Breaking Off Engagement: Readers' Disengagement as a Function of Reader and Text Characteristics

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ABSTRACT
Engagement during reading can be measured by the amount of time readers invest in the reading process. It is hypothesized that disengagement is marked by a decrease in time investment as compared with the demands made on the reader by the text. In this study, self-paced reading times for screens of text were predicted by a text complexity score called formality; formality scores increase with cohesion, informational content/genre, syntactic complexity, and word abstractness as measured by the Coh-Metrix text-analysis program. Cognitive decoupling is defined as the difference between actual reading times and reading times predicted by text formality. Decoupling patterns were found to differ as a function of the serial position of the screens of text and the text genre (i.e., informational, persuasive, and narrative) but surprisingly not as a function of reader characteristics (reading speed and comprehension). This underscores the importance of mining text characteristics in addition to individual differences and task constraints in understanding engagement during reading.

Keywords

Coh-Metrix; comprehension; decoupling; engagement; formality; genre; mind wandering; reader characteristics; reading; text characteristics.

1. INTRODUCTION
Engagement during reading is essential for comprehension and learning [1]. Methods for gauging engagement include measuring time invested in the reading process and eye tracking [2-5]. We hypothesize that when mind wandering or other forms of disengagement occur, there is a marked decrease in time allocation; text characteristics then have little impact on reading times. The disjoint relationship between textual demands and time investment is termed decoupling. Cognitive decoupling is defined as the difference between actual reading times and reading times predicted by text characteristics.

This study investigates how engagement changes as a reader progresses through screens of text in moderately lengthy documents. Changes are expected to be moderated by characteristics of reader and text. Relevant reader characteristics included overall reading speed and comprehension; text characteristics included text difficulty and genre.

1.1 Text Difficulty
Text difficulty can been scaled in a variety of ways, validated by predicting grade levels of text and performance on psychometric tests of comprehension [6]. The Flesch-Kincaid Grade Level formula is a readability assessment based on word length and sentence length [7]. The Coh-Metrix tool analyzes text on multiple levels of language and discourse using computational linguistics techniques [8, 9]. Graesser et al [10] have introduced formality as a composite measure of text difficulty based on Coh-Metrix higher order principal components. Formality has a high correlation (0.72) with Flesch-Kincaid Grade Level. Discourse formality is calculated as a mean of five Coh-Metrix principal components having positive values for increasing levels of difficulty. These include: (1) referential cohesion; (2) deep (causal) cohesion; (3) informational content; (4) syntactic complexity and (5) word abstractness. Normative values (z-scores) for these 5 factors and formality are based on the TASA corpus. These norms are used to compute difficulty scores on new texts that researchers wish to analyze.

1.2 Genre and Order of Information
Genre is a discourse feature that is expected to influence engagement as well as text difficulty. Narrative texts are considered the most intrinsically engaging genre for most readers; and least difficult, compared with informational texts [6], [9], [11, 12]. Persuasive texts lie in-between narrative and informational text in expected difficulty and engagement.

The order of information presented in the text is also expected to influence engagement as well as text complexity. Readers begin engaged with a text, but may eventually lose interest and disengage as the text progresses. Research is needed to document the time allocated to texts at different points in the text. Interestingly, basic research questions have not yet been investigated at a fine grained level. Available research has only compared mind wandering as a function of texts that vary in difficulty as entire texts and these

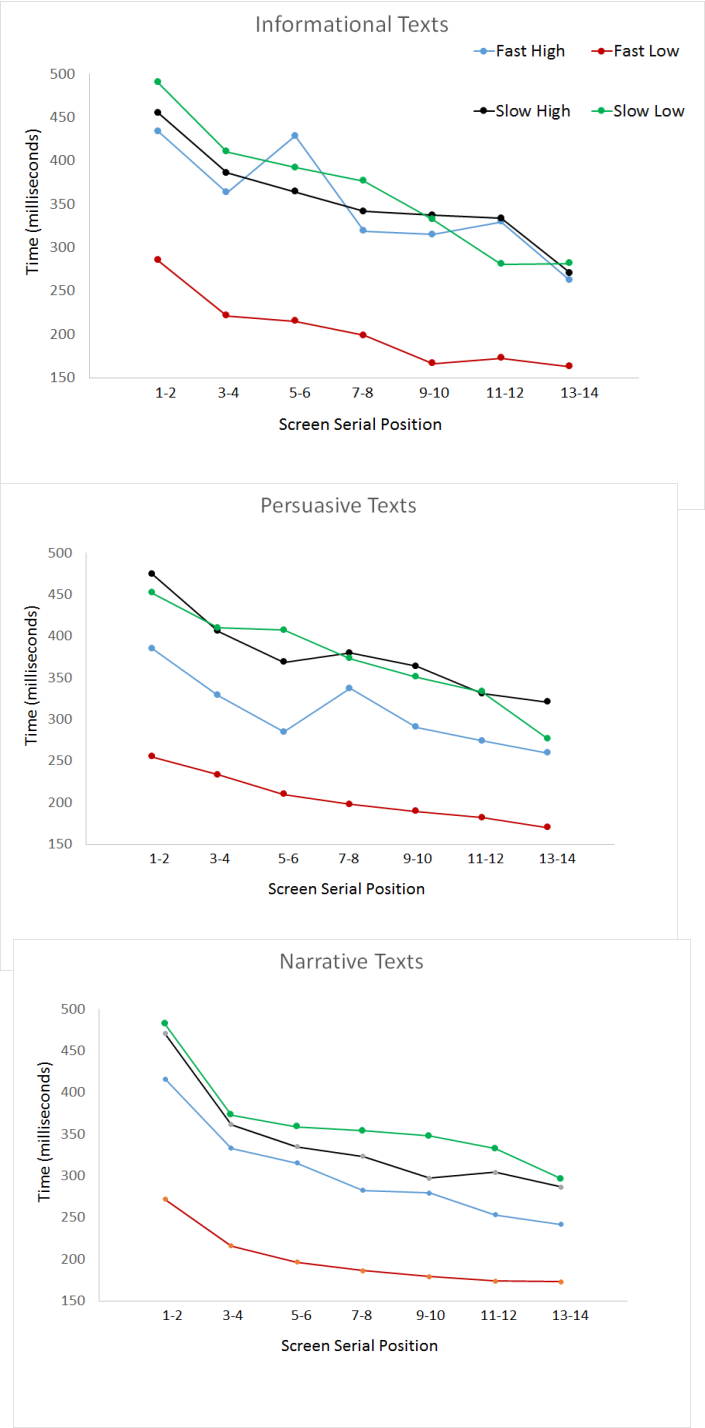

Figure 1. Reading Time per Word as a Function of Screen Serial Position, Segregated by Genre and Reader Type

studies are not consistent with respect to mind wandering increasing or decreasing with text difficulty [13].

1.3 Decoupling

Cognitive decoupling is a discrepancy between textual demands and the time a participant invests in reading a text. Decoupling increases as a function of the readers' disengagement with the text. Decoupling in this study is measured as the difference between actual reading times and times predicted by text characteristics. We interpret positive decoupling scores to indicate that a participant is investing more time in reading a text than the text characteristics demand. According to our assumptions, negative values of decoupling represent a participant investing less time than text characteristics' demands. The Coh-Metrix formality z-scores were used to measure text difficulty of a text, as normalized by the TASA corpus. Analogously, the reading time for each text segment was normalized through z-scores for individual readers on the mean reading time per word for the text segment under consideration (compared with the other text segments for that individual). Decoupling is normalized reading times for a particular person minus the normalized text difficulty based on the TASA corpus.

We predict that decoupling scores will become more negative or less positive as a reader progresses through a text, corresponding with a decrease in engagement. However, previous research [14] has not identified the shape of this decreasing function for different categories of texts and readers. These effects are predicted to be moderated by reader characteristics and genre.

2. METHODS

This study had 254 participants in two groups: 128 participated online via Mechanical Turk; 126 undergraduate Psychology students participated in a lab study.

Participants were classified according to reading time and comprehension using the Nelson Denny assessment with median split criteria. Participants read one text from each of three genres in counterbalanced order; texts assigned were randomly sampled from 24 informational, 24 persuasive, and 25 narrative texts. Following reading, participants wrote a 75-100 word summary of each text; then rated the familiarity, value, and interest for each text.

Participants used the spacebar to advance through each screen, providing reading time measurements Self-paced reading times were measured as average time per word in milliseconds for each screen of text. The number of words per screen ranged from 79 to 131, with a mean of 88.8 and a standard deviation of 11.0. The number of screens ranged from 10 to 23 per text.

3. RESULTS

3.1 Word Reading Times as Function of Text and Reader Characteristics

Mean reading times per word are presented as a function of serial position of screens of text, through position 14. Figure 1 shows times for informational (1a), persuasive (1b), and narrative texts (1c). Participants are segregated into slow versus fast readers and high versus low comprehenders.

In Figure 1, reading time functions are similar for readers with differing comprehension levels and reading speeds. We fit linear functions to each reader's times as a function of serial position, performing an ANOVA on the slopes. As expected, the slopes were negative, reflecting serial reading time decreases. A significant effect appeared in the Genre x Reading Time x Comprehension ANOVA: the slopes were lower for fast than slow readers, $F(1, 748) = 16.54$, $p < .001$. Intercepts were lower for fast readers, $F(1, 748) = 153.93$, $p < .001$. No other significant effects or interactions appeared, indicating individual differences had minimal impact on raw reading time functions. Predicted reading time per word on a page RT' follows the function: RT' (milliseconds per word) = 536 -10 * serial position (SP) of screen.

There did appear to be a dip in early serial positions and then a leveling off. Therefore we fit a quadratic equation to the reading time data. When averaging over the reader groups, the resulting

predictive equation was RT' = 409 + -23* SP + 88*SP^2. The improvement in the quadratic equation over the linear function was small when fitting curves to mean data points, R^2 = 0.97 versus 0.88, respectively. Moreover, the only coefficient that showed any differences in the Genre x Reading Time X Comprehension ANOVA was the intercept, which was lower for faster readers, F (1, 748) = 79.95, p < .001 In summary, the raw reading times showed decreases over serial position and a slight quadratic trend, but did not unveil differences in genre or individual differences.

3.2 Formality as a Function of Text Formality and Genre

It is possible that the above trends in decreasing reading times over serial position could be explained by characteristics of the text, as opposed to the readers' strategies (implicit or explicit) in allocation of reading time. We conducted an analysis of formality scores as a function of serial position, segregating the three text genres. These formality scores are plotted in Figure 2 for serial positions 1-14. The slopes for each genre were essentially flat as a function of serial position, with mean slopes of 0.00, 0.07, and 0.11 for informational, persuasive, and narrative texts, respectively. Therefore, decreasing trends in reading times cannot be attributed to systematic changes in text characteristics over serial positions.

In contrast, formality scores differed by genre, as consistent in previous studies [10]. The mean formality scores were 0.18, 0.09, and -0.26 for informational, persuasive, and narrative texts, respectively. These differences were significantly different, p < .001, showing the predicted ordering of informational > persuasion > narrative. Therefore, text characteristics varied over genre but not serial position.

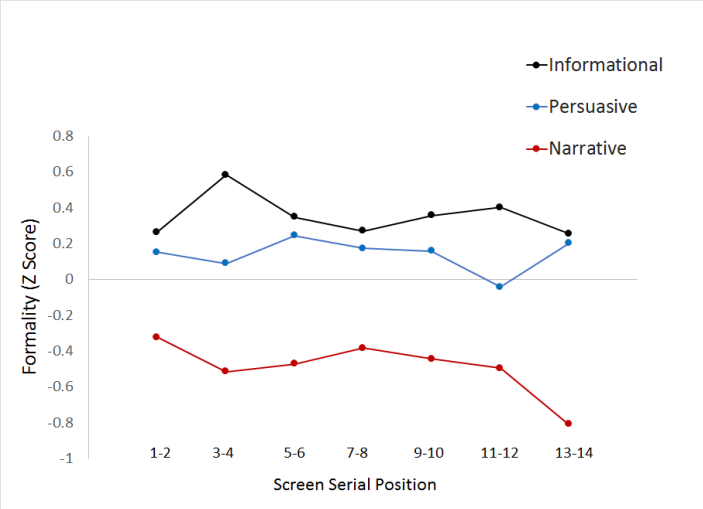

Figure 2. Formality as a Function of Screen Position, Segregated by Genre

3.3 Decoupling as a Function of Genre, Serial Position, and Reader Characteristics

It is possible that decoupling, rather than raw reading times, provides a more sensitive approach to analyzing disengagement. Figure 3 shows the decoupling scores for informational (3a), persuasive (3b), and narrative texts (3c). The participants are segregated into slow versus fast readers and high versus low comprehenders. As in the raw reading times, there did appear to be a dip in early serial positions and then a leveling off with a slow descent. The only exception was a slight upward trend for the narrative texts at the very end. When we fit a linear function to all of the participants for all of the texts, the best fit regression line yielded an R^2 =.63. A quadratic equation had a significant increase in variance explained of R^2 =.88. The best fit function was Decoupling' = 0.835 -0.204*SP + 0.010*SP^2. When we conducted a Genre x Reading Time x Comprehension ANOVA, there was only one significant effect. There was a significant effect of genre for the three coefficients in the quadratic function: F (2, 748) = 36.37; F (2, 748) = 8.46, p < .001, F (2, 748) = 11.00, all p < .001. There were no significant individual differences (reading speed or comprehension) and no interactions.

4. DISCUSSION

This study has revealed how reading times and cognitive decoupling are significantly influenced by text characteristics, namely genre and the serial position of information in the text. The pattern of results showed higher engagement (reflected in decoupling scores) in the first few screens of text and a subsequent decrease over the serial position of the screens. The deepest engagement is in the first 200-400 words, then noticeably decreases and slowly decreases thereafter (aside from an interesting upsweep for narrative texts). The quadratic function captures this trend and shows a better fit than a linear trend. It is of course strategically wise to pay attention to the early text segments because that is a critical point when the situation model is set up [11, 14], and the reader can make judgments whether the text is interesting or important to continue reading [1]. It is important to acknowledge that text difficulty is not comparatively high in early text segments, as shown in Figure 2, so increased time allocation at the beginning of a text cannot be attributed to text difficulty.

Regarding decoupling scores, text formality and difficulty show the following trend compatible with previous research using Coh-Metrix [2, 10]: informational > persuasive > narrative. However, cognitive decoupling showed the opposite ordering, such that readers tended to over allocate reading times to narrative text and under-allocate for the difficult informational text. In essence, there was a tendency to have lower engagement when the text was more difficult. The role of text difficulty has also been found to predict mind-wandering during text comprehension [13, 15] and listening to lectures [16], but the jury is still out as to (a) whether mind wandering is more prevalent in discourse that is very easy or very difficult and (b) what level of discourse analysis is most diagnostic of mind-wandering. Future research awaits an analysis of the impact on decoupling as computed via a deviation between reading time and formality and mind wandering.

5. ACKNOWLEDGMENTS

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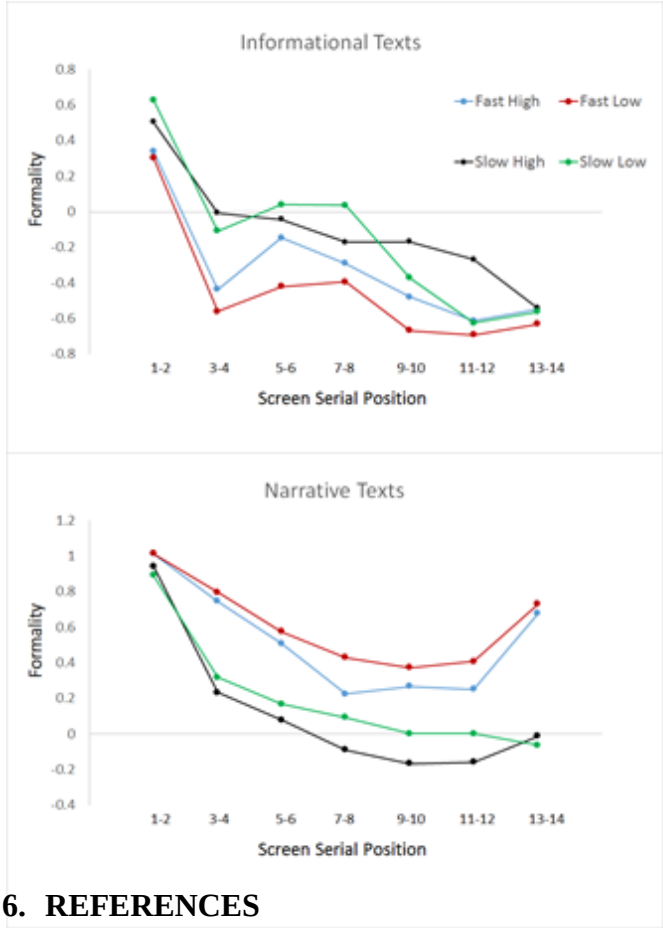

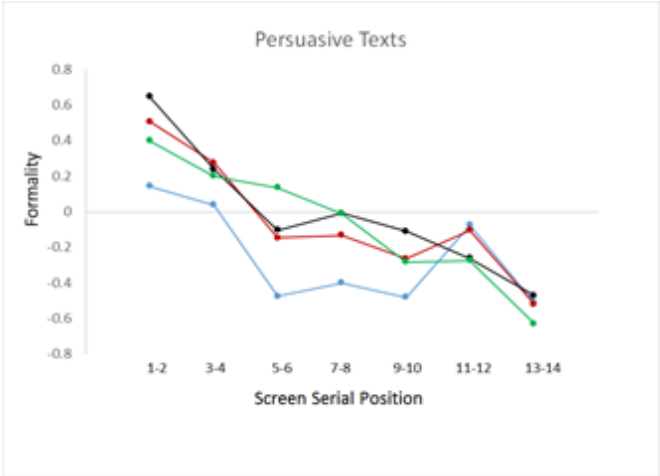

Figure 3. Decoupling by Formality as a Function of Screen Position, Segregated by Reader Type

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