

RSVP Reading on a Smart Watch

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Reading with Rapid Serial Visual Presentation (RSVP) has shown promise for optimizing screen space and increasing reading speed without compromising comprehension. Given the wide use of small-screen devices, the present study compared RSVP and traditional reading on three types of reading comprehension, reading speed, and subjective measures on a smart watch. Results confirm previous studies that show faster reading speed with RSVP without detracting from comprehension. Subjective data indicate that Traditional is strongly preferred to RSVP as a primary reading method. Given the optimal use of screen space, increased speed and comparable comprehension, future studies should focus on making RSVP a more comfortable format.

INTRODUCTION

A considerable amount of past research has explored various text presentation methods to optimize reading comprehension, speed, and experience for electronic text (Juola, 1988; Mills & Weldon, 1987). With the widespread use of mobile devices, recent research has focused on displaying text on small screens. Studies have compared traditional, line-by-line scrolling (the most common method used for reading on mobile phones) with alternative presentations like leading (text that automatically scrolls across a display), paging (text presented as pages that fit the size of the screen) and RSVP (Öquist & Lundin, 2007, Öquist & Goldstein, 2003) with mixed results as to which is most appropriate for particular devices in optimizing reading comprehension, speed, and satisfaction.

RSVP provides an alternative to traditional text presentation by displaying isolated words sequentially at a stable speed in a fixed position (Gilbert, 1959). RSVP has a few advantages over other reading presentations, both static and dynamic. Because text is in a fixed position, saccadic eye movements are greatly reduced or eliminated (Rubin & Turano, 1992; Rubin & Turano, 1994). Reductions in eye movements likely contribute to the increases in reading speed that have been observed using RSVP compared to traditional reading formats (Bernard, Chaparro, & Russell, 2000). Potter (1984) suggested that reading with RSVP could improve reading habits due to the attention required, and could be ideal for those who have trouble with eye movements or dyslexia.

Some drawbacks to RSVP involve the lack of preview for upcoming text (parafoveal information) and an inability to reread (make regressive eye movements). Reading research has demonstrated a benefit to parafoveal previews in that we may better recognize upcoming words, and are able to more accurately execute future saccades and fixation placement based on word length (Juhász, White, Liversedge, & Rayner, 2008; Rayner, Schotter, Drieghe, 2014). Regressive eye movements account for approximately 10-15% of all eye movements during reading, and the number of regressions often depends on the difficulty of the text (Rayner & Pollatsek, 1989). Since conventional RSVP only allows for forward movement of the text, being unable to reread past content intuitively presents a disadvantage to RSVP.

However, despite the apparent contradictions to typical reading behavior, studies have demonstrated that

RSVP can be read with similar levels of comprehension to traditional reading formats (Bernard et al., 2000; Öquist & Goldstein, 2003). Hedin & Lindgren (2007) compared traditional scroll-based reading with RSVP on a mobile phone. The researchers computed a measure of efficiency using words per minute (WPM) reading speed and comprehension scores. Results indicated that RSVP was more than twice as efficient at 400 WPM than self-paced scrolling. Even so, most participants preferred using the traditional reading method.

Aversion to RSVP compared to traditional presentations is a common finding across studies assessing various reading techniques (Hedin & Lindgren, 2007). One reason for this may be a perceived increase in mental workload. Öquist & Goldstein (2003) assessed task load for participants reading with RSVP compared to traditional reading. Their findings suggested that despite no differences in comprehension, RSVP significantly increased task load for long texts compared to traditional format. Task load ratings were improved, however, by using an “adaptive RSVP” that presented words at different durations depending on processing time rather than at a fixed rate. Studies have also demonstrated that opinions of RSVP improve with practice, and with the addition of modifications like a completion meter and punctuation pauses (Castelhano & Muter, 2001).

Although RSVP denotes elimination of regressions and suppression of parafoveal information, comprehension generally does not suffer. This is especially true with smaller pieces of text, which are more typical of reading on small screens. Given efficiency in reading speed and comparable understanding of content, RSVP may show an advantage over traditional formats when screen space is limited. While many studies have considered variations of text presentation on mobile devices, few empirical studies have explored optimal reading techniques on small screen displays such as wearable devices (Chien, Chen, & Wei, 2008).

Shipment of wearable devices such as smart watches and fitness bands are expected to jump 173% in 2015 compared to 2014 (International Data Corporation, 2015). This rise in demand draws attention to optimizing space on ultra-small screens. Products like Uno Noteband (UnoNoteband, 2014) have incorporated Spritz (Maurer, Klein, & Waldman, 2014), a popular speed-reading software that allows for reading electronic content with a modified version of RSVP. Microsoft has also adopted an optional RSVP presentation for reading on the tiny screen of the

Microsoft Band (Microsoft, 2015). Not only does an automatic presentation of text take advantage of screen real estate, but it also eliminates the need for manual scrolling. These potential benefits of RSVP to modern technology and the need to reconcile text content with limited screen space led us to explore RSVP on a wearable device. To ascertain a complete understanding of reading performance and satisfaction, the present study examined depth of reading comprehension, text length, and subjective preferences across RSVP and traditional reading on a smart watch.

METHOD

Participants

A total of 20 undergraduate psychology students (8 males, 12 females) at Wichita State University were recruited and gave written informed consent prior to beginning the study. All participants had normal or corrected-to-normal vision, and all passed the REALM-R assessment (defined as a score of 7 or above) prior to the experiment to ensure English fluency. Participants' ages ranged from 18-33 ($M = 21.2$, $SD = 3.98$). One person indicated having experience reading with RSVP prior to the study, and 9 had experience using a smart watch. Eight of those with smart watch experience had only used the device in the context of another research study. Participants were given course credit for their participation.

Materials

To examine differences between reading presentation types on a small screen, passages were read on a Samsung Galaxy Gear smart watch. Comprehension questions were answered on a desktop computer monitor. Comprehension responses were collected using Qualtrics.

Stimuli

Presentation types. Two types of reading presentations were compared: Traditional and RSVP. Conditions were counterbalanced across participants. Text was 21 pixels and typeface was Roboto. Black text was displayed on a white background in both conditions, and font size and typeface remained constant. Smart watch apps for both conditions were written in Java and developed using the Android SDK, with the RSVP app also using the official Spritzer SDK.

In the Traditional reading condition, all text was displayed on the screen at once to ensure that no scrolling was necessary to view the entire passage. Participants were instructed to read at a comfortable pace, but to read through the passage only one time without re-reading. Upon reaching the end of a passage, participants tapped on the smart watch screen and the passage was replaced with a "Next" screen. In the RSVP condition, one word at a time was presented sequentially at a rate of 220 WPM and all words were presented at the same duration. Due to system variability of the watch, this speed differed slightly between participants ($SD = .25$). Text was presented at the center of the screen. At

the end of each passage, a "Next" screen automatically appeared. Participants were told that they could pause and restart the flow of text by tapping on the word, but they could not go backward. Only one participant utilized the pause/restart capability.

Reading material. A total of 32 passages were derived from 501 Comprehension Questions (Learning Express, LLC, 2006). Two types of passages were compared: Short (50-100 characters) and Long (230-300 characters). To control for reading level, minor edits to passages were made to ensure that all content was between 7th and 12th grade reading level ($M = 9.54$, $SD = .34$) according to the Flesch-Kincaid Grade Level formula (Flesch, 1994), and passages had Flesch Reading Ease (Flesch, 1948, Kincaid, Fishburne, Rogers, & Chissom, 1975) scores ranging from 34.1 to 71 ($M = 54.43$, $SD = .35$). Passages were also edited for length so as to not exceed 300 characters. To eliminate the need for scrolling, 300 was the determined character limit for an entire passage to be displayed on the smart watch. Passages were randomized and counterbalanced across participants.

Measures

Comprehension. After reading each passage, participants answered three true/false questions. Each question assessed a different type of reading comprehension: Word Recognition, Inference, and Fact. Similar to Kintsch, Welsch, Schmalhofer, & Zimny (1990), Word Recognition questions involved identifying one noun in the passage as a target word, and asking whether this word was in the passage. The location of the target word varied between the beginning, middle, or end of the passage. In 50% of word recognition questions, the target noun was replaced by a semantically similar foil word. Semantic similarity was determined using the DISCO Java API (Kolb, 2008). Inference questions were broad and addressed the overall concept of the passage, while Fact questions targeted specific details. The purpose of comparing question types was to see whether a difference would exist between presentation methods when considering the specificity of comprehension (Masson, 1983; Potter et al., 1980; Benedetto et al., 2015). Question types were asked in the same order after each passage: Word Recognition, Inference, Fact.

Reading speed. Time stamps were collected for both Traditional and RSVP conditions. For the Traditional condition, time was recorded by the participant tapping the screen upon reaching the end of a passage. In RSVP, time stamps were recorded between start of the passage and upon reaching the automatically presented "Next" screen at the end of a passage.

Mental workload. Mental workload was assessed using the C-SWAT (Luximon & Goonetilleke, 1998).

Reading satisfaction. A questionnaire from Chaparro, Shaikh, & Baker (2005) was modified for the current study and used to assess subjective elements of reading experience. Participants completed the same questionnaire following each presentation condition.

Overall preference. A verbal preference for Traditional or RSVP was obtained at the end of the study.

Qualitative data. In addition to preference, participants were verbally asked follow-up questions about why they preferred one reading method over another, and whether certain presentations are more conducive to specific reading content.

Procedure

After signing informed consent and passing the REALM-R, participants completed a demographics questionnaire and the pairwise comparisons of the C-SWAT. Participants read and answered comprehension questions for four practice passages (two short and two long) at the beginning of each condition to familiarize them with the presentation method. After the practice sessions, 16 passages were presented in either RSVP or Traditional. After the first condition, participants answered C-SWAT and reading satisfaction questions for that condition. This procedure was repeated for the second condition, resulting in a total of 32 passages and 96 scored comprehension questions. After both conditions were complete, participants were verbally asked for an overall preference and an explanation for their choice.

RESULTS

Performance

Comprehension. A 2x2x3 repeated-measures ANOVA was conducted to assess comprehension differences in presentation type, passage length, and question type. A main effect was found for question type, in which Word Recognition questions resulted in significantly lower comprehension than Inference and Fact, $F(2,19) = 12.31, p < .001, \eta^2_p = .39$. Comprehension was significantly better for Short passages than Long passages, $F(1,19) = 67.05, p < .001, \eta^2_p = .78$. There was no significant effect for presentation type, $F(1,19) = .003, p > .05$. A significant interaction was present for passage length and question type, $F(2,38) = 22.03, p < .001, \eta^2_p = .54$ (Figure 1). Pairwise comparisons with a Bonferroni correction revealed that comprehension performance for Word Recognition was significantly worse for Long passages than Short passages.

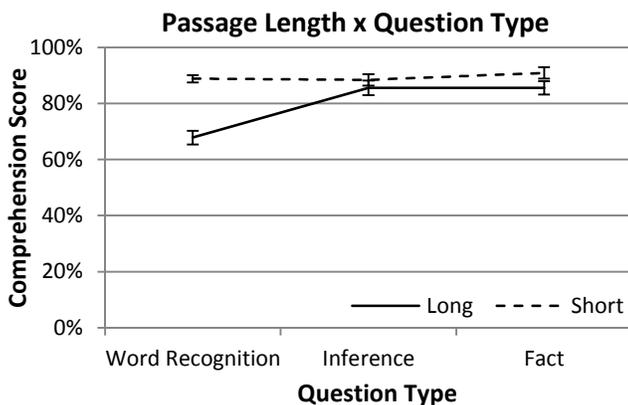


Figure 1. Passage Length x Question Type. The interaction between Passage Length and Question Type demonstrates significantly worse performance for Word Recognition on Long passages.

Reading speed. To explore differences in reading speed between RSVP and Traditional, a paired samples t-test was conducted. One person's speed data was unable to be recorded, so $N = 19$ for the speed data. RSVP reading ($M = 219.18, SD = .25$) was significantly faster than Traditional ($M = 179.60, SD = 47.04$) (see Figure 2) by an average of 39.61 WPM, $t(18) = 3.67, p < .01, d = .84$. Short passages ($M = 196.22, SD = 25.55$) were significantly slower than Long passages, ($M = 204.55, SD = 22.17$), $t(18) = 3.51, p < .01, d = .81$. We surmised that this was due to re-reading of Short passages. Two one sample t-tests were run to compare Long and Short Traditional with the RSVP reading speed of 220 WPM. Both Long Normal ($M = 188.19, SD = 44.99$), $t(18) = 3.08, p < .01, d = .71$, and Short Normal ($M = 171.03, SD = 52.42$), $t(18) = 4.15, p < .01, d = .95$ were significantly different from the test value of 220. A paired samples t-test revealed that they were also significantly different from each other, $t(18) = 3.45, p < .01, d = .79$.

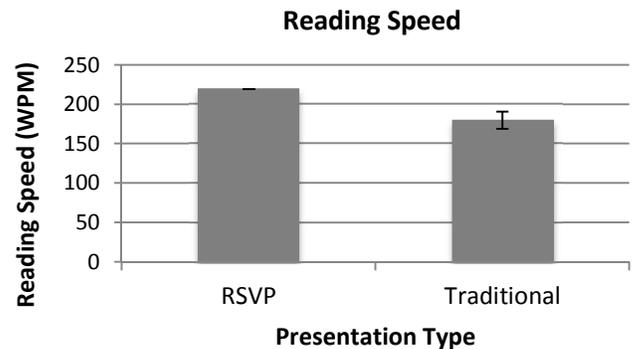


Figure 2. Reading Speed. RSVP reading was faster than Traditional by an average of 39.61 WPM.

Subjective Measures

Mental workload. A paired samples t-test was run to examine the effect of presentation type on overall C-SWAT scores. Mental workload was significantly higher for RSVP ($M = 77.22, SD = 20.86$) than Traditional ($M = 53.33, SD = 16.36$), $t(19) = 4.61, p < .001, d = 1.03$. See Figure 3.

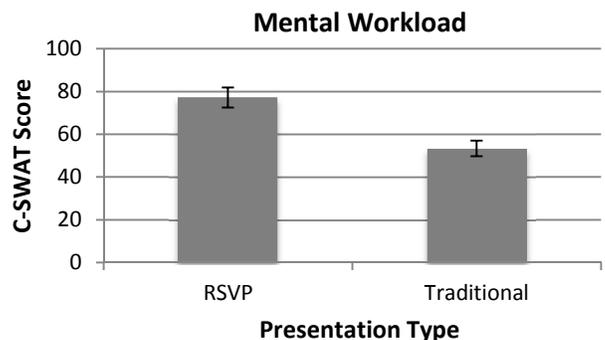


Figure 3. Mental Workload. RSVP elicited significantly higher workload than Traditional on the C-SWAT.

Reading satisfaction. Paired samples t-tests were performed to evaluate differences in reading satisfaction between RSVP and Traditional. Traditional received more

positive ratings on all significant items. Non-significant items included Text Size, Crispness of Text, Physical Fatigue, Mental Fatigue, and Eyestrain. Means and standard deviations are summarized in Table 1.

Table 1

Means and standard deviations indicate ratings on a 7-point scale.

	RSVP		Traditional	
	Mean	SD	Mean	SD
Reading Ease*	3.85	1.57	6.10	1.07
Ability to concentrate*	4.45	1.19	5.75	1.48
Text Size	4.45	1.70	5.10	1.65
Text Layout*	4.60	1.73	5.65	1.23
Text Crispness	5.20	1.67	5.65	1.18
Physical Fatigue	4.95	1.61	5.60	1.43
Mental Fatigue	4.30	1.84	5.00	1.65
Confidence in comprehension*	4.15	1.81	5.70	1.26
Eyestrain	4.40	1.67	4.90	1.45
Likelihood to read textbook*	1.90	1.52	3.80	2.29
Likelihood to read leisure*	3.05	2.14	4.75	2.02
Likelihood to read news*	2.55	1.79	5.00	2.00

* $p \leq .004$

Overall preference. A chi-square test of goodness-of-fit was performed to determine the difference in preference of presentation type. Traditional was preferred more than RSVP, $\chi^2(1, N = 20) = 12.80, p < .01, w = .80$. See Figure 4.

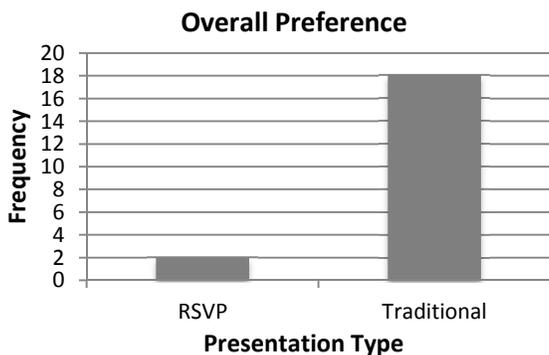


Figure 4. Overall Preference. Traditional was the preferred reading method over RSVP by 18 of 20 participants.

Qualitative data. Those that preferred Traditional indicated that RSVP was “stressful” and “unpredictable.” Participants expressed frustration with the inability to see upcoming words or go backward. They struggled with the speed and sequential presentation of words, and felt overwhelmed with the constant presentation of new information. That is, participants felt that they often hadn’t fully absorbed the content that had already passed by the time new information was being presented. Those who preferred RSVP said they were able to read more quickly, and stated that they felt retention was better as a result of the sustained attention required to keep up with RSVP. RSVP was also

preferable due to the small screen size, where all words at once appeared overwhelming. Most participants mentioned that RSVP would be a better reading method for small pieces of text such as text messages or emails, but longer content such as books or news articles are best for Traditional.

DISCUSSION

Our results indicate that RSVP and Traditional text presentations can be read at a similar level of understanding regardless of passage length or question specificity. Despite a perceived decrease in comprehension, participants can read faster with RSVP than Traditional with similar understanding.

Our finding of a discrepancy between reading performance (both comprehension and speed) and subjective measures are consistent with previous studies. Traditional was strongly preferred to RSVP according to subjective measures and qualitative data. Participants reported higher mental workload on the C-SWAT and gave Traditional more positive ratings for all significant subjective items on the reading satisfaction questionnaire: on average, Traditional resulted in easier reading and concentration, a better text layout, and more confidence in comprehension than RSVP. Participants also indicated that they would be more likely to read all three content types assessed (News, Leisure, and Textbook) with Traditional. Interestingly, ratings of mental fatigue, physical fatigue, and eyestrain did not differ significantly between presentation methods. We expected detriments to RSVP on these items, especially given the results of the C-SWAT.

There are a few limitations to this study. While we believe the character differences between Short and Long passages were sufficient to draw conclusions about passage length, the Long passages still needed to be short enough to fit on the smart watch screen. Future studies may want to increase the length of long passages to confirm the effect of passage length. Additionally, while past research has utilized modified versions of RSVP that have been altered to flow at a more natural pace and provide the reader with more control over speed, our RSVP condition was conventional (every word presented for the same amount of time at a set speed) and may not have had the advantages of an improved RSVP.

It is difficult to determine the degree to which experience plays a role in the overwhelming preference for Traditional presentation over RSVP. Further studies are needed to examine whether practice and familiarity may improve opinions of RSVP. Since many participants indicated that RSVP may be better for short pieces of text, more research as to the optimal type of reading content for various presentation types may be beneficial.

Qualitative data revealed that a major factor in preference for Traditional was the inability in RSVP to make regressive eye movements and adjust the speed or stop text when necessary. Further studies should look into modifications for RSVP that would make reading with this method more pleasant and less stressful. To preserve methodological control, the text size in our study remained constant across presentation methods. This detracts from one of the major potential advantages of RSVP in maximizing the use of small screen space. Additionally, since the traditional

condition did not involve scrolling, the advantage of a free hand afforded by RSVP was also not observed. Future studies should incorporate these potential benefits with modified versions of RSVP to more fairly assess reading performance and satisfaction.

REFERENCES

- Benedetto, S., Carbone, A., Pedrotti, M., Fevre, K., Bey, L., & Baccino, T. (2015). Rapid serial visual presentation in reading: The case of Spritz. *Computers in Human Behavior*, *45*, 352-358.
- Bernard, M., Chaparro, B., & Russell, M. (2000). Is RSVP a Solution for Reading from Small Displays? *Usability News*, 2.2. Retrieved from <http://usabilitynews.org/is-rsvp-a-solution-for-reading-from-small-displays/>.
- Castelano, M.S. & Muter, P. (2001). Optimizing the reading of electronic text using rapid serial visual presentation. *Behaviour and Information Technology*, *20*, 237-247.
- Chaparro, B., Shaikh, D., & Baker, J. (2005). Reading Online Text with a Poor Layout: Is Performance Worse? *Usability News*, 7.1. Retrieved from <http://usabilitynews.org/reading-online-text-with-a-poor-layout-is-performance-worse/>.
- Chien, Y. H., Chen, C. H., & Wei, W. L. (2008). Effects of dynamic display, presentation method, speed, and task type on reading comprehension of wristwatch screens. *Displays*, *29*, 471-477.
- Flesch, R. (1994). *The art of readable writing*. Hoboken, NJ: John Wiley & Sons.
- Flesch, R. (1948) A new readability yardstick. *Journal of Applied Psychology*, *32*(3), 221-233.
- Gilbert, L.C. (1959). Saccadic movements as a factor in visual perception in reading. *Journal of Educational Psychology*, *50*(1), 15-19.
- Hedin, B., & Lindgren, E. (2007). A Comparison of Presentation Methods for Reading on Mobile Phones. *Distributed Systems Online, IEEE*, *8*(6), 2.
- International Data Corporation. (2015). Worldwide Wearables Market Forecast to Grow 173.3% in 2015 with 72.1 Million Units to be Shipped, According to IDC [Press release]. Retrieved from <http://www.idc.com/getdoc.jsp?containerId=prUS25696715>
- Juhasz, B. J., White, S. J., Liversedge, S. P., & Rayner, K. (2008). Eye movements and the use of parafoveal word length information in reading. *Journal of Experimental Psychology: Human Perception and Performance*, *34*, 1560-1579.
- Juola, J. F. (1988). The use of computer displays to improve reading comprehension. *Applied Cognitive Psychology*, *2*(1), 87-95.
- Kincaid, J.P., Fishburne, R.P., Rogers, R.L., & Chissom, B.S. (1975). Derivation of new readability formulas (automated readability index, fog count, and flesch reading ease formula) for Navy enlisted personnel. Research Branch Report 8-75. Chief of Naval Technical Training: Naval Air Station Memphis.
- Kintsch, W., & Welsch, D.M., Schmalhofer, F., & Zimny, S. (1990). Sentence memory: A theoretical analysis. *Journal of Memory and Language*, *29*, 133-159.
- Kolb, P. DISCO: A Multilingual Database of Distributionally Similar Words. In *Proceedings of KONVENS-2008*, Berlin, 2008.
- Luximon, A., & Goonetilleke, R. (1998). Continuous subjective workload assessment technique. In R. Bishu, W. Karwowski, & R. Goonetilleke (Eds.), *Ergonomics for Global Quality and Productivity*, Clear Water Bay, Kowloon, Hong Kong. Retrieved from <http://www-icem.ust.hk/dfaculty/ravi/papers/cswat.pdf>
- Masson, M. E. J. (1983). Conceptual processing of text during skimming and rapid sequential reading. *Memory & Cognition*, *11*(3), 262-274.
- Microsoft. (2015). *Use Quick Read to view notifications*. Retrieved from <https://www.microsoft.com/microsoft-band/en-us/support/tiles/quick-read-notifications>.
- Maurer, M. S., Klein, M., & Waldman, F. A. (2014). U.S. Patent No. 20140016867.
- Mills, C. B. & Weldon, L. J. (1987). Reading text from computer screens. *ACM Computing Surveys*, *19*(4), 329-358.
- Potter, M. C., Kroll, J. F., & Harris, C. (1980). Comprehension and Memory in Sequential Reading. In R. Nickerson (Ed.), *Attention and Performance VIII*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Potter, M. C. (1984). Rapid serial visual presentation (RSVP): A method for studying language processing. *New Methods in Reading Comprehension Research*, *118*, 91-118.
- Rayner, K. (2009). Eye movements and attention in reading, scene perception, and visual search. *The Quarterly Journal of Experimental Psychology*, *62*(8), 1457-1506.
- Rayner, K., & Pollatsek, A. (1989). *The Psychology of Reading*. Englewood Cliffs, NJ: Prentice Hall.
- Rayner, K., Schotter, E. R., & Drieghe, D. (2014). Lack of semantic parafoveal preview benefit in reading revisited. *Psychonomic Bulletin & Review*, *21*(4), 1067-1072.
- Rubin, G. S., & Turano, K. (1992). Reading without saccadic eye movements. *Vision Research*, *32*, 895-902.
- Rubin, G. S., & Turano, K. (1994). Low vision reading with sequential word presentation. *Vision Research*, *34*, 1723-1733.
- UnoNoteband. (2014). *Say hello to Uno!* Retrieved from <https://www.youtube.com/watch?v=6Lu7BVZPaTw>
- Öquist, G., & Goldstein, M. (2003). Towards an improved readability on mobile devices: Evaluating adaptive rapid serial visual presentation. *Interacting with Computers*, *15*(4), 539-558.
- Öquist, G. & Lundin, K. (2007). Eye movement study of reading text on a mobile phone using paging, scrolling, leading, and RSVP. In: Proceedings of the 6th International Conference on Mobile and Ubiquitous Multimedia. Oulu, Finland, 176-183.