KWARTALNIK NEOFILOLOGICZNY, LXVII, 1/2020
DOI 10.24425/kn.2020.132847

ARTYKUŁY

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THE PROCESSING OF TEXTBOOK MATERIAL BY LEARNERS OF ENGLISH AS A FOREIGN LANGUAGE WITH AND WITHOUT DYSLEXIA: A COMPARATIVE EYE-TRACKING STUDY[1]

ABSTRACT
The article presents the results of the second part of an eye-tracking study conducted on Polish secondary school students working with a textbook for learning English. 20 dyslexic and 20 non-dyslexic school students worked with two sets of materials that had different graphic layouts but the same content. Their eye movements were recorded. The analysed data show that the arrangement of the material and images on the textbook page influence both the way the students (especially dyslexic ones) work with the book and their results.

KEYWORDS: (NON)DYSLEXIC STUDENT, VARIABLE, FIXATION, SET, LAYOUT

ABSTRAKT
Praca uczniów z i bez dysleksji z materiałem podręcznikowym do nauki języka angielskiego – okulograficzne studium porównawcze
Artykuł przedstawia wyniki drugiej części badania okulograficznego, przeprowadzonego na polskich uczniach szkoły średniej, pracujących z podręcznikiem do nauki języka angielskiego. 20 uczniów z i 20 bez dysleksji pracowało z dwoma zestawami, które różniły się pod względem graficznym, ale były identyczne z punktu widzenia treści. Ruchy gałek ocznych uczniów były rejestrowane. Zebrane dane pokazują, że rozkład materiału oraz zastosowany na stronie podręcznika układ graficzny wpływają na sposób pracy z nim oraz uzyskane rezultaty (szczególnie u uczniów z dysleksją).

SŁOWA KLUCZOWE: UCZEŃ Z/BEZ DYSLEKSJI, WSKAŹNIK, FIKSACJA, MATERIAŁ, UKŁAD GRAFICZNY

[1] The text was written as a part of the second stage of the "Kształtowanie kompetencji językowych u uczniów z dysleksją rozwojową" (Developing language competences in secondary school students with developmental dyslexia) project. The project was financed by the Ministry of Science and Higher Education, research grant No. 206428/E-343/S/2017-1 of 12.12.2017. The second part was conducted by the following team: S. Grucza (head), A. Andrychowicz-Trojanowska, K.M. Bogdanowicz, K. Wiejak, and M. Płużyczka.

INTRODUCTION

It should come as no surprise that Polish school students are not a homogenous group at any level of their education. Except for social differences, there are many other factors that make them different from each other. One of these many divisions is related to school students' problems with learning. Some of these problems are very often related to students' special educational needs, e.g. dyslexia.

The variation in school students influences the way they function (react, behave etc.) in school and in class. It also influences the types of communication situations they accept, avoid or reject (the two latter behaviours are related to, for example, students with Asperger syndrome).

In Poland the situation of school students with special educational needs has changed considerably since 2009. This was the moment when a new core curriculum was introduced to the Polish system of education. This curriculum, for the very first time, emphasised the need to adjust the teaching process to students with special educational needs and to increase their chances for success (Rozporządzenie MEN z dnia 23 grudnia 2008 r. w sprawie podstawy programowej…). In September 2017, yet another core curriculum was introduced which also draws some attention to the special educational needs of school students. However, seldom are these needs reflected in school textbooks.

SPECIAL EDUCATIONAL NEEDS – DYSLEXIA

In Poland special educational needs of children are usually diagnosed in the first stages of education (in kindergartens, schools etc.). This is done by the teachers and specialists who conduct the classes.

The plight of students with special educational needs in Poland has recently changed for the better. By law they are entitled to proper help not only at school but also in special counselling centres. What is more, teachers are obliged to give psychological and learning support to such students.

Students with special educational needs include, for example, mentally handicapped children, disabled children, children and students with lower-than-average IQs, the visually-impaired, the hearing-impaired, those with speech impediments (Bogdanowicz/ Adryjanek 2005: 12), as well as dyslexic ones.

Developmental dyslexia is a specific type of learning difference, primarily manifesting itself in difficulties with reading and spelling. However, the behavioural signs of dyslexia are not limited to problems with written language. They can be related to problems with sustaining attention, automatizing new knowledge, and gross and fine motor skills. Nonetheless, dyslexic people often possess good visual skills and might be very talented and creative in solving different problems

(Nijakowska 2016: 46). Dyslexia "has a biological, constitutional basis. Moreover, this developmental disorder is most commonly characterised in terms of inadequate facility in language processing, which is manifested by decoding and encoding difficulties. The most ubiquitous cause of dyslexic reading problems is below-standard word identification ability, which itself is brought about by print decoding impairments. Word identification is heavily dependent on the successful acquisition of phonological awareness – defined as the knowledge that spoken words are composed of individual speech sounds. [… What is more], dyslexic difficulties do not arise as a result of sight or hearing impairment, secondly, they are not due to emotional problems, environmental or didactic negligence or mental retardation" (Nijakowska 2010: 9). Dyslexia can also be combined with dysphasia (a speech development disorder in children), dyscalculia, dyspraxia (lack of physical coordination), with problems related to keeping track of time, with issues linked to spatial and directional orientation, motor hyperactivity or attention disorders etc. It has a neurobiological background and is associated with the structure and functioning of the brain (Habib 2000).

In the Polish school system dyslexic students learn in the same class as those not suffering from dyslexia. They use the same textbooks, which have not usually been specially adjusted to cater their requirements. However, due to the difficulties encountered by dyslexic students, some recommendations have been drawn up to help them perceive information better (these recommendations are important from the point of view of our studies, and they are also important for teachers who are obliged to support such students on an everyday basis at school). For example, even at the stage of learning to read and write, it is recommended that (in exercises prepared for dyslexic students or materials prepared by the teacher) large spaces be used between words and that they be displayed in an appropriate font, ensuring good legibility. In addition, it should be remembered that text presented in one big block is illegible for people with dyslexia, and therefore it should be broken up with illustrations. A text intended for reading should not be printed densely (Bogdanowicz 2011). Sentences and titles written in capital letters should be avoided (words run into each other because they start and end at the same height). Presentation slides prepared for people with dyslexia should be devoid of unnecessary words, but should contain bullet points (instead of sentences), charts, diagrams instead of text, and should be presented on a coloured background (e.g. cream) (Pollak 2012). It is also necessary to choose the colours of materials so as to reduce the contrast between the print and the background (Evans 2001). The paper should be cream or a natural shade of white (not snow-white), matte, and in addition thick enough so that print from the other side does not show through. What is more, light text should not be put on a darker background. The text should not be surrounded by complicated graphic elements (Mitchell/ Wightman 2012: 344–345).

All these recommendations are very important due to the fact that students with developmental dyslexia learn visually and they absorb material without finding links in it, on a random basis (Zaleska et al. 2012). Unfortunately, not many textbooks

used in Polish schools meet these guidelines. A broad analysis of the issue, and suggestions for changes, has been produced by Andrychowicz-Trojanowska (2018, 2016a, 2016b). On the basis of her eye-tracking research on dyslexic and non-dyslexic subjects, she states that:

(1) the foreign language teaching potential of a textbook can be reduced or increased through specific graphic and editorial actions;
(2) the areas close to the material on which the student's visual attention must be focused (e.g. the text for reading or the content of the task being performed) are particularly important for visual perception in the textbook;
(3) the way pictures are set out in the textbook, as well as their number, are of educational importance, because although the removal of photos from the text reading area reduces the degree of visual attention paid, in the case of dyslexic subjects graphic representations seem to increase reception;
(4) the choice of colour is also significant for foreign language teaching – excessive colour and strong contrasts are negatively evaluated by both dyslexic and non-dyslexic students; the results of a questionnaire included in the pilot study show that students consider excessive colouring and strong contrasts to negatively affect their reception level;
(5) in textbooks there are superfluous, graphically distracting areas which are not educationally relevant for foreign language teaching;
(6) editorial decisions should seriously consider the effects of carelessly positioning instructions for tasks;
(7) students do not have sufficient abilities to work effectively with textbook material (most students do not usually work in a methodical way, they do not read instructions for tasks, etc.).

It is known that the eye movements of people with dyslexia differ from the eye movements of people without dyslexia and this was initially recognised as the cause of reading difficulties in people with dyslexia (Pavlidis 1981). Currently, however, it is considered secondary to a deficit in the visual processing of language material (Borkowska/ Francuz 2013). As for the eye movements of people with and without dyslexia while doing non-textual tasks, it must be said that studies carried out so far have failed to demonstrate oculomotor differences between these two groups. It should be emphasised, however, that although school textbooks are a combination of text and visual information, this combination and its reference to perception have not been the subject of large-scale eye-tracking studies. The only results described so far are as follows (Andrychowicz-Trojanowska 2018):

(1) teaching/learning a foreign language (here: English) with the help of modern textbook material is effective as long as it takes into account the individual needs of subjects (here: subjects with and without dyslexia). Eye-tracking research has shown that the graphic layout of the textbook, including the proper

layout of its textual and non-textual components, is significant for its language teaching potential. The results leave no doubt that a textbook page adjusted to the needs of subjects with dyslexia can improve the perception of information and, as a consequence, the results obtained by them. This observation is significant because it shows that the layout of the textbook page (in a textbook for learning English) largely determines the educational potential of such a textbook page and, consequently, the whole textbook;

(2) on the basis of the results of eye-tracking studies, it is possible to identify the graphic layout of a textbook page that will best support the work of the student. This is so because the eye tracker not only allows researchers to collect and analyse oculomotor data, but also to track how the task is carried out. Importantly, all eye-tracking data are of a completely objective nature and sometimes they contradict the subjective feelings of the subjects, as recorded in the written questionnaire. This means that the researcher should not rely purely and simply on eye-tracking records, or solely on questionnaire data. Only a combination of the two allows one to gather truly significant, i.e. comprehensive, data;

(3) there can be no doubt that the way the student works should determine the graphic layout of the textbook, not the other way round.

Eye-tracking studies on dyslexia have mainly been conducted by psychologists, however, the studies are not oriented towards foreign language learning.

EYE-TRACKING STUDY

The eye-tracking study was conducted between June and November 2018 in Gdansk (it was a continuation of the first part of the study that was described in detail in Andrychowicz-Trojanowska (2018)). This study was conducted on 40 secondary school students, both dyslexic (20) and non-dyslexic (20). By "dyslexic students" we mean those who had an official certificate from psychological-pedagogical counselling centres confirming their dyslexia. The participants worked with two sets of materials (set 1 and set 2) that had turned out, in the earlier study, to be the most significant when it came to results (in the first part of the study there were three sets; here two out of the three were used – for more see Andrychowicz-Trojanowska (2018)).

METHODOLOGY

EYE TRACKER

The tool used in the study was an eye tracker, i.e. a device that enables a researcher to observe and analyse the way a subject looks at an object. It makes it possible to see in detail what is at the centre of someone's gaze, as well as to follow the path as the visual attention of the subject wanders (Duchowski 2007: 23). Modern video-based eye trackers register eye movements with the aid of a camera directed at the eyes and a measuring system integrated with a computer, and it allows one to identify the areas which catch the participant's attention (Holmqvist et al. 2011; Duchowski 2007).

Fixations and *saccades* are the two basic eye movements. Fixations stabilise the retina over an object of interest which is stationary (Duchowski 2007). They are moments when our eyes focus on a particular object lasting approximately 200–300 milliseconds. Saccades are rapid eye movements occurring between fixations and lasting (depending on the source) 30–80 ms (Holmqvist et al. 2011; Lorigo et al. 2008). During a saccade the eyes move very rapidly and because of this no new information is obtained during a saccade (Rayner 1998). Information is only acquired during a fixation.

Eye trackers are used in many different areas of human interest and activity, for example: neuroscience, sociology and psychology (reading, visual scene perception, visual perception and information processing etc.), medicine (eye movement tests in the treatment of neurological, psychiatric, and ophthalmic diseases; assessment of the effects of behavioural or pharmacological therapy, as well as the results of eye operations; assessment of oculomotor speed reaction and the stability of eye fixations etc.), industrial engineering, human activities (aviation, driving etc.), sport, marketing and advertising (copy testing, print advertising, ad placement, product label design, consumer behaviour etc.), computer science (human-computer interaction etc.), and ergonomics and usability (of web pages, computer programmes, computer games etc.) (Duchowski 2007; Opach 2011).

HYPOTHESIS AND EYE-TRACKING METRICS

Our hypothesis is that properly designing a textbook page improves the ease of working with the textbook material, especially in the case of school students with dyslexia. Proper design is understood here as adjusting it to the needs of dyslexic students when it comes to fonts, colours used, the location of different parts of the material etc., according to the suggestions made in the literature (Evans 2001; Bogdanowicz 2011; Mitchell/ Wightman 2012; Pollak 2012 etc.)

To test the hypothesis we chose a set of variables to be compared between the two sets of materials and between participant groups. The variables were: the time a participant needed to complete the given two tasks (there was no time limit), the

number of correct answers given (there were two tasks to be done, each earning a maximum of 5 points, so a participant could get a maximum of 10 points), fixation count, fixation frequency, fixation duration average, and fixation duration total versus saccade duration total. Fixation count is the number of fixations in a session; frequency of fixations is the number of fixations per second; fixation duration average is the sum of all fixation durations divided by the number of fixations in a session; fixation duration total versus saccade duration total is the ratio of total fixation time to total time of saccades.

It should be remembered that:

- generally, fixation count is directly proportional to the level of cognitive load (Duchowski 2007);
- the smaller the fixation count, the more informative the structure of the material (Grobelny et al. 2006);
- fixation time is directly proportional to the time needed to interpret the scene that is being observed by the subject (Goldberg/ Kotval 1999). This means that the longer the fixation time, the more problems they have perceiving the information (Renshaw et al. 2004a, 2004b). This is also related to more cognitive effort;
- in the case of research on reading, it has been observed that the more complicated the text, the longer the average fixation time (longer fixations are noticed with rarer words or more complicated grammatical structures) (Rayner 1998).

What is more, dyslexic people (like poor readers and those who are only just learning to read) make longer fixations, shorter saccades, and more fixations and regressions than typical readers (Rayner 1998). This occurs because such people suffer from deficits in the area of language processing, deficits which are reflected in the movements of their eyes (for example, dyslexic people have longer fixations on rare words – Hyönä/ Olson 1995). In other words, the problems that people with dyslexia have are not the result of their reading problems as such. It is known, too, that in the case of dyslexic children, the length of fixations does not shorten as the children grow up, saccades do not become longer, and the frequency of regressions does not change as is the case with typical children when they grow up and mature (Rayner 1998).

In our case it should be remembered, however, that the two sets – being an imitation of a textbook page – combine both textual and visual information. Very often it happens that the visual kind ends up being something of a distraction.

THE PARTICIPANTS

The study was conducted on 40 secondary school students, dyslexic (20) and non-dyslexic (20). The characteristics of the participants are given in Table 1 (set 1) and Table 2 (set 2), including information about their age, sex, diagnosis of dyslexia

(D) or no dyslexia (ND), the level of their command of English (according to CEFR, the Common European Framework of Reference for Languages), the code of every participant, and the percentage of correct answers (on the basis of the answers given by the participants; they were to complete task 2, which consisted of reading a text and choosing one proper ending/answer (a, b, c, or d) to five sentences/questions that were given, and task 3 which was matching five definitions that were given with 5 words highlighted in a text; the maximum number of points in every task was 5). In every code the first number is the number of the set the person was working with, the letter in the middle stands for dyslexia (D) or no dyslexia (ND), and the second number is the serial number of the participant. For example, 1D1[2] means the participant worked with set 1, was dyslexic and their serial number was 1; 2ND9 means the participant worked with set 2[3], was not dyslexic and their serial number was 9.

Table 1. Characteristics of the participants – set 1

Participant	Age	Sex	Dyslexia (D) / no dyslexia (ND)	CEFR	Code	Correct answers [%]
1	16	M	D	B2	1D1	60
2	17	F	D	B1	1D2	50
3	18	F	D	C1	1D3	90
4	17	F	D	B1	1D4	30
5	18	F	D	B2	1D5	90
6	17	F	D	B1	1D6	40
7	17	F	D	A2	1D7	20
8	16	F	D	B1	1D8	20
9	18	F	D	B1	1D9	40
10	19	F	D	C1	1D10	70
11	17	F	ND	B1	1ND1	20
12	16	M	ND	B2	1ND2	50
13	20	F	ND	B2	1ND3	90

[2] The serial numbers are not linked to the numbers used in Andrychowicz-Trojanowska (2018). This means that the participants listed in the following article are not the same participants as those in Andrychowicz-Trojanowska (2018).

[3] The set 2 that is presented here was given the symbol for set 3 in Andrychowicz-Trojanowska (2018).

Participant	Age	Sex	Dyslexia (D) / no dyslexia (ND)	CEFR	Code	Correct answers [%]
14	19	M	ND	A2	1ND4	20
15	18	M	ND	C1	1ND5	90
16	18	M	ND	B1	1ND6	80
17	19	F	ND	B2	1ND7	80
18	18	F	ND	B1	1ND8	90
19	16	F	ND	B1	1ND9	40
20	17	F	ND	B2	1ND10	90

Table 2. Characteristics of the participants – set 2

Participant	Age	Sex	Dyslexia (D) / no dyslexia (ND)	CEFR	Code	Correct answers [%]
1	19	M	D	B1	2D1	30
2	17	F	D	B1	2D2	70
3	16	M	D	B1	2D3	50
4	16	M	D	B1	2D4	30
5	18	M	D	B1	2D5	80
6	18	M	D	B2	2D6	80
7	18	M	D	B2	2D7	80
8	18	M	D	B2	2D8	90
9	20	F	D	B2	2D9	80
10	16	F	D	B1	2D10	20
11	16	F	ND	B1	2ND1	30
12	19	F	ND	B2	2ND2	80
13	18	F	ND	B2	2ND3	70
14	18	F	ND	B2	2ND4	90
15	18	M	ND	C1	2ND5	90
16	18	F	ND	C1	2ND6	80

Participant	Age	Sex	Dyslexia (D) / no dyslexia (ND)	CEFR	Code	Correct answers [%]
17	18	M	ND	B2	2ND7	70
18	18	F	ND	B1	2ND8	40
19	19	M	ND	B2	2ND9	60
20	18	M	ND	B1	2ND10	30

The eye-tracking study took place in the students' school.

THE MATERIAL

There were two sets of material (hereinafter called sets) which the participants worked with. The participants were divided into two groups, each consisting of 10 dyslexic and 10 non-dyslexic students, working with one of the two sets. The sets (set 1 and set 2) the students worked with were shown on a computer screen. There

Figure 1. Set 1

was a questionnaire in written form that was given after completing the tasks (a participant had a chance to write down any of his/her opinions that could be helpful when analysing the research results – the questionnaire answers are, however, of no interest in this article). Both materials presented to the students are shown in Figures 1 and 2.

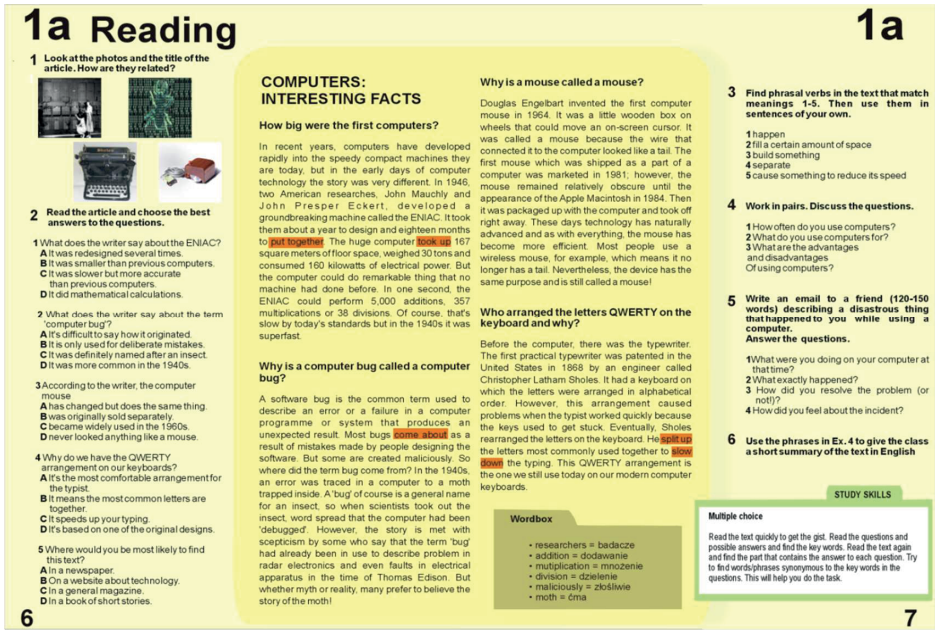

Figure 2. Set 2

It should be emphasised that the content of the language learning material in both sets was the same, except for the colours used, the location of pictures and the location and content of three boxes. Set 1 mirrored a real, existing English textbook (*On Screen*, Evans/ Dooley 2014, p. 6–7) and was put together in Corel Draw by the author. In set 1 the pictures were located within the paragraphs of the text – though they were not directly related to it. There were also three boxes located in the lower right-hand corner of the page. Set 2 was created in Corel Draw by the author, as well. In set 2 the pictures were moved from the text area and placed in exercise 1 (they were a part of it). One of the boxes was removed and moved to exercise 6. The second one was made a bit smaller and moved to a new location, and the third one was slightly reduced in size, moved to a new location (it was moved closer to the text area) and its content was adjusted (Polish equivalents of the English words from the box were added, as were a shape and colours). The types of exercises the students were asked to complete were the same in both sets.

THE SOURCE OF DATA

The participants' eye movements were recorded with an SMI RED 500 eye-tracking system with a sampling rate of 250 Hz. The participants sat in front of a 22-inch LCD monitor, equipped with a mini video camera, i.e. an eye tracker, placed just under it, at a distance of about 60 cm. The average tracking ratio (i.e. the proportion of time the eye tracker recorded point-of-gaze coordinates during the task – Amso et al. (2014: 2)) was 97% for the whole study (set 1 = 96.41%, set 2 = 97.61%) with a standard deviation of 2.63% (set 1 = 3.29%, set 2 = 1.52%). The recorded data was analysed with the aid of BeGaze 3.7 analysis software and IBM SPSS Statistics (version 25).

The first step was calibration, i.e. the geometric characteristics of the eye tracker, screen position and subject's eyes were estimated (Drewes et al. 2019) as the basis for accurate gaze point calculation. When calibration had been completed, the set was displayed on the computer monitor and the task was explained to the student.

RESULTS OF THE EYE-TRACKING STUDY

The results of the eye-tracking study are presented below in two sections: eye movements and answer correctness. In the eye movements section the results will be compared between the sets and groups of participants (i.e. dyslexic and non-dyslexic).

EYE MOVEMENTS

Table 3 and Table 4 show the chosen variables for non-dyslexic (Table 3) and dyslexic (Table 4) students who worked with set 1.

Table 3. Time [s] and eye movement metrics of non-dyslexic students, set 1

		Participant	Time [s]	Fixation Count	Fixation Frequency [count/s]	Fixation Duration Average [s]	Fixation Duration Total versus Saccade Duration Total
Set 1	No dyslexia	1ND1	418	1257	3.00	0.27	8.87
		1ND2	600	1820	3.00	0.23	3.57
		1ND3	784	2100	2.70	0.33	14.42
		1ND4	1215	2136	1.80	0.55	45.91

		Participant	Time [s]	Fixation Count	Fixation Frequency [count/s]	Fixation Duration Average [s]	Fixation Duration Total versus Saccade Duration Total
		1ND5	421	1264	3.00	0.25	6.92
		1ND6	721	1932	2.70	0.35	16.14
		1ND7	821	2537	3.10	0.30	15.77
		1ND8	626	1905	3.00	0.30	13.48
		1ND9	453	986	2.20	0.43	22.20
		1ND10	395	1010	2.60	0.36	16.54
Mean			645	1695	2.71	0.34	16.38
SD			242	503	0.40	0.09	11.08

Table 4. Time [s] and eye movement metrics of dyslexic students, set 1

		Participant	Time [s]	Fixation Count	Fixation Frequency [count/s]	Fixation Duration Average [s]	Fixation Duration Total versus Saccade Duration Total
Set 1	Dyslexia	1D1	946	2388	2.50	0.37	14.89
		1D2	996	2467	2.50	0.34	9.70
		1D3	329	1147	3.50	0.25	7.74
		1D4	613	1661	2.70	0.33	14.59
		1D5	840	1961	2.30	0.40	23.59
		1D6	613	1551	2.50	0.28	3.80
		1D7	820	1834	2.20	0.42	21.45
		1D8	946	1502	1.60	0.61	50.80
		1D9	878	1796	2.00	0.46	32.78
		1D10	804	1719	2.10	0.44	28.53
Mean			779	1803	2.39	0.39	20.79
SD			194	377	0.48	0.10	13.30

The same variables are presented for set 2 in Tables 5 and 6.

Table 5. Time [s] and eye movement metrics of non-dyslexic students, set 2

			Time [s]	Fixation Count	Fixation Frequency [count/s]	Fixation Duration Average [s]	Fixation Duration Total versus Saccade Duration Total
Set 2	No dyslexia	2ND1	954	2902	3.00	0.28	8.68
		2ND2	566	1618	2.90	0.32	16.83
		2ND3	735	2291	3.10	0.29	12.67
		2ND4	363	1202	3.30	0.28	22.27
		2ND5	395	1341	3.40	0.27	16.34
		2ND6	448	1441	3.20	0.28	11.15
		2ND7	519	1426	2.70	0.34	24.22
		2ND8	493	1356	2.80	0.34	24.96
		2ND9	586	2004	3.40	0.27	16.06
		2ND10	732	2240	3.10	0.31	17.88
Mean			579	1782	3.09	0.30	17.11
SD			172	525	0.23	0.03	5.17

Table 6. Time [s] and eye movement metrics of dyslexic students, set 2

			Time [s]	Fixation Count	Fixation Frequency [count/s]	Fixation Duration Average [s]	Fixation Duration Total versus Saccade Duration Total
Set 2	Dyslexia	2D1	951	997	2468	2.50	0.38
		2D2	1881	24.59	726	1566	2.20
		2D3	2.00	0.43	29.33	2024	3642
		2D4	0.49	1.80	0.52	28.50	489
		2D5	40.20	1423	2.90	0.30	10.41

			Time [s]	Fixation Count	Fixation Frequency [count/s]	Fixation Duration Average [s]	Fixation Duration Total versus Saccade Duration Total
		2D6	624	1958	3.10	0.28	11.62
		2D7	412	1230	3.00	0.32	26.73
		2D8	594	2005	3.40	0.27	11.48
		2D9	512	1457	2.80	0.30	14.43
		2D10	782	2208	2.80	0.32	14.58
Mean			811	1984	2.65	0.36	20.89
SD			444	662	0.49	0.09	9.82

The first level of data analysis is related to the comparison of the two sets (i.e. set 1 and set 2) to check if either of them is better to work with and, if so, to what extent. It should be noticed that the standard deviation (SD) given in the Tables is rather high so not all the conclusions may be binding and they simply show a tendency that should be verified on another (bigger) group of participants.

Comparison of the sets:

The first variable is the time a participant needed to complete the given tasks. In set 1 (Tables 3 and 4) the time non-dyslexic students needed to complete the tasks was 134 seconds shorter than dyslexic students. In the case of set 2 (Tables 5 and 6) the time was 232 s shorter for non-dyslexic students. What is more, the non-dyslexic students were 66 s faster than in set 1. The dyslexic subjects were 32 s slower but if we exclude the outlier, 2D4, the time for the dyslexic group is 676 s and the time difference for dyslexic students between set 1 and set 2 becomes 102 s in favour of set 2. Thus it can be said that in set 2 the time needed to complete the tasks was shorter for both groups of students than in set 1.

Differences related to fixations can also be noticed (it should be remembered that information is perceived during a fixation, not a saccade). In set 1 the number of fixations (fixation count) was smaller in both groups than in set 2. In the case of non-dyslexic students there were, on average, 87 fixations more in set 2 and in the case of dyslexic students – 181 fixations more (but if we exclude the outlier, 2D4, the situation is reversed, i.e. fixation count amounts to 1800, and the number of fixations turns out to be the same for both sets). But because the time required for the work is different, the fixation frequency differs, too. In set 1 it is lower for both groups of participants than in set 2 (2.71 and 3.09 for non-dyslexic students; 2.39

and 2.65 for dyslexic students, without the outlier, 2D4, registering 2.8). A possible explanation is that the rise in the fixation frequency for set 2 is a consequence of the lack of distractions in the material, something which could have helped the students concentrate on the tasks. The latter is supported by the fixation duration average which is lower in set 2 in both groups of participants. This substantiates the rule that the shorter the fixation, the less cognitive effort required. What is more, the ratio of fixation duration total and saccade duration total also increases in set 2 (without the outlier 2D4 it stands at 20.04 in the dyslexic group), which is evidence of the prevalence of fixations over saccades.

Summing up, it can be concluded that when comparing the sets from the point of view of the chosen variables' values, it turns out that set 2 is better to work with as it improves the distribution of the visual attention of all participant groups. The reason for that may be related to the graphic layout and, mainly, to the location of the pictures; in set 2 there were fewer graphic distractions to slow down the pace of a student's work.

Comparison of dyslexic and non-dyslexic participants:

The dyslexic subjects needed more time to complete the tasks in both sets. The individual time results of the majority of the dyslexic students were longer than the individual ones of the non-dyslexic participants.

As the fixation count directly depends on the time spent on task, it is of no surprise that completing the task fast must be connected with a small fixation count. Thus fixation counts for the dyslexic subjects are higher than those for the non-dyslexic students. Additionally, their fixation duration average is longer than the non-dyslexic ones. Because of the shorter time that non-dyslexic students needed for one fixation, they were able to make more fixations in a time unit which is reflected in the higher frequency of fixations. This suggests that dyslexic students need more time to process information gleaned from the text (here: set) and that is why their fixation count is higher.

The ratio of the fixation duration total to the saccade duration total was higher for the dyslexic participants than the non-dyslexic ones, which may reflect more cognitive effort for this group of students.

Summing up, it can be concluded that eye-tracking variables for the dyslexic and non-dyslexic students working with both sets show that, in set 2, the values of the eye-tracking variables for dyslexic students were higher than in set 1. That may be related to more cognitive effort being put in by dyslexic subjects in set 2, probably caused by the graphic layout and location of the pictures.

CORRECTNESS OF ANSWERS

All of the above mentioned variables for eye movements show how the secondary school students performed while completing the tasks. The most significant question, though, is if it in any way influenced the process of learning, here measured by the correctness of the given answers.

As has been pointed out, set 1 and set 2 were identical from the point of view of their content and that is why the answers given by the subjects can be compared. It should be remembered that in both sets the participants were asked to complete task 2, which consisted of reading the text and choosing one proper ending/answer (a, b, c, or d) to five sentences/questions that were given. Task 3 entailed matching five definitions with 5 words highlighted in the text. The maximum number of points in every task was 5.

Answer correctness is shown in Figure 3.

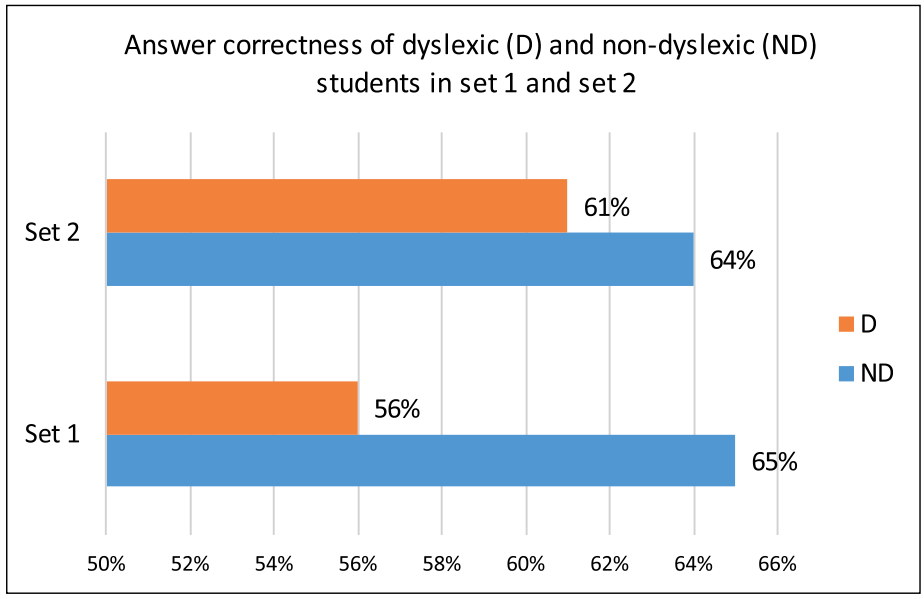

Figure 3. Correctness of the answers given by dyslexic and non-dyslexic students in set 1 and set 2

Figure 3 shows the difference in answer correctness for both groups of subjects. In set 1 the difference between dyslexic and non-dyslexic students was 9% in favour of the latter. However, in set 2 – which was devoid of pictures in the text area and of graphic embellishments – the difference between the groups was smaller. The non-dyslexic students gave 1% fewer correct answers than in set 1, but at the same time the dyslexic pupils' results changed – the correctness of their answers was only 3% worse than the non-dyslexic students. More detailed data on this is presented in Figure 4.

In Figure 4 it is visible that the results of dyslexic students improved for task 3 in set 2. In the case of task 2 it turned out to be more problematic for dyslexic students and the correctness did not change in set 2. An interesting and important observation is that in both sets the average correctness of the answers given in task 2

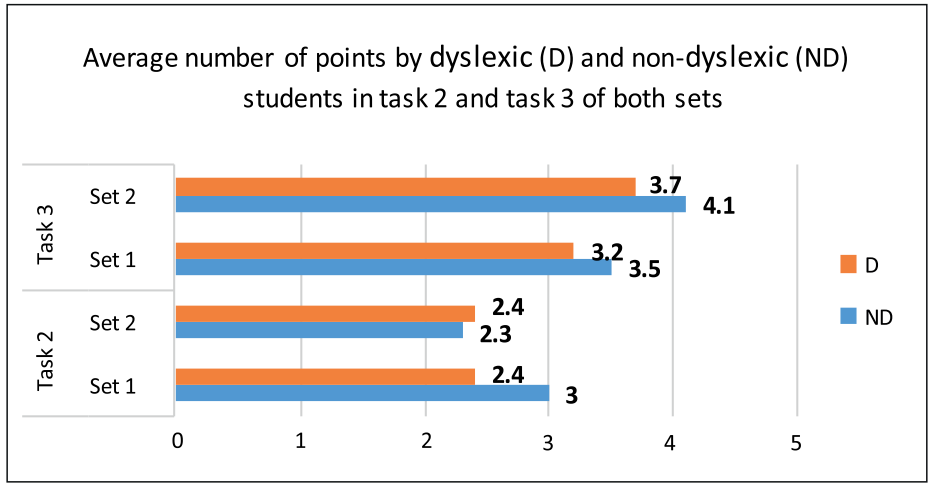

Figure 4. Average number of points received by dyslexic and non-dyslexic students in task 2 and task 3 in set 1 and set 2

by dyslexic students was the same and it was the non-dyslexic pupils who performed worse in set 2. But in the case of task 3 and non-dyslexic students, there was an improvement in their results. A similar thing occurred in the case of the dyslexic students.

It can therefore be concluded that the alterations introduced in set 2 (changes to the graphic layout and the location of the pictures) helped the dyslexic students answer more questions correctly. At the same time the non-dyslexic students' results did not worsen. From the point of view of creating a level playing field for students with special educational needs this is of great significance.

CONCLUSIONS

It can be said with confidence that in our study set 2 was better to work with. The evidence for this is the shorter time needed to complete the tasks in set 2 and the changes related to the values of the analysed fixation-related variables. The most eye-catching one is fixation frequency which was higher in set 2 for both groups of participants – their fixations occurred more often because they were shorter than in set 1. One of the possible reasons for this is the reduced cognitive effort required in set 2. The reduced cognitive effort is, however, related to the changes in the layout of set 2 – the fewer distractions (i.e. graphic elements), the better the conditions for reading and searching for information. This improved information perception and was reflected in the correctness of the given answers – it significantly increased in set 2.

From the point of view of dyslexic and non-dyslexic participants as a whole it can be concluded that, firstly, there was a smaller difference in time taken between dyslexic and non-dyslexic students working with set 2. Secondly, the average fixation time of dyslexic students was shorter than in set 1 and this means less cognitive effort was required in set 2. Thirdly, the difference between the average fixation time of dyslexic and non-dyslexic students was shorter than in set 1. Fourthly, there was a significant increase in the percentage of correct answers by dyslexic students in set 2. However, it should be remembered that because of the high standard deviation values, the above results merely show tendencies which should be verified on a bigger group of subjects.

The fact that the way teaching material is presented on the textbook page has an impact on how linguistic competence is shaped in learners, because it influences how they pay visual attention, has been known for a long time. However, this knowledge was intuitive rather than empirical. Until now, no reliable experimental research had been conducted. The eye-tracking data presented above prove experimentally that the layout of the textbook page (in an English textbook) significantly determines the educational potential of it and, consequently, of the whole textbook. The quality of the teaching and learning process is reflected in the results students get in tests and exams. Thus, the quality is linked to the language teaching materials that are used. If they are adjusted to the needs of dyslexic students, they can help them learn the language better.

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