Using bicoloured text to improve reading abilities and experience

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ABSTRACT In hopes of finding a new way to improve reading abilities or experiences, we researched, from a gestalt-design point of view, the effects of bicoloured text; texts in which some words are coloured grey instead of black, so to separate them and make for easier interpretation. Our findings show indications that marking function words, sans auxiliary verbs, grey in Dutch could lead to a better understanding of texts.

I. Introduction

The colour of a text and its contrast to its background can have a significant impact on the speed with which people read text and find information in tables [1, 2]. Text with a high contrast, black on white for example, has been proven to remarkably increase people's reading speed [2]. Although important, text colour [2] and the font the text is written in [3, 4] are not the only factors that influence a person's reading speed. The reader's language proficiency and the thoroughness with which we read a text naturally play a role as well. But it is not just the reader's own character and background that influence the way a text is read. External factors, such as the sounds around the reader [5] and lighting [6, 7] can also make or break ones reading speed.

Even though texts may vary wildly in their content and application, almost all of them have in common that most of the individual words that make up the text have the same font, colour and size. Due to this, we can easily perceive the entire text as a whole, instead of individual words or even letters. This grouping can be explained using the Gestalt laws, a set of rules-of-thumb that suggest how we cognitively interpret sensory input [8, 9]. One of these Gestalt laws, the gestalt law of similarity, tells us that we perceive items as a group when they share certain aspects (e.g. form or colour), resulting in us easier perceiving an image if some of the elements share visual aspects [8, 9]. This way, words with the same colour and size can be identified as a single text. Using this law of similarity, we do not only group elements together, but divide them as well. This kind of dividing and grouping of elements is a technique used in all kinds of fields of design: From giving each link in a website's navigation bar the same background to group them together and distinguish them from the sites content, to making the title of a text bigger to clearly separate it from the text itself. Even in this text we use whitespace, fonts, letter sizes and italics to visually separate words from one another. All three design choices can be interpreted using the gestalt law of similarity [8].

But can't we go one step further and apply the gestalt law of similarity to texts in a more useful way than just grouping and dividing titles and bodies of text from each other? The visual aspect of colour for example, is almost left untouched when talking about texts. We use a background- and text colour with a high contrast for readability without thinking too much about the other possibilities colours allow for [2, 10]. But if we could colour words in a text differently instead of all the same, perhaps we could highlight the core of each sentence, and perhaps make them easier to read or interpret.

From this gestalt point of view and in hopes of finding a way to improve our reading abilities or experience, we researched the effects of bicoloured text; texts where some words are coloured in a different colour than black, so to separate from them from black words and group them together. Using this grouping and separation by colour, we can put an emphasis on certain words and their correlation to each other for easier interpretation. With this in mind, we hypothesize that we can improve people's reading speed and text retention by colouring text not in a single colour, but in two.

In this paper we describe how we created the bicoloured mark-ups and how we compared them to black on white texts on reading speed, comprehensibility and text enjoyment. Before we go into the choices made creating the mark-ups, such as what colour to use and which words to colour, we first describe some of the effects already know that can result from changing a text's style, as well as the already available commercial options of increasing text readability. After explaining the method of testing, we conclude this paper with a description of the test results and possible explanation of the positive test results.

II. Related works

As mentioned in the introduction, the way a text looks can greatly impact the way in which we read it. Some effects of a text's look can be obvious, highlighting with boldface, italic or underlined typesetting for example clearly puts emphasis on certain words. Other effects are more subtle albeit still well known. Take for example the Stroop-effect where colours are written out in text and then coloured in a different colour; 'red' coloured green and 'blue' coloured in yellow for example. When speaking the colour each word is written in aloud, people tend to make more mistakes and read slower when compared to the same text with each word coloured in the same colour as each word states [11], showing that a clash between a texts visual style and content is possible.

In this chapter we will take a look at what kind of methods are being used to enhance texts for better readability, giving us a frame of reference for creating the bicoloured mark-ups, the tests and our conclusions.

A. Stylizing text for readability

Different methods of changing texts' looks for reading purposes already exists and have been further developed into commercial products, claiming to let people read faster without retention loss. These technologies aim to lessen the burden on the reader either cognitively or physically [12]. Some of them use computer screens to rapidly flash each word to the reader so 'to lessen eye movement and decrease time loss', some magnify words next the readers focus to give the readers eyes a larger preview of what is to come, and another colours every sentence with a gradient so readers can more easily track what words belong to a single sentence and can return their focus faster to the left side of the page. Some of the more popular products have been tested and seem to increase reading speed, but at a loss of reading comprehension [12]. Another drawback to consider, is that some of these products are more cognitively or physically intensive and demand more from readers than ordinary texts [13].

Besides researches on commercial products, some researches into stylizing texts to increasing reading speed and comprehension have already been done. Although most of them focus on people with disabilities such as Dyslexia and Irlen syndrome (visual stress), they are often positive in outcome (e.g. [6]). By increasing the space between letters just a little bit for example, it has been found that people's reading speed can be slightly increased [14], and when making the space between words and letters much bigger, people with Dyslexia tend to read faster. This is due to them being less influenced by a negative crowding effect when looking at a lot of letters simultaneously [15].

B. The effects of colour on reading

As mentioned above, most researches on improvement of reading tend to focus on people with disabilities. Multiple studies have been done, researching the effects of colour tinted lenses and overlays to alleviate symptoms of Irlen syndrome and Dyslexia. Test subjects chose their preferred colour of overlay and put it over their text, effectively colourizing it. While most of these researches on Irlen syndrome and the ones on Dyslexia result in the studies pointing that out coloured overlays and lenses help the reader, the effects are still debated. In a study on coloured overlays for children with Irlen syndrome, published by the American academy of pediatrics (AAP), the authors point out that most previous studies on said overlays seem to select their test subjects with a bias towards a positive result; selecting people that are already using said overlays [16]. But even while critical of previous ones, this study does acknowledge that overlays can help a select group of people read better [16]. A more recent study following the one done by the AAP and careful of the positive selection bias, tested the overlays on undergraduate students with and without dyslexia and concludes that the overlays are probably a temporary help for people with Dyslexia but could have a prolonged positive effect on people without Dyslexia [17]. The momentary effect on people with Dyslexia might be due to them being extra sensitive to novelty effects when reading, temporarily relieving them of their symptoms.

Not only can colour boost rudimentary reading skills such as tested in the aforementioned researches on Irlen Syndrome and Dylexia, but can also help improve other skills such as searching and navigation at poorly designed websites [18]. This seems especially the case when using aesthetically complementary colours such as blue and yellow [7, 18]. Even when using non-aesthetically pleasing colour combinations, such as shades of the same colour, skills related to reading such as searching and navigating are not decreased [18]. While of course, people prefer different kinds of colour combinations, people tend to prefer chromatic colour-combinations over achromatic ones such as black on white when reading [10].

C. The effects of contrast on reading

Although specific colours can have an effect on peoples reading abilities, it has been found that actual contrast, difference in brightness, between the background and text is a more dominant factor for reading speed [2]. Texts darker than their background lead to faster reading times, even though people tend to prefer otherwise [1, 2]. This difference in brightness is derived from the combined difference in luminance (black or white) and the difference in chroma (white with a hint of red or pure red). Thus, we find black on yellow with a high difference in both luminance and chroma more readable than red on green (low luminance and low chroma difference) [2].

D. Related work summarized

[rw1] - A multitude of commercial options to read faster already exists, but are at a cost of comprehension or demand more of the reader [12, 13].

[rw2] - Increasing letter spacing can increase reading speed and decreases the negative crowding effect when dyslexic people look at a body of text [14, 15].

[rw3] - Using a coloured overlay on top of a text can increase reading skills for dyslexic people temporarily and presumably for longer duration for non-dyslexic people [16, 17].

[rw4] - Aesthetically pleasing colour combinations can help increase reading-related skill such as navigation and searching in cases of bad usability, but do not hamper them [7, 18].

[rw5] - People prefer chromatic colours of achromatic colour when reading [10]

[rw6] - Even though colour has an effect on readers, the contrast of text to its background is a more dominant factor [1, 2]

[rw7] - People tend to prefer light colours as foreground and dark colours as background [1, 2]

III. Method

Before we start to colour words differently to create a bicoloured text, we need to decide upon which colour we want to use as a secondary text colour and which words we want to remain black and which ones we want to colour.

We decided to follow up on the studies that conclude that contrast between the text and its background is an essential factor for readability and choose to complement the neutral and ubiquitous black on white colour combination with the colour grey as secondary text colour. Doing this, we maximize the important aspect of luminance difference between the three colours *[rw6]*. Even though people tend to prefer chromatic coloured text and light coloured text on dark backgrounds, we decided to put text readability and ubiquity in front of text enjoyment, letting colour preference, aesthetics and colour associations play less of a role *[rw4, rw5, rw7]*.

Now decided upon a secondary colour, a lot of decisions can still be made on which words to colour grey to alternate them with, and distinguish them from, the black words in the text. Words or sentences could alternate between black and grey, or only the colour of important bits could be changed, just to name a few. Some of these ‘rulesets’ would result in the text containing larger strings of words with the same colour, whereas others could have words alternate colour more often, making texts overall visually very different.

A. Pilot study

Before doing a larger study, a pilot was done with 12 participants to see if an online questionnaire would be a sufficient method to measure peoples reading speed, their text comprehension and to pre-test two bicoloured mark-ups. This pilot questionnaire was done in a controlled environment and contained three versions of three different texts. Each text with one version coloured in black on white and two versions with different bicoloured mark-ups. These three texts, about 200 words long each, were taken from a Dutch medical science textbook, so to ensure more complex sentence structures. More complex sentences would give the mark-ups more space for improving the readability of the texts, thus allowing for a bigger difference in results between normal coloured texts and bicoloured ones.

The questionnaire consisted of each of the three texts in random order, with each one of the three mark-ups applied to one of the texts in random order. This setup resulted in each participant reading one of the six combinations of text and mark-ups in random order. Each of the texts was followed by three multiple choice bridging inference questions, with answers in random order, to assess how much of the text the subjects understood. These kind of questions ask something that can be answered correctly when correlating two sentences of the text together. Using these questions we could assess their mental situation model (i.e. their comprehension of the text) [19, 20]. We carefully crafted these questions by choosing sentences that elaborate on prior ones, often containing pronouns that refer to a previous sentence. An example of such a bridging inference question can be found in Fig 1.

Text

The lazy dog had already fallen asleep, she quietly lay down next to the big tree stump. The quick brown fox however, had energy to spend and jumped over it.

Question

Over who or what did the quick brown fox jump?

Answer

The tree stump (The neuter pronoun '*it'* in the last sentence refers to the tree stump seeing as the lazy dog was already referred to as '*she'*)

Fig 1. Example of a bridging inference question testing the reader's mental model. The question can be answered correctly when correlating two sentences in the right way

As previously stated, a lot of rulesets can be thought of for creating the bicoloured mark-ups. Seeing how we cannot test all possible rulesets, we needed to decide which ones to test against our hypothesis. Before deciding, we grouped all theoretical rulesets into three possible groups: rulesets based on syntax (e.g. colouring the subjects in every sentence), those that colour words based on semantic reasons (e.g. most important words), and the rulesets without semantic- or syntax-based background. We decided to test two different syntax based rulesets during this research, because we prefer having a theoretical background over not having one and different people find different words important. Thus we excluded rulesets without a syntax or semantic background and excluded semantic-based rulesets upon their subjective background.

For this pilot, a high frequency and low frequency mark-up were decided upon. With convenient automation in mind, the two syntax rulesets tested, were made using a web-based version of Alpino; a natural language analysis system for Dutch which outputs a tree diagram for input sentences [21]. Examples of both mark-ups can be found in Fig 2. The first mark-up takes each highest level of grammatical constituent *and* each word marking a conjunction, and colours them alternatively black and grey. This results in the texts changing colour not so frequently and the texts containing longer strings of text in a single colour. The second bicoloured mark-up colours most function words (i.e. conjunctions, articles, pronouns and prepositions) grey and content words black, resulting in texts where the colour changes with a higher frequency. The choice was made to group auxiliary verbs, also function words, together with their main verb and leave them coloured black. This way we make no distinction between different kinds of verbs, so to make the connection between the words more clear and presumably their interpretation. The choice was made to colour content words black, due to its high contrast to the white background, complementing the substantive meaning of content words compared to function words.

Bicoloured top level consituent mark-up

Meting van doorbloeding en metabolisme tijdens cognitieve taken toont nog duidelijker verschillen tussen patiënten met schizofrenie en gezonde controlepersonen.

Bicoloured function word mark-up

Meting van doorbloeding en metabolisme tijdens cognitieve taken toont nog duidelijker verschillen tussen patiënten met schizofrenie en gezonde controlepersonen.

Fig 2. Examples of the bicoloured top level constituents and function word mark-up

For each of the six text-mark-up combinations, two participants were sought out. These participants were self-reported non-dyslexic and had Dutch as their first language, resulting in 12 participants for the pilot. Each of these 12 participants thus had read 3 different texts, each with one of the three different mark-ups, resulting in 36 unique data points, containing 12 data points for each text, 12 data points for every mark-up and 4 for every text-mark-up. After comparing the scores on the questions and reading speed between the mark-ups on each text using Welch T-tests, no differences of significance have been found, as can be seen in Table 1. Subjects did however, answer questions noticeably correct on the three questions following each text-mark-up (n = 36, mean = 2.39, SD = 0.803), indicating that the texts were easy to remember, or the questions were too simple.

Black on white and bicoloured top-level constituent mark-up over 3 texts (n = 12 for both groups)			
	t	**df**	**p ***
Questions answered correctly	0.277	17.45	0.785
Reading time	0.009	21.56	0.993

Black on white and bicoloured function word mark-up over 3 texts (n = 12 for both groups)			
	t	**df**	**p ***
Questions answered correctly	0.655	21.91	0.520
Reading time	-0.802	18.97	0.432

Bicoloured top-level constituent and function word mark-up over 3 texts (n = 12 for both groups)			
	t	**df**	**p ***
Questions answered correctly	0.528	16.79	0.605
Reading time	-0.772	20.48	0.449

***alpha level <= 0.05**

Table 1: Welch T-test results, comparing the results of both bicoloured mark-ups against each other and against the results of the black on white mark-up. Different text lengths have been accounted for by comparing reading time as seconds per word.

B. Method

Based on the results and feedback from the participants during the pilot, the base method of a computer questionnaire was deemed successful for a larger test. Instead of multiple mark-ups with short texts, we decided to test one mark-up more extensively with two longer texts. By making the text longer, we could decrease the effect of the test subject's ability to memorize the text on their score, give them more time to get accustomed to the bicoloured mark-up and allow ourselves for more than three questions per text.

Each participant for this new questionnaire (n=58) had to meet the same standards as for the pilot: Dutch as native language and non-dyslexic. This time however, with practical usage in mind, the questionnaire wasn't put into a controlled environment, but publicly spread online on social networking sites (Facebook, LinkedIn, and Twitter). Instructions on how to make sure a difference could be seen between the black and grey colour and a note, telling the participants their undivided attention was needed, were included. A prize in the form of gift certificates for best score and fastest reader was added to the test as an incentive for the test subjects to focus outside of a controlled environment.

Two excerpts, each about 850 words and divided into four parts, about equal, were prepared from the same Dutch medical science textbook as used in the pilot. This division allowed us to add a progress bar to the questionnaire, updating the subjects of their progress and giving us the ability to measure an increase or decrease in speed if present. Of both texts, two versions were made, one coloured black on white and one marked bicoloured black and grey on white. Seeing how none of the two bicoloured mark-ups scored significantly different than the black on white mark-up during the pilot, the choice was made to further test the mark-up colouring function words, based on its ease of implementation and the verbal feedback of the pilot participants.

After filling out their personal information and how many books they read in the last month to put their reading abilities into context, each test subject was given both texts in random order. The first mark-up applied to the first or second text at random, and the other mark-up to the other text. Like the pilot, after each text, several multiple choice bridging inference-questions followed. For this test however, four questions were prepared; one for each part of the text. When answered, the participant was able to give feedback on how much they enjoyed reading the text, using a slider on a scale from one to ten.

IV. Results

A. Participants and averages

In total, 58 participants had filled in the online questionnaire; 17 of which male, 41 of which female. On average the participants were 32.45 years old (SD = 12.04), most of which had received at least college-level education, only eleven had not.

Chi-squared tests were done to test if the two groups participants were randomly assigned to, had been assigned people that differed significantly from each other. Their age, gender, level of education and the amount of books they had read in the last 30 days were compared. As can be seen in Table 2, no significant differences have been found, meaning both groups consisted of a comparable demographic. For these tests, and all other test in this research, the alpha-level used to check for significance is 0.05.

	χ^2	df	p *
Gender	0.083	1	0.773
Level of education	2.699	5	0. 746
Book read in previous 30 days	6.259	7	0. 510
Age	23.00	29	0.777

***alpha level <= 0.05**

Table 2: Chi-squared tests' results comparing whether the two groups participants were randomly assigned to, had differences in their demographics (n=29 for both groups)

Overall, the participants did not seem to enjoy reading the texts. As can be seen in Table 3, they rated the texts between a 4.6 and 6 out of 10 when asked how much they enjoyed reading the texts. This is, presumably, due to of their static scientific nature.

Means text 1 – Black on white read by group 1 and bicoloured by group 2			
	Mark-up	**Mean**	**SD**
Questions answered correctly (scale 0 to 4)	Black	1.483	0.986
	Bicoloured	1.862	0.963
Seconds per word	Black	0.355	0.143
	Bicoloured	0.336	0.155
Enjoyment (scale 1 to 10)	Black	4.621	2.043
	Bicoloured	4.897	1.915

Means text 2 – Black on white read by group 2 and bicoloured by group 1			
	Mark-up	**Mean**	**SD**
Questions answered correctly (scale 0 to 4)	Black	2.103	1.319
	Bicoloured	2.690	1.039
Seconds per word	Black	0.337	0.150
	Bicoloured	0.327	0.134
Enjoyment (scale 1 to 10)	Black	5.966	1.842
	Bicoloured	4.828	2.221

Table 3: Average results on the online questionnaire of both groups people were randomly assigned to (n=29 for both groups)

B. Correlations

In total, three correlations of significance have been found as points of interest. People who enjoyed one text, also often also enjoy the other ($r = .473$, $p < .001$). Another point of interest is the correlation between the amount of books read in the month prior to the test and the score on text 2 ($r = .360$, $p = 0.005$). Interesting to note is the average enjoyment of this text when coloured black on white, like a book. As can be seen in Table 3, this average enjoyment of 5.966 out of 10, scored more than an entire point higher than the other texts. As one might expect, this suggests that some texts are easier to enjoy for people who read more books. If by chance, those who read more books were put into the same group and read the same text-mark-up combinations of text 2, this correlation could have influenced the measurements. This however, is not the case. As can be seen from the demography checks in Table 2, there exists no significant difference between the two groups in the amount of books read.

C. Differences in reading time and score

As can be seen from the results of the Welch T-tests displayed in Table 4, no significant difference has been found between black on white text and the bicoloured function word mark-up. Not in reading speed nor in the amount of questions answered correctly. Text 2 however, was less enjoyable when bicoloured compared to its normal black on white counterpart, which ties together with the finding that people who read more books, liked text 2 better when simply coloured black on white.

Whilst not significant, the most interesting result of this research is the fact that on both texts, subjects scored better on the bridging inference questions when having read the version with the bicoloured mark-up.

Difference in text 1 – Black on white (group 1) and bicoloured (group 2)			
	t	**df**	**p ***
Questions answered correctly	1.489	55.94	0.142
Reading time	-0.483	55.60	0.631
Enjoyment	0.531	55.77	0.598

Difference in text 2 – Black on white (group 2) and bicoloured (group 1)			
	t	**df**	**p ***
Questions answered correctly	1.881	53.09	0.066
Reading time	-0.272	55.24	0.786
Enjoyment	-2.124	54.14	**0.038**

***alpha level <= 0.05**

Table 4: Welch T-test results of the black on white mark-up against the bicoloured function words mark-up. (n=29 for both groups)

V. Discussion

A. Conclusion

Due to significance levels of the differences in test results between the black on white versions and the bicoloured function word mark-up (excluding auxiliary verbs), we cannot conclude that the bicoloured mark-up can allow for better reading comprehension. We do however, see the fact that on both texts the group who read the bicoloured mark-up scored better as a promising result. On text 1, group 1 read the bicoloured mark-up and scored better than group 2 ($p = 0.142$), and on text 2, group 2 read the bicoloured mark-up and performed better than group 1 ($p = 0.066$). Although the differences in reading speed are very non-significant, it makes it unlikely that both of these higher average scores on the questions resulted from a longer time spent reading the text seeing that on both texts those who read the bicoloured text, read faster on average compared to those who read the black on white text. A repeated study using more participants could possibly lead to more significant results and insights.

B. Research design remarks

This study was done using Dutch texts in Arial 12pt size, each about 850 words long. Seeing how subjects were more used to black on white text than the bicoloured text, the length of the texts could, in theory, be too short for the effect of a bicoloured mark-up to show properly. On the other hand, the unusual colouring compared to the ubiquitous black on white mark-up, could be a reason for the participants to put more effort into their reading, resulting in a higher score. If accustomed to this bicoloured text, this theorized effect could weaken, losing its effect. This kind of novelty effect is already theorized to be the source of the increase in reading skills when using coloured overlays and could be applicable here as well *[rw3]*.

Another important thing to note, is that this research focused only reading speed, comprehension and enjoyment, and no measurements of reading fatigue or eye strain were made. Even if bicoloured text could improve reading comprehension, the possibility still exists that like the available products on the market that improve reading speed, this kind of presenting of text with three colours demands more of the reader than two colours over a longer duration *[rw1]*.

C. Further Research

During this research, one bicoloured mark-up has been tested more extensively. Future researchers might be interested in discovering what kinds of texts are suitable for this treatment and if this effect shows when accustomed to the mark-up as well. Seeing as how an enormous amount of rulesets to colour words grey can be thought of, others might be interested in testing different rulesets or see if this effect applies better or worse to other languages such as English.

Another curious thing is that in theory, we decreased the contrasts between some words and their background by colouring them grey. Previous studies have noted that contrast is a crucial element for reading, but still people scored higher on average when reading the bicoloured mark-up without loss of speed *[rw6]*. Perhaps the bicoloured mark-ups could be more effective when using a light grey colour to create more contrast between the black and grey words, or a dark grey to create more contrast to the background. It could also be the case that when reading a bicoloured mark-up, the black words are remembered better than the grey ones are.

Another possibility for future research is to use chromatic colours such as blue or red to mark and group words together. The choice was made to use a neutral colour like grey during this study, even though people prefer chromatic colours over achromatic ones *[rw5]*. It could be possible an increase in chroma-difference and thus an increase in contrast between black and the secondary colour could increase the effects of the bicoloured markup even more.

Finally, perhaps the most interesting food for thought is what mechanism really lies beneath these higher mean scores? If this is known, perhaps we can optimise our texts for easier readability, better comprehension and more enjoyment even better.

REFERENCES

[1] Wu, J. H., & Yuan, Y. (2003). Improving searching and reading performance: the effect of highlighting and text color coding. Information & Management, 40(7), 617-637.

[2] Tinker, M. A., & Paterson, D. G. (1931). Studies of typographical factors influencing speed of reading. VII. Variations in color of print and background. Journal of Applied Psychology, 15(5), 471.

[3] Arditi, A., Knoblauch, K., & Grunwald, I. (1990). Reading with fixed and variable character pitch. JOSA A, 7(10), 2011-2015.

[4] Mansfield, J. S., Legge, G. E., & Bane, M. C. (1996). Psychophysics of reading. XV: Font effects in normal and low vision. Investigative Ophthalmology & Visual Science, 37(8), 1492-1501.

[5] Furnham, A., & Strbac, L. (2002). Music is as distracting as noise: the differential distraction of background music and noise on the cognitive test performance of introverts and extraverts. Ergonomics, 45(3), 203-217.

[6] Wilkins, A. (1994). Overlays for classroom and optometric use. Ophthalmic and Physiological Optics, 14(1), 97-99.

[7] Shieh, K. K., & Lin, C. C. (2000). Effects of screen type, ambient illumination, and color combination on VDT visual performance and subjective preference. International Journal of Industrial Ergonomics, 26(5), 527-536.

[8] Graham, L. (2008). Gestalt theory in interactive media design. Journal of Humanities & Social Sciences, 2(1).

[9] Soegaard, M. (2010). Gestalt principles of form perception. Interaction-Design. org, 8.

[10] Hall, R. H., & Hanna, P. (2004). The impact of web page text-background colour combinations on readability, retention, aesthetics and behavioural intention. Behaviour & information technology, 23(3), 183-195.

[11] Stroop, J. R. (1935). Studies of interference in serial verbal reactions. Journal of experimental psychology, 18(6), 643.

[12] Rayner, K., Schotter, E. R., Masson, M. E., Potter, M. C., & Treiman, R. (2016). So much to read, so little time: How do we read, and can speed reading help?. Psychological Science in the Public Interest, 17(1), 4-34.

[13] Benedetto, S., Carbone, A., Pedrotti, M., Le Fevre, K., Bey, L. A. Y., & Baccino, T. (2015). Rapid serial visual presentation in reading: The case of Spritz. Computers in Human Behavior, 45, 352-358.

[14] Chung, S. T. (2002). The effect of letter spacing on reading speed in central and peripheral vision. Investigative Ophthalmology & Visual Science, 43(4), 1270-1276.

[15] Zorzi, M., Barbiero, C., Facoetti, A., Lonciari, I., Carrozzi, M., Montico, M., ... & Ziegler, J. C. (2012). Extra-large letter spacing improves reading in dyslexia. Proceedings of the National Academy of Sciences, 109(28), 11455-11459.

[16] Ritchie, S. J., Della Sala, S., & McIntosh, R. D. (2011). Irlen colored overlays do not alleviate reading difficulties. Pediatrics, 128(4), e932-e938.

[17] Henderson, L. M., Tsogka, N., & Snowling, M. J. (2013). Questioning the benefits that coloured overlays can have for reading in students with and without dyslexia. Journal of Research in Special Educational Needs, 13(1), 57-65.

[18] Moshagen, M., Musch, J., & Göritz, A. S. (2009). A blessing, not a curse: Experimental evidence for beneficial effects of visual aesthetics on performance. Ergonomics, 52(10), 1311-1320.

[19] Zwaan, R. A., & Radvansky, G. A. (1998). Situation models in language comprehension and memory. Psychological bulletin, 123(2), 162.

[20] McNamara, D. S. (2001). Reading both high-coherence and low-coherence texts: Effects of text sequence and prior knowledge. Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale, 55(1), 51.

[21] Van Noord, G. (2006, April). At last parsing is now operational. TALN06. Verbum Ex Machina. Actes de la 13e conference sur le traitement automatique des langues naturelles, 20-42