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Digital Media Impact on Reading

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Abstract

Introduction: This research observes whether there is a difference in the way information is memorized based on the means it is obtained: printed or digital. **Objectives**: To observe if the memory of information is affected by the media it is obtained from—printed or digital—and also to observe if there is any response time difference, considering participants' gender and academic area in the information apprehension process. **Method**: To evaluate these observations, a memory test has been developed and applied to Technology and Psychology graduate students at BandTec Digital School and at Pontifícia Universidade Católica de São Paulo (PUC-SP), respectively. The total of 195 students was interviewed, 62 (31.8%) from Psychology area (PUC-SP) and 133 (68.2%) from Technology area (BandTec Digital School). There were 103 (52.8%) interviews with digital media and 92 (47.2%) with printed content, 117 (60%) tests were answered by men and 76 (39%) by women, and the age range was 16 - 43. **Conclusion**: Based on quantitative research information, expected hypothesis was achieved: information acquired through printed material is better apprehended than when acquired through digital media. This conclusion provides significant information to educators, giving support to the creation of new teaching strategies for future generations.

Keywords

Memory, Technology, Education, Reading, Psychology, Digital Media

1. Introduction

1.1. Changes Occurred in the Past—How Technology Has Changed the Way Knowledge Is Gained

Humanity—*Homo sapiens*—was born 70,000 years due to the cognitive revolution (Harari, 2016). We had existed before, but we were just another *Homo* species on the planet. By virtue of this new capacity of having a symbolic language,

we became the top of the chain of all species, dominating, by either mating or destruction, other species such as Neanderthals and *Homo erectus*. Currently, mating is the most likely scenario because of the discovery of Neanderthal DNA in Europeans. In a study conducted by John Hawks in 2012, it was suggested that the 5000 years old frozen mummy of a man found in the Italian Alps, in 1991, contained more Neanderthal genetic material than in modern Europeans (Adam, 2005).

Mind transformation has been the greatest weapon of our species. Probably, it was at that time that our psyche, as we know it today, took its first form.

In the existential journey, our species has been developing many technologies and a complex explanation of the universe we inhabit. Our creations have transformed our mind into our journey, on an ongoing basis. Some of these creations may be considered inflection points of our way of thinking. For example:

- The invention of writing: passage from oral culture to written culture. Plato explored this theme in his famous *Dialogues* (Plato, 427-347 BC). Written culture valued memory less, according to the speaker Socrates.
- The invention of cartography: change in intellectual experience on the abstraction of space. Translation of a natural phenomenon into an artificial and intellectual conception of the space phenomenon.

"The intellectual process of the transformation of the experience of space into the abstraction of space is a revolution in the way of thinking" (Virga, 2007: p. 5).

- The invention of the mechanical clock: human life, once dominated by agrarian rhythms, without accuracy and productivity pressures, has changed both the way we see ourselves and our way of thinking.
- The invention of the printed book: the explosion of titles spread a linear and literary mind with an impact on culture, art, science and society.
- The invention of the Internet and smartphones is bringing a new era for humanity.

1.2. Possible Future Scenarios

In this study, we understand consciousness as our perception of how things actually happen, that is, the here and now: my act of writing and mastering the environment and equipment that I use, as well as the act of reading and understanding the reading, for example. Through sensory organs, the information that is captured from the environment in which the individual finds himself forms the awareness of experience and knowledge. Memory is not consciousness. By outsourcing my memory to a device, such as a piece of a paper or a smartphone, I do not run the risk of having my memory copied. As Jung defined, consciousness is the function or activity that maintains the relation of psychic content to the ego conceptually distinct from the psyche, which encompasses both the consciousness and the unconsciousness (Jung, 2014).

Consciousness is influenced by the constant use of external and internal information to form conclusions. Thus, the use of technology to obtain information can make us dependent on this process in the formation of our knowledge.

The constant use of social networks, instant messaging and other technologies are stimulating different areas of our brains (Carr, 2010); our capacity for cognition and the way of thinking always seem to require external support to complete. The capture of information is relative to the level of consciousness and its complexities. Currently, we are only memorizing the place where we can get the information we need, as if we just kept the index. It is more practical to use technology. For example, it is a habit to use it to guide us back home in our routine, as there is no need to think about how we will get anywhere, either in the place where we live or in any unknown area. We simply use technology.

The benefits are enormous because the access to great part of the human knowledge fits in the palm of a hand. We can communicate, verbally and visually, with other people instantaneously, regardless of the distance.

We wanted to observe if the information apprehension through reading in the digital form is different from the information apprehension in the printed form, emphasizing that knowing is different from informing oneself. However, we question whether the habit of using technological instruments can influence our apprehension capacity.

Socrates was right. When people became accustomed to writing their ideas and to reading the ideas of others, they became less dependent on the content of their own memory (Havelock, 1963). Today technology has brought this condition to a new frontier. People are getting used to just memorizing the place where possibly a certain content can be found. You just have to know how to look for it. According to Umberto Eco (1996), fear can be dislocated, since books, besides being a supplement for memory, also challenge and improve it.

The extended mind is a notion that goes beyond gray matter. It is the idea that allows the understanding of human cognition, acting in a system coupled with the environment (Clark, 1998). In their work *The Extended Mind*, Clark and Chalmers defined a system of extended cognition as an external object to perform the function; otherwise it would be obtained through the action of an internal cognitive process. A simple example would be to write a number on a piece of paper instead of keeping that information in memory. Internet coupled with smartphone technology provide an excellent way to outsource. We are increasingly dependent on the external memory of our smartphones for various important and daily information.

David Brooks (2007), a *New York Times* journalist, wrote that the information age would make us wiser, but he realized that it, in fact, enabled us to know less. It provides external cognitive servants: applications, algorithms, and the knowledge network. "We can leave the work with these technological servants and free ourselves" (Brooks, 2007). Why do I have to memorize a book if I can use my brain to keep a quick guide to an entire library? "Memorizing has become a waste of time" (Frean, 2008: p. 115).

The increasing use of technology for working, playing and learning activities requires a multitasking concept, that is, many simultaneous activities for children, young people and adults. The uses of multifunction devices have created the

sense that we need to stay always connected from a variety of sources, raising concerns about the quality of learning in these settings, especially among children. The literature considers that multitasking learning is generally more inefficient than the single task. The study *Growing up multitasking*: *The costs and benefits for cognitive development* (2014), by Mary L. Courage, Aishah Bakhtiar, Cheryll Fitzpatrick, Sophie Kenny and Katie Brandeau, however, showed that multitasking learning may not only be successful, but it also can result in more accurate visual and perceptual abilities when tool development and platforms are adequate and activities are controlled by the individual (Courage et al., 2015).

In the research *The Brain in Your Pocket*: *Evidence that smartphones are used to supplant thinking* (Barr et al., 2015), it has been explored what might be the consequence for human cognition the fact of having the basis of human information at the fingertips instantaneously. The authors sought to understand if individuals less likely to engage in rational efforts could compensate for such lack by relying on the Internet through their smartphones. The results indicate that people are using their handsets as part of their thinking equipment. This procedure is different from obtaining information in a library, where the search for information involves introspection and the need to establish knowledge.

Getting informed is a process of identifying and selecting subjects that are relevant and interesting to the researcher. On the Internet, this search occurs instantaneously and does not require the content obtained to be memorized, since the access is immediate, and it can be done again in a simple and fast way. The evolution of human knowledge, which was recently stored in libraries around the world with limited access, is immediately available to most inhabitants of the planet, with the right to a reasonable translation of the material into the most widely spoken languages.

In the research *Storing information in-the-world*: *Metacognition and cognitive offloading in a short-term memory task* (Risko et al., 2015), the authors investigated motifs that influence the decision of storing the information in external *versus* internal format (in memory), using a variant of a traditional short-term memory test: remember a set of letters that is presented in ascending order, that is, from 1 to 10 letters. In one of the studies, two forms of experiments were performed. In the first, the participants had to remember by heart the presented items and, in the second, they could take notes. In set 1, without the alternative of taking notes, the participants did well with two letters, decreasing the level of accuracy until they could not remember almost anything with 10 letters. In the alternative of taking notes, the performance improved a lot, because the hits were decreasing in a less accentuated way, reaching almost 70% in the sets of 10 letters. Participants scored much less with two-letter sets until they almost always jotted down the 10-letter sets. The performance of those who scored was always better, and the choice to score begins with 40% when they were in the two-letter stage and ends with 90% in the 10-letter stage. By using an external mechanism, this study clearly demonstrates that memory is greatly improved through cognitive performance.

The research *Answers in your fingertips—Internet influence to answer questions—Fewer correct*, conducted by the Universities of Toronto and Waterloo, in Canada (2015), sought to understand how the access to this powerful information tool, the Internet, influences our way of thinking, which represents an important issue for Psychology. In this study, the impact of Internet access was examined on the metacognitive process, which governs our decision about what we *know* and what *we do not know*. By answering a battery of questions, the study showed that one group with Internet access produced a set of more wrong answers than the group that did not have that access. The correct answers of the group with Internet access, however, were more complete, demonstrating that this access can influence the metacognitive process, bringing new concepts in the operation of the memory system (Ferguson et al., 2015).

The use of predefined signs on smartphone keyboards, such as the emojis, icons used to express an idea or emotion through electronic messages, is now a universal form of communication. If we consider English as the most spoken language, emojis surpass it (Evans, 2017).

The comparison with emojis, however, already shows their greater use in the world. By 2017, there was 4 billion smartphones[1] on the planet, and they all have emoji keyboards and 6 billion emojis are transmitted per day. Since the creation of emojitracker.com website, on July 4, 2013, the emojis used on Twitter have been counted. On April 1st, 2018, more than 22 billion emoji tweets have been registered, the page of that site ignites emojis just as they are being sent and they are hundreds per second[2]. This volume is only on Twitter. If we consider other social networking tools, such as Facebook, WhatsApp and others, that amount can even triple.

As Vyvyan Evans stated in his book *The Emoji Code* (2017), the widespread use of emojis is due to our constant truncated digital messages, which we now use in our day to day communication, and they are replacing casual conversation. Emojis convey emotion, which is not possible only with words in a short text.

We always use pictures to teach children a formal communication.

Because we are increasingly dependent on virtual relationships, the form of visual communication becomes necessary. It adds emotional experience and personality in communication. It has an important communicative value in the digital age, where we are increasingly leaving the written form of communication to use images, loaded with emotional content, that are more adherent to the process of understanding our brain (*Evans*, 2017).

Machlulan (1964) astonished the world when, with the phrase *The Medium is the Message*, also said that in the future we would reach a transition juncture in our intellectual and cultural history, a moment between two modes of thinking. Our calm, focused and concentrated thinking is being exchanged for a mind that

[1]<http://www1.folha.uol.com.br/mercado/2017/09/1917782-brasil-lidera-numero-de-smartphones-conectados-na-america-latina.shtml>. Accessed June 7, 2018.
[2]<www.emojitracker.com>. Accessed May 15, 2018.

needs and wants to receive and distribute information in a short, disjointed form in frequent bursts, the faster, the better.

Throughout our history, some inventions have brought important transformations for humanity. The abandonment of oral culture in favor of written culture made information kept in the memory lose its prominent place. With the invention of cartography, our minds came to understand everything as a map. Today we tend to map our problems in order to equate them better. The clock, which sets the time of day, causes people to eat lunch at noon because it is time, conditioning their organism to the time controlled by the mechanism by creating an entire culture of the hour. The printed book spread knowledge and made an impact at that time for those who could read, as they were inundated with many titles, wondering what they would do with so much information.

Behavior change in reading has been researched before. Ziming Liu, in his article *Reading behavior in the digital environment* (2005), investigated the reading behavior in digital environment, analyzing the subject behavior 10 years prior to the research, using the method of research with questionnaires.

"*With the increase in the volume of digital information available and the increase in the time we spend reading electronic devices, the digital environment has begun to alter people's reading behavior*" (*Liu*, 2005: *p.* 701).

At that time, however, Facebook had just been released (2004) and the Kindle (tablet reading) did not exist but entered the market through Amazon in 2007. The changes that have occurred until today, 2019, have been enormous. When Liu's research was conducted, digital reading was on a console, not like now on tablets and smartphones. This study consisted of sending a questionnaire with 17 questions in order to explore how reading in the digital environment had changed in the last 10 years, and interviewees sent their statements, including reading time for work and leisure. Questions that reflected general changes ("increase", "decrease", "without change") were used and, if the participant did not remember, the "do not remember" category was included. The study found that in an increasingly digital environment readers (especially the younger ones) are more likely to switch to digital reading and increase the use of keyword browsing and word search strategies to cope with the environment of information abundance. On the other hand, readers continued to use printed reading material, especially for in-depth reading.

"The preference of people for paper as a means of reading implies that the printed text will not tend to disappear in the digital age" (LIU, 2005: p. 705).

The invention of writing was central to human development, as Harari well described:

Before the invention of writing, the stories were confined to the limit of the human brain's capacity. It was not possible to invent overly complicated stories that people could not remember. Writing, however, suddenly made it possible to create long and intricate stories, which were stored on tablets and papyri and not on human heads (…).

Thus, writing enabled humans to organize entire societies into an algorithmic

model (…).

In illiterate societies people do all the calculations and make all the decisions by heart (*Harari*, 2015, *e-book*, *loc*. 2755).

The smartphone advent is transforming our minds considerably, just as it has happened before with the invention of writing, leading to the end of the oral knowledge transmission and, with the invention of Gutenberg's book, such important moments have changed our way of thinking. The Internet and smartphones are making us shallow, without depth in knowledge, but we now have the ability to get any existing information by typing a single word. This is a new moment for humanity.

It is possible that this new way of gaining knowledge, for example, icons, films, and short texts, may seem beneficial to mankind because our brain is built to recognize patterns. Written texts are not really a standard, for they require a rationality still to be understood. They are an attempt to describe our senses in one way only: rationally.

The new forms of content dissemination brought by technology are much more in line with our neural capacity, which is based on pattern recognition (Basulto, 2013). Zinnig Liu, in his 2005 paper *Reading behavior in the digital environment*, showed that there was a significant increase (83%) in time spent with digital reading, an increase (82%) in non-linear reading and a decrease (almost of 50%) of attention maintenance.

Nicholas Carr made these observations in his book *The Shallows* (2010):

A research and consulting company, *called nGenera*, *produced a study on the effects of the Internet on young people*. *Interviewing* 600 *young people*, *who*, *in the report*, *are called Net Generation—young people who were born using the Internet*. *Digital immersion*, *writes the researcher*, *has affected even the way they absorb information*. *They do not necessarily read a page from left to right and top to bottom*. *They can jump around*, *instead*, *looking for information about a particular issue of interest* (*Carr*, 2010: *p*. 9).

It seems that we have arrived, as McLuhan had mentioned, at an important juncture in our intellectual and cultural history, a time of transition between two different ways of thinking.

"Calm, focused, attentive, the linear mode of thinking is being set aside in a new way that wants and needs to assimilate and distribute information in small bursts, disjointed and usually superimposed—the faster, the better" (Carr, 2010: p. 9).

"For the last five centuries, ever since Gutenberg's printing press made book reading a populist pursuit, the linear literary mind has been at the center of art, science, and society. As supple as it is subtle, it has been the imaginative mind of the Renaissance, the rational mind of the Enlightenment, the inventive mind of the Industrial Revolution, even the subversive mind of Modernism. It may soon be the yesterday's minds" (Carr, 2010: p. 10).

The study *Reading linear texts on paper versus computer screen*: *Effects on Reading Comprehension* (Mangen et al., 2013) had the objective of studying the

effects of the technological interface on reading comprehension in a Norwegian school with 10th grade students, concluding that those who read printed information had far better scores on reading comprehension compared to those who read the texts in digital form.

In this work, we will search for implicit memory. What is the interference of the use of technology to apprehend information, comparing digital and printed apprehension?

1.3. Hypothesis

The information procedural memorization when obtained through printing means is more effective than when obtained through digital means.

2. Method

2.1. Participants

Young people are the ones who coexist with technology on a daily basis, especially the so-called generation Z (born after 1997, up to 21 years of age) and the generation Y (born between 1977 and 1996, above 21 years old)[3], called *millennials* also had contact with technology from an early age. Aiming at this population through convenience sampling, we selected the following:

- Students of undergraduate courses, 1st year of Computer Science at BandTec Digital School, in São Paulo (SP).
- Postgraduate students of Technology at BandTec Digital School, in São Paulo (SP).
- Graduating students, from the 1st and 3rd semesters, of Clinical Psychology at Pontifícia Universidade Católica de São Paulo (PUC-SP).
- Postgraduate students of Clinical Psychology at Pontifícia Universidade Católica de São Paulo (PUC-SP).

2.2. Instrument

To carry out a study with the highest degree of precision possible, we performed a quantitative research using the game *Lost*! described in Appendix B. This game was adapted from *Balloon Debates*, developed by the University of Kent (UK), and the use authorization is found in Appendix A.

2.3. Procedure

Students who volunteered to participate were divided into two randomly chosen groups, and they were given instructions at the beginning of the process.

One group, randomly chosen by lot, received instructions in printed form, and the other group, in digital form, accessing the instructions through the mobile phone, or in a link available on the Internet. Participants had 10 minutes to read the instructions. After this period, the instructions were collected, the access to the link was interrupted, and the students no longer could see them. After

[3]http://socialmarketing.org/archives/generations-xy-z-and-the-others/.

that, the students with the printed instructions received one sheet of paper for the response, and the other group was directed to another link. Both groups of participants informed sex and age and then filled in the comprehension responses from the reading text, which also recorded the execution time of the responses. The results were captured in a database for further analysis. In this database, there are information on participants' academic background.

The game consists of assessing what should be taken to a lifeboat from a sinking ship. There is a description of each of passenger, containing information to help the participants find the best response requested by the survey. It is only possible to take to the lifeboat five objects out of a total of 13, which belong to the passengers and to the captain. Some passengers have objects that obviously should not be taken, and others have objects that clearly must be taken. There are some objects, however, that will raise doubts. As there is a deadline for participants to read the information and another deadline to choose the five objects, it will be possible to evaluate the ability to obtain and retain the information of each participant. The details of the game are described in Appendix B.

3. Results

Research

During the research, 195 students answered the test, 103 (52.8%) had a digital content and 92 (47.2%) had a printed content, 117 (61%), Table 1, were men and 76 (39%) were women, with two answers without gender identification. The students in the Psychology area were 62 (31.8%) and the Technology students were 133 (68.2%), Table 2. The age of the participants ranged from 16 to 43 years old, Table 3. They were Psychology undergraduate and graduate students at the Pontifícia Universidade Católica de São Paulo and Technology undergraduate and graduate students at BandTec Digital School. Revising respondents' profile of collected data, there was a significant number of questionnaires answered by men, that is, 117 out of 195. This fact was totally random, and it is due to the greater presence of men in the Technology area and, although there are more women in the Psychology area, these classes were smaller.

The statistical analysis of the data had the objective of studying the different correlations between the defined variables of each participant. In the study, such variables were correlated with the individual results of each participant.

The general results showed that the dependent variable studied (score) differs from the independent variable (instruction), either digital or printed, and it has statistical significance.

Table 1. Form of instruction.

Instruction	Frequency	Percent	Valid Percent	Cumulative Percent
1 Digital	103	52.8	52.8	52.8
2 Printed	92	47.2	47.2	100.0
Total	195	100.0	100.0	

Table 2. Academic area.

Academic Area	Frequency	Percent	Valid Percent	Cumulative Percent
1 Technology	133	68.2	68.2	68.2
2 Psychology	62	31.8	31.8	100.0
Total	195	100.0	100.0	

Table 3. Age distribution.

Age	Frequency	Percent	Valid Percent	Cumulative Percent
1 Up to 21 (Z)	125	64.1	67.2	67.2
2 Over 21 (Y)	61	31.3	32.8	100.0
Total	186	95.4	100.0	
SR	9	4.6		
Total	195	100.0		

This analysis was performed using the General Purpose Simulation System (GPSS), a software that received all data from each participant and performed the correlation calculation of each variable and the statistical significance of each correlation. Every resulting final factor represents a group of individualized points of view with high correlation with each other, not correlating with others.

Most of the students took 10 minutes to read the instructions. The variables obtained in this study are presented as mean and standard deviations. To analyze the two sets, Student's *t*-test was used to evaluate our hypothesis that, by using the printed form, the memorization would be more efficient. This test verified whether there was a significant difference between the two sets of data: responses from participants who read the printed material and those who read it digitally. The average responses from those who read the instructions digitally were lower than the average responses from participants who read the printed instructions.

The means obtained for each of the instruction types of each group were: 10.96 (digital) and 11.77 (printed), on a scale of 6 to 15. As we can see in the following table, the probability of sets (Table 4) is 99.9% ($p = .001$), with a confidence index equaling to 95%, thus confirming our hypothesis.

Figure 1 clearly shows that the two sets—digital and printed—have a significant separation.

Other correlations were made for the gender, response time, academic area and age variables.

In the correlation of gender and instruction, there was statistical significance as we can see in the following Table 5 and Figure 2, thus confirming our hypothesis for the two genders. Both men and women revealed that the apprehension—and consequent memorization—of the content in printed form was more efficient than the seizure of content in digital form.

Analysis of the results separating the sample in two sets by the student's academic area variable (Technology and Psychology) presented an interesting re-

sult. The study has not focused on the differences in the area of origin of the students participating in the research, but rather on the ability to memorize in relation to the means of obtaining the information instruction to be apprehended. This analysis revealed that our hypothesis was confirmed for all participants in the Technology area (p = .000). For the subset of the sample with participants in the Psychology academic area, although the mean of the results was better in the printed group, statistically this differentiation was not significant (p = .123), and the test results with the digital form presented a dispersion (high standard deviation), as shown in Table 6 and Figure 3 below, suggesting the need for further studies to evaluate this observation.

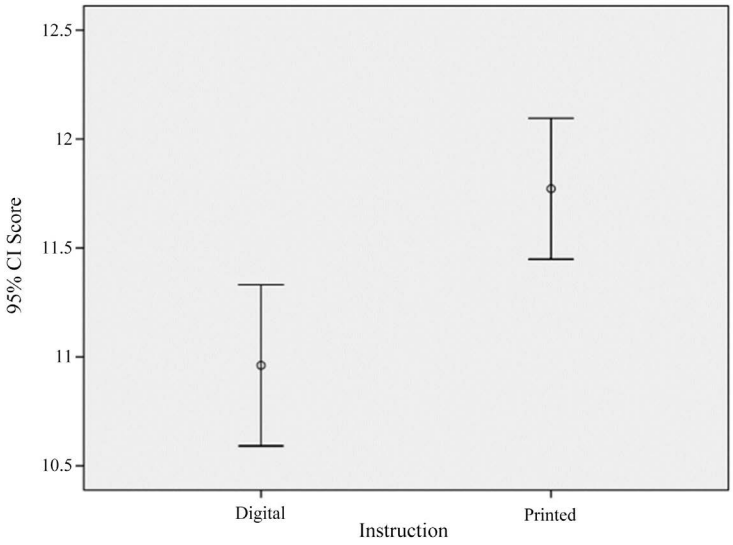

Figure 1. Score by type of instruction, confidence interval and margin of error. Source: personal file.

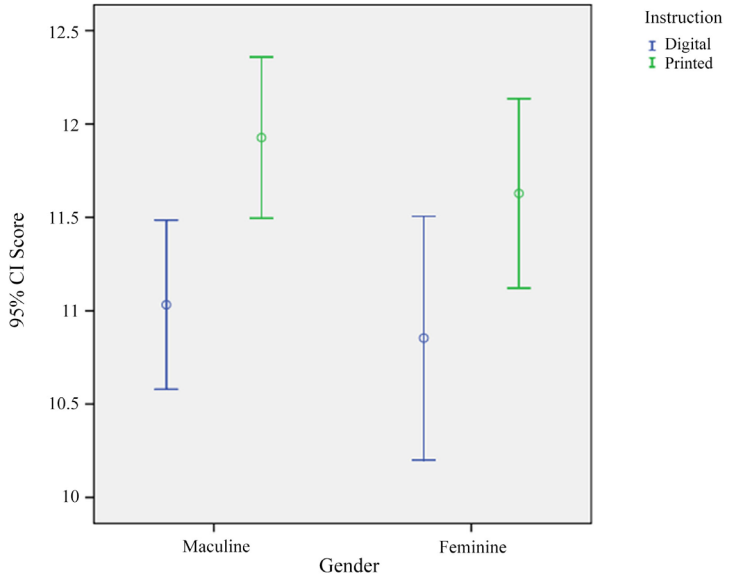

Figure 2. Score by type of instruction and academic area. Source: personal file.

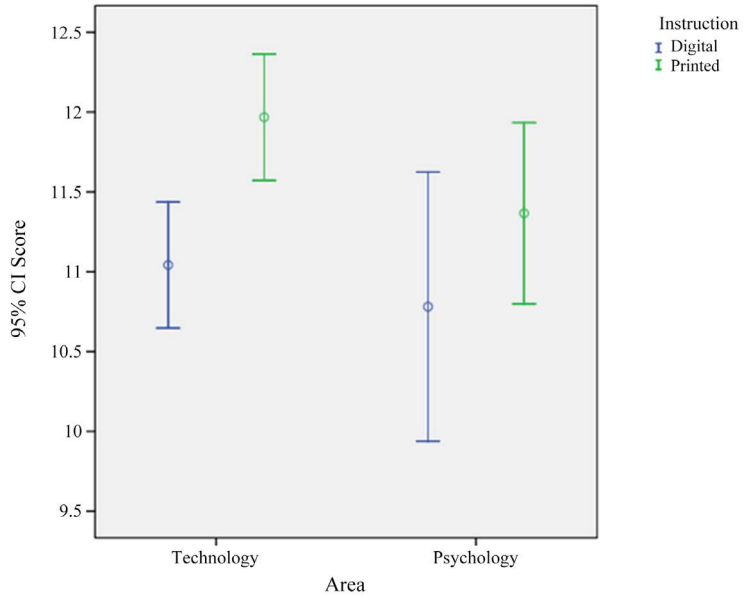

Figure 3. Instruction versus academic area. Source: personal file.

Table 4. Score by type of instruction.

	Instruction	N	Mean	Standard Deviation Standard	Error	*t*	*p*
Score	1 Digital	103	10.96	1.894	.187	−3.272	**.001**
	2 Printed	92	11.77	1.563	.163		

Source: personal file.

Table 5. Punctuation by type of instruction and gender.

	Instruction	N	Mean	Standard Deviation Standard	Error	*t*	*p*
Male							
Score	**1 Digital**	62	11.03	1.783	.226	−2.845	.003
	2 Printed	55	11.93	1.597	.215		
Female							
Score	**1 Digital**	41	10.85	2.068	.323	−1.898	.031
	2 Printed	35	11.63	1.477	.250		

Source: personal file.

Table 6. Score per type of instruction and academic area.

	Instruction	N	Mean	Standard Deviation	Standard Error	*t*	*p*
Technology							
Score	**1 Digital**	71	11.04	1.669	198	−3.291	.000
	2 Printed	62	11.97	1.557	198		
Psychology							
Score	**1 Digital**	32	10.78	2.338	.413	−1.160	.123
	2 Printed	30	11.37	1.520	.277		

Source: personal file.

In the correlation between the independent variables (gender and academic variable) and the independent variable (instruction), it was observed that the academic area variable is statistically relevant only for the participants of the Technology area, there being no statistical significance for our hypothesis for the Psychology area participants, pointing out the need for studies to explain this interesting phenomenon, Table 7 and Figure 4.

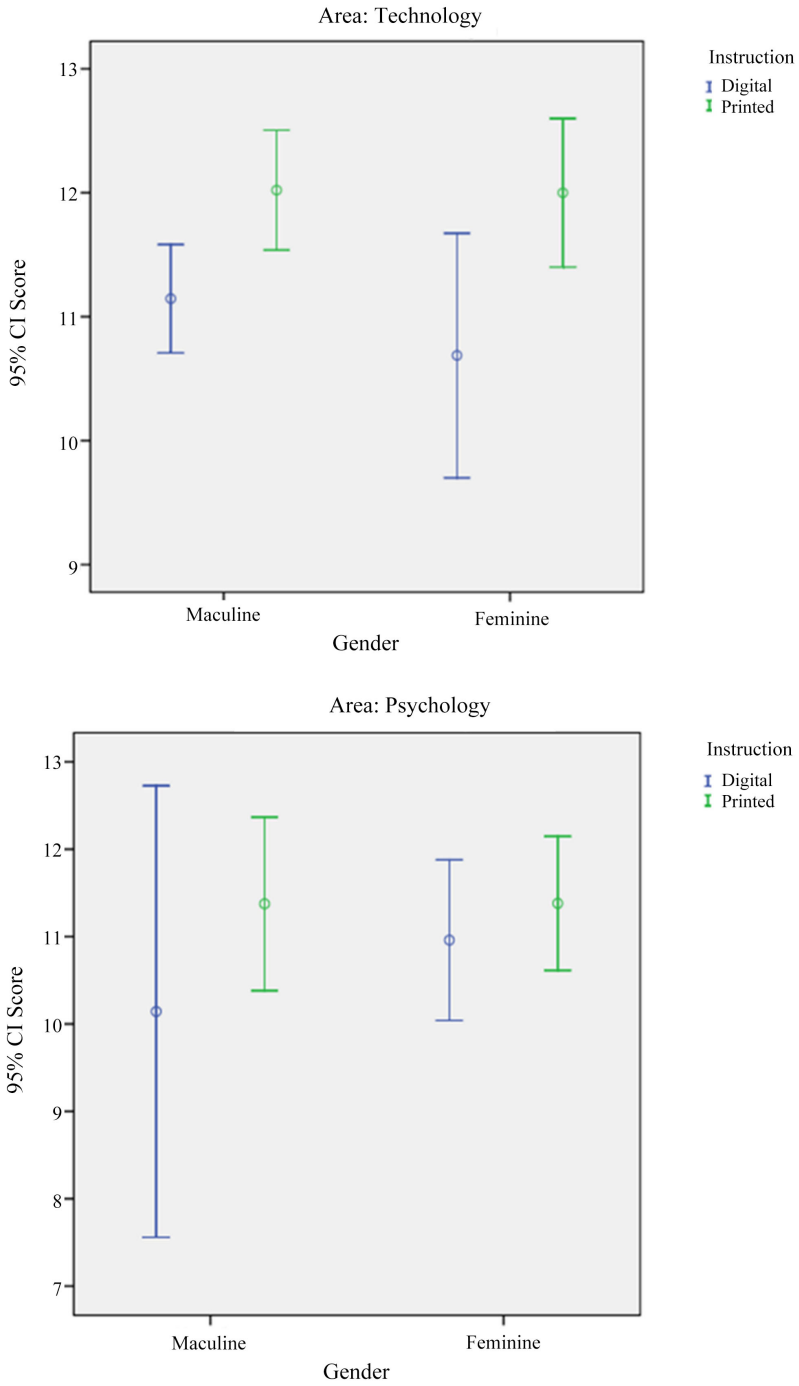

Figure 4. Score by type of instruction, academic area and gender. Source: personal file.

The time variable was relevant to differentiate between digital and print reading for females ($p = .019$), see Table 8. Women who finished faster had a higher score for the digital instruction variable, suggesting that the understanding of the outcome was more efficient for this group. For the male gender, the time variable did not present statistical significance. This phenomenon requires detailed studies for an adequate evaluation. It was verified that the previously mentioned independent variables are significant in the sense of influencing the comprehension and memorability of the read text, contributing directly to the results of the participants in the research, Figure 5.

The age variable did not present significant correlation, revealing that there is no difference in this variable, for both men and women, Table 9.

Table 7. Score per type of instruction, academic area and gender.

	Instruction	N	Mean	Standard Deviation	Standard Error	*t*	*p*
Technology Male							
Score	**1 Digital**	55	11.15	1.615	.218	−2.704	.004
	2 Printed	47	12.02	1.648	.240		
Technology Female							
Score	**1 Digital**	16	10.69	1.852	.463	−2.432	.013
	2 Printed	14	12.00	1.038	.277		
Psychology Male							
Score	**1 Digital**	7	10.14	2.795	1.056	−1.084	.105
	2 Printed	8	11.38	1.188	.420		
Psychology Female							
Score	**1 Digital**	25	10.96	2.226	.445	−.729	.235
	2 Printed	21	11.38	1.687	.368		

Source: personal file

Table 8. Correlation between education, gender and execution time.

	Instruction	N	Mean	Standard Deviation	Standard Error	*t*	*p*
Male							
Time	**1 Digital**	62	116.26	89.213	11.330	−1.387	.084
	2 Printed	55	141.02	103.831	14.001		
Female							
Time	**1 Digital**	41	116.12	63.534	9.922	−2.114	.019
	2 Printed	35	144.97	53.887	9.109		

Source: personal file.

Table 9. Correlation between age, time and instruction.

		Age	Digital		Age	Printed		Age
	r	.035		r	.116		r	−.071
Time	P	.316	Time	P	.122	Time	P	.254
	N	193		N	103		N	90
	r	.032		r	.138		r	−.149
Score	P	.328	Score	P	.082	Score	P	.080
	N	193		N	103		N	90

Source: personal file.

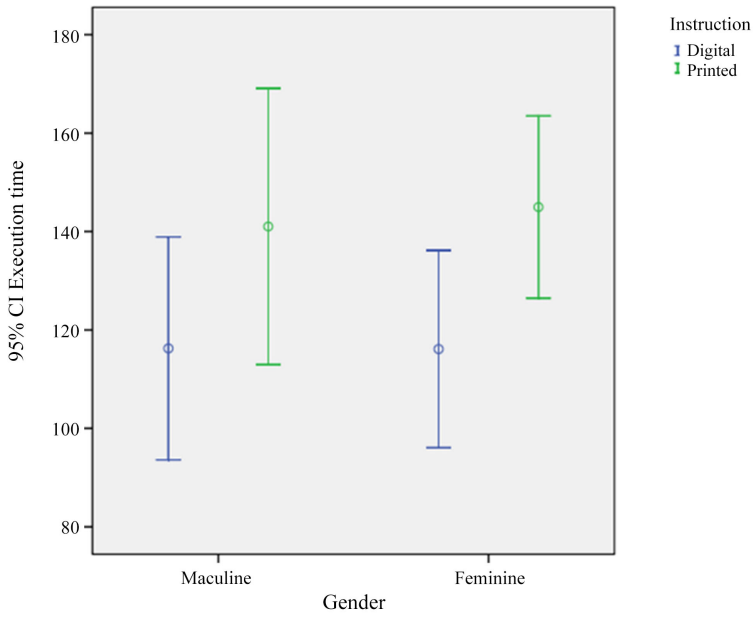

Figure 5. Correlation between instruction, gender and execution time. Source: personal file

4. Discussion and Conclusion

This research has confirmed our hypothesis for the main objective. The participants who did the research with printed material had a more effective performance than the ones who made the research with digital material, with a statistically significant difference. There are some possible explanations for this fact, and the most important is the form of text navigation. When reading digitally, text scrolling is inevitable, except in e-books that have pages defined as in a book. Scrolling is known to hamper the reading process by imposing spatial instability, which can negatively affect the mental representation of the text for the reader and, consequently, comprehension and memorization (Mangen et al., 2013).

Another aspect of navigation relates to how each format, printed or digital, restricts access to the text in its entirety. Evidence suggests that readers remember *where* a particular piece of information is in a text read in print. In two stu-

dies using experimental psychology methods, with page by page and text scrolling information, both on a screen simulating a word processor, the participants' performance evidenced that they created a mental image of the text, remember the main ideas when reading page by page (Piolat et al., 1997). "A good mental representation of the physical layout of the text supports a better reading comprehension, suggesting that the fixation of the text mentally reinforces its comprehension" (Mangen et al., 2013: p. 66).

Another potential explanation may be related to the level of metacognition, that is, to the ability that someone has to monitor its cognitive performance. In a study by Ackerman and Goldsmith (2011), the text reading and comprehension comparisons were performed in digital and printed forms, and the authors observed that in one of the experiments with fixed time, there was no differentiation performance of participants. When the study was self-regulated, however, the performance of the group with the digital form was lower than the group with the printed form. The conclusion of the study shows that people tend to perceive printed media as a better source for depth reading and to perceive digital media as a more suitable manner for quick and shallow reading, for example, short news stories, e-mails and forums (Ackerman and Goldsmith, 2011). In our study, although we had a fixed time, the result was worse for the digital format. All participants, however, completed the responses much before the limit, averaging 2 minutes and 13 seconds for a limit of 8 minutes, which may have caused a self-regulated effect pointed out by this study.

The instruction text contains two pages and it was delivered on a double-sided printed sheet, allowing the printed format readers to have immediate access to all content. In a tactile and visual way, these readers could have a complete view of the whole text. Digital format readers, on the other hand, viewed only one screen and could go back and forth using the *next* and *back* buttons, making it difficult to see and understand the entire text structure. This suggests that the mind map of the content may have been impaired, which leads to future research using e-book digital content format, which does not have the scrolling process. In the e-book, however, there is no sense of volume. When picking up an electronic book, you need to research to know its size, unlike a printed book, the understanding of which is almost instant when you have it in your hands.

The results of this study showed that reading a text in digital format leads to an understanding and consequent less effective memory than reading in printed format. We need, however, to evaluate if the memorization based on the reading in digital format, with the scrolling of the text, would have the same effect as in digital format, in which there are pages with spatial markers defined, helping the process of memorization. As this result has a strong pedagogical implication and the current study was carried out with the scrolling of the text, more comprehensive studies will be needed to evaluate the impact on cognition and memorability in digital formats without scrolling text. With the information environment increasingly digital and abundant, students (especially the younger ones)

are gradually developing digital reading behavior. On the other hand, readers generally still use printed material for in-depth reading, which suggests the paper will not disappear anytime soon. This behavior, reading printed material, should be encouraged for the young ones to increase their content apprehension.

As the age of a considerable part of the participants consists of people of the so-called generation Z, that is, those who were born after 1997 (67%), who grew up with new technologies, this fact can consequently influence the result. Despite this, it is notable that the age variable did not present a significant difference in the results of this study.

Future research may extend the conclusions of this analysis to students from other areas, since there was a statistically significant difference between Technology and Psychology students.

As already pointed out, new research using the digital format of an e-book, which does not have the scrolling screen navigation, should be conducted to evaluate if this feature is relevant to the understanding and memorization of the text.

The hypothesis confirmation that the acquisition of information through print format is more effective than through digital format provides important data to teaching professionals, supporting the creation of new learning strategies for next generations.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Appendix A. Balloon Debates Game Use Authorization

20/04/2017 Gmail Balloon Debates

joaquim jose silveira <joaquimsilveira@gmail.com>

Ballon Debates

2 mensagens

joaquim jose silveira <joaquimsilveira@gmail.com> 19 de abril de 2017 19:30

Para: bewoodcock@kent.ac.uk

HI,

I am a Post-graduation student in Brazil at Pontifícia Universidade Católica in São Paulo, in Jungian studies at Psychology department.

My dissertation subject is about the impact technology is producing in human mind. People are becoming "shallow" in their capacity of reading text specifically.

In order to conduct my research, I would like to utilize one adaptation of one of the Balloon Debates Lost! of your University that seems to me to fit perfectly in my goals. Therefore, I would like to get authorization for it. It will be applied in groups of students.

Thanks in advance.

Best Regards,

Joaquim Silveira

Tel: 982 568 882

Bruce Woodcock <BEWoodcock@kent.ac.uk> 20 de abril de 2017 05:10

Para: joaquim jose silveira <joaquimsilveira@gmail.com>

Hi Joaquim, that's fine. You are most welcome to use the balloon debate for your dissertation.

Best wishes,

Bruce Woodcock

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Appendix B. Lost! Instructions

You are the captain of the ship. A fire on board destroyed the radio. By the speed that the water is rising inside the ship, you estimate that it will sink from here to at most 2 hours 30 minutes. You had not informed your fate to the authorities.

It will take 10 minutes to launch the only lifeboat the ship has and it takes 10 minutes to accommodate each person in the boat. Passengers can not jump in the water because it is infested with sharks. The nearest mainland is an uninhabited tropical island 30 kilometers away.

Your task is to decide which objects the passengers have to enter the boat. There is no room for all objects. Everyone agrees to follow your instructions.

Each passenger has one object, including that of the captain. Among those that each one has, in total, only five objects can be taken.

YOU NEED TO DECIDE WHAT THE FIVE OBJECTS ARE TO BE TAKEN TO GUARANTEE THE SURVIVAL OF THE GROUP.

Read the instructions carefully. The solution comes from the most important resources of each item that guarantee the survival of the group. In the answers, they will be requested WHO ARE THE HOLDERS OF EACH OBJECT. Thus, if you choose the object that the captain owns, you must indicate it as one of the answers. And so for the other four responses requested.

It takes 10 minutes to launch the boat, leaving 140 minutes before the ship sinks. Each person takes 10 minutes to board. In this way all people can be embarked and saved. Therefore, it is necessary to choose the five items that must be taken on board so that everyone is saved in 10 minutes.

List of Passengers and Crew

- **Captain**: 57 years old, married 3 times, 5 children between 5 and 27 years old. His younger son has Down Syndrome. The captain drinks and smokes a lot. Play the accordion. Has a bottle of rum.
- **Ship engineer**: married; accompanied by the pregnant wife. His heroism in fighting the fire allowed the crew and passengers to launch the lifeboat in time. He was seriously burned. It has a razor mirror.

- **Radio operator**: he was an Israeli Marine and raised in a *kibbutz* agricultural. He is a gym fanatic and *kickboxing* champion. He escaped from the fire that destroyed his radio because he was on the *deck*, impressing the food scientist with a demonstration of his *kickboxing* capabilities. He has a long rope.
- **Cook**: Special Forces veteran reduced to cook after convicted of martial court, due to a misfortune incident involving a torpedo and the president's yacht. He carries a knife.
- **Anglican nun**: graduated in Philosophy who, after teaching English in South America for many years, returns to her country to take care of her mother who is 85 years old and without mobility. Trained as a counselor was ordained in 1990. She has a first aid kit.
- **Dive instructor**: after 20 years as a stock trader in London, he moved to Tahiti to open his diving school. Divorced, with a son at boarding school in Wales. He practices the hunting of geese in Yorkshire every August. He has a signed copy of the latest book *Harry Potter*.
- **Indian carpenter of the ship**: married with four children between six months and seven years of age. In a riot in Mumbai, he was convicted of violence for 10 years. He writes poetry and has two poems published in Indian literary magazines. He has a magnifying glass.
- **French botanist**: lived in the Brazilian Amazon for 18 months, doing his Ph.D. research with medicinal plants that can be used in anticancer drugs, which are being tested by a large multinational pharmacy. He voted for Le Pen in the last election. He has a rifle.
- **Retired soldier**: recently, he registered a Non-Governmental Organization (NGO) with a longtime partner, a 45-year-old political journalist. Together they have campaigned to improve the health of wounded soldiers in Iraq. He has a compass.
- **Food scientist**: a vegetarian whose research is focused on the development of alternative foods with low cholesterol plants. She was involved in several demonstrations against the use of animals in medical research. She has a box of chocolates.
- **Nurse**: she went to Scotland eight years ago as a Sudanese teenage refugee. She has earned six Certificates of Education and recently obtained a Nurse's degree. A devout Muslim who plans to make the pilgrimage to Mecca next year. She has a box of matches.
- **Ship engineer's wife**: 35 years old, pregnant and will soon start her maternity leave from her job as a sales representative of a medical products company, on account of the birth of her first child. For some reason only she knows, she has a fishing rod and hook.
- **Bank manager**: lives in a small town in Sussex; strong leadership, parish counselor in his spare time. In a small briefcase, he has $ 50,000 in cash.

Assessment Method

The maximum score is 15 points, obtained in Table A below, which qualifies

the most important items. The minimum score is 6 points.

Attention to the objects that each one possesses is the key to the solution, as they greatly increase the chance of survival. There are five objects that generate maximum points, five objects that score average points, and three objects that generate the minimum score.

The fishing rod, kit aid, magnifying glass, knife and compass are key. There is one that will not score points and the others have some characteristics that can be considered. Matches are worse than magnifying glass, as they can get wet in the sea easily. Rum can be used as a disinfectant and the bottle is useful for storing water. The book can serve as a fuel for a fire. The rope is used to provide rescue.

The exercise will be done in two steps. In the first step, the instructions should be read for 10 minutes. In the second step, there is the collection of answers that will always be online, lasting 10 minutes.

The results will be analyzed on the four scales generated: 1) male with paper instructions, 2) male with digital instructions, 3) female with paper instructions and 4) female with digital instructions. The answers mapped on the scales that approach the 15 points will demonstrate the best memorization and comprehension of the instructions, with the correct calculations of means and standard deviations, thus allowing the verification or not of our hypothesis.

Table A. Score.

Passanger & Crew	Owns	Points
Captain	Bottle of Rum	2
Engineer	Shaving mirror	2
Radio Operator	Long Rope	2
Cook	Knife	3
Anglican Nun	First Aid Kit	3
Diving Instructor	Harry Poter book signed copy	0
Indian Carpenter	Magnifying lens	3
French botanica student	Rifle	1
Retired soldier	Compass	3
Food Scientist	Chocolate Box	2
Nurse	Matchbox	2
Engineer's Wife	Fishing rod and hook	3
Banker	$50,00 cash	0