.18, p < .004). Fixation duration is highest for the video with text condition (Figure 5).

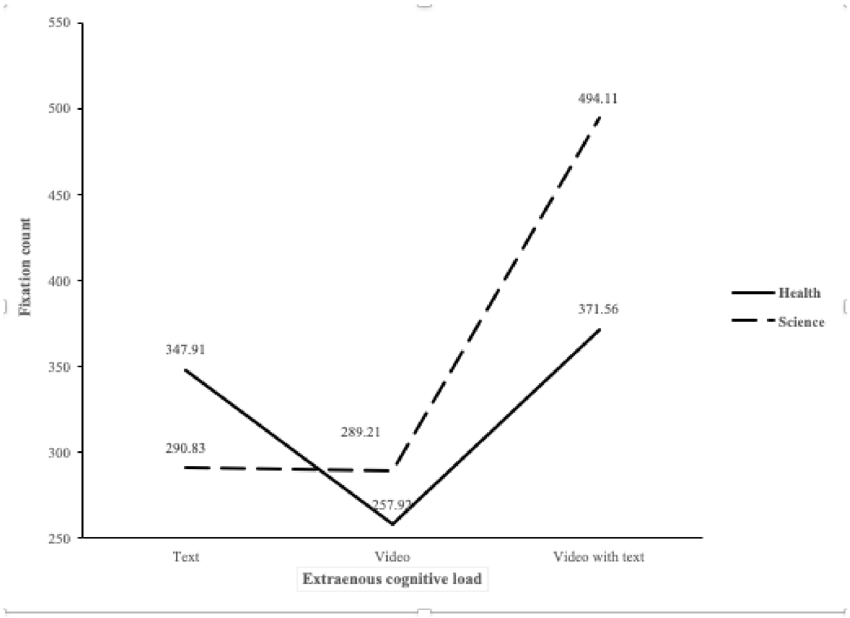
Figure 5. Fixation duration for text, video, and video with text conditions.



Fixation Count

For fixation count, results demonstrate a significant main effect of extraneous load, $F(2, 142) = 13.83$, p < .001, on fixation count, and a significant interaction effect of intrinsic and extraneous cognitive load, *F*(2, 144) = 3.53, *p* = .04, for fixation count such that cognitive load impacts attention to content (Figure 6).

Figure 6. Interaction effect of intrinsic and extraneous cognitive load on fixation count.



Both issue salience, *F*(1, 142) = 1.95, *p* = .16), and self-reported attention, *F*(1, 142) = 1.07, *p* = .31, were not significant predictors in the model. Fixation count is highest for the video with text condition (*M* = 453.42, *SD* = 178.98), followed by text (*M* = 318.73, *SD* = 207.47), and video-only (*M* = 275.04, *SD* = 135.64; Figure 7). Simple effects for the interaction are reported in Table 1. For low intrinsic load, fixation count is lowest for the medium complexity condition. Fixation count however seems to increase with increase in intrinsic cognitive load. Overall, these results provide support for H2b but not H1 and H2a (Table 2).

Figure 7. Fixation count for text, video, and video with text conditions.

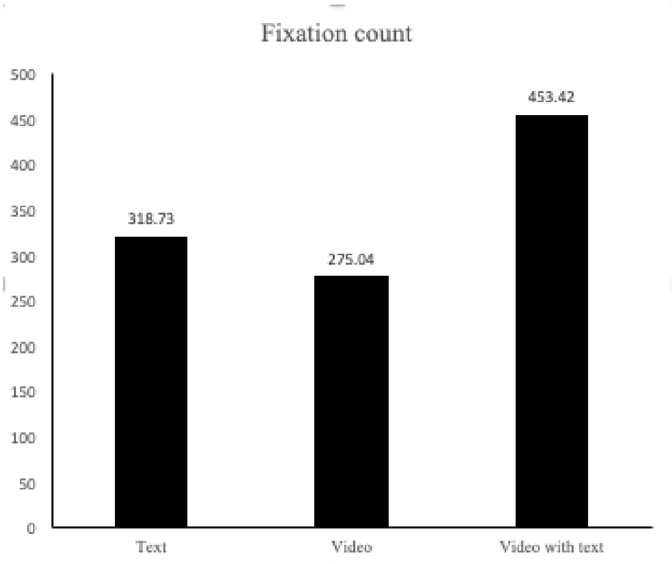


Table 1. Simple effects for interaction effect for intrinsic and extraneous cognitive load on fixation count.

Intrinsic	Extraneous (1)	Extraneous (2)	Mean difference	SE
Health	Text	Video	87.71	47.17
	Text	Video with text	-68.54	48.46
	Video	Video with text	-156.35**	47.03
Science	Text	Video	-30.19	45.91
	Text	Video with text	-230.72**	47.5
	Video	Video with text	-200.53**	45.99
*p < .05, **p < .01				

Table 2. Descriptive statistics for interaction effects of intrinsic and extraneous cognitive load on fixation count and fixation duration.

Dependent variable	Intrinsic load	Extraneous load		
		Text only	Video only	Video with text
Fixation count	Health (Low)	M = 347.91	M = 257.92	M = 381.08
		SD = 197.15	SD = 117.97	SD = 203.55
		N = 22	N = 24	N = 25
	Science (High)	M = 290.83	M = 289.21	M = 520.41
		SD = 177.72	SD = 121.89	SD = 146.83
		N = 23	N = 29	N = 27
Fixation duration	Health (Low)	M = 145.47	M = 111.65	M = 150.98
		SD = 226.86	SD = 43.01	SD = 71.54
		N = 22	N = 23	N = 25
	Science (High)	M = 97.01	M = 134.21	M = 206.98
		SD = 65.67	SD = 50.28	SD = 61.58
		N = 23	N = 29	N = 27

H3 predicted that an inverted-U shaped pattern of attention will be observed such that for the science stories, those in the video-only (medium complexity) condition will exhibit highest a) fixation duration, and b) fixation count. To test H3, we examined the individual means of the groups. As demonstrated in Table 1, the means do not suggest an inverted U-shaped pattern of attention for the news stories for complexity and story topic. Interestingly, for the health condition, a U-shaped pattern was observed such that fixation duration was lowest for the video-only condition; hence H3 is not supported.

Discussion

This study applied the cognitive load theory to the context of social media news to understand how extraneous cognitive load in the form of presentation format and intrinsic cognitive load in the form of story topic affect attention to news content on Facebook. Attention to content was measured using an eye-tracking device. Contrary to previous research, we find that cognitive load does impact attention allocation such that the news stories with high extraneous and intrinsic load elicited highest visual attention.

Results from the manipulation check indicate a difference in perceptions of cognitive load for story topic with those who viewed science stories experiencing higher cognitive load than those who viewed health stories. This might suggest that story topic might affect the number of cognitive resources required to process the content. Science stories might contain more unfamiliar elements compared to health stories and may also require the user to learn new elements to interpret the content. Also, the science story may have a high level of element interactivity that may have imposed higher intrinsic cognitive load. Consequently, the user is unable to link this back to pre-existing schemata, hence increasing cognitive load associated with science stories.

However, an opposite effect is seen with regard to visual attention. Results suggest that while extraneous load affects visual attention, intrinsic load does not. One possible explanation for this non-significant effect of intrinsic load on visual attention can be due to users' varying levels of prior knowledge on the news topics that they viewed (Karnowski et al., 2017). A significant interaction effect of extraneous and intrinsic load is observed for fixation count, but not for fixation duration. This might suggest that while story topic and presentation format might drive attention to the story, they may not be able to sustain this attention. Results indicated that visual attention represented by fixation count and fixation duration were highest for video with text condition. This is because when viewing video with text, users were focusing on two modalities at once, straining their already limited cognitive resources (Lang, 2000). In the video with text condition, element interactivity was higher since the users had to go back and forth between the text and the video to interpret the stimuli as a whole. Text can impose additional cognitive constraints on the user, taking longer for users to process the information. The text-only condition was consistently low for fixation duration suggesting that even though text is processed on a deeper level than video content, text-only content is not able to sustain attention; richer content like videos may not lead to deeper cognitive processing but are more efficient with respect to capturing the visual attention of users.

We also find no evidence of an inverted U-shaped pattern of attention. In fact, a U-shaped pattern is observed for fixation count for health stories. Fixation count is least for the video-only condition (medium complexity) and most for the video with text condition (high complexity). This may be because the content of the story might be familiar and therefore, users might not want to allocate focused visual attention that might be required to process stories with higher cognitive load. Since element interactivity is low, users might not expend effort into lending visual attention to this content, explaining the U-shaped pattern of attention for health stories. For science stories, fixation count seems to be about the same for text and video conditions, and highest for the video with text conditions. However, fixation duration increases linearly with complexity of the presentation format (Figure 4). A possible reason for this is that as users face an increase in cognitive load, they might try to compensate for it by lending more focused attention on the content to grasp the material, expending more cognitive resources than they would for a story with medium complexity. However, whether this greater attention pattern leads to better memory outcomes, needs more elaboration. Another possible reason for the text-only condition eliciting more visual attention is because users might lend more focused attention when reading than merely watching motion picture. Users tend to expend more cognitive resources when reading and find it “easier” to process video content compared to written text (Cennamo, 1993).

Our results suggest implications for both theory development and practical implications for social media site designers. Firstly, the CLT may not hold true to explain attentional patterns to news content on dynamic platforms such as social media. The cognitive load theory states that attention diminishes after an optimum level due to increases in cognitive load. However, this might be more so when users are unfamiliar with an interface. Since we studied Facebook users in this study, users were already familiar with the platform and its features. Thus, cognitive load resulting from unfamiliarity with a platform may have been minimal. It might also be worth considering if text within video should be viewed as a load-imposing element on an interface. Contrary to previous findings about redundancy and cognitive load, users might not perceive the addition of text to video as imposing cognitive constraints. Users might in fact use the text to better understand or reinforce the content being presented. This is evidenced in results from RQ1.

Our results also indicate that users have a strong preference for news stories that contain both video and text. Both fixation count and fixation duration are highest for the video with text conditions. Design-wise, this can prove advantageous as it might be easier to understand certain terms or concepts when text is accompanied by visuals. Furthermore, many users tend to get their news on-the-go through Facebook; when traveling or at places where they are unable to listen to audio. The presence of text within video can help in such situations by eliminating the need to play any audio at all. Furthermore, from an accessibility perspective, the presence of text within video promotes greater understandability and access to the content. For example, presence of text that can be easily picked up by a screen reader for blind users, or the presence of text for those with a hearing impairment or assisting cognitively impaired users to couple visuals with textual description.

While using video in combination with text could prove advantageous for promoting more attention, it could also result in proliferation of fake news. Since this modality garners maximum attention, dubious news can also find its way on users' news feeds and spread misinformation when presented in this format. This finding provides implications for content moderators and site designers to be even more mindful of content in video with text format that might likely attract more attention and lead to the spread of fake news. Sites can adopt stronger filter policies, especially for content presented in video with text format.

Our results also provide implications for future eye-tracking studies by providing a distinction between fixation count and fixation duration. Both measures have been used concurrently in several studies; however, they may be indicative of different dimensions of visual attention allocation. Fixation count refers to visual attention allocated to a stimulus while fixation duration refers to the sustenance of this attention on the stimuli. While certain stimuli may draw attention by virtue of being more attractive, they may not be able to sustain the attention unless the stimulus imposes less cognitive load. As evidenced in our results, text-only stories (less-rich stimuli) elicited higher fixation count but low fixation duration. Content that is multimodal in nature can help elicit as well as sustain this attention.

Limitations and Future Directions

The present study has several limitations. Firstly, a college sample was used for this study. Although college students constitute an important user-base for Facebook news, other populations such as older adults need to be addressed in future studies as well to underscore any age-related effects. A college sample also implies a bias in the demographic since the sample is expected to have at least a certain level of education. The interaction of both the age and the education level might further impact data collection and results obtained. The results of the study may not be completely generalizable to the entire population of Facebook users.

Next, the format of the experiment may have reduced the external validity of the results. Participants in the study were assigned to view one of six stories, rather than letting them view the story of their choice. This might have potential issues as in reality, where they might not have chosen this particular story. Future studies must look at studying this in a more naturalistic fashion by allowing participants to choose their own stories and engage with the story as they please.

Third, the experimental setup and the presence of the eye-tracker might interfere with true behaviour. Future studies must incorporate these factors and try to naturalize this observation by studying participants beyond the lab environment, using portable eye-tracking equipment to minimize lab-induced noise.

Next, this study was part of a larger experiment. The effects of cognitive load and attention on elaboration and memory are presented as part of another paper, while focusing this paper on assessing the impacts of extraneous and intrinsic cognitive load on visual attention.

Lastly, prior knowledge on the topic was not measured as part of this study. The inclusion of this measure could provide meaningful data to interpret the (non)effects of intrinsic cognitive load, since knowledge on the topic can influence cognitive load. Future studies must look to control for users' prior knowledge on the topic to better explain these results.

Conclusion

As social media grow in importance as primary sources of news, it becomes increasingly important to assess how users allocate attention to various content formats on these platforms. This study provides important implications about the presentation formats of news stories on Facebook, particularly from a cognitive load perspective, and to understand differences in attentional patterns thereof. We find that the format of a news story posted on Facebook affects attention, and differentially so for various topics, but may not be able to sustain this attention beyond a certain time point. For users, this means they may not be able to give all news content equal attention, depending on its format and content. For designers, this offers important implications for how news story posts on Facebook may be formatted differently for different news topics.

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References

Adam, P.S., Quinn, S., & Edmonds, R. (2007). Eyetracking the news. The Pointer Institute for Media Studies Ed.

Ahmed, L., & de Fockert, J.W. (2012). Focusing on attention: The effects of working memory capacity and load on selective attention. PLoS ONE. https://doi.org/10.1371/journal.pone.0043101

Anderson, E.W., Potter, K.C., Matzen, L.E., Shepherd, J.F., Preston, G.A., & Silva, C.T. (2011). A user study of visualization effectiveness using EEG and cognitive load. Computer Graphics Forum. https://doi.org/10.1111/j.1467-8659.2011.01928.x

Antonenko, P.D., & Niederhauser, D.S. (2010). The influence of leads on cognitive load and learning in a hypertext environment. Computers in Human Behavior. https://doi.org/10.1016/j.chb.2009.10.014

Ayres, P., & Sweller, J. (2014). The split-attention principle in multimedia learning. In The Cambridge Handbook of Multimedia Learning, Second Edition. https://doi.org/10.1017/CBO9781139547369.011

Beymer, D., Orton, P.Z., & Russell, D.M. (2007). An eye tracking study of how pictures influence online reading. In Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics).

Blignaut, P. (2009). Fixation identification: The optimum threshold for a dispersion algorithm. Attention, Perception, & Psychophysics, 71(4), 881-895.

Cárcamo Ulloa, L., Marcos Mora, M.C., Cladellas Pros, R., & Castelló Tarrida, A. (2015). News photography for Facebook: Effects of images on the visual behaviour of readers in three simulated newspaper formats. Information Research.

Cennamo, K.S. (1993). Learning from video: Factors influencing learners' preconceptions and invested mental effort. Educational Technology Research and Development. https://doi.org/10.1007/BF02297356

Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. Cognition and Instruction. https://doi.org/10.1207/s1532690xci0804_2

Chandler, P., & Sweller, J. (1992). The split??? Attention effect as a factor in the design of instruction. British Journal of Educational Psychology. https://doi.org/10.1111/j.2044-8279.1992.tb01017.x

Chang, C.C., & Yang, F.Y. (2010). Exploring the cognitive loads of high-school students as they learn concepts in web-based environments. Computers and Education. https://doi.org/10.1016/j.compedu.2010.03.001

DeLeeuw, K.E., & Mayer, R.E. (2008). A comparison of three measures of cognitive load: Evidence for separable measures of intrinsic, extraneous, and germane load. Journal of Educational Psychology. https://doi.org/10.1037/0022-0663.100.1.223

Ehmke, C., & Wilson, S. (2007). Identifying web usability problems from eye-tracking data. In People and Computers XXI HCI.But Not as We Know It - Proceedings of HCI 2007: The 21st British HCI Group Annual Conference. https://doi.org/10.14236/ewic/hci2007.12

Galy, E., Cariou, M., & Mélan, C. (2012). What is the relationship between mental workload factors and cognitive load types? International Journal of Psychophysiology. https://doi.org/10.1016/j.ijpsycho.2011.09.023

Geissler, G., Zinkhan, G., & Watson, R. (2001). Web home page complexity and communication effectiveness. Journal of the Association for Information Systems. https://doi.org/10.17705/1jais.00014

Gerjets, P., Scheiter, K., & Catrambone, R. (2006). Can learning from molar and modular worked examples be enhanced by providing instructional explanations and prompting self-explanations? Learning and Instruction. https://doi.org/10.1016/j.learninstruc.2006.02.007

Goldberg, J.H., & Wichansky, A.M. (2003). Eye tracking in usability evaluation. In The Mind's Eye (pp. 493–516). https://doi.org/10.1016/b978-044451020-4/50027-x

Harper, S., Michailidou, E., & Stevens, R. (2009). Toward a definition of visual complexity as an implicit measure of cognitive load. ACM Transactions on Applied Perception. https://doi.org/10.1145/1498700.1498704

Huang, M.H. (2003). Designing website attributes to induce experiential encounters. Computers in Human Behavior. https://doi.org/10.1016/S0747-5632(02)00080-8

Jacob, R.J.K., & Karn, K.S. (2003). Eye tracking in human-computer interaction and usability research: Ready to deliver the promises. In The Mind's Eye: Cognitive and Applied Aspects of Eye Movement Research. https://doi.org/10.1016/B978-044451020-4/50031-1

Karnowski, V., Kümpel, A.S., Leonhard, L., & Leiner, D.J. (2017). From incidental news exposure to news engagement. How perceptions of the news post and news usage patterns influence engagement with news articles encountered on Facebook. Computers in Human Behavior. https://doi.org/10.1016/j.chb.2017.06.041

Klepsch, M., Schmitz, F., & Seufert, T. (2017). Development and validation of two instruments measuring intrinsic, extraneous, and germane cognitive load. Frontiers in Psychology. https://doi.org/10.3389/fpsyg.2017.01997

Kruger, J.L., Hefer, E., & Matthew, G. (2013). Measuring the impact of subtitles on cognitive load: Eye tracking and dynamic audiovisual texts. In ACM International Conference Proceeding Series. https://doi.org/10.1145/2509315.2509331

Kruikemeier, S., Lecheler, S., & Boyer, M.M. (2018). Learning from news on different media platforms: An eye-tracking experiment. Political Communication. https://doi.org/10.1080/10584609.2017.1388310

Lambert, J., Kalyuga, S., & Capan, L.A. (2009). Student perceptions and cognitive load: What can they tell us about e-learning Web 2.0 course design? E-Learning. https://doi.org/10.2304/elea.2009.6.2.150

Lavie, N. (2010). Attention, distraction, and cognitive control under load. Current Directions in Psychological Science. https://doi.org/10.1177/0963721410370295

Lavie, N., Hirst, A., De Fockert, J.W., & Viding, E. (2004). Load theory of selective attention and cognitive control. Journal of Experimental Psychology: General. https://doi.org/10.1037/0096-3445.133.3.339

Leahy, W., & Sweller, J. (2011). Cognitive load theory, modality of presentation and the transient information effect. Applied Cognitive Psychology. https://doi.org/10.1002/acp.1787

Leuthold, S., Schmutz, P., Bargas-Avila, J.A., Tuch, A.N., & Opwis, K. (2011). Vertical versus dynamic menus on the world wide web: Eye tracking study measuring the influence of menu design and task complexity on user performance and subjective preference. Computers in Human Behavior. https://doi.org/10.1016/j.chb.2010.09.009

Lin, Y. C., Yeh, C. H., & Wei, C.C. (2013). How will the use of graphics affect visual aesthetics? A user-centered approach for web page design. International Journal of Human Computer Studies. https://doi.org/10.1016/j.ijhcs.2012.10.013

Little, J.J. (2010). Cognitive load theory and library research guides. Internet Reference Services Quarterly. https://doi.org/10.1080/10875300903530199

Liu, H.C., Lai, M.L., & Chuang, H.H. (2011). Using eye-tracking technology to investigate the redundant effect of multimedia web pages on viewers' cognitive processes. Computers in Human Behavior. https://doi.org/10.1016/j.chb.2011.06.012

Manor, B.R., & Gordon, E. (2003). Defining the temporal threshold for ocular fixation in free-viewing visuocognitive tasks. Journal of neuroscience methods, 128(1-2), 85-93.

Mayer, R.E. (2002). Multimedia learning. Psychology of Learning and Motivation - Advances in Research and Theory. https://doi.org/10.5926/arepj1962.41.0_27

Mayer, R.E., Heiser, J., & Lonn, S. (2001). Cognitive constraints on multimedia learning: When presenting more material results in less understanding. Journal of Educational Psychology. https://doi.org/10.1037/0022-0663.93.1.187

Mayer, R.E., & Moreno, R. (2003). Mayer 2003. Educational Psychologist.

Nic, N., Fletcher, R., Kalogeropoulos, A., & Nielsen, R.K. (2019). Reuters Institute Digital News Report 2019. University of Oxford.

Nielsen, J., & Pernice, K. (2009). Eyetracking web usability. New Riders.

Oeldorf-Hirsch, A., & Srinivasan, P. (2018). Reflecting on Facebook news posts: Effects of active reflection strategies on knowledge. In 68th annual conference of the International Communication Association (ICA).

Orquin, J.L., Ashby, N.J.S., & Clarke, A.D.F. (2016). Areas of interest as a signal detection problem in behavioral eye-tracking research. Journal of Behavioral Decision Making. https://doi.org/10.1002/bdm.1867

Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive load theory and instructional design: Recent developments. In Educational Psychologist. https://doi.org/10.1207/S15326985EP3801_1

Paek, H.J., Hove, T., Kim, M., Jeong, H.J., & Dillard, J.P. (2012). When distant others matter more: Perceived effectiveness for self and other in the child abuse PSA context. Media Psychology. https://doi.org/10.1080/15213269.2011.653002

Pincus, H., Wojcieszak, M., & Boomgarden, H. (2017). Do multimedia matter? Cognitive and affective effects of embedded multimedia journalism. Journalism and Mass Communication Quarterly. https://doi.org/10.1177/1077699016654679

Pomeroy, R. (2019). Top 100 world news websites to follow in 2019. https://blog.feedspot.com/world_news_blogs/

Schmeck, A., Opfermann, M., van Gog, T., Paas, F., & Leutner, D. (2015). Measuring cognitive load with subjective rating scales during problem solving: differences between immediate and delayed ratings. Instructional Science. https://doi.org/10.1007/s11251-014-9328-3

Sundar, S.S., Kang, J., & Oprean, D. (2017). Being there in the midst of the story: How immersive journalism affects our perceptions and cognitions. Cyberpsychology, Behavior, and Social Networking. https://doi.org/10.1089/cyber.2017.0271

Susac, A., Bubic, A., Planinic, M., Movre, M., & Palmovic, M. (2019). Role of diagrams in problem solving: An evaluation of eye-tracking parameters as a measure of visual attention. Physical Review Physics Education Research, 15(1).

https://doi.org/10.1103/PhysRevPhysEducRes.15.013101

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. Learning and Instruction. https://doi.org/10.1016/0959-4752(94)90003-5

Sweller, J. (2010). Element interactivity and intrinsic, extraneous, and germane cognitive load. Educational Psychology Review. https://doi.org/10.1007/s10648-010-9128-5

Top 100 World News Websites To Follow in 2019. (2019).

Vraga, E., Bode, L., & Troller-Renfree, S. (2016). Beyond self-reports: Using eye tracking to measure topic and style differences in attention to social media content. Communication Methods and Measures. https://doi.org/10.1080/19312458.2016.1150443

Wang, Q., Yang, S., Liu, M., Cao, Z., & Ma, Q. (2014). An eye-tracking study of website complexity from cognitive load perspective. Decision Support Systems. https://doi.org/10.1016/j.dss.2014.02.007

Wang, Z., & Duff, B.R.L. (2016). All loads are not equal: Distinct influences of perceptual load and cognitive load on peripheral ad processing. Media Psychology. https://doi.org/10.1080/15213269.2015.1108204

Yang, F., & Shen, F. (2018). Effects of web interactivity: A meta-analysis. Communication Research. https://doi.org/10.1177/0093650217700748

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