Impact of Mobile Reading Tools on University Students' Academic Literature Reading Efficiency: Postprint

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Abstract

【Objective】To investigate the impact of different mobile phone screen sizes and reading APPs on the efficiency of academic literature reading among university students. 【Methods】Through questionnaire surveys, interviews, and experimental methods, we analyzed users' time spent reading academic literature, comprehension rate, and retention rate. 【Results】Mobile phone screen size affected reading time but had no significant effect on reading comprehension rate or reading retention rate; APP user experience influenced reading comprehension rate but had no significant effect on reading time or reading retention rate. 【Limitations】The types and number of experimental users were limited, and the assessment methods for reading comprehension rate and retention rate were not sufficiently objective. 【Conclusion】Screen size and reading APPs affect different aspects of reading efficiency; optimizing mobile reading tools and APP user experience can improve users' reading efficiency.

Full Text

Preamble

Impacts of Mobile Reading Tools on University Students' Academic Reading Efficiency

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Abstract

[**Objective**] This study investigates how different cell phone screen sizes and reading applications affect university students' efficiency in reading academic literature. [**Methods**] We employed questionnaire surveys, interviews, and experiments to analyze users' reading time, comprehension rate, and memory retention

when reading academic papers. [**Results**] Cell phone screen size significantly affected reading time but showed no significant impact on reading comprehension or memory rates. Application user experience influenced reading comprehension rates but did not significantly affect reading time or memory rates. [**Limitations**] The study had a limited number and type of participants, and the assessment methods for reading comprehension and memory rates lacked objectivity. [**Conclusions**] Screen size and reading applications influence different aspects of reading efficiency. Optimizing mobile reading devices and application user experience can enhance users' reading efficiency.

Keywords: Mobile Reading; Reading Efficiency; Reading Tool; Academic Literature Reading

Introduction

With the continuous improvement of reading devices and applications, mobile reading has flourished. University students constitute the primary user group of mobile devices. A 2015 Pearson survey revealed that 85% of university students owned smartphones and 52% owned tablets, indicating that students possess the necessary equipment for mobile reading. According to the "13th National Reading Survey" released by the China Institute of Press and Publication, in 2015, 60% of Chinese adults used mobile phones, 8.8% used e-readers, and 11.3% used tablets for digital reading. Among digital reading users, individuals aged 18-29 accounted for 38.6%, representing the primary demographic for digital reading. Since university students typically fall within the 18-29 age range, they constitute a significant proportion of mobile reading users.

Mobile reading tools encompass all hardware and software that support mobile reading. Hardware includes reading devices such as smartphones, tablets, and e-readers, as well as device attributes like screens, CPUs, and batteries. Software includes mobile applications (APPs). As an indispensable hardware component, screen size represents users' most direct physical interaction with the device during reading. Reading applications serve as software tools that facilitate mobile reading. These tools and their attributes can significantly influence reading efficiency. Understanding how university students use mobile devices for academic reading can help meet the research needs of professional users, while exploring the impacts of screen size and reading applications on academic reading efficiency can provide valuable insights for the development of mobile reading tools.

Reading research has yielded substantial achievements since the late 19th century, evolving toward an interdisciplinary synthesis that has attracted scholars from linguistics, psychology, education, library and information science, and other fields. From the perspective of reading studies, existing research can be categorized into three domains: reading ontology, reading subject, and reading object.

(1) Reading Ontology Research examines fundamental concepts, reading

models, reading services, and development trends. For instance, Huang Jungui reflected on nationwide reading issues, clarifying the concept and characteristics of reading. Hu Shi and Xiao Lijie studied ancient book reading patterns in new media environments, analyzing current status and future promotion models. Reading services, particularly library-provided services such as reading promotion and guidance, have become mainstream library services. Fan Bingsi elaborated on fundamental theoretical issues in reading promotion. With the development of smart terminals, mobile reading has emerged as a significant trend, and Gao Xiaojing et al. explored this trend using two mainstream news applications as examples.

(2) Reading Subject Research focuses on individuals with reading competence, examining reading behavior, psychology, and abilities among specific user groups or in particular contexts. Reading subjects can be categorized by age (children, adolescents, young adults, middle-aged and elderly) or by special needs (visually impaired, hearing impaired, etc.). User reading behavior represents a primary research focus, encompassing reading speed, methods, purposes, and preferences. Pinto et al. studied Spanish university students' reading methods and frequency, controlling for gender, age, socioeconomic factors, and disciplinary background. Li Wu et al. investigated mobile reading usage and gratification among Shanghai university students, controlling for gender, grade, discipline, and mobile phone type. The reading psychological process combines cognitive and regulatory processes. Lu Jing et al. analyzed how large open reading spaces in university libraries affect readers' psychology and proposed improvement measures. Reading ability research is closely related to reading literacy, with some studies based on PISA and PIRLS assessments. Wen Hongbo et al. examined how family environments affect middle school students' reading abilities using reading tests and questionnaires.

(3) Reading Object Research examines the objects of reading subjects' cognition and practice, primarily focusing on reading technologies, tools, and environments. Studies on reading technologies and tools typically address hardware and software aspects. Zakaria et al. researched optimizing RFID mobile reader paths using particle swarm optimization and genetic algorithms. Huang Xiaobin and Fu Yuean evaluated the usability of mobile reading terminals based on user experience. The reading environment encompasses all external factors affecting readers. Deng Xiaozhao et al. studied the extracurricular reading environment of rural left-behind children in Chongqing, providing references for equitable public information resource services.

Research on reading ontology, subject, and object is interdependent and inseparable. Studies of reading objects require consideration of subjects and ontology, while subject research similarly requires attention to objects and ontology. These three dimensions form an integrated whole with distinct emphases.

In reading efficiency research, scholars primarily investigate specific languages (e.g., English, Chinese) and particular populations (e.g., visually impaired individuals, students, middle-aged and elderly groups), often integrating reading

subject research. Pečjak et al. examined relationships between reading motivation, efficiency, and classroom activities among third and seventh-grade students. Miller studied how age and domain knowledge affect reading efficiency. Segura et al. compared reading efficiency among university students, high school students, and art school students. Li Jianjun et al. investigated how font size and word frequency affect low-vision students' reading efficiency and proposed educational strategies.

With internet development and smart device proliferation, reading research has expanded from traditional paper-based reading to digital and mobile reading. Current mobile reading research predominantly uses demographic variables (gender, age, disciplinary background) as control variables, with few studies employing screen size and applications as controls. Moreover, few studies have examined users' mobile reading efficiency for academic literature. Therefore, this paper focuses on screen size and reading applications as control variables to investigate users' academic literature reading behavior.

Research Questions

This study addresses two primary questions:

(1) Does cell phone screen size affect reading efficiency? If so, which aspects does it influence?

(2) Do reading applications with different user experiences affect reading efficiency? If so, which aspects do they influence?

Mobile Reading Efficiency Evaluation Metrics

Mobile reading efficiency refers to the amount of reading completed within a certain time or the ratio of effective reading. LaBerge and Samuels' Automaticity Theory and Perfetti's Verbal Efficiency Theory emphasize that reading efficiency, involving accuracy and speed in reading words and their composition, has been central to automaticity theory. During reading, people segment word streams into meaningful phrases or sentences. Texts consist of characters, words, and sentences, and reading a text essentially involves understanding and processing these integrated components. According to LaBerge et al., reading accuracy primarily refers to comprehension accuracy. Fry defined "reading efficiency" as the product of reading time and reading comprehension rate. Li Yongfang viewed reading efficiency as the dialectical unity of reading speed and comprehension rate. Su Guizhen proposed that "reading efficiency = information obtained / (effort expended + reading time)," suggesting that comprehension and memory (input) and time/effort (output) comprehensively reflect reading efficiency. Since comprehension and memory are closely related, and building upon previous research, we argue that reading efficiency primarily relates to reading time, reading comprehension, and reading memory. Consequently, we constructed an evaluation framework comprising three components: reading time, reading

comprehension rate, and reading memory rate, as shown in Table 1 .

Table 1 Mobile Reading Efficiency Evaluation Metrics

Metric	Definition	Measurement
Reading Time	Time required to read a text	User timing
Reading Comprehension Rate	Accuracy in understanding the text	Percentage of correct answers to comprehension questions
Reading Memory Rate	Completeness of text recall	Percentage of correct answers to memory questions

Experimental Procedure

We randomly assigned 20 experimental participants into two groups (Group 1: S1-S10; Group 2: S11-S20). In the experiment controlling for "cell phone screen size," both groups read the same academic paper (Gao Xiaojing et al.' s "On the Development Trend of Mobile Digital Reading") using phones with 5.36-inch and 4-inch screens, respectively. In the experiment controlling for "reading applications," we selected "Duokan Reading APP" (with the highest user experience rating) and "Amazon Kindle" (which has profoundly influenced the mobile reading industry) as experimental applications based on previous research. Both groups used the same phone to read the same text (the "Three S' s of Team Management" section from *McKinsey' s Team Management*). We recorded each participant' s reading time for each session. After each reading, participants completed a questionnaire with 10 multiple-choice questions—5 assessing comprehension and 5 assessing memory—measured as the percentage of correct answers in each category. Before the formal experiment, we conducted a small-scale pilot test to revise inappropriate questionnaire items and ensure operational feasibility and objectivity.

Prior to the formal experiment, we administered a questionnaire to understand participants' general mobile reading habits. After completing the experiments, participants filled out a post-test questionnaire and participated in interviews. The overall experimental procedure is illustrated in Figure 1 [Figure 1: see original paper].

Participants

The study involved 20 voluntary student participants from Wuhan University, with a male-to-female ratio of 2:3, including 4 graduate students and 16 undergraduates. Participants were randomly selected regardless of education level, age, or gender, but all had mobile reading experience. Each participant received a book valued at 30 RMB as compensation.

Participants used a 5-point Likert scale to self-assess their academic reading comprehension and memory abilities (1 = poorest, 5 = best). Sixteen participants rated themselves as 4 (“relatively satisfied”), while four rated themselves as 3 (“average”). This indicates that participants generally evaluated their academic reading abilities positively, which facilitated the experiment.

Results: Screen Size as Control Variable

(1) User Operation Behavior Analysis

We quantified screen recording data. Following reference [29], which classified mobile device interactions into 13 categories (input, deletion, clicking, screenshot, sliding, selection, copy, paste, zoom-in, zoom-out, dragging, double-clicking, scanning), we selected three relevant behaviors for mobile reading: sliding, zoom-in, and zoom-out. Using SPSS descriptive statistics, we calculated the average frequency of these behaviors among users of 5.36-inch and 4-inch phones, as shown in Table 2 .

Table 2 Average Frequency of User Operation Behaviors During Reading

Behavior	5.36-inch	4-inch
Sliding	0.002*	0.023*

(Note: * indicates significant difference at the 0.05 level.)

Table 2 shows significant differences in zoom-in and zoom-out operations between screen sizes. Users of 4-inch phones performed significantly more zoom operations than 5.36-inch phone users. Screen recording analysis revealed that due to screen size limitations, the initial font size displayed on smaller screens was smaller, requiring multiple zoom adjustments to achieve a comfortable reading state. Consequently, 4-inch phone users performed more zoom operations.

(2) Reading Efficiency Differences Analysis

Using SPSS, we conducted descriptive statistical analysis (means and standard deviations) of reading time, comprehension rate, and memory rate across different screen sizes, as shown in Table 3 .

Table 3 Means and Standard Deviations of Reading Efficiency by Screen Size

Evaluation Metric	Screen Size	Mean	Standard Deviation
Reading Time	5.36-inch	2 min 08 sec	0.06*
Reading Comprehension Rate	5.36-inch		
Reading Memory Rate	5.36-inch		

(Note: * indicates significant difference at the 0.05 level.)

Table 3 indicates significant differences in reading time between screen sizes. Users of 5.36-inch phones read faster than those using 4-inch phones. Combined with Table 2, since 5.36-inch phone users performed an average of 2.8 fewer zoom-in operations and 1.8 fewer zoom-out operations than 4-inch phone users, the frequent zoom adjustments required on smaller screens increased reading time and reduced reading speed.

(3) Correlation Analysis of Reading Efficiency

Correlation Among Reading Time, Comprehension Rate, and Memory Rate Spearman correlation analysis examined relationships between reading time and comprehension rate, reading time and memory rate, and comprehension rate and memory rate. Results showed that in the screen size experiment, the significance value (Sig.) between reading time and comprehension rate was 0.023 (<0.05), indicating a significant correlation. However, Sig. values for reading time-memory rate (0.221) and comprehension rate-memory rate (0.786) exceeded 0.05, indicating no significant correlations. Thus, reading time changes did not affect memory rate, and comprehension rate changes did not affect memory rate.

Regression analysis of the significantly correlated reading time and comprehension rate yielded a Sig. value of 0.028 (<0.05), confirming a significant relationship where reading time changes affect comprehension rate. The correlation coefficient was -0.505, indicating a negative correlation: users with shorter reading times demonstrated higher comprehension rates. Questionnaire and interview analyses revealed:

1) Among users with short reading times but high comprehension rates, four were graduate students who could utilize all auxiliary reading functions provided by Kindle or Duokan. These applications' auxiliary features are listed in Table 5 . Generally, graduate students read more academic papers than undergraduates in daily study, which enhances their reading speed through practice. Additionally, graduate students typically have more research experience, leading to better academic comprehension. Participants S3 and S11 noted in interviews that education level affects reading speed and comprehension, with graduate students generally achieving better comprehension of academic literature.

2) Analysis of responses revealed that most users with short reading times and high comprehension rates used large-screen phones. Since large-screen users required fewer zoom operations, they not only saved time but also more easily achieved deep reading, facilitating better comprehension. Frequent operations on small screens may negatively affect users' reading psychology, causing frustration. Participant S15 (small-screen user) stated in an interview: "Too many operations on the phone during reading affect my mood."

Correlation Between User Behavior and Reading Efficiency Spearman correlation analysis examined relationships among sliding, zoom-in, and zoom-out behaviors and reading time, comprehension rate, and memory rate, as shown in Table 4 .

Table 4 Correlation Analysis Between Three Operation Behaviors and Reading Efficiency

Correlation Test	Behavior	Reading Comprehension Rate	Reading Memory Rate
Reading Time	Zoom-in	0.016*	

(Note: * indicates significant difference at the 0.05 level.)

Table 4 shows a significant correlation between reading time and zoom-in operations (Sig. = 0.016). Regression analysis yielded Sig. = 0.048 (<0.05), indicating that reading time changes with zoom-in behavior frequency. The correlation coefficient was 0.532, showing a positive correlation: more zoom-in operations led to longer reading times and slower reading speed. Since sliding frequencies were nearly equal across conditions, zoom-in operations had the most significant impact on reading time.

Results: Reading Application as Control Variable

(1) User Operation Behavior Analysis

Combining auxiliary reading functions and screen recording data, we used SPSS descriptive statistics to analyze operation behaviors including sliding, reviewing, font adjustment, and font selection. Screen recordings revealed that participants primarily performed sliding, reviewing, and marking behaviors. Average frequencies of these behaviors are shown in Table 6 .

Table 6 Average Frequency of User Operation Behaviors During Reading

Behavior	Kindle	Duokan Reading APP
Marking	0.03*	

(Note: * indicates significant difference at the 0.05 level.)

Table 6 shows significant differences in marking behavior. With similar page numbers and reading modes, differences in users'reading habits caused variations in marking frequency.

(2) Reading Efficiency Differences Analysis

We conducted descriptive statistical analysis of the three reading efficiency metrics across different applications, as shown in Table 7 .

Table 7 Means and Standard Deviations of Reading Efficiency by Application

Evaluation Metric	Kindle	Duokan Reading APP
Reading Time	1 min 26 sec	
Reading Comprehension Rate		
Reading Memory Rate		

(Note: * indicates significant difference at the 0.05 level.)

Table 7 reveals significant differences in reading comprehension rates between applications. Duokan Reading APP users achieved higher average comprehension scores than Kindle users, indicating better understanding. Analysis of screen recordings and interview content revealed:

1) Duokan users performed marking operations (underlining, highlighting) due to reading habits. Participants S6, S13, and S16 stated in interviews that marking helps focus attention on important content and facilitates deep reading, thereby improving comprehension.

2) Based on online forum evaluations and our own experience, Kindle' s font variety, interface friendliness, and functional diversity are inferior to Duokan' s. Additionally, Kindle' s content layout and pagination are not fixed, making Duokan superior in user experience.

In the pre-test questionnaire, participants rated "the impact of APP user experience on reading comprehension" on a 5-point Likert scale (1 = minimal impact, 5 = maximum impact). Results showed: 2 participants rated 5, 5 rated 4, 10 rated 3, 2 rated 2, and 1 rated 1, with an average score of 3.25. This indicates that users believe APP user experience moderately affects reading comprehension. Participant S3 noted: "Poor APP user experience affects reading mood and prevents users from engaging in and enjoying the reading process."

(3) Correlation Analysis of Reading Efficiency

Correlation Among Reading Time, Comprehension Rate, and Memory Rate Spearman correlation analysis showed that in the application experiment, Sig. values for reading time-comprehension rate (0.923), reading time-memory rate (0.661), and comprehension rate-memory rate (0.311) all exceeded 0.05, indicating no significant correlations. Thus, reading time changes did not affect comprehension or memory rates, and comprehension rate changes did not affect memory rates.

Correlation Between User Behavior and Reading Efficiency Spearman correlation analysis examined relationships among sliding, reviewing, and marking behaviors and reading time, comprehension rate, and memory rate, as shown in Table 8 .

Table 8 Correlation Analysis Between Operation Behaviors and Reading Efficiency

Correlation Test	Behavior	Reading Comprehension Rate	Reading Memory Rate
Reading Time	Reviewing	0.032*	

(Note: * indicates significant difference at the 0.05 level.)

Table 8 shows a significant correlation between reading time and reviewing behavior (Sig. = 0.032). Regression analysis yielded Sig. = 0.051, approaching 0.05. Within acceptable error margins, we can conclude that reading time changes with reviewing behavior frequency. The correlation coefficient was 0.481, indicating a positive correlation: more reviewing behavior led to longer reading times and slower speed, as users needed to flip back to previously read content.

Discussion and Conclusions

Through experiments controlling for "cell phone screen size" and "reading applications," we investigated three evaluation metrics of mobile reading efficiency (reading time, comprehension rate, memory rate) and reached the following conclusions:

(1) Regarding mobile reading tool hardware, cell phone screen size affects academic reading time. Large-screen phones required less average reading time than small-screen phones. Different screen sizes did not significantly affect reading comprehension or memory rates. Reading time and comprehension rate were correlated, with time changes affecting comprehension rate. However, no significant correlations existed between reading time and memory rate or between comprehension rate and memory rate. Users' zoom-in behavior affected reading time—more zoom-in operations led to longer reading times.

(2) Regarding mobile reading tool software, applications with different user experiences affected academic reading comprehension rates. Duokan Reading APP users achieved higher comprehension rates than Kindle users. Different applications did not significantly affect reading time or memory rates. No significant correlations existed among reading time, comprehension rate, and memory rate. Users' reviewing behavior affected reading time—more reviewing led to longer reading times.

Screen size and reading applications influence different aspects of academic reading efficiency. During academic reading, screen size significantly impacts reading time, while applications with better user experience facilitate reading comprehension. Given today's diverse mobile phone market, studying screen size effects can guide users in selecting appropriate mobile reading tools for research and learning. Investigating application effects can provide developers with references for offering more convenient auxiliary reading functions or developing applications that automatically adjust font size and layout based on screen dimensions, thereby continuously improving user experience. This not only promotes user comprehension but also drives application development and helps users select suitable applications for reading, research, and learning.

Limitations and Future Work

This study has several limitations. The limited participant types and numbers, coupled with insufficiently objective assessment methods for comprehension and memory rates, reduce the generalizability of findings. The evaluation metrics were relatively general and did not include important reading process indicators such as "copying." Future research should expand participant diversity and numbers, design more detailed evaluation metrics, and incorporate eye-tracking or EEG devices to enable multi-channel interaction for more objective measurement of comprehension and memory rates, thereby enhancing scientific rigor and generalizability.

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Author Contributions

Wu Dan: Proposed research questions, designed the study and experimental protocol, revised the manuscript, and finalized the paper.
Lu Liuxing: Conducted the experiment, analyzed results, and drafted and revised the manuscript.

Conflict of Interest Statement

All authors declare no conflict of interest.

Supporting Data

Supporting data is available in the online version of the journal at http://www.infotech.ac.cn:
[1] Wu Dan, Lu Liuxing. sywj.doc. Experimental questionnaire.
[2] Wu Dan, Lu Liuxing. djtm.doc. Experimental answer sheet questions.
[3] Wu Dan, Lu Liuxing. sysj.doc. Experimental data.
[4] Wu Dan, Lu Liuxing. fttg.doc. Interview outline.
[5] Wu Dan, Lu Liuxing. ftjl.doc. User interview records.

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Note: Figure translations are in progress. See original paper for figures.