DIGITAL VS HARD COPY: DIFFERENCES IN READING 2/3

A THREE-PART SERIES EXAMINING VISUAL NEEDS AT SCHOOL, READING, AND DIFFERENCES IN READING AND LEARNING BETWEEN DIGITAL VS. HARD COPY FROM AN OPTOMETRIST'S PERSPECTIVE.

In this second part of our series, we will briefly analyse the differences between digital and print formats. Since these differences cause certain changes in posture, ergonomics, cognition and visual abilities, they come with the emergence of a series of symptoms that have been categorized under the label - Digital Eye Strain (DES). However, we note that the differences between these two formats can cause differences in the reader's development and visual performance in reading activities.

Víctor Javier García Molina BSc. MSc

Victor Molina is a qualified optometrist who graduated from Complutense University in Madrid with a Master's in Scientific Communication from the International University of Valencia. He has managed the Divisions of Optometry and Contactology at the Spanish company Tu Visión (S.L) for the last 27 years. He subsequently developed business-oriented skills by following the Executive Education in Company Training and the Corporate Program for Management, both in the ESADE Business School in Barcelona, and the Leadership & Digital Innovation custom program from M.I.T. He has lectured in Clinical Optometry and was a professor in the Master's program of Contact Lens Fitting at the European University of Madrid (UEM), as well as a lecturer of Contactology at the Universidad Nacional Autónoma de Managua in Nicaragua. He is currently teaching Myopia Control and Visual Ergonomics in the Master´s program of CUNIMAD in the University of Alcalá in Madrid. Victor has reported on ocular health via various media (television, radio, press) since 1993, and usually does outreach work in schools on issues related to eye health, mainly digital abuse and myopia control. He also plays in a punk rock band and maintains a vivid interest in Military History.

Format differences and Digital Eye Strain (DES)

There are a whole range of differences between print and digital, all of which may impact visual performance. Font, text size, reflections, work distance, and posture- amongst other aspects-are all directly related to eye fatigue associated with the use of digital devices (for tablets, e-readers and computers alike). We have attempted to summarize them in the below table:

EVENT	CONSEQUENCE	VISUAL EFFECT
The smaller the screen size, the closer the device is held	Shorter working distances	More accommodation and vergence effort
Smaller font sizes on handheld devices and smartphones	More reading time required. Loss of reading efficiency.	More accommodation and vergence effort
Problems with resolution on screen font edges. Screen-text differences.	Loss of contrast, flickering.	Difficulty in focusing properly. More visual effort in general.
Screens are reflective and emit light.	Uncomfortable reflections. Glares from and on the screen.	Loss of contrast. Bad ergonomic yield. Constant changing of position. Reduction in workspace.
LED backlighting	Artificial bluish light	Uncomfortable reflections, symptoms related to dry eye disease (DED) and more visual fatigue.
Refresh rate	Lower refresh rates mean lower comprehension and reading speed.	Increase in visual fatigue
Ergonomic-postural changes. Prolonged use of handheld digital devices	Highly static positions. Greater spine inflection, change in the angle of the gaze.	Musculo-skeletal issues.
	Reduction in the distance of the work space	Greater accommodative-vergence effort. Increase in accommodative micro-fluctuations.

Table 2. Consequences and visual effects of certain characteristics and continued use of backlit handheld devices. Own conclusions. Sources (3, 4, 5, 6, 7, 8, 9, 10, 11)

KEY WORDS:
Digital Eye Strain, visual performance, reading efficiency, digital vs print copy.

In contrast, working on paper has the following characteristics:

No refresh rate, resolution, or pixel issues-its presentation is stable. However, its readability depends upon the environmental lighting.	
In textbooks, the images and letters are normally printed with solid fonts and adequate contrast.	
There are no issues with surface reflections in ergonomic environments.	
The spine inflects less.	
The underlying distance is ergonomic and visually more appropriate (41.8cm), which is optimal compared to handheld digital devices	(*) For a comparative study, see wPaillé in PDV.

Table 3. Summary of characteristics of work on paper, listing its differences compared to digital media. Own conclusions, Sources (13, 14, 15, 16)

Clinical literature has extensively examined the effects associated with viewing digital displays. Initially the studies focused on computer use, but today there are a series of studies on handheld devices. There are three categories (1) of research on the eye problems related to the use of digital devices (2):

- Visual problems
- Asthenopia or tension problems
- Corneal / tear film problems

Each category has a whole series of symptoms. All together, they make up a phenomenon called Digital Eye Strain (DES), which is also associated with a myriad of musculo-skeletal issues. Although related, these latter issues will be the subject of a different study (on DES, which you can find here).

MOST COMMON SYMPTOMS ASSOCIATED TO DES.
Visual fatigue.
Headache / Eye pain.
Blurry vision during or after the activity. Difficulty and slowness when changing focus.
Dry eyes / Ocular irritation.
Neck and back pain / Musculo-skeletal problems.

Table 4. Table summarizing the various symptoms related to computer DES, in order of prevalence. Visual fatigue, headache and eye ache are considered asthenopic symptoms. Source: 16, 17, 18, 51, 52

DES is a mixture of inter-related environmental and ergonomic factors, including: underlying refractive errors, deficiencies in visual abilities (accommodation and vergence), demanding visual and cognitive tasks, and static body postures over extended periods of time (16, 17, 18). For example, many studies have found significant changes in accommodation and binocular skills linked to time of use: a higher lag of accommodation (43, 44), increase in accommodative micro-fluctuations (45). Additionally, a relationship between the need for better accommodative skills as the task time increases and abnormal changes in accommodative and binocular skills (47) are some of the clinical findings. We found a series of clinical signs related to the use of LCD devices for which we would recommend, citing Esteban Porcar et al (47), "an appropriate evaluation of the accommodation and binocular vision" for the population that continuously uses these devices.

Whether due to the widespread use of handheld digital devices for leisure, occupational, or educational reasons, the lower age threshold for the prevalence of DES has increased. Younger and younger children are complaining about symptoms similar to those described by other typical DES profiles. Furthermore, symptoms associated to DES (specifically asthenopic symptoms) seem to be associated with earlier ages of starting "digital work" (20). This finding should not be completely surprising if you consider Palaiologou's findings (2016) on a sample of children under 5 from different EEC countries: at 3 years of age, 68% of children regularly use a computer and 54% have carried out some type of online work (19). There are very few studies that try to specifically determine the prevalence of DES in an infantile population. Vilela et al (48) performed a meta-analysis that can guide us- they found a 19.7% prevalence of asthenopia for the whole sample (children from 0 to 18 years old) and 12.6% for the 6-year-old range, with the addition that most of the subjects who complained of these symptoms did not have URE or VA deficit (meaning we cannot link these symptoms to a refractive defect – there was another cause). The authors conclude that due to the relationship of the asthenopic symptoms with the increased time on digital devices, future generations of children might see an increase in the prevalence of asthenopia, "with additional consequences for learning and school performance", as Sheppard & Wolffshon (9) also point out. Within the prevalence of dry eyes in infant users of digital devices, there is a positive relationship between prolonged daily use and greater risk of dry eye (49, 50) and all the associated risks for eye health and academic performance.

Logically, if there are differences between one format and another, and there are specific symptoms associated with these differences, we can assume that:

1. There might be a higher prevalence of DES if, (and we believe this is key) the use is not reasonable. By reasonable, we mean environmental conditions are optimal (lighting, orientation of the tables and study positions, ventilation, etc.), and the appropriate behavioural aspects of digital device use are being respected (hours of continued use, pauses, work distance, etc.).
2. Visual and reading performance could be better with printed copy compared to performance with digital displays.

Therefore, the next natural question is: do we read more efficiently on paper?

Hard copy vs. digital

Earlier we showed a rather complex table linking reading and visual skills. In it, and from our perspective as optometrists, any alteration or dysfunction of the motor-ocular, accommodative, vergence, or binocular skills (not counting the possible presence of an uncorrected refractive defect) could affect reading skills. However, the reality is that normally, **people can read for prolonged periods without problem, regardless of the medium.**

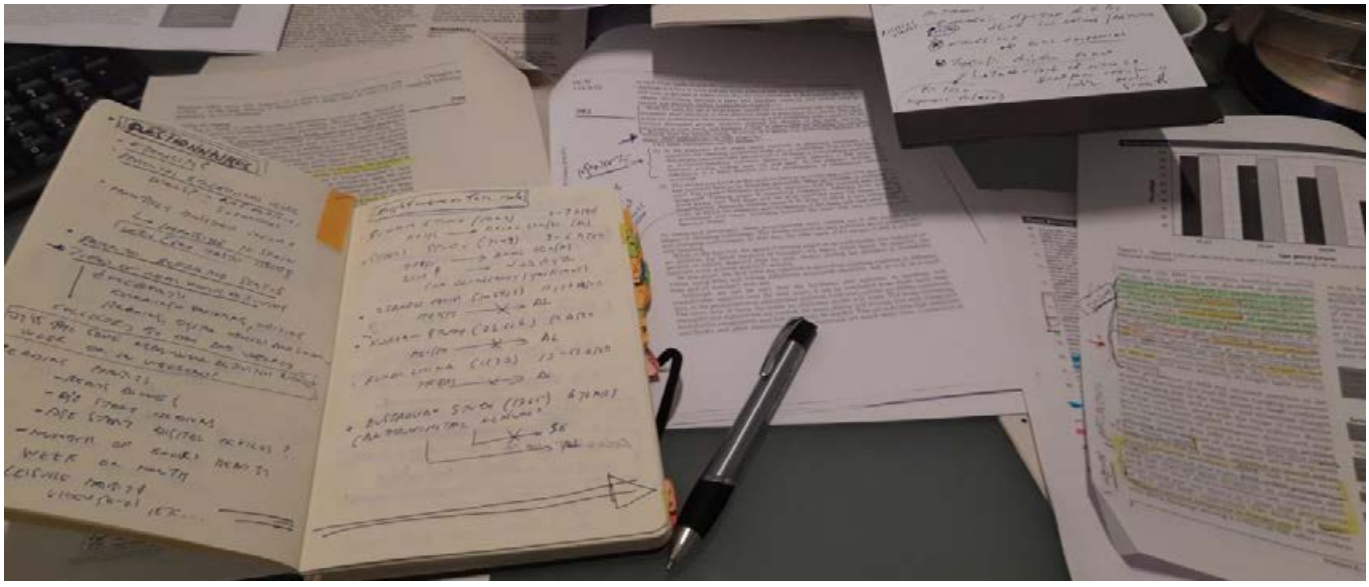
Examining the differences between digital and print has made it quite clear that **sustained reading on computers, tablets, or e-readers is not equivalent to the same activity on print** in **similar visualization conditions** 21, 22). It seems that, **in terms of cognitive performance, print continues to reign for learning and understanding of complex texts** (23). Even if that makes it seem like the answer to our question (at least partly), we must understand why. We have to take that statement with a grain of salt, since studies are not always conclusive, and many questions arise from the discipline studied, the technology analysed, the methodology of the investigations, and the populations studied, which can cause hasty or erroneous conclusions. We believe the answers lie in the clinical studies themselves.

Analysing the results of the clinical studies

Bear in mind that, when evaluating reading and cognitive performance from one format to another, there are always several factors in play. They involve: perception, processing information, acquiring and storing knowledge. These factors are not always considered. So before strictly claiming that "paper is better", we have to make several considerations and disclaimers (4, 23, 24, 25, 26):

- A whole series of behavioural phenomena associated with the use of digital devices pop up. Perhaps the visual processes related to reading/studying/learning are not as relevant in comparison. For example, there are many applications you can switch to with just a touch of the finger. Paper devices do not have these distractions built in.
- There is often no digital version of the study material: it is usually just scanned images that aren't adapted to the format.
- The "hypertext" format, which is very common in digital content, adds another layer of visual and cognitive effort for processing and comprehension.
- As shown in many studies, preference for a format partly determines the results. Study subjects who prefer print format get better cognitive results on paper, and subjects who prefer digital formats get better results using digital devices. We can infer that the differences in reading skills are influenced by bias to a format rather than real, quantifiable differences based on the nature of the formats. That means that the results from studies of older cohorts who have a specific cultural background might not be very significant. Studies on digital natives are probably more relevant.
- Technology is progressing so fast that we need a fine-tooth comb to work through the research done years ago with devices that are now outdated or obsolete. If the characteristics inherent to the capabilities of the device (resolution, screen brightness, etc.) may cause visual problems, it is legitimate to think that once certain technical limitations are overcome, visual performance will be better and thus, reflected in greater comfort and performance for users in any kind of task.

Stoop et al. (23) were right to point out that **the reading process, as used for studying, requires the use of various techniques**, such as: taking notes, highlighting, drawing, and skimming. **Doing this on paper** is **much easier and more flexible** than on any digital device (at least for now). Additionally, and as noted by Zambarbieri & Carniglia (49), **we have been doing this since we were children. That is how we were taught to study.** We find it important to stress this point.
Plus, digital technology is still limited for studying through reading and understanding texts (e.g writing notes or sketching on texts). It is not the same with a mouse, touch screen or some other kind of controller.



When it comes to studying techniques like drawing diagrams, underlining, or taking notes, paper is the more flexible choice. Together with the visual and special cues that the format offers, paper remains the most efficient format for performing tasks that are cognitively demanding, like attentive reading or studying.

The data supports the above arguments: reading and studying on paper has multiple visual and cognitive benefits that digital media does not have:

STUDY	KEY FINDINGS
Stoop J et al. 2013(23)	All post-reading tests (on the comprehension of the text and other aspects related to learning) show that paper is better for learning and processing complex texts.
Noyes & Garland. 2003 y 2008 (27, 28)	Paper is better for long-term retention of information. Subjects better assimilated and remembered information when presented on paper.
Kerr & Symons. 2006 (87)	Study subjects required less time to assimilate information and content when working on paper. With more time, the results became equal.
Mangen et al. 2013 (29)	Students who worked with print scored higher on the post-reading test (comprehension, vocabulary, etc.) than those who worked on a screen.

Table 5. Differences in processing reading information in digital media and print.

This suggests that, in terms of reading for studying, print offers the following benefits:

1. It takes less time to retain more information for a longer duration.
2. Visual fatigue and stress caused by the task are reduced.
3. Cognitive effort is reduced.

Even when students prefer working with computers or tablets, they still think the most efficient way to learn new information is through books or print format. Myrberg & Wilberg N. (25) confirmed Ramirez's (31) findings on this: "nearly 80 percent of students prefer to read a digital piece of text in print, in order to understand the text with clarity". There's even more evidence that supports this: Liu Z (32) claimed that, even though the number of people reading on electronic format is growing exponentially, and regardless of personal preference for one format or another, most of the subjects studied preferred paper for reading or studying "serious" topics. This applies to any discipline or field (e.g. science or humanities) (33).

So what causes this phenomenon? We once again find ourselves tangled in a series of physiological, behavioural, cultural, technological and psychological motives that add up and accumulate. We can attempt to summarise it as:

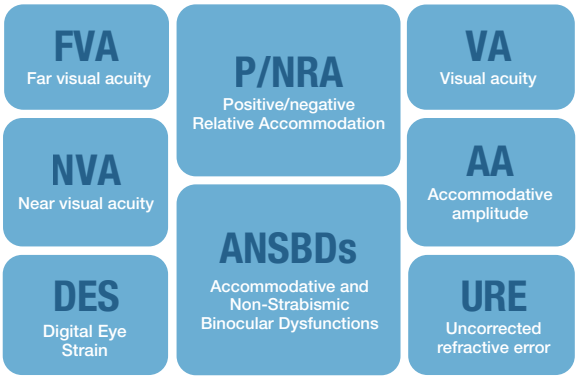
- Cultural tradition passed down over millennia, from the invention of writing by the Sumerians in Mesopotamia, of physically and comfortably "holding" what you are reading with your hands. This aspect is missing when you read on computers, but is present in e-readers and tablets.
- The peculiarities of hand-eye coordination may be one reason that we enjoy having a physical object to read. In his book *Information Payoff: the transformation of work in the Electronic Age, Strassmann* (34) explains that the hand-eye coordination of the nervous system makes subjects favour focusing on objects in their hands. It is less work to focus on something that we are holding in our hands than something that is on a screen or on a tablet. In fact, we instinctively grab things in order to see them better. We can say it is written into our behaviour.
- Scrolling, or moving down a digital text, creates a "spatial instability" that affects how the subject remembers the text, its content and mental representation (35). Scrolling may also have implications on perceptual span and reading, mainly when doing so online and with computers. If the span "window" is linear, and e-reading is done using vertical scrolling, we can suppose that the cognitive skills associated with this window are affected by the constant movement of images and text. This forces the viewer to have to constantly reposition their perception, which affects speed and reading efficiency.
- Reading and studying in digital format does not produce as good of a mental spatial representation as reading on paper. A visual-mental schema of the text read is much easier to set on paper, because of the sensory clues that the format provides. You get a better overall picture, which in turn better imprints in your long-term memory, making it possible to retain and recall information and concepts much better (36, 37, 38).
- Readers of print can immediately access the whole text with visual and tactile cues, which allow a more intense perception and better retention capacity and information recall (39).
- The tasks in which many text "windows", which are common in hypertexts, force people to switch between them, require more cognitive effort (40, 41).
- From a metacognitive perspective (people's abilities to reflect on their thinking processes and how they learn), many users see tablets or e-reading devices as instruments to be used for fun, or for communicating with friends or colleagues, but not as vehicles for learning or deep studying. Therefore, the brain has a harder time mobilizing the cognitive resources associated with studying and reading (4). This is a process that mixes individual and psychological perceptions of the format and technology.

These difficulties are not particularly insurmountable. For one, we can reasonably say that the problem is not the device itself, but the **limitations that technology** still has when it comes to **studying based on reading and understanding texts in the way it is traditionally done.** One conclusion is that we should **rethink our educational methods to take advantage of the benefits that new technologies offer us.** We agree with Myrberg & Wilberg (25) that, if learning is reading-based, then the way (and the moment , in our opinion) we teach children to read, is vital. It would also be imperative to adjust the texts and update the learning material to digital. Many students across various clinical studies requested this (e.g. Stoop J et al).
Technological limitations also affect certain characteristics and technical capacities of the backlit devices (refresh rate, screen contrast, resolution, etc.), which interfere with cognitive processes and, as Mangen et al. (30) mention, can "potentially interfere with long-term memory". We can analogically infer that if the first phase of the reading process is the visual perception of the text, and this largely depends on the ability to discern characters (readability), these limitations also affect

the understanding of what has been read (42). But we think this will be resolved over time as devices improve.
On the other hand, the inferred relationship between the preference for format and the reading results would indicate that part of the problem is psychological (25). That might also show that there is a lack of technological assimilation, which would not occur in cohorts of digital natives, who are used to digital interaction and the coexistence of diverse formats.

At this point, we should be asking a fundamental question: if digitization is as unstoppable as it seems to be, what should we do, as optometrists, to minimize its possible effects? We will try to answer this key question in the next article.

ACRONYMS USED



KEY TAKEAWAYS:

- Working with screens can produce a series of visual, asthenopic and ocular symptoms that are grouped under the label Digital Eye Strain (DES).
- A detailed analysis of accommodation and binocularity is necessary in those people who, regardless of their age, continuously use digital devices.
- The sustained reading for the retention of information and study is not the same in digital format as in hard copy. Certain evidence echoed by various clinical studies suggest that for the moment, our performance is worse in the digital format.
- In addition to the current limitations of technology, physiological, behavioral, environmental or cultural factors, among others, could be behind this phenomenon.
- Regardless of this, we can expect an increase in the prevalence of DES related to digitization, so we must ask ourselves what we can do to minimize its possible effects.

REFERENCES 2/3.

1. Rosenfield M. Computer Vision Syndrome: a review of ocular causes and potential treatments. Ophthalmic Phsyiol Opt. 2011;31(5)502-515.
2. Bali J., Neeraj N., Bali RT. Computer Vision Syndrome: a review. J Clin Ophthalmol Res. 2014; 2(1):61-68.
3. Peiyi K., Mohapatra A., Bailey I. Effects of Font size and reflective glare on text-based task performance and postural change behavior of presbyopic and nonpresbyopic computer users. Proceedings of the Human Factors and ergonomic society. 2012; Paper. 56th annual meeting.
4. C.Ackerman, R and Lauterman, T. Taking Reading Comprehension Exams on Screen or on Paper? A Metacognitive Analysis of Learning Texts under Time Pressure. Computers in Human Behavior. 2012; 28(5): 1816–182.
5. Maniwa H., Kotani K. et al. Changes in Posture of the Upper Extremity Through the Use of Various Sizes of Tablets and Characters. In: Yamamoto S. (eds) Human Interface and the Management of Information. Information and Interaction Design. HIMI 2013. Lecture Notes in Computer Science, vol 8016. Springer, Berlin, Heidelberg.
6. James E. Sheedy, Rob Smith & John Hayes Visual effects of the luminance surrounding a computer display, Ergonomics, 2005; 48:9, 1114-1128.
7. Paillé D. Impact of new digital technologies on posture. PDV. International Review of ophthalmic optics. N°72. Autumn 2015.
8. Long, Jennifer & Cheung, Rene & Duong, Simon & Paynter, Rosemary & Asper, Lisa. Viewing distance and eyestrain symptoms with prolonged viewing of smartphones. Clinical and Experimental Optometry. 2016; 100. 10.1111/cxo.12453.
9. Bababekova Y, Rosenfield M, Hue J et al. Font size and viewing distance of handheld smart phones. Optom Vis Sci 2011; 88: 795–797.
10. Villanueva et al. Adjustements of posture and viewing parameters of the eye to changes in the screen height of the visual display terminal. Industrial Health. 1997; 35:330-336.
11. Seghers J., Jochem A., Spaepen A. Posoture, muscle activity and muscle fatigue in prolongued VDT work at differente screen heights. Ergonomics. 2014; 46(7):714-730.
12. Anshel J. Computer Vision syndrome: causes and cures. Managing Office Tech. 1997; 42(7):17-19.
13. Blehm et al. Computer Vision Syndrome: a review, Survey of Ophthalmlogy. 2005; 50(3):253-262.
14. Miyao M., Hacisalihazade S.S. et al. Effects of VDT resolution on visual fatigue and readability:an eye movement approach. Ergonomics. 1989; 32(6); 603-614.
15. Jaschinski W. The proximity-fixation-disparity curve and the preferred viewing distance at a visual display as an indicator of near vision fatigue. Optom Vis Sci.. 2002; 79(3):158-169.
16. Ranasinghe et al. Computer Vision Syndrome among computer office workers in a developing country: an evaluation of prevalence and risk factors. BMC Res Notes. 2016; 9:150-9.
17. Anjila B., Pragnya B. et al. Computer Vision Syndrome Prevalence and Associated Factors Among the Medical Student in Kist Medical College. Nepal Med J. 2018; 1:29-31.
18. Agarwal S., Goel D., Sharma A. Evaluation of factors which contribute to the ocular complaints in computer users. J Clin Diag Res. 2013; 7(2):331-335.
19. Palaiologou I. Children under five and digital technologies: implications for early years pedagogy. European Early Childhood Education Research Journal 2016;24:5–24.
20. Bhanderi DJ., Choudhay S., Doshi VG. A community-based Study of asthenopia in computer operators. Indian J Ophthalmol. 2008; 56(1):51-5.
21. Maducdoc et al. Visual consecuences of electronic reader use: a pilot Study. Int Ophthalmol. 2017; 37(2):433-9.
22. Benedetto S., Drai-Zerbib V. et al E-Readers and Visual fatigue. PLoS One. 2013; 8(12): e83676.
23. Stoop, J, Kreutzer, P and Kircz, J G, Reading and Learning from Screens Versus Print: A Study in Changing Habits: Part 2, Comparing Different Text Structures on Paper and on Screen, New Library World. 2013; 114(9/10).
24. Zacharis N.Z. The effect of learning style on preference web-based courses and learning outcomes. Brit J Edu Tech. 2011; 45(5):790-800.
25. Myrberg C., Wiberg N. Screen vs paper: what is the difference for reading and learning?. Insights. 2015; 28(2):49-54.
26. Wästlund E. et al. Effects of VDT and paper presentation on consumption and production of information: psychological and physiological factors. Computers in Human Behaviour. 2005; 21:377-394.
27. Noyes J.M., Garland K.J. VDT vs paper-based text: reply to Mayes, Sims and Koonce. International Journal of Industrial Ergonomics. 2003; 31:411-423.
28. Noyes J.M., Garland K.J. Computer vs paper based task: are they equivalent?. Ergonomics. 2008; 51(9):1352-1375.
29. Kerr M.A., Symons S.E. Computerized presentation on text: effects on children´s reading of informational material. Readind and Writing. 2006; 19(1):1-19.
30. Mangen A., Walgermo B., Bronnick K. Reading linear text on paper versus computer on screen: effects on reading comprehension. Inter J Edu Research. 2013; 58:61-68.
31. Ramirez E. The impact of the internet on the reading practices of a university community: the case of UNAM". Procedings of the 68th IFLA General conference and Council. www.ifla.org/IV/ifla69/papers/019e-Ramirez.pdf
32. Liu Z. Reading behavior in the digital environment. Changes in reading behavior over the past ten years. J Of Documentation. 2005; 61(6): 700-712.
33. Liu Z. Print vs electronic resources: a study of user perceptions, preferences and use. Information Processing and Management. 2006; 42(2): 583-92.
34. Strassmann P.A. Information Payoff: the transformation of work in the Electronic Age. The Free Press. 1985. New York.
35. Eklundh K.S. Problems in achieving a global perspective of the text in computer-based writing. Instructional Science. 1992; 9:143-155.
36. Hooper V. Herath Ch. Is Google Making us Stupid:The Impact of the internet on reading behaivour. 27th Bled eConference. 2014.
37. Baccino T., Pynte J. Spatial coding and discourse models during text reading. *Language and Cognitive Processes*.1994;9:143-155.
38. Cataldo M.G., Oakhill J. Why are poor comprehenders inefficient searchers?. An Investigation into the effects of the text. Journal Edu Psychool. 2000; 92(4): 791-799.
39. Mangen A. A new narrative pleasures? A cognitive-phenomenological study of the experience of reading digital narrative fictions. Doctoral Thesis. NTNU OPen. 2006.
40. Kirscnher P.A., Karpinski A.C. Facebook ® and academic perfomance. Computers in Human Behaviour. 2010; 26(6):1237-1245.
41. Lin L. Breadth-biased versus focused cognitive control in media multitasking behaviours. P.N.A.S. 2009; 106(3):15521-2.
42. Lee D et al. Effect of light source, ambient illumination, character size and interline spacing on visual performance and visual fatigue with electronic paper displays. Displays. 2011; 32(1):1-7.
43. Penisten DK., Goss DA. et al. Comparisions of dynamic retinoscopy measurements with a print card, a video display terminal and a PRIO® system tester as test targets. Optometry Journal of the American Optometric Association. 2004; 75:231-40.
44. Wick B., Worse S. Accommodative accuracy to video display monitors. Optom Vis Sci. 2002; 79:218.
45. Iwasaki T., Kurimoto S. Objective evaluation of eye strain using measurements of accommodative oscillation. Ergonomics. 1987; 30:581-587.
46. Chi C-F., Lin F-T. A comparision of seven visual fatigue assessments techniques in three data-acquisition VDT tasks. Hum Factors. 1998; 40:557-90.
47. Porcar E., Montalt J.C., Pons A.M., España-Gregori E. Symptomatic accommodative and binocular dysfunctions from the use of flat panel displays. Int J Ophthalmol. 2018; 11(3):501-505.
48. Vilela MAP, Pellanda LC, Fassa AG et al. Prevalence of asthenopia in children: a systematic review with meta-analysis. J Pediatr. 2015; 91:320-325.
49. Zambarbieri D., Carniglia E. Eye movement analysis of reading from computer displays, eReaders and printed books. Ophthalmol Phsyil Opt. 2012; 32:390-96.
50. Sheppard A.L., Wolffshon J.S. Digital Eye Strain:prevalence, measurement and amelioriation. BMJ Opne Ophthalmology. 2018; 3e000146