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Effect of Text Difficulty on Mind Wandering and Reading Comprehension: A Systematic Review

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People often experience mind wandering during reading which leads to attention lapses and difficulties in comprehension making it a cause of concern. This systematic review was an attempt to investigate the effect of task demand on mind wandering and reading comprehension. It seeks to analyze how text difficulty affects the patterns of mind wandering and how it interacts with individual differences during a reading comprehension task which could impact mind wandering. Following PRISMA guidelines a systematic search was carried out using four academic databases Web of science, Scopus, PubMed, JSTOR for selecting and screening the articles, six articles were found to be eligible for current review and were analyzed based on their results. Text difficulty along with participant related factors seem to affect both voluntary and involuntary mind wandering as well as the direction of this relationship which varies with respect to variables like text difficulty, text length, working memory capacity, attentional control, text interest and prior knowledge. This review highlighted that rising difficulty increased mind wandering which explains the negative impact of text difficulty on reading comprehension. It also suggested that no single theory of mind-wandering can fully account for the interaction between text difficulty and mind-wandering instead different theories explain certain aspects of the mechanism. Situation model view, executive control hypothesis, cognitive -flexibility hypothesis emerged as potential explanations to this dynamic relationship.

Keywords: Text difficulty, Mind Wandering, Reading comprehension, Individual differences.

Mind wandering has emerged as a rapidly evolving phenomenon in psychological research over the past few decades (Callard et al., 2013, Szpunar et al., 2013, Smallwood & Schooler, 2015, Christoff et al., 2018). Its growing popularity stems from its widespread relevance to everyday life experiences (Song & Wang, 2012, Smallwood & Schooler, 2015, Baird et al., 2011). For instance, from students zoning out during lectures to adults daydreaming while driving, to elderly individuals ruminating while reading newspapers, mind wandering affects people across various age groups and activities. This tendency to drift towards thoughts unrelated to the current task is particularly prevalent during reading, making it a significant concern for comprehension and retention of information (Feng et al., 2013, Smallwood & Schooler, 2015, D'Mello & Mills, 2021,). We face episodes of mind wandering and daydreaming while performing a number of tasks in our day-to-day life, but this tendency is often observed while reading. The intricate relationship between mind wandering and reading comprehension is characterized by its multifaceted nature. When readers experience mind wandering, they encounter interruptions in the continuous flow of textual information, resulting in attentional lapses, difficulties in articulating written content, and diminished retention (McVay & Kane, 2012). Furthermore, the complexity of this

relationship is exacerbated by individual variations in working memory capacity and attentional control, which can significantly influence an individual's susceptibility to mind wandering (Unsworth & McMillan, 2013). These factors collectively contribute to the intricate interplay between cognitive processes and reading comprehension outcomes.

Reading comprehension, defined as the ability to understand, analyze, and interpret written text, is a complex process essential for academic success and many aspects of daily life. Several theories attempt to explain the reading process, including the Simple View of Reading and the Construction-Integration Model. The Simple View (Hoover and Gough, 1990) posits that reading comprehension results from the interaction of decoding ability and linguistic comprehension. The Construction-Integration Model (Wharton and Kintsch 1990) proposes that comprehension involves three core components: lexical (word and sentence level), text base (paragraph level), and situation model.

The phenomenon of mind wandering has garnered increasing attention in recent research, with studies exploring its complex relationship to cognitive processes. A comprehensive review by Mooneyham & Schooler (2013) examined the costs and benefits associated with mind wandering highlighting its detrimental impact on reading comprehension and its interference with model construction during reading (Mooneyham et al.2013). Building on this, Randell's (2014) theory-driven meta-analysis provided supporting evidence for the resource theory of mind wandering, revealing a more pronounced negative relationship between mind wandering and task performance based on task complexity rather than duration.

Recent meta-analytical findings on mind wandering and reading comprehension suggest a dynamic interplay between these two cognitive processes. This relationship can be conceptualized as a seesaw effect, where reading comprehension and mind wandering occupy opposite ends of a cognitive balance. As one process intensifies, the other correspondingly diminishes, illustrating the intricate and inverse nature of their interaction.

Differences in the frequency and duration of mind wandering can be affected by a variety of factors as suggested by previous reviews, however this review delves deeper into one variable i.e. text difficulty and tries to assess what other variables are related to it. Although previous studies have included text difficulty as potential moderating variable between mind wandering and reading comprehension, it does not clearly mentioned how text difficulty was measured, and how different levels of text difficulty affects patterns of mind wandering and direction of this relationship, Thus, a dearth of comprehensive reviews was observed which focus on assessing text difficulty on a single standardized criteria in order to recognize its effect on mind wandering.

Earlier reviews took all the methods of assessing mind wandering like 'trait-based mind wandering', 'experience sampling' and 'self-report measures' but it has been seen that different methods to assess mind wandering can give varying results, hence a single method should be adopted as a measure of mind wandering in order to make results more comparable. Also, previous reviews have not explored differences in voluntary and involuntary mind-wandering based on the difficulty of the text, which needs to be analyzed. Thus, this systematic search is an attempt to address these voids in the literature. This review primarily assesses how text difficulty impacts patterns of mind wandering during a reading comprehension task and what participant related characteristics in turn affects this relationship.

This knowledge can inform the development of effective reading strategies and interventions to enhance comprehension and retention of information across various contexts, from academic settings to everyday reading activities. The insights gained from this review may prove valuable for educators, researchers, and individuals seeking to improve their reading experiences and outcomes. By addressing the factors that contribute to mind wandering during reading and their impact on comprehension, this study can contribute to the development of targeted interventions and strategies to support effective reading practices in an increasingly information-rich world.

Method

Study Criteria

The experimental studies selected for this review purpose were which analyzed the effect of text difficulty on mind wandering among healthy participants, whereas studies on clinical sample were excluded. Only those studies that used Flesch-Kincaid grade level scores as measure of text difficulty were included as it provides a parameter to quantify text difficulty and maintain methodological heterogeneity. Likewise, studies assessing mind wandering using thought probes were included (other measures of mind wandering, e.g. 'self-caught' and 'trait-based' measures of mind wandering were excluded) as literature suggested that different methods of measuring mind wandering can give varying results (Bonifacci et. al., 2022), this review has focused on 'probe -caught' method of mind wandering assessment. Studies which used any tasks other than reading comprehension (e.g. SART, recall tasks, cognitive flexibility) were excluded. Studies having physiological markers of mind wandering (e.g. Eye-tracking, fMRI studies) alone, without any probe-caught measures were not included in this review. Articles that are review studies, including previous systematic reviews or meta-analyses, were excluded from direct analysis but may be used for identifying additional primary studies.

Literature sources and Search Strategy

This review was carried out following the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) checklist for selecting and screening the articles to identify studies reporting the influence of text difficulty on mind wandering and reading comprehension. Four academic database Web of science, Scopus, PubMed, and JSTOR were searched. The search terms used included three main domains, words related to mind wandering (mind wandering, daydreaming, Task independent thoughts, zoning out), text difficulty (task demand, text difficulty, text length) also terms related to Reading Comprehension (reading comprehension, reading, comprehension, RC). Boolean operators OR and AND were used to ensure studies including terms from all the categories were identified. All searches were performed at the abstract, subject and title levels of the databases. Appropriate filters specific to the database were used. The search was restricted to English language peer-reviewed journal and grey literature was not included in the study.

Study Selection

Two authors independently searched for keywords on the mentioned databases and fetch all the articles. All the articles were screened for their eligibility in the study according to the mentioned inclusion and criteria, Articles were first retrieved on the basis of title and abstracts. Then full-text of the articles measuring the effect of task demand on mind wandering in a reading comprehension task were studied. Both the authors independently completed the full-screening process and any disagreements were resolved with discussion with an independent reviewer.

Results

The search led to a total of 2,542 papers (124 on scopes, 1,626 on Web of Science, 180 on PubMed, 225 on JSTOR and 387 on Wiley online library). 376 studies were dropped after removing duplicates and other reasons. After assessing the title, abstract and key words, 1,981 studies were removed from the pool, bringing the total of relevant studies for the present review down to 185. These studies were sought for retrieval and almost all the studies were retrieved. These studies were then screened for eligibility in the present review. Among these studies 160

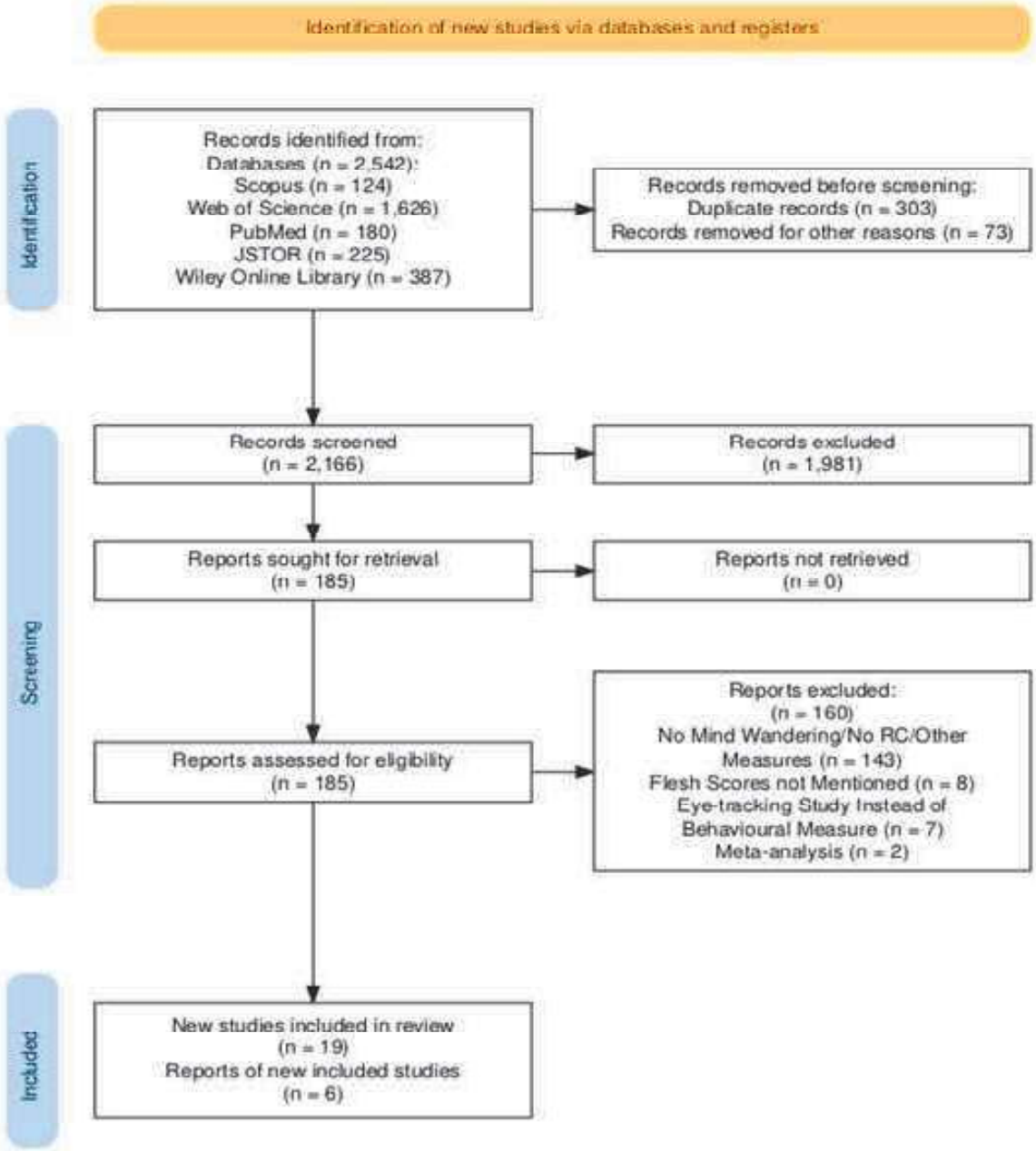

Figure 1. PRISMA flow diagram of study selection process for systematic review

studies were not eligible for studies as 143 studies were either not reporting mind wandering or using measures of mind wandering other than thought probes. Likewise, 8 studies did not mention flesh kin grade scores while manipulating text difficulty. Furthermore 7 studies used eye-tracking to trace mind wandering instead of thought probes and two of them were meta-analysis. Thus, 19 studies were read and only 6 studies full-filled all the eligibility criteria and were finally included in the review.

Characteristics of studies included

All the eligible papers are summarized in Table 1, which describes how text difficulty was assessed, type and content of text used in reading comprehension task, age group included in the study sample, what participant related factors were included, what were the major findings of the study. In terms of location, most of these studies were from USA, Canada and Neatherland. Every study was published after undergoing peer review between 2013 and 2022. In terms of outcome measures reading comprehension task performance and mind wandering were reported in all studies.

Effect of Task Characteristics on Mind wandering

Text difficulty

Studies revealed that there is high mind wandering in case of difficult text condition as compared to easy text condition (Feng et al., 2013; Kahmann et al., 2022; Schurer et al., 2020; Soemer & Schiefele, 2019). Also, in accordance with previous literature studies included in this review suggest that mind wandering has a negative relationship with text comprehension which is more prevalent for high text demand (Feng et al., 2013; Soemer & Schiefele, 2019).

Text length

A prominent question which appears when investigating MW and RC is weather text length also seem to effect text comprehension. Findings indicate that that longer sections of text increases unintentional mind wandering, although it does not have any significant impact on intentional mind wandering (Forrin et al., 2021).

Effect of participant related characteristics on Mind wandering

Past literature has identified some variables which appears to be inextricably related to mind wandering and reading comprehension, working memory capacity (WMC), prior knowledge, perceived topic difficulty, text interest (Schurer et al., 2020; Kahmann et al., 2022, Soemer & Schiefele, 2019).

Working Memory Capacity and Attentional control

Prior studies have documented that the vulnerability to mind wander moderates the relationship between attentional control, working memory capacity and reading comprehension (McVay & Kane, 2012). According to Schurer et al., 2020 high working memory participants clearly outperformed the low working memory capacity participants in reading comprehension task. It warrants emphasis that effect of text difficulty on mind wandering is modulated by WMC such that high WMC participants showed less mind wandering compared to low WMC participants in case of high text difficulty or low coherence condition (Schurer et al., 2020).

Text interest and Prior knowledge

Another significant variable that has been repeatedly related to mind wandering and reading comprehension is text interest. It has been found that text interest moderates the relationship between mind wandering and text difficulty (Kahmann et al., 2022; Soemer & Schiefele, 2019). Such that when text interest was low there was high negative effect of text demand on mind wandering and reading comprehension. Prior knowledge

does not have a significant impact on mind wandering, increased content knowledge was found to have a positive impact on reading comprehension however it does not modulate the rate of task unrelated thoughts (Schurer et al., 2020).

Direction of Relationship

According to Soemer & Schiefele (2019), the association between voluntary mind-wandering and text difficulty is typically characterized as U-shaped, the study employed only two levels of text difficulty. This suggested mind wandering occured when the task demand was either too low or too high but not when task has moderate level of difficulty. Kahmann et al., (2022) retested the direction of relationship between mind wandering and reading comprehension. In this study they designed 10 passages of increasing difficulty from very easy to very difficult, instead to traditional approach of two or three levels of difficulty and it was found that mind wandering increased linearly with text difficulty, and text interest moderated this relationship although there existed some methodological differences, these results highlight a contrasting picture. It has been consistently found in literature that reading difficult text increases both voluntary as well as involuntary mind wandering voluntary mind-wandering shows minimal impact after controlling for topic interest (Soemer & Schiefele, 2019).

Study	Schurer, Bertam Opitz, Torsten Schubert	Soemer, A. ; Schiefele, V.	Kahmann, R; Ozuer, Y ; Zedelius, CM Bijleveld, E	Forrin et. al	Feng Shi; D'Mello Sidney; Graesser Arthur C.
Year	2020	2019	2022	2020	2013
Number of participants	90	216	97	80	80
Age	23.80 (mean age)	18-37	18-30	18-22	University students
Text used	Expository hyper-text about copyright law, covering topics like authorship, limitations and exceptions, copied material amounts, and infringements	Three expository texts: 'the origins of wind' (physics), 'market bubbles' (economy), and 'semantic networks' (psychology)	Ten non-fiction text passages about animals and politics, gathered from popular-science magazines and scientific journals	Eight Academic passages derived from wikipedia.	Eight passages taken from the Nelson–Denny Reading Comprehension test, version E
Text difficulty conditions	2	2	5	3	2
Text difficulty (FLESH scores)	high-cohesive version- 35 low-cohesive version -38	Easy text- 56.15 - 65.06Difficult text - 37.95 - 43.4	level 1 - 5.8;7.1 level 2 - 8.3; 9.1 level 3 - 11.9; 11.1 level 4 -13.4; 13.6 level 5 - 15.7; 16.1	The mean (M) Flesch-Kincaid grade level was 9.00	Easy text- 8.9 Difficult text - 10.9
Text length	high-cohesive version- 4,870	Easy text- 1243 to 1281	level 1 - 742,939 level 2 - 1005, 1088	Short passage - 12.51 words/	Easy text- 261.3 Difficult text - 255.3

	low-cohesive version- 4,620	Difficult text - 913 to 951	level 3 - 848; 889 level 4 - 1193, 1063 level 5 - 849, 1482	screenLong passage- 1.40 words/screen	
Topic interest		mean topic interest- 1.77	level 1 - 3.4,3.8 level 2 - 3.4,2.8 level 3 - 3.0, 3.4 level 4 - 3.0, 2.3 level 5 - 2.0, 2.4	Short passage - 3.99 Long passage - 3.90	
Topic familiarity	Overall CK Score: 3.88 (± 0.012 SE) • Non-law students: 3.65 (± 0.100 SE) • Law students: 4.12 (± 0.150 SE)	1.29 (± 0.76)			
Other variables included	Overall Score: 3.88 (± 0.012 SE) • Non-law students: 3.65 (± 0.100 SE) • Law students: 4.12 (± 0.150 SE)	Executive control capability			
Major findings	Mind wandering increases when participants read difficult texts, and this effect is modulated by Working Memory Capacity (WMC); Prior knowledge improved reading comprehension but it had no significant impact on mind wandering rates. Although mind wandering did not directly decrease comprehension, it was associated with longer reading times when thoughts were oriented to the past or future	Difficult texts increases both voluntary and involuntary mind wandering, Topic interest fully mediated the effect of text difficulty on both forms of mind wandering, Although voluntary mind wandering's negative effect on comprehension became non-significant when topic interest is included, involuntary mind wandering consistently showed a negative effect on comprehension	Mind wandering increase linearly with text difficulty, contrary to the hypothesized U-shaped relationship. Text interest significantly moderates this effect, with participants reporting less mind wandering when texts were more interesting.	Longer sections of electronic text significantly increased unintentional mind-wandering, while intentional mind-wandering remained constant.Mind-wandering, both intentional and unintentional, was negatively linked to reading comprehension and generally increased over time alongside a decrease in interest.	This study revealed that mind wandering occurred more frequently when participants read difficult texts compared to easy ones, which contrasted with some previous findings in other more, while mind wandering generally predicted lower comprehension, its negative impact on reading comprehension was substantial only for difficult texts, showing a negligible effect on easy texts.

Discussion

The present study was an attempt to conduct a systematic review analyzing the effect of text demand on mind wandering considering all the text and participant related factors which can modulate this relationship. The strength and direction of relationship between text difficulty, reading comprehension and mind wandering followed with what participant related factors affect this relationship. Subsequently examining how variables like topic interest, topic familiarity and prior knowledge influences this association. Also, if there was any difference with regard to different forms of mind wandering (e.g. voluntary and involuntary mind wandering).

As indicated by the systematic literature search encompassing the selected study, it emerged that there was high mind wandering in case of difficult text condition as compared to easy text (Feng et al., 2013; Schurer et al., 2020; Kahmann et al., 2022), consistent with previous literature (Smallwood and Schooler, 2006; Feng et al., 2013; Mills et al., 2015). Reading comprehension was negatively affected by text difficulty such that comprehension scores were often low in high difficulty text condition as compared to low difficult text condition (Kahmann et al., 2022; Schurer et al., 2020). This supports the control failure hypothesis and resource-demand hypothesis of mind wandering, suggesting that when task demand is high participants do not have adequate resources to suppress TUT's (Task Unrelated Thoughts) and hence lower comprehension and increased mind wandering (Schurer et al., 2020).

Mind wandering interfered with reading comprehension as unrelated thoughts may interfere with drawing inferences while reading (Sumuer and Kaþýkcý, 2022). When participants reported mind wandering, it was indeed associated with decreased comprehension (Bonifacci et. al., 2022). A study by Feng, D'Mello, & Graesser (2013) also suggested that participants are 1.5 times less likely to respond correctly to a comprehension question if they indulged in mind wandering while reading that sentence. It is often seen that mind wandering affects text comprehension in difficult text condition but not during easy text condition (Feng, D'Mello, and Graesser ,2013). Kahmann et al., (2022) reported that the effect of difficulty on text comprehension was because difficulty makes the text more conductive to mind wandering.

According to the present review higher Working Memory Capacity (WMC) was usually associated with lower mind wandering tendency. This can be attributed to stronger executive control and being better at preventing task unrelated thoughts from entering focus of attention (McVay and Kane ,2012a, 2012b; Kane et al. 2007; Unsworth and McMillan 2013). In difficult text condition high WMC participants exhibits less mind wandering than low WMC participants (Schurer, Opitz, and Schubert ,2020) which contradicts Rummel and Boywitt's hypothesis (2014) that high WMC participants should have higher mind wandering in low demand task condition as they can perform the task and simultaneously mind wander (Kahmann et al., 2022). WMC was identified as a predictor of reading comprehension as higher working memory capacity participants outperformed individuals with lower working memory capacity participants in terms of reading comprehension (McVay and Kane 2012b; Schurer, Opitz, and Schubert 2020) and this was particularly the case for difficult text condition as participants with higher working memory capacity scored higher than low WMC participants especially when text difficulty was high (Schurer, Opitz, and Schubert ,2020). These findings suggest that lower working memory participants face

difficulty in building a working mental model by integrating textual information.

Another important variable was topic interest which emerged as a negative predictor of mind wandering, since more interested individuals reported less mind wandering. Hence increasing text interest suggested lower propensity to mind wander (Unsworth and McMillan 2013; Soemer and Schiefele 2019; Kahmann, Ozuer, Zedelius, and Bijleveld 2022). Topic interest fully mediated mind wandering in difficult text condition (Soemer and Schiefele 2019). This finding indicated that text interest can be reduced by high difficulty which in turn can lead to mind wandering (Soemer and Schiefele 2019). It modulated both voluntary and involuntary mind wandering, indicating that interest affected both intentional disengagement and rate at which readers refocus after an unintentional lapse (Soemer and Schiefele; 2019). The negative effect of voluntary mind wandering on comprehension was insignificant when topic interest was included in the model which suggested that topic interest shared variance in comprehension explained by voluntary mind wandering (Soemer and Schiefele 2019).

Higher prior knowledge was associated with higher reading comprehension scores (Schurer, Opitz, and Schubert 2020) but no significant effect on proportions of mind wandering which stands contrary to theories like control-failure hypothesis (McVay & Kane, 2010) which predicts lower mind wandering with increased prior knowledge. Topic familiarity, a variable largely correlated with topic interest was found to have non-significant effects on both voluntary and involuntary mind wandering (Soemer and Schiefele 2019).

Increased text difficulty increased voluntary mind wandering (Soemer and Schiefele 2019), this marks a difference from other cognitive laboratory tasks like SART (Seli et al., 2016). It may be understood from these findings that such a difference was related to different levels of task demand associated in reading versus automatic response task.

Another key finding in this regard was related to text length, which affects involuntary mind wandering but not voluntary mind wandering (Forrin et al., 2021). There was higher comprehension in short text condition as compared to long text condition, this difference however was small (Forrin et al., 2021).

Implications and Future Directions

Studies included in this review were either English or German, both were primary languages of the participants (Forrin et al., 2021;). Hence, it is suggested that future studies may attempt to assess whether this relationship will exist if text material used participant's secondary language in RC task. All studies used multiple choice questions for reading comprehension task and assessed state MW using thought probes. Further researches can explore trait mind wandering, and how text comprehension measured on the basis of other question formats (open ended question) affects this relationship. The population included in this review is healthy young adults. However, analyzing this relationship to more diverse groups e.g. ADHD or autism spectrum disorder participants can open new horizons of research in this field. This study has implications in both academic and everyday settings. Designing reading materials keeping in mind the difficulty level, text length and interest of the readers can help people facing difficulties in managing their reading habits.

Conclusion

The present study was a systematic review to investigate the effect of task demand on mind wandering and reading comprehension.

The interplay between text difficulty, mind wandering and reading comprehension revealed a subtle relationship between these aspects. This review highlighted that elevated text difficulty during reading comprehension increased mind wandering. It may be concluded that no single theory of mind-wandering can fully account for the interaction between text difficulty and mind-wandering instead different theories explain specific aspects of the mechanism. This implies the necessity to further explore these variables to develop insights about the reading comprehension performance.

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