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Functional Headings' Effects on Selective Attention and Reading Processes

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ABSTRACT

Textual devices such as headings convey both content information and functional information. One type of headings is referred to as functional headings, since they provide functional information but not content information. Headings such as "Introduction" denote the function of a text section but not the content information of that section. The current study included three experiments that investigated the processing of functional information during reading. Experiment 1 investigated the effects of functional information in a timed reading situation. Experiments 2 and 3 looked at the effects of functional information when there was a contradiction in the text. Our results indicated that functional information promoted selective attention during timed reading (Experiment 1). Findings from our contradiction manipulation (Experiments 2 and 3) revealed that readers used functional headings to guide their structural reading process. Implications for cognitive processes during reading and pedagogical practices are described in the general discussion section.

La influencia de los encabezados funcionales en los procesos de atención selectiva y lectura

RESUMEN

Las ayudas de texto, como los encabezados, transmiten tanto información de contenido como información funcional. Uno de los tipos de encabezados se conoce como encabezados funcionales, pues proporcionan información funcional pero no información de contenido. Los encabezados como "Introducción" denotan la función de una sección de texto, pero no la información de contenido de esa sección. El estudio actual incluyó tres experimentos que investigaron el procesamiento de información funcional durante la lectura. El experimento 1 investigó los efectos de la información funcional en una situación de lectura cronometrada. Los experimentos 2 y 3 analizaron los efectos de la información funcional cuando había una contradicción en el texto. Nuestros resultados indicaron que la información funcional propició la atención selectiva durante la lectura cronometrada (experimento 1). Los resultados de nuestra manipulación de contradicciones (experimentos 2 y 3) revelaron que los lectores usaban encabezados funcionales para guiar su proceso de lectura estructural. Las implicaciones para los procesos cognitivos durante la lectura y las prácticas pedagógicas se describen en la sección de discusión general.

Expository text is often used as a broad category to describe texts that convey instructional information, such as college-level textbooks. Most research studies related to text processing utilize narrative texts and not expository texts (Lorch, 2015, 2017). This preference is likely because expository texts have more variability in their structures, in the relationship across within-text ideas, and in readers' purposes for reading (Meyer, 1983, 2017). Furthermore, expository texts often include textual devices such as headings that could sometimes denote non-content information such as structural or demarcation information (Chen & Lorch, 2018; Lemarié et al., 2008; Lorch, 1989; Lorch et al., 2013; Lorch et al., 2011a, 2011b). For example, white spaces, such as the space between paragraphs, convey the separation of two text objects. The demarcation

information denotes the separation of content information but does not allow readers to deduce individual paragraphs' meaning or main points. More research is warranted to increase our understanding of the processing of non-content, functional information in expository texts. Functional headings are uniquely positioned to further our current understanding of functional information in expository texts.

SARA: A Theory of Signaling Devices

Expository texts are characterized by their complex structure and presentation of new information (Lorch, 2017). Examples of expository texts include college-level science textbooks or scientific journal articles that adhere to the American Psychological Association

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(APA) style formatting. To aid readers in navigating these complex texts, signaling devices such as headings, paragraph indentation, italicized words, and highlighting are often utilized (Lorch, 1989). A signaling theory known as SARA [Signal Available Relevant Accessible information] has been developed to analyze signals in expository texts systematically (Lemarié et al., 2008; Lorch et al., 2011a, 2011b). SARA examines signals across four dimensions: scope, realization, location, and information function (Lemarié et al., 2008). Scope refers to the extent of text to which a signal points, with examples ranging from the main title of a manuscript encompassing the entire paper to section headings with a narrower scope. Realization involves how a signal expresses its intended message, such as through bold font or underlined words. Location refers to the typical placement of signals in relation to the object of signaling. Information function pertains to the type of information that signals convey, such as topical or structural information within a text. The current study primarily focuses on the analysis of information function within SARA, while also incorporating analyses related to scope, realization, and location.

SARA's proposal identifies seven distinct types of information that signals in expository texts can convey, each with a unique purpose (Lemarié et al., 2008). Demarcation serves as a marker that separates text into different sections, while headings indicate hierarchical organization, distinguishing major text sections from minor ones. Enumerated bullet points, on the other hand, provide sequential organization, while non-enumerated bullet points serve as unique identifiers for indexing information. Signals can also be used to emphasize specific text content through visual contrast, such as bold-type font to make keywords stand out. Topical headings succinctly summarize the content of a section, while function identification signals indicate the purpose of a section without revealing its actual content. Overall, SARA's proposal emphasizes the importance of these various cues, as they aid readers in comprehending and navigating expository texts. Previous studies have tested the effects of six out of seven types of signaling information (Cashen & Leicht, 1970; Crouse & Idstein, 1972; Fowler & Barker, 1974; Lorch et al., 2011a, 2011b; Lorch et al., 1995), but the unique impact of function identification signaling information, conveyed through functional headings, has not been studied yet.

Functional headings are text labels that serve multiple purposes, including indicating the function of a section of the text (Lemarié et al., 2008). For example, in an APA-style scientific paper, a heading like "Method" serves as a functional heading. The "Method" functional heading demarcates structural information and conveys the section's specific purpose, which describes a study's methodology. The current study aims to provide insights into the unique effect of the functional information conveyed by headings. In addition to focusing on isolating functional information, the current study also distinguished between investigating the effects of functional information and content information. Content information refers to information that conveys information relevant to the main topic or the main character but not relevant to the format or purpose of the text. For example, Albrecht and O'Brien (1993) used a narrative text that described Mary being a vegetarian and later ordering a cheeseburger. Participants' reading slowed when they encountered the inconsistency between Mary being a vegetarian and Mary ordering a cheeseburger. The slowing of reading pace when inconsistency is encountered could be due to an error in the integration and validation phase of incorporating new information (Cook & O'Brien, 2019; O'Brien & Cook, 2016; Sonia & O'Brien, 2021). A similar inconsistency effect on reading has also been found in scientific expository texts (Kendeou & van den Broek, 2007; Smith et al., 2021). Readers whose prior knowledge was inconsistent with the scientific refutation text would slow down as they tried to integrate the information. Similar to the studies involving narrative texts, the studies that utilized scientific expository text also focused on inconsistencies with content information. These studies address how readers process texts that convey content information but not

functional and structural information (Cook & O'Brien, 2014; O'Brien & Albrecht, 1991; Trabasso & Suh, 1993; van den Broek & Helder, 2017). The current investigation of functional headings thus directly addressed a distinct issue and explored the underlying processes when readers encounter functional information in the text.

The current study consisted of three experiments aimed at investigating readers' processing of functional headings in different contexts. Experiment 1 focused on a timed reading situation where readers were required to utilize a selective reading strategy. The goal was to examine whether readers could activate their pre-existing knowledge of functional information and use it to focus their attention selectively. Participants in Experiment 1 were placed in a situation that required them to quickly scan the global structure of the text and read selectively. We hypothesized that readers possess pre-existing knowledge about functional headings and could use this knowledge as a navigational guide in a selective reading situation.

Experiments 2 and 3 were variations of a similar manipulation that examined the effects of functional headings on readers' sentence-to-sentence local processing. These experiments specifically looked at the presence of an inconsistency between a paragraph's functional heading and the subsequent section. We hypothesized that readers carry forward functional heading information and use it to process the content of the subsequent paragraph. If an inconsistency is encountered, it would disrupt the reading process and manifest as a slow-down in reading speed. Due to the similarity in the design of Experiments 2 and 3, their findings were reported together.

Experiment 1

One of the questions related to the cognitive processing of reading is how functional headings might affect the active reading process when readers selectively focus their attention. Some text-processing models refer to the active reading process as reader-initiated (van den Broek & Helder, 2017; van den Broek et al., 2005; van den Broek et al., 1995). Other text-processing models refer to this active, reader-initiated process as strategic (Albrecht & O'Brien, 1993; O'Brien & Cook, 2016). The various names are meant to highlight the reader-controlled and reader-moderated part of reading. The reader-initiated process is triggered when a reader encounters a situation that an automated reading process alone is insufficient to achieve comprehension (van den Broek & Helder, 2017). In such a reading situation, the reader engages in an effortful process that requires control and attention allocation from the reader directly. Reader-initiated processes do not always take place in every reading situation and only occur as needed. An example of a reader-initiated process would be re-reading a sentence in the text. A reader who encountered a sentence but was not able to encode and integrate the new information into prior knowledge might deliberately choose to re-read the sentence. This only occurs if the new information fails to integrate with pre-existing information (O'Brien & Cook, 2016; van den Broek & Helder, 2017). The purpose of Experiment 1 was to put readers in a timed reading situation that required readers to use functional headings to engage in an active, selective, and reader-initiated reading process.

A few past studies have looked at the general effects of signals, such as headings, on reader-initiated processes (Lorch et al., 2011a, 2011b). The researchers found that signals' organizational information could enable readers to locate relevant information in the text much faster in a search task (Lorch et al., 2011a). The same organizational information of headings also allows readers to create better outlines after reading (Lorch et al., 2011b). In both instances, signals provide readers with structural information that the readers find useful in an active, reader-initiated task such as searching for information or outlining. Signals also encourage readers to switch their reading

strategies from a linear, sentence-by-sentence method to a more holistic and organizational approach (Lorch, Klusewitz, et al., 1995). These past findings utilized signals that convey content information. Functional headings that convey only functional information should be similarly helpful in a reader-initiated reading process. Functional headings provide global structural information, such as the location of the methodology of a study or the summary section of an exposition (Lemarié et al., 2008). Functional headings also provide demarcation and labeling information to allow a reader to easily separate distinct major sections in a paper (Lorch et al., 2011b). Readers with pre-existing knowledge about functional headings such as "Introduction" or "Summary" could use these headings to navigate a text quickly and accomplish the intended reading goals.

Experiment 1 isolated and specifically tested the function identification property of headings. More specifically, we were interested in seeing how functional information conveyed by functional headings affected the reader-initiated process. In Experiment 1, readers were placed into a timed reading situation with free recall as the intended reading goal. Because the text was long and readers could not read the entire text line-by-line in the given time frame, readers were forced to engage in selective reading. We hypothesized that in Experiment 1's reading situation readers would activate their pre-existing knowledge about functional headings, use the functional headings to selectively target certain text sections, and ignore text sections that were less relevant to the specified reading goal.

Method

Participants

The participants were 120 undergraduate students at a large state university. All participants were native English speakers and received credit as part of their course requirements. Gender and age data were not collected because they were not relevant to the current study. It was assumed that participant demographics would mirror student demographics from the psychology subject pool, with participants' mean age being 22 ($SD = 5.86$) and 80% of the participants being female students.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Internal Review Board of Eastern Kentucky University (000638).

Materials

Two texts were used in this experiment. One text was on the topic of energy problems, and the other text was on the solutions to energy-related problems. Half of the participants received one text, and the other half received the other text. Both texts contained two major text sections and a total of eight minor sections. The first major section contained three minor sections, and the second major section contained five minor sections. The last minor section of each major section was a summary paragraph that summarized all the main points from the section. The major sections were preceded by the headings "Section 1" and "Section 2." Both headings were printed in all caps with boldfaced font and were left-justified. Heading labels were separated from the rest of the text by one line of white space above and below them. The subsections were labeled with the headings "Section 1a," "Section 1b," etc., and were also left-justified but indented and were underlined and typed in the boldfaced font. The corresponding text content began on the same line as the subsection headings and no white space separated the subsections.

Both texts were three pages long, single-spaced, and it was estimated that they would each require participants approximately 12 minutes to read at an average reading pace.

Two versions for each of the two texts were created. These two versions differed only in the labeling of the two summary subsections. In the control version of each text, the two summary subsections were labeled as either "Section 1c" or "Section 2e." In the signaled version of each text, the "Section 1c" and "Section 2e" headings were replaced with the heading "Summary." This manipulation ensured that participants in both the control condition (Section 1c/Section 2e) and the experiment condition (Summary) received functional headings that conveyed the same signaling information (emphasis by bold font, demarcation, labeling, and organizational information) except for the function identification information. One could argue that participants in the experimental condition had functional headings that lacked hierarchical and sequential information. We propose, however, that the headings proceeding the summary paragraphs were part of a holistic system of headings throughout the text. The previous headings such as "Section 1b" and "Section 2d" provided enough hierarchical and sequential information for the readers to deduce the structural and sequence information of the "Summary" headings.

Procedure

The study had a between-group design with one independent variable (Functional Heading) that had two levels (Summary vs. Section 1c or Section 2e). Half of the participants received a text that had the heading "Summary" preceding the two summary paragraphs in the text. The other half of the participants received a text that had the headings "Section 1c" and "Section 2e" preceding the two summary paragraphs.

Small groups of 12 participants were given a packet containing an informed consent form, an answer sheet, and one of two text versions. They were told they had three minutes to read a text that would normally take twelve minutes to read and were instructed to identify the main points because they would be asked to recall them later. Participants read the text, wrote down the main points on a blank sheet without referring back to the text, and were allowed unlimited time for this task. The average duration of each session was about 25 minutes, with session times not varying significantly across conditions.

Results and Discussion

Each noun in a participant's free recall was classified as coming either from the assigned text or not from the assigned text. The words that were classified as coming from the text were further divided into summary words and non-summary words. The scorers were given a list of nouns that were derived from the summary paragraph during the training phase. The number of summary words and non-summary words in each participant's answer sheet was recorded. Two independent raters scored 14 answer sheets to evaluate reliability. Inter-rater reliability from the initial scoring was good ($\kappa = .83$), and the remaining answer sheets were divided between the two scorers to complete the scoring.

We conducted two one-way ANOVAs to analyze participants' recall information. One analysis looked at the effects of text condition (control vs. experiment) on participants' total recall as measured by the total number of nouns derived directly from the assigned text. The second analysis looked at the effects of text condition (control vs. experiment) on the total number of nouns derived from each text's summary sections.

Participants from the control condition and experiment condition recalled similar number of nouns derived directly from the assigned

text (control, $M = 78.45$ words and experimental, $M = 72.73$ words), $F(1, 119) = 1.08$, $\eta_p^2 = .01$. However, the distribution of recalled information from the summary and non-summary paragraphs differed for the two conditions. As predicted, participants who read the control text recalled fewer words from the summary paragraphs ($M = 13.98$, $SD = 16.32$) than participants who read the experimental text with the Summary headings ($M = 24.92$, $SD = 18.56$), $F(1, 119) = 11.60$, $p < .05$, $\eta_p^2 = .09$. Participants who read the control text recalled more words from the non-summary portion of the text ($M = 64.47$, $SD = 32.76$) than participants who read the experimental text ($M = 47.82$, $SD = 33.47$), $F(1, 119) = 7.50$, $p < .05$, $\eta_p^2 = .06$. Our results indicated that readers used the function-identifying headings to focus on the text's main points by allocating more attention to the summary sections. As a result, readers who read texts with the Summary headings recalled more information from the two summary paragraphs.

Experiment 1 was conducted to investigate how functional headings, specifically function identification information, affect reader-initiated expository text processing. In the experimental condition, participants inferred that paragraphs signaled by the functional headings likely contained relevant information for their reading purpose, which was to identify and remember the main ideas of the text. As a result, participants selectively focused their attention on the summary paragraphs and devoted more time to these sections due to the time pressure of the task. Consequently, their recall included a higher proportion of information from the summary paragraphs. These results are consistent with prior research, which suggests that signaling devices enable readers to selectively attend to specific sections of the text (Lorch et al., 2011a, 2011b).

Moreover, the findings of Experiment 1 supported the hypotheses of SARA, as readers correctly utilized the functional heading based on the information function it conveyed and the scope of the information (Lemarié et al., 2008). Readers deduced that the Summary heading signaled the summary paragraph and targeted it within the limited time task, likely drawing on their pre-existing knowledge. These results provide further evidence for the effectiveness of functional headings in guiding readers' attention and comprehension of expository texts.

Experiments 2 and 3

Experiment 1 provided evidence that functional headings and the function identification information they convey could be useful in a reading situation that required selective attention. Participants in Experiment 1 strategically activated their background knowledge about text structure and utilized the functional headings in the experiment condition to achieve their reading goal. Experiment 1, however, did not provide findings concerning the local, sentence-by-sentence linear reading process that differs from an active process involving selective attention. When readers encounter a functional heading in a text as they read sequentially and linearly (sentence-by-sentence), their knowledge about functional headings is activated upon encountering the heading (Albrecht & O'Brien, 1993; Goldman et al., 1995; Lemarié et al., 2008; O'Brien & Cook, 2016). One could presume that mature college-level readers would be knowledgeable of all six types of signaling information that can be conveyed by functional headings (Lemarié et al., 2008; Lorch et al., 2011a, 2011b). The activated knowledge about signaling information is then used to process subsequent information in the body of the paragraph.

Experiments 2 and 3 were conducted using the contradiction paradigm, which has been previously used in other reading-related studies (Albrecht & O'Brien, 1993; Kendeou & O'Brien, 2014; Kendeou & van den Broek, 2005; O'Brien & Cook, 2016). The contradiction paradigm involves inducing a mismatch between new and existing information during the information integration process, which has been shown to result in reduced reading speed as readers attempt to resolve inconsistent information and achieve comprehension.

Experiments 2 and 3 utilized a similar manipulation, where a functional heading was mismatched with the subsequent paragraph. For example, the content of a paragraph might be about the methodology of the study, but the functional heading preceding the paragraph labeled it as "Results." Previous studies have used the information mismatch paradigm to investigate passive resonance processes in narratives (O'Brien & Albrecht, 1991; O'Brien et al., 2010) and narrative-like scientific texts (Kendeou & O'Brien, 2014; Kendeou & van den Broek, 2005), focusing on mismatches related to content information such as characteristics of protagonists or scientific misconceptions that readers might have. However, to the best of our knowledge, no existing study has systematically examined the effects of functional (non-content) information in a sentence-by-sentence linear reading situation. Thus, Experiments 2 and 3 contributed important information to our understanding of text processing beyond the processing of content information. Moreover, these experiments also tested SARA's proposal regarding signals' information function, scope, and location properties. According to SARA, if a functional signal denotes the function of an entire subsequent paragraph in its scope, we should expect reading to slow down if the signaling object contradicts the signal itself. Similarly, if the location of a particular functional signal is not the same as its expected location, we should also expect the reading process to slow down as readers attempt to resolve the inconsistent location information.

Experiments 2 and 3 employed a similar methodology, utilizing the same manipulation of functional headings and content paragraphs, but differed in the level of mismatch between them. In Experiment 2, the mismatch was set between the headings "Introduction" and "Results," which are typically non-adjacent and dissimilar in content in a traditional scientific journal article following APA-style headings. This created a greater level of mismatch. In Experiment 3, the mismatch was set between the headings "Abstract" and "Introduction," which are relatively more similar in content and are adjacent sections in APA formatting, creating a lower level of mismatch.

Based on the notion that readers have a preset level of comprehension based on their reading goal, we hypothesized that readers would be more likely to notice the greater-mismatched headings (Introduction and Results) but not the lower-mismatched headings (Abstract and Introduction). The lower-mismatched headings are likely to be perceived as "good enough" for general understanding, and readers would likely continue reading without being significantly disrupted by the mismatched headings. On the other hand, the greater-mismatched headings are expected to disrupt the reading process and cause a slow-down as readers attempt to integrate and reconcile the contradictory functional information (Albrecht & O'Brien, 1993; Kendeou & O'Brien, 2014; O'Brien & Cook, 2016).

Method

Participants

Participants in Experiment 2 ($n = 86$) and Experiment 3 ($n = 67$) were undergraduate college students from the psychology subject pool at a large state university. Each experiment had unique participants. Participants were all native English speakers. Similar to Experiment 1, it was assumed that participant demographics would mirror student demographics from the psychology subject pool, with participants' mean age being 22 ($SD = 5.86$) and 80% of the participants were female.

Materials and Procedure

Experiments 2 and 3 utilized a within-group design with a single independent variable with two levels (matched versus mismatched).

Every participant read the same 18 texts across the two experiments. Nine of the 18 texts had matched headings, where the functional headings matched the content of the paragraph. The other nine texts had mismatched headings, where two functional headings were switched so that they were mismatched with their signaled content paragraphs.

We created 19 vignettes in the style of scientific journal articles. One vignette served as the sample text during the instruction phase, and the remaining 18 vignettes were used in Experiments 2 and 3. Both Experiments 2 and 3 utilized the same 18 vignettes. The average length of the 18 vignettes was 313 words. Each vignette was written with APA-style formatting and included the corresponding functional headings. The list of functional headings included: Abstract, Introduction, Method, Results, Discussion, and References. The 18 vignettes varied in topics. Examples of topics included “Anxiety and Reading”, “Cellphone Usage and Sleep”, and “Eating Disorders”.

Participants took part in the study in groups of three. Participants first received the experiment description, instructions, and informed consent. The instruction sheet indicated that participants were to read short scientific texts that included APA-style headings. During the instruction phase, participants were given the list of APA-style headings in order (Abstract, Introduction, Method, Results, Discussion, and References). This was done so that participants' prior knowledge of functional headings was normalized. Participants were then instructed to sit in front of the computers and read the sample text. The sample text was controlled by E-Prime 3.0, a psychological research software program. The sample text was released at the pace of one sentence per screen. Each functional heading was treated as a separate “sentence” and appeared by itself on the screen. Participants were instructed to read at a normal pace for understanding. They could advance through the text by pressing the spacebar key on the keyboard. After going through the sample text, participants were asked if they had any questions. Participants were then instructed to read through the 18 vignettes. After participants had finished reading the 18 experimental texts, they were debriefed and dismissed as a group.

Results and Discussion

Experiment 2 (Introduction/Results Mismatch)

Experiment 2 compared participants' reading time (in milliseconds) between the matched and mismatched heading, the first sentence after the heading, and the second sentence after the heading. The two sentences after the heading were analyzed because the mismatch effect might “spillover” from the mismatched heading to the two subsequent sentences (O'Brien & Cook, 2016). That is, a slow-down in reading might not be observed until the reader has begun reading one or two sentences after the mismatched heading. Each text had two target headings (Introduction and Results), two first sentences (first sentence after the target heading), and two second sentences (the second sentence after the target heading). There were also two groups of texts (matched headings versus mismatched headings). The reading times for the nine matched texts were averaged together per participant; average reading times were also calculated for the nine mismatched texts. Every participant thus had 12 averaged reading times (2 Heading-Match Manipulation x 6 Targets-Headings and Subsequent Sentences).

Three separate repeated-measures ANOVAs were conducted to compare mean reading time differences for the target headings, first sentences after the target headings, and second sentences after the target headings. The first analysis examined the effects of Heading Manipulation on reading time for the target headings (matched vs. mismatched). The second analysis looked at the effects of heading

manipulation for the first sentences (matched vs. mismatched) on reading time. The third analysis looked at the effects of heading manipulation for the second sentences. Our results indicated that participants read the mismatched headings ($M = 756.11$, $SE = 26.18$) slower than the matched headings ($M = 675.67$, $SE = 21.47$), $F(1, 85) = 14.29$, $p < .05$, $\eta_p^2 = .144$. The first sentence after the mismatched heading ($M = 5089.55$, $SE = 157.22$) was read slower than the first sentence after the matched heading ($M = 4568.25$, $SE = 137.36$), $F(1, 85) = 18.63$, $p < .05$, $\eta_p^2 = .18$. The second sentence after the mismatched heading ($M = 5215.58$, $SE = 166.83$) was also read slower than the second sentence after the matched heading ($M = 4831.37$, $SE = 156.12$), $F(1, 85) = 5.65$, $p < .05$, $\eta_p^2 = .062$. Table 1 summarized the mean reading times.

Table 1. Mean Reading Times (Introduction & Results Mismatch)

	Matched Heading		Mismatched Heading	
	<i>M</i> (ms)	<i>SE</i>	<i>M</i> (ms)	<i>SE</i>
Heading	675.67*	21.47	756.11*	26.18
Sentence 1	4568.25*	137.36	5089.55*	157.22
Sentence 2	4831.37*	156.12	5215.58*	166.83

* $p < .05$.

Our findings from Experiment 2 revealed that participants' reading time slowed significantly as they encountered the mismatched heading, and this slower reading time continued to the first and second sentences after the mismatched headings. This suggests that functional headings likely triggered participants' pre-existing knowledge about scientific journal articles' global structure and formatting. The manipulation of Experiment 2, which created an inconsistency between participants' knowledge about the order of functional headings in a scientific text and the experiment's stimuli in the mismatch condition, forced participants to engage in a linear reading style instead of the strategic and selective reading style from Experiment 1. When a linear reading process encountered inconsistent information, it required participants to resolve the inconsistency, resulting in the slower reading time of the mismatched headings (Albrecht & O'Brien, 1993; Cook & O'Brien, 2014, 2019; O'Brien & Cook, 2016). While Experiment 1 demonstrated the strategic and selective use of knowledge about global structures and formatting, Experiment 2 showed that a linear sentence-by-sentence reading situation could also trigger the same knowledge about functional headings' global structure.

Other than triggering participants' pre-existing knowledge about global and formatting structure, mismatched headings also affected the processing of subsequent sentences. Participants read both the first and the second sentences after the mismatched headings slower. Similar to the slower reading for the mismatched headings, the slower reading speed of sentences one and two was likely caused by the inconsistent information encountered during the information integration process (Albrecht & O'Brien, 1993; Cook & O'Brien, 2014, 2019; O'Brien & Cook, 2016). Functional headings were used to signal the purpose of an entire section of the text (Lemarié et al., 2008; Lorch et al., 1995). An inconsistent functional heading thus had the potential to disrupt the reading process for an entire text section.

Experiment 3 (Abstract/Introduction Mismatch)

Experiment 2 exchanged the Introduction and the Results headings. These headings signaled non-adjacent text sections and had relatively different content information. Experiment 3 had a similar design as Experiment 2 but exchanged the Abstract and the Introduction headings. These headings signaled adjacent text sections with content information that was relatively more similar than the manipulation from Experiment 2. The results analyses conducted for Experiment 3 were identical to Experiment 2.

Experiment 3's results indicated that our heading mismatch manipulation had no effect on participants' reading time for the headings, $F(1, 66) = 1.21$, $\eta_p^2 = .02$. Participants did not read the mismatched headings ($M = 711.43$, $SE = 20.45$) significantly slower than the matched headings ($M = 688.05$, $SE = 21.99$). The effect size of the ANOVA for Experiment 3's heading comparison was also smaller ($\eta_p^2 = .02$) compared to Experiment 2 ($\eta_p^2 = .144$). Although no significant difference was found in the reading speed for the matched and mismatched headings, a main effect was found with the first sentences, $F(1, 66) = 9.78$, $p < .05$, $\eta_p^2 = .13$. The first sentences after the mismatched headings were read slower ($M = 4855.05$, $SE = 186.51$) than the first sentences after the matched headings ($M = 4441.41$, $SE = 150.71$). This difference continued to the second sentences after the headings, $F(1, 66) = 6.58$, $p < .05$, $\eta_p^2 = .09$. The second sentences in the mismatched headings condition were also read slower ($M = 4348.11$, $SE = 171.15$) than the second sentences in the matched headings condition ($M = 4034.92$, $SE = 169.35$). Table 2 summarized the mean reading times.

Table 2. Mean Reading Times (Abstract & Introduction Mismatch)

	Matched Heading		Mismatched Heading	
	<i>M</i> (ms)	<i>SE</i>	<i>M</i> (ms)	<i>SE</i>
Heading	688.05	21.99	711.43	20.45
Sentence 1	4441.41*	150.71	4855.05*	186.51
Sentence 2	4034.92*	169.35	4348.11*	171.15

* $p < .05$.

The results of Experiment 3 differed from Experiment 2, as participants did not read the mismatched headings slower than the matched headings. Two possible reasons could explain this finding. Firstly, many non-scientific expository texts start with an introduction section without an abstract section, so the mismatched heading manipulation in Experiment 2 violated the genre-specific heading order for scientific texts, but not a more general heading order. It is possible that readers have a preset standard for comprehension level based on their reading goal (van den Broek et al., 1995; van den Broek et al., 2011; van den Broek & Helder, 2017). In Experiment 2, the heading manipulation likely violated readers' preset standard for text coherence due to the misalignment between an Introduction and a Results heading being too disruptive. On the other hand, in Experiment 3, the heading manipulation between an Abstract heading and an Introduction heading was less disruptive and likely did not violate readers' standard of coherence, at least initially.

Secondly, the two manipulated headings in Experiment 3 (Abstract and Introduction) were closer in proximity in the correct APA-style heading order compared to the two manipulated headings in Experiment 2 (Introduction and Results). Furthermore, the content information that followed the manipulated headings in Experiment 3 was relatively more similar to the manipulation in Experiment 2. The closer heading proximity and the more similar content could have caused readers to ignore the initial inconsistency and proceed with hopes of resolving the inconsistency later. Sometimes, readers may continue with the reading process if the initial comprehension is considered "good enough" (Cook et al., 1998; Kendeou et al., 2013; O'Brien & Cook, 2016). As readers moved to the first and second sentences, they encountered content information that contradicted the functional information signaled by the headings. Therefore, readers slowed their reading in the mismatched condition for both the first and second sentences after the target heading. The issue of heading inconsistency was not addressed until readers encountered subsequent "spillover" sentences (O'Brien & Cook, 2016). Similar to Experiment 2, participants in Experiment 3 were likely attempting to resolve the inconsistency between content information and the mismatched functional headings. However, unlike previous studies, readers in Experiment 3 were unable to resolve the inconsistency

even through the second spillover sentence. The continued slower reading likely indicated that readers continued to use the functional information signaled by the mismatched heading to process the content information of the entire text section.

The findings from Experiments 2 and 3 have significant implications for the signal processing theory. These experiments have demonstrated that signals influence reading, both when readers actively and selectively focus their attention (e.g., Experiment 1) and when they read linearly from one sentence to the next. In contrast to Experiment 1, where readers were motivated to selectively focus on functional headings and navigate the text accordingly, readers in Experiments 2 and 3 likely encountered functional headings without a clear selective attention strategy and were not motivated to engage in effortful active processing. In the situation of linear sentence-by-sentence reading, functional headings activated readers' pre-existing knowledge, and readers could use that knowledge to process the subsequent paragraph.

General Discussion

The current study investigated the effects of functional headings on readers' selective reading process and sentence-by-sentence linear reading. In Experiment 1, readers' usage of functional headings was examined in a reading situation that required strategic and selective reading. The findings from Experiment 1 revealed that readers strategically chose to focus on certain parts of the text based on the functional information provided by the headings. Experiments 2 and 3 explored the effect of functional headings in a linear line-by-line reading situation. The findings from Experiments 2 and 3 indicated that inconsistent functional information disrupted the reading process, but the degree of disruption depended on the level of inconsistency. When the functional inconsistency was not too great, readers might consider the inconsistent information "good enough" and move on, with the slowdown effect from inconsistent functional information not appearing until one sentence after the inconsistent heading. The overall findings from the three experiments suggested that functional information is useful in both reader-initiated strategic reading and line-by-line reading, where headings are used to process subsequent information.

The current study makes a valuable contribution to the field of reading research by providing novel findings on readers' processing of functional information (Kendeou & O'Brien, 2014; Kendeou & van den Broek, 2005; O'Brien & Cook, 2016; van den Broek et al., 2001). These findings fill a gap in previous research that had primarily focused on content information processing (Albrecht & O'Brien, 1993). Building on the work of Lorch et al. (1995), who demonstrated that signals like headings promote the adoption of a structural processing strategy during reading, the current study further supports the role of functional information in guiding readers' processing (Kintsch, 1988; Kintsch & van Dijk, 1978). Specifically, readers not only attend to content information but also to functional information in their efforts to construct a coherent macrostructure representation of the text. They use functional information to guide their processing of subsequent information, and inconsistencies between functional information and subsequent content information can disrupt the building process of the text representation. Moreover, readers also rely on functional information, in addition to hierarchical and organizational information, to selectively attend to information as they construct a coherent text structure. Thus, the findings of this study significantly advance the field of reading research and signaling theory (Lemarié et al., 2008). It also provided empirical evidence of the effects of SARA's seventh type of information, which had not been previously addressed (Lorch et al. 2011a, 2011b).

Teaching the usage of functional information and functional headings could benefit learners in at least two areas. First, findings

concerning functional headings and functional information processing would provide useful information for reading intervention programs that teach text structure awareness (Rapp et al., 2007). Explicit instruction on text structure awareness has been found to increase students' recall of main ideas from the text (Taylor, 1982; Taylor & Beach, 1984; Taylor & Samuels, 1983). Although most research on teaching text structure focuses on shorter expository texts in problem/solution or cause/effect formats, knowledge about functional information and functional headings could be useful when students are reading lengthier academic materials such as textbooks. Familiarity with functional information in the text could allow readers to search through a text faster, develop better reading strategies, and recall more information from the text (Reder & Anderson, 1980; Rouet & Bigot, 2007; Rouet & Coutelet, 2008). For example, functional headings could allow readers to selectively attend to the methodology section of a scientific article if the reader is interested in replicating the study. This could be beneficial not just for younger readers but also for adults, given that close to 20% of adults in the United States meet only basic reading proficiency levels (National Center for Education Statistics [NCES], 2017; Pressley & Harris, 2006).

Another possible educational application of teaching functional information is with writing interventions. Most research that uses knowledge of text structure to guide writing instruction focuses on teaching expository and narrative text structures (Graham & Perin, 2007). However, incorporating information about functional headings as part of writing instruction could allow novice writers to think more about their audiences and whether their writing will enable readers to navigate the document easily. For example, writers could use headings such as "Introduction" to denote text sections and organize their writing accordingly.

The current study had several limitations. First, the current study utilized undergraduate psychology students as study participants and investigated the processing effects of APA-style functional headings in Experiments 2 and 3. It was not clear if similar processing effects would be found in other formatting styles (e.g., MLA or Chicago style) or non-specific types of expository texts (e.g., college textbooks). Future studies could look at functional information processing in other text genre types. Second, Experiments 2 and 3 placed readers in a line-by-line reading situation. Most natural reading situations allow readers to skip ahead or re-read a previous sentence instead of forcing readers to proceed in a line-by-line fashion. Future studies could attempt to replicate the current findings using more natural and less intrusive study designs. Third, Experiment 1 only investigated one type of functional heading (Summary) and did not provide information on other types of functional headings (e.g., Introduction, Conclusion, etc.). We propose that although there were many examples of functional headings, they should all exhibit strong reader-initiated processing in relevant reading situations. Replications of Experiment 1 with other examples of functional headings should yield similar results. Fourth, participants' age and gender information were not collected. Although gender and age are not likely to affect the current experiment, future studies should consider collecting participants' age and gender information. Fifth, the participants in the study were all college students in the United States. Findings might differ with participants from a different culture or from participants who might not be college students. For example, individuals who did not receive a college degree might not have the pre-existing knowledge about functional headings to notice a contradiction manipulation. Similarly, some languages, such as traditional Mandarin Chinese, could be presented vertically from right to left. Readers of Mandarin Chinese might respond very differently to the type of signaling manipulations from the current experiment. Despite these limitations, the current study provided robust evidence for readers' usage of functional information in both a reader-initiated reading process and a local sentence-by-sentence reading process.

Conflict of Interest

The authors of this article declare no conflict of interest.

Note

The datasets generated during and/or analyzed during the current study are available in the OSF repository https://osf.io/y4m3e/?view_only=44dccc1bd09ca4d2f8670fc9dff3bb035

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Appendix

Sample Text from Experiments 2 and 3 (Control Condition) Online Disinhibition Effect

Abstract

The online disinhibition effect refers to the fact that individuals are more likely to express negative comments in an online setting. This study investigates the effects of priming using red letters to decrease negative comments online. The results indicate that red-letter priming is effective in reducing negative comments.

Introduction

Online disinhibition involves the expression of negative comments and has been a problem for online communities for many years. Several online gaming providers have tested the possibility of using short priming messages to reduce negative comments and behavior. This study seeks to replicate the effect in a simulated online classroom discussion forum.

Method

A total of 300 participants from a large state university participated in the study. Participants were first given a gender-biased description that equates physical attractiveness and happiness. They were then prompted to express their opinion in response. Some participants received the prompt in red that reminded them to be professional and courteous, and some participants received a generic prompt to post their thoughts. The number of negative comments expressed was recorded.

Results

The results indicated that the number of negative comments was affected by the priming manipulation. Participants who were in the red priming prompt condition expressed half as many negative comments as those in the control condition. The results indicated that priming manipulation was effective.

Discussion

Past studies have shown that red priming inhibits behavior. The current study further confirms this idea and has shown that red-letter priming could be effective in inhibiting negative online comments. Future studies could investigate other methods of priming to decrease online negative comments.

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