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The Effects of Reading Mode on Recall and Comprehension

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Abstract

This study explored students' differences in reading comprehension between digital and paper reading modes. This quasi-experiment consisted of adult students enrolled in military leadership courses. Each randomly selected group read the same leadership article, either digital or paper. Students completed an assessment to determine differences in recall accuracy and comprehension between digital and paper readers. While there were no significant differences in group means of recall between reading versions, a persistent pattern in differences of score ranges and frequencies was evident for recall accuracy and comprehension. The implications and considerations of individual differences in score frequencies are discussed.

Keywords: cognitive information processing, reading skills, instructional technology, learning.

The Effects of Reading Mode on Recall and Comprehension

Since the 1990s, researchers studied the effects of reading modes by measuring different aspects of information processing to include attention, cognitive load, navigation, eye movement, electrophysiological brain activity, reading speed, and reading comprehension (Ackerman & Goldsmith, 2011; Dillon, 1992; Mayes, Sims, & Koonce, 2001). Researchers continue to accumulate knowledge involving the effects of digital reading by measuring psychological processing and brain activity (e.g., Dillon, 1992; Payne & Reader, 2006; Universität Mainz, 2011).

However, several studies present conflicting findings (e.g., Farris, 2013). Because of advances and differences in electronic devices, it is difficult to compare studies; while earlier investigations used computer screens, more recent studies include tablets. Tablet readers may have greater control to manipulate for optimal visual and physical comfort compared to desktops or laptops (e.g., Dillon, 1992; Mayes, Sims, & Koonce, 2001; Wastlund, Reinikka, Norlander, & Archer, 2005).

Statement of the Problem

There is a scarcity of research on the effects of digital reading in relation to recall accuracy and comprehension. Moreover, there is inadequate guidance for choosing reading modes for instruction and learning.

Theoretical Framework

Recall and comprehension encompasses cognitive operations such as selecting, attending, memorizing, retrieving, and reasoning. Therefore, this study draws upon concepts, principles, and assumptions associated with **cognitive information-processing**.

Significance

The results point educators to possible areas of concern regarding instructional and educational decisions: 1) whether to use electronic devices for specific activities or assignments and 2) determining the use of test scores originating from electronic devices. The distinguishing features of this study include a two-page reading; single column text format; assess after reading; and a closed-book assessment.

Literature Review

Ackerman and Goldsmith (2011) uncovered differences in students' metacognition skills between digital and paper reading modes. Paper readers manifested greater self-regulation that resulted in better performance. Liu (2005) examined changes in reading behavior when using digital devices and reported that digital screen readers engaged in greater use of shortcuts such as browsing for keywords and selectivity. Furthermore, they were more likely to read a document only once and spend less time with in-depth reading.

Studies yield conflicting results between digital and paper reading (Johnson, 2013; Managen, Walgermo, & Bronnick, 2013; Taylor, 2011; Wastlund, Norlander, & Archer, 2008). Advances in digital technology and design, such as screen displays and navigation aids explain some inconsistencies. Contradictions may also reflect variations in research design and methodology. Students for an experiment conducted by Managen et al. (2013) reviewed and navigated either a digital or paper reading while completing an open-book, hour-long test. Paper readers showed significantly higher comprehension scores compared to digital readers. The results reported by Managen et al. counter findings from Johnson's (2013) experiment in which students also read either a digital or textbook chapter, followed by an open-book assessment. According to Johnson, there was no

difference in assessment scores between digital and paper reading groups. Likewise, an experiment by Taylor (2011) included readings of textbook chapters and reported similar findings as Johnson (2013).

Several experiments examined the effects of page layout on participants' eye movements between paper and digital modes and the impact of scrolling and page columns (Noyes & Garland, 2008; Payne & Reader, 2006; Wastlund, Norlander, & Archer, 2008). Although experimental studies of digital reading report design variations, common elements include: a) two-column text formats; b) chapter-length readings; and c) open-book assessments.

Hypotheses

To determine the effects of reading mode, the researcher tested the following hypotheses:

H1: *Students who read a paper article will have a statistically significant difference in greater recall accuracy as shown by test scores compared to those who read the same digital article using a tablet.*

H2: *Students who read a paper article will have a statistically significant difference in reading comprehension as shown by higher test scores compared to those who read the same digital article using a tablet.*

Method

This study is a quasi-experimental design, using convenience groups to create conditions.

Variables

Assessment scores for recall and comprehension provided measures for the Dependent Variable (DV) while the reading mode condition (paper or digital tablet) was the Independent Variable (IV).

Sample

Participants were enrolled in military leadership courses (N = 231). Class groups were randomly assigned to read either digital (n = 119) or paper (n = 112) versions of a leadership article. Students were somewhat homogeneous with regards to professional career experiences and years in service (eight or more). Although military students, participation was voluntary and no incentives or credits were offered.

Procedure

Convenience groups were randomly selected to read either a digital tablet or paper reading (Table 1). The leadership article, *Chairman Champions Character in Graduation Address* (Lye, 2013), is approximately 800 words (Appendix A).

Following the reading, students completed a 10-item multiple choice assessment (Appendix B) and two short answers to measure the effects of reading mode (IV) on recall accuracy and comprehension between reading modes (DV).

Results

The total sample size was 231 students; 119 digital tablet and 112 paper readers. Students completed the assessment following the reading (Appendix B). The multiple choice questions consisted of 10 items (0 - 10). The two short answer questions were coded for comprehension (0 - 4).

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T-test results for the reading mode factor did not indicate statistically significant differences in means between digital tablet and paper readers for the multiple choice items that measured recall accuracy or for the short answers that measured comprehension.

However, a pattern emerged with the range and frequencies of score distributions. Paper readers had greater frequencies of higher scores compared to tablet readers for both multiple choice recall and short answers that measured comprehension (Tables 2, 3, Figures 1, 2). While there was no difference between group means, the differences in individual scores may be a significant factor when individual scores determine ranking, such as with the military.

Discussion and Implications

The purpose of this study was to examine the differences of recall and comprehension scores between tablet and paper readers. This study was unique in that students completed a customized test right after reading the article. Whereas most other study designs included chapter-length readings with open-book assessments, the reading for this study was limited to just over two pages with a closed book assessment. These limitations were deliberate because the researcher wanted to limit cognitive load from digital reading due to scrolling.

Furthermore, another intentional design was a paper assessment for both the digital and reading groups. The aim was to reduce cognitive load for digital readers by reducing navigation actions and switching of windows for digital assessments, thereby restricting unnecessary variation between conditions. Moreover, completing the assessment after the reading limited memory decay or threats from interference of learning by other topics.

While no significant difference in group means between digital tablet and paper readers was evident, there were differences in score frequencies for both recall and comprehension. However, individual score differences may be an important consideration when used for ranking and selection purposes, such as in military domains.

The reading for this study was a single column format and limited to two pages compared to double columns or chapter-length readings used in several studies. Although Johnson's study (2013) also used an e-textbook chapter, nonetheless, it presents an interesting comparison to this study. Both studies presented unfamiliar reading topics to students to limit confounding factors due to prior course studies. Similar to this study, Johnson compared comprehension test scores of tablet vs. paper readers¹. Likewise, his sample study comprised of 233 participants vs. 231 for this study. Johnson's sample consisted of undergraduates drawn from a state university, whereas military participants of this study represent non-traditional students in a non-typical learning environment.

Comparing the results between this study and Johnson's (2013) uncovers two similar patterns: 1) there was no significant difference in group test score means between digital tablet and paper readers and 2) paper readers showed higher frequency rates of the two highest scores. Both studies showed no differences in group means, albeit different readings and assessments. Similarly, both studies revealed the same pattern with individual scores: paper readers had higher frequencies of the highest possible scores, notwithstanding the demographically different samples.

Concerns remain about the influence of digital reading for in-depth reading comprehension (Rosenwald, 2014). If educators understand the effects of digital reading

¹ Both studies used Apple iPad® tablets and exposed participants to unfamiliar reading material. College students in Johnson's (2013) study completed a comprehension test comprised of test bank items provided by the textbook publisher, whereas the assessment for Niccoli's study was customized for the short article.

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on the development of deep reading, and students' grasp of difficult material, they can formulate instructional decisions. In addition, questions linger regarding the consequences on brain processing from nonlinear reading, especially adaptive shortcuts due to scrolling and hyperlinks, which may inform future studies (Wolf & Barzillai, 2009).

This phase of the study did not collect data regarding college course experiences. There may be a relationship between exposure of college studies and scores for memory recall or comprehension. College students with more recent experiences in reading, recalling, and comprehending material may present contributing factors that influence scores. Perhaps recent study skills afford students enduring benefits that transfer to related performances, such as this study. More to the point, we do not know the full moderating effects by frequent exposure to digital reading, such as cognitive shortcuts, and whether they influence assessment scores.

This study is currently extending to Phase 2 to shed more light in determining factors that influence differences in scores between digital tablet and paper readers. Additional data collection regarding college enrollment history and experiences using digital devices may deepen our understanding of the nexus between devices and learning.

Limitations

While students were aware that an assessment followed the reading, there was no incentive offered, therefore, there is a chance that this affected students' motivation. The sample for this study represents diverse military students with about eight years of service experience in a homogenous context; generalizations to other demographic populations may be limited. Although Johnson (2013) reported similar results from

traditional college students, future studies with primary and secondary students will further advance our understanding, especially in relationship to developmental concerns.

Recommendations

Whereas this study used a short article, future experiments may consider longer readings that create a slight increase in cognitive load for digital readers. Because the assessment followed the reading for this phase of the experiment, future conditions may consider a longer time interval between reading and assessing. Educational leaders need to engage and promote research involving digital devices to be better informed about the effects and implications on learning and assessments.

Acknowledgement

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Tables and Figures

Table 1

Reading mode study variables: N = 231

IV: Paper	Group A: All read leadership article	DV: Paper Assessment
IV: Digital	Group B: All read leadership article using same device (tablet)	DV: Paper Assessment
Time	5 minutes	12 minutes

Note: Leadership article was approximately 800 words. After reading, students completed the assessment.

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Table 2

Frequencies, Multiple Choice Recall: N = 231

Score	Frequency T (n = 119)	Percent % Tablet	Frequency P (n = 112)	Percent % Paper
10	6	0.05	12	0.11
9	15	0.13	19	0.17
8	37	0.31	25	0.22
7	21	0.18	22	0.20
6	19	0.16	13	0.12
5	11	0.09	10	0.09
4	5	0.04	4	0.04
3	3	0.03	7	0.06
2	3	0.03	0	0

Note: High to low score (10 - 0).

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Table 3

Short Answers Comprehension: N = 134

Score	Frequency T (n = 70)	Percent % Tablet	Frequency P (n = 64)	Percent % Paper
4	15	0.21	11	0.17
3	13	0.19	17	0.27
2	29	0.41	21	0.33
1	8	0.11	6	0.09
0	5	0.07	9	0.14

Note: Students for this sample were drawn from the same course.
High to low score (4 - 0).

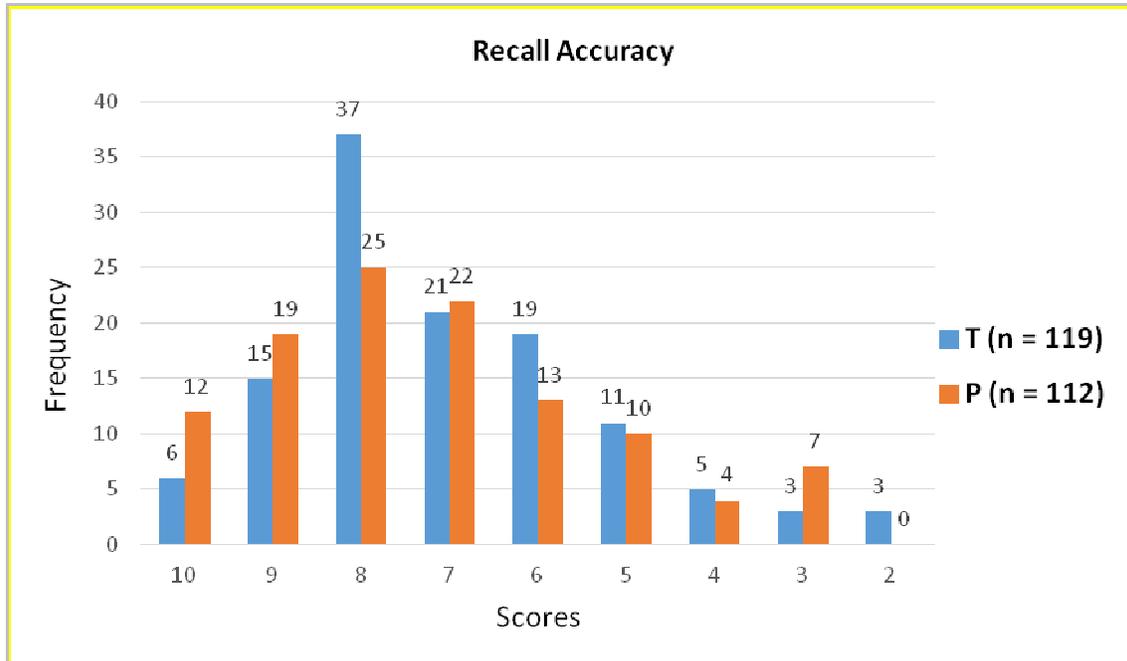
Figures

Figure 1: Multiple choice items that measures recall accuracy. High to low score (10 - 0).

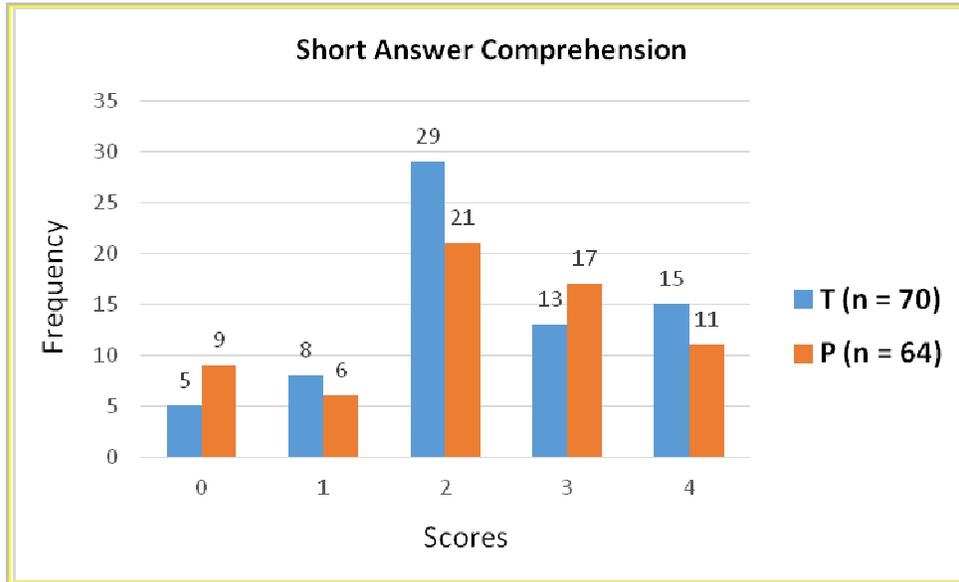


Figure 2. Short answer comprehension scores of students drawn from same course. Low to high score (0 - 4).

Appendix A: Reading

Chairman Champions Character in Graduation Address

By Amaani Lyle
American Forces Press Service

FORT LESLEY J. MCNAIR, D.C., June 13, 2013 – In an era of burgeoning social media and budget uncertainty, competence and character are vital to maintaining public trust and confidence, the chairman of the Joint Chiefs of Staff said in his address at the National Defense University graduation here today.



Army Gen. Martin E. Dempsey, chairman of the Joint Chiefs of Staff, addresses graduates at the National Defense University on Fort McNair, Washington, D.C., June 13, 2013. DOD photo by Army Staff Sgt. Sean K. Harp
(Click photo for screen-resolution image); [high-resolution image](#) available.

Army Gen. Martin E. Dempsey told the 658 students from the College of International Security Affairs, the Eisenhower School, the Information Resources Management College and the National War College that leaders must embrace selfless duty as the unifying moral force for decisions.

“While competence is built over a career, high standards must start from the very beginning,” Dempsey said. “In all we do, ... our actions must be clear, consistent, values-based and intimately tied to the defense of the nation, without flourish or fanfare.”

Dempsey told the graduates that pluralized partnerships with other services, agencies and nations increase the U.S. military’s capability, capacity and credibility.

“These relationships of trust and context provide you with a network of resources that make us far more informed about the decisions we need to make amid uncertainty, and they create process where none exists,” Dempsey said.

The world now finds itself in an unprecedented information exchange era, the chairman said, with more than 6 billion cell phone subscribers in the world and one in every three people using the Internet.

“News and information arrive in a continuous stream, and we’ve seen what happens when social media [rally] like-minded people around a common cause,” Dempsey said. “When we chose this uncommon profession, we subscribed to unrelenting scrutiny, ... and in the post-modern era of war, we expect an accounting of our conduct.” And missteps of confidence often are perceived less harshly than stumbles of character, he added.

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“Our world’s speed and our mission significance converge in the present,” the chairman said. “For the first time, our competence and character are being evaluated by experts and pundits while we fight.”

Ultimately, for those who serve the public’s trust, winning the nation’s wars is no longer enough, Dempsey said.

“How we win is becoming as important as the fact that we win,” the chairman told the graduates.

And this reality, he said, is not limited to military operations, but is applicable to almost any government agency.

“The people of all of our nations -- those who we serve -- are speaking loudly with a consistent message,” Dempsey said. “They require that we are both extraordinary and extra-ethical -- that we are men and women of the highest character and competence.”

Dempsey cited a speech by Army Gen. H. Norman Schwarzkopf’s speech at the U.S. Military Academy in 1991, in which he said he based his ideas of competence and character on his experiences in Vietnam.

“He noted that some highly competent leaders with little character were in it for themselves,” Dempsey said. “They sought rewards through promotions, awards and degrees that, in turn, would lead to faster promotions -- all too often to the detriment of those that they led and the causes they served.”

In contrast, the chairman said, Schwarzkopf noted that leaders of low competence but of high character weren’t willing to go the extra mile.

“He bluntly told his audience that, in his judgment, we had lost our integrity in Vietnam -- not everyone, of course, but the institution had lost the trust because of its missteps,” Dempsey said.

After Vietnam, Dempsey said, the services had to consciously and consistently rebuild both the readiness and reputation of the armed forces. And with that progress came setbacks, the chairman added.

“Seventeen years after I joined, we emerged, like the cicadas this spring, in the desert of Kuwait as the world’s pre-eminent joint force,” Dempsey recalled.

With the passing of nearly another 17 years, Iraq and Afghanistan tested the U.S. military’s competence, calling for troops to relearn counterinsurgency tactics and strategies and adapt to new types of conflict.

“Several instances reminded us that character is always tested in war, no matter how we wage it,” the chairman said. “As with Vietnam, negative impressions about our character

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eclipsed the courage and sacrifices of many of the men and women who served honorably ... in that war.”

But the chairman reminded graduates that they don't have another 17-year cycle to rebuild and regain the trust of the American people in its military force.

“There will be an ever-increasing expectation of servicewomen and men to achieve that intricate balance of high character and high competence,” Dempsey said.

Roughly 50 percent of the graduates are senior officers from the U.S. armed forces. Federal government and private-sector civilians and international students from 62 countries make up the other 50 percent.

Source:

Defense.gov/news

Biographies:

[Army Gen. Martin E. Dempsey](#)

Related Sites:

[Photo Essay](#)

[National Defense University](#)

Appendix B: Assessment

General Dempsey Graduation Address Test-Answer Key

COURSE: (OCS, CWO, BFCC, etc.) _____

DATE: _____

Please select the best choice to fill in the blanks questions 1-10.

1. Chairman Gen. Dempsey (2013) told the graduates that pluralized partnerships with other services, agencies and nations increase the U.S. military's capability, capacity, and _____.
 - a. confidence
 - b. credibility**
 - c. flexibility
 - d. accuracy

2. Gen. Dempsey claims that the world now finds itself in an unprecedented era of _____.
 - a. information exchange**
 - b. terrorists threats
 - c. human migration
 - d. weapons proliferation

3. The chairman stated that missteps of confidence often are perceived less harshly than stumbles related to _____.
 - a. incompetence
 - b. character**
 - c. decisions
 - d. results

4. Gen. Dempsey said, "In all we do, ... our actions must be clear, consistent, _____."
 - a. values-based**
 - b. competent
 - c. professional
 - d. accurate

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5. According to Gen. Dempsey, leaders must embrace selfless duty as the unifying moral force for _____.
 - a. officials
 - b. missions
 - c. decisions**
 - d. actions

6. “For the first time, our competence and _____ are being evaluated by experts and pundits while we fight,” stated Chairman Dempsey.
 - a. decisions
 - b. character**
 - c. standards
 - d. leadership

7. “_____ is becoming as important as the fact that we win,” stated Gen. Dempsey.
 - a. The long-term consequence
 - b. Our commitment to partners
 - c. The post war plan
 - d. How we win**

8. Gen. Dempsey cited Gen. Schwarzkopf, explaining that he formulated his ideas of competence and _____ based on his experiences in Vietnam.
 - a. leadership
 - b. readiness
 - c. character**
 - d. standards

9. Gen. Dempsey reminded graduates that they don’t have another 17-year cycle to rebuild and regain the trust of _____ in its military force.
 - a. allies and partners
 - b. emerging democracies
 - c. media reporters
 - d. American people**

10. “Several instances reminded us that _____ is always tested in war, no matter how we wage it,” the chairman said.
 - a. leadership
 - b. competence
 - c. character**
 - d. planning

Sentence completion: Please provide a short response to the following prompts:

11. The main point or assertion of General Dempsey's address to the graduates was...
Given the era of information exchange and new media (i.e., social media), to maintain public trust, service members must embody both competence and character.
12. General Dempsey's main point or assertion is important because....
The military lost integrity during the Vietnam War, taking 17 years to regain confidence and trust lost and because of the ever increasing expectations about conduct (integrity) of service members.

Short Answer Scoring

(Possible Points, low to high: 0-2 each short answer.)

1 point:

That they are expected to remain competent at all times.

2 points (includes a reason or short explanation):

Learn from our past mistakes, be mindful of everything you do, and losing the confidence of people because of poor character decisions is quick, but regaining is often lengthy.