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THE VALIDITY OF EYE BLINK RATE BY USING EVALUATION OF ATTENTION

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ABSTRACT

There are three main types of blinks: reflex blinks, voluntary blinks and endogenous blinks. The focus of our research is on endogenous eye blinks, that present changes of attention and changes in thought processes. According to the literature, blink rate is reduced in neurodegenerative diseases such as Parkinson's disease.

The blink rate has not yet been properly standardised. There is a need to test the hypothesis that eye blink rate could depend on standardized attention level, it could be a leading factor, which determines the eye blink rate on standardized conditions. It is important to establish equal standardized eye blink rate on healthy subjects' group, because it could be a simple diagnostic criterion for Parkinson's disease. We have attempted to validate eye blink rate by using quantitative parameters of attention level. An exercise, concentration grid, was given to the participants to evaluate concentration. The Neurosky Mindwave® BCI (brain computed interface) single-channel dry-sensor recording device was used for recording a frontal lobe EEG, the data were recorded by using our developed software. The attention was categorized into five levels which were: 1-19 (very poor attention), 20-39 (poor attention), 40-59 (neutral), 60-79 (good attention) and 80-100 (great attention).

In this study we have examined 14 participants. The average age of all subjects is 23,4 ± 0,9 years. The average mean of attention during the examination was 56,6 ± 7,1. The duration of the task was 8,7 ± 2 minutes. General eye blink rate per minute was 4,5 ± 2,2. No significant differences of eye blink rate between different attention levels have been found.

Keywords: *eye blink rate*, *blinking*, *electroencephalography*, *attention*, *Parkinson's disease*

Introduction

Blinking is an essential function of the eye, it protects the conjuctiva from drying and other possible injuries. Some external conditions such as humidity and lightning of environment or several physiological factors related to the general status of a human including attention could change the blink rate [1]. These changes reflect three main types of blinks: reflex blinks, voluntary blinks and endogenous blinks. The focus of our research is on endogenous eye blinks, that occur during reading or speaking, present changes of attention and changes in thought processes. The more attention is required by a task, the fewer endogenous blinks occur [2]. Other study has found that people blink less frequently when performing tasks involving visual activity such as reading than during non-visual activities such as conversation. It means that blinks are centrally controlled and are linked to cognitive states [3].There are some health conditions, where the anatomical pathways and physiological connections, involving the central control of blinking, could be affected. According to the literature, blink rate is reduced in neurodegenerative diseases such as Parkinson's disease. There was observed a significant difference in blink rate in a variety of testing conditions (conversation, watching video, reading) between subjects with Parkinson's disease and healthy controls. For example, when subjects were investigated by reading a book, the mean of blink rate was 10.7 ± 7.9 for healthy subjects and 2.4 ± 4.4 for patients of Parkinson's disease [1,4]. It is associated with reduced dopaminergic functions and it has been suggested that reduced blink rate can be used as a measure to aid diagnosis [5].

The blink rate can be easily obtained during the clinical examination, but it has not yet been properly standardised because eye blinking rate has quite wide ranges. The results of previous studies, because of high value of standard deviation, could be applied only on population assessment, but it is important to evaluate patients individually.

Considering these studies, there is a need to test the hypothesis that eye blink rate could depend on standardized attention level, it could be a leading factor, which determines the eye blink rate on standardized conditions.

It is important to establish equal standardized eye blink rate on healthy subjects' group, because it could be a simple diagnostic criterion for neurodegenerative diseases.

In this study we have attempted to validate eye blink rate by using quantitative parameters of attention level.

METHODS

Environmental conditions and participants

We evaluated the eye blink rate in healthy adults. They were selected randomly from the students of Lithuanian University of Health Sciences. They were free of disability, medical disease or neurological deficit. Participants were required to sleep before 23:00 and awake at 07:30 in the morning, be inside a silent room between 09:00 and 10:00 at room temperature [5,6]. The measurements were made in a relaxed atmosphere in a quiet place in the hospital. The research was carried out with the authorization (No.BEC-MF-35) of the department of social sciences and humanities.

The task and process

An exercise, concentration grid, was given to the participants to evaluate concentration. A grid consists of 10 rows and 10 columns, drawn up into cells. Each cell has a two-digit number (00–99) randomly assigned to it. The participant was required to mark the number in ascending numerical sequence, the task duration was observed. During the task, EEG activity, attention level and an eye blink were recorded.

Technical equipment

The Neurosky Mindwave® BCI (brain computed interface) was used for recording a frontal lobe EEG. It is a single-channel dry-sensor recording device. The Neurosky Mindwave BCI sends brainwave and debugging information wirelessly through Bluetooth communication. The device creates a virtual communication port (COM port) and sends data serially by serial over Bluetooth communication protocol. Raw data is available as a .dll file. These data were recorded by using our developed software [9].

EEG data is a summation of various brain wave oscillations (alpha, beta, theta and delta waves) and artifacts. The beta wave can be attributed to the "concentration" part of the brain activity and this is what is being used to control the output magnitude. The beta wave magnitude is deduced by first building a waveform 450 samples long by inserting samples sent by the BCI point-by point into an array and then using an elliptic bandpass filter and the power spectrums are respectively calculated after using fast Fourier transform on the input signal. The power spectrum is put on a 0 to 100 numeric scale, which is presented as the meaning of attention [9].

The attention was categorized into five levels which were: 1-19 (very poor attention), 20-39 (poor attention), 40-59 (neutral), 60-79 (good attention) and 80-100 (great attention) [7].

The duration, instant attention, assigned to corresponding attention level, and eye blink have been recorded. We have received the information about eye blink from EEG, fixed on the forehead, because it has a specific biological artifact of eye blink detection due to muscle related movements in the ocular region. Blinking causes a spike in the EEG of appreciable magnitude as compared to the base signal without the blink artifact. This enables to detect eye blinks by thresholding the EEG signal[9]. When the task is finished, our software calculates data: the duration of attention levels and the index of eye blink in each attention level.

Statistical analysis

Student's t-test has been used. A significance level of $P < 0.05$ has been adopted for all statistical tests.

The results have been analyzed by considering the smallest value of mean and standard deviation.

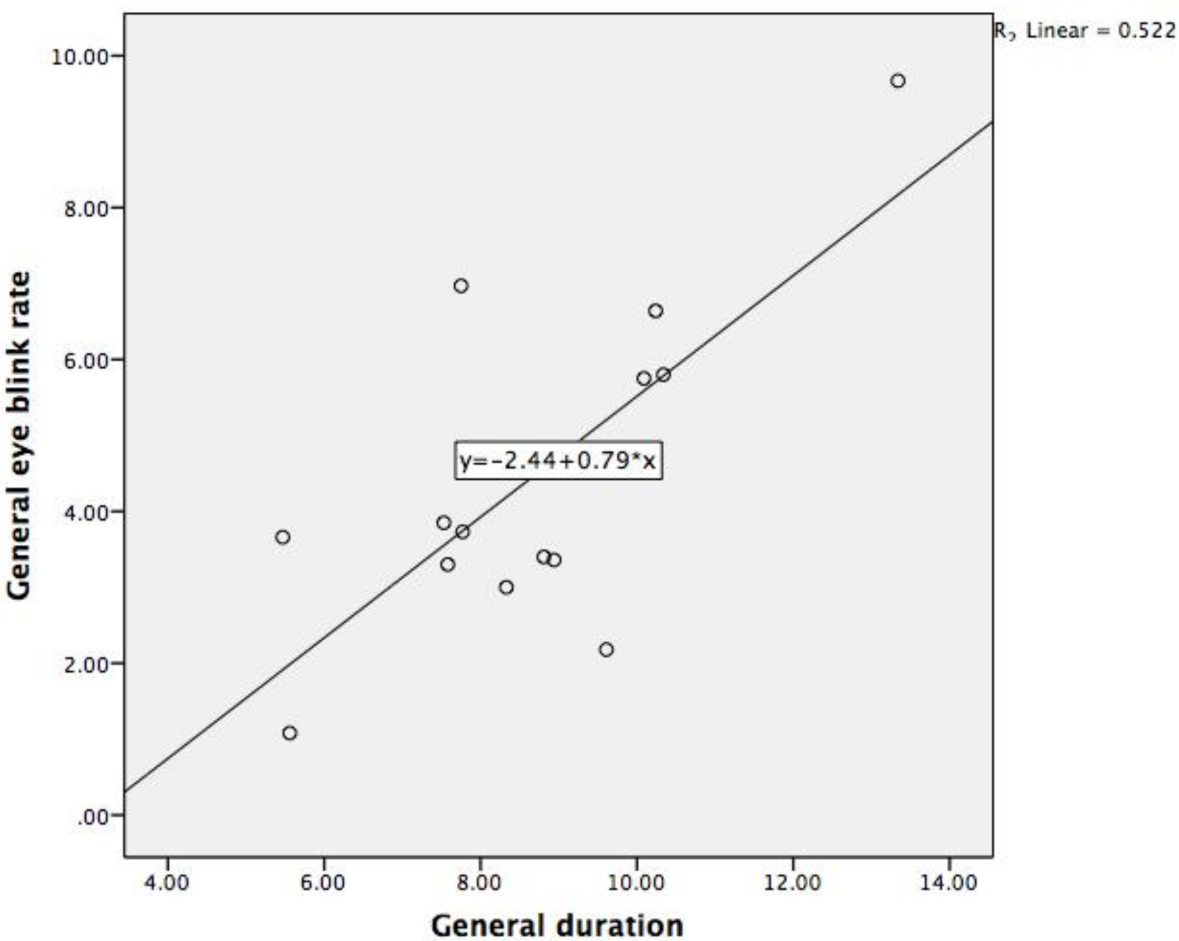
Data analysis

According to our algorithms for all subjects, we have assessed these values: the eye blink rate per minute in a selected attention level; the personal eye blink rate per minute, which depends on the mean value of attention during the given task time; the eye blink rate per minute without the assessment of attention level.

Also, we have divided the task duration into three equal sections and have evaluated the eye blink rate in each section without considering standardized attention level. These results have been used as a control value.

RESULTS

In this study we have examined 14 participants (n=14): 10 women and 4 men. The average age of all subjects is 23,4 ± 0,9 years. The average mean of attention during the examination was 56,6 ± 7,1. The duration of the task was 8,7 ± 2 minutes. General eye blink rate per minute was 4,5 ± 2,2. There was a positive relation between general eye blink rate and the duration of the task, when the duration of the task was longer, the eye blink rate was higher too, the relation is illustrated in graph 1, but the relation between the average mean of attention and general eye blink rate was not found (p=0,169).



Graph 1: the relation between general duration of the task and general eye blink rate (p=0,004).

Analysis in three divided sections of duration

After the analysis of the attention and eye blink rate per minute in three equal duration sections, we have noticed that the attention and eye blink rate during the task has decreased, the changes are illustrated in figure 1 and table 1. In the first section the average mean of attention was 58,9 ± 7,9, in the second – 57,3 ± 7,8, and in the third section – 53,7 ± 8,8.

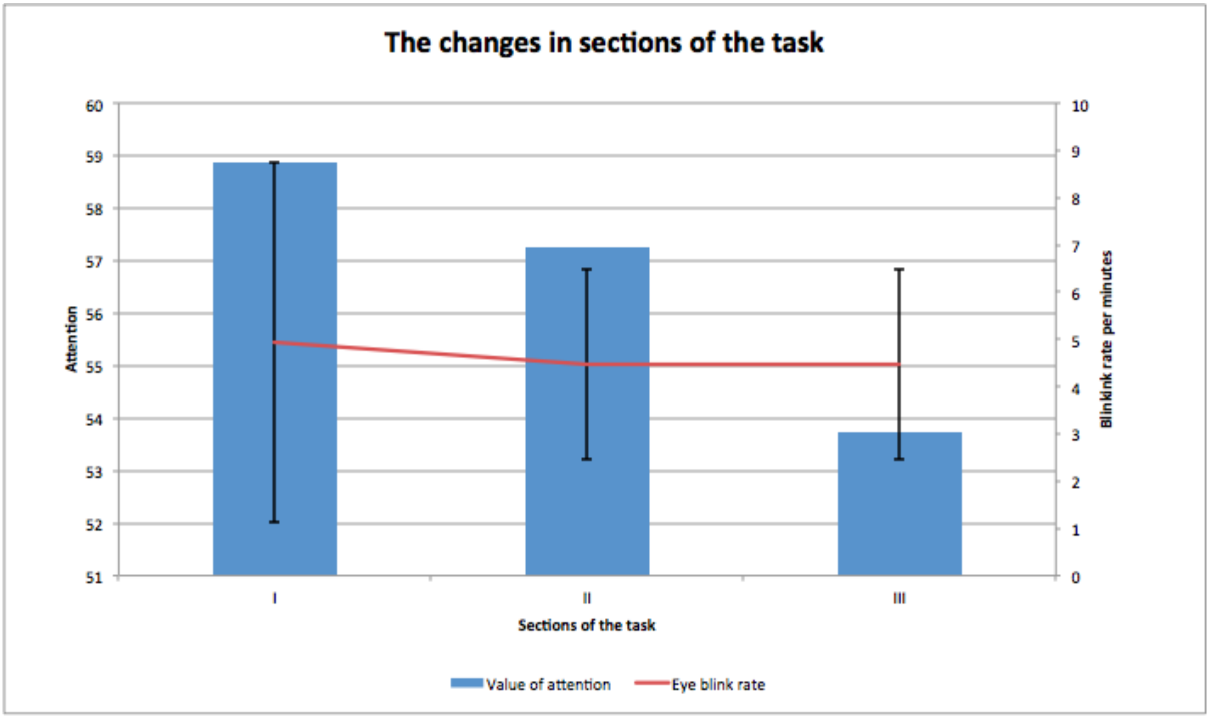


Figure 1: the changes in sections of the task

	Eye blink rate per minute		Attention	
	Mean	SD	Mean	SD
First section	4.9	3.8	58.9	7.9
Second section	4.5	2.0	57.3	7.8
Third section	4.0	2.3	53.7	8.8

Table 1: Eye blink rate and attention in three sections of the task

The statistical analysis comparing attention and eye blink rate per minute between sections of the task has been done. Table 2 below shows the differences in sections. There was a significant difference of the average mean of attention between the first and the third section of the task (p=0,042) and between the second and the third sections (p=0,039). Comparing eye blink rate per minute in the task sections, no statistically significant results have been found. We are inclined to believe that significant differences of the average mean of attention

had no impact on eye blink rate per minute in sections.

	Differences in sections	
	Attention (p value)	Eye blink rate (p value)
I section – II section	0,414	0,501
I section – III section	0,042	0,308
II section – III section	0,039	0,377

Table 2: differences of attention and eye blink rate in three sections of duration

Analysis in different attention levels

The mean of attention has been evaluated for all participants, the attention has been categorized into 5 levels. The duration of each attention level has been calculated by using algorithm. After the task, eye blinks have been identified and assigned to the proper attention level. In each attention level the index of eye blinks has been calculated.

By using the index of eye blinks and the duration of each attention level, the eye blink rate in the proper attention level has been calculated, the results are given in Table 3.

The average time in a very poor attention level (1-19) was only 0,1 ± 0,2 minutes, this interval was eliminated because of short duration.

Analysing the duration of attention levels, we noticed that the main part of time during the task had been spent in higher attention levels – neutral and good attention.

	Eye blink rate per minute		Duration	
	Mean	SD	Mean	SD
Very poor attention level (1-19)	5.1	9.3	0.1	0.2
Poor attention level (20-39)	4.3	3.1	1.1	0.8
Neutral attention level (40-59)	3.9	2.2	3.5	1.4
Good attention level (60-79)	4.6	2.2	3.2	1.1
Great attention level (80-100)	3.5	3.9	0.7	0.5

Table 3: eye blink rate per minute and duration in different attention levels

The statistical analysis comparing eye blink rate per minute between attention levels has been done, the results of p value are given in Table 4 below.

Atention levels	P value	Attention levels	P value
Very poor - poor	0,767	Poor - good	0,715
Very poor - neutral	0,632	Poor - great	0,479
Very poor - good	0,851	Neutral - good	0,141
Very poor - great	0,619	Neutral - great	0,702
Poor - neutral	0,477	Good - great	0,215

Table 4: differences of blinking rate per minute in attention levels

After statistical analysis, a significant difference of duration between neutral and good attention levels (p=0,001), between good and great attention levels (p=0,001) has been found, but no significant difference between neutral and great attention levels (p=0,56) has been noticed.

Evaluating the eye blink rate in different attention levels, the rate varies from 3,5 to 5,1 eye blinks per minute. The highest eye blink rate was at poor attention level, but, as mentioned before, because of short duration this interval was eliminated.

General eye blink rate per minute was 4,5 ± 2,2. Similar eye blink rate per minute remained in neutral attention level (40-59) – 3,9 ± 2,2 and in good attention level (60-79) – 4,6 ± 2,2 eye blinks per minute. The results are illustrated in Figure 2.

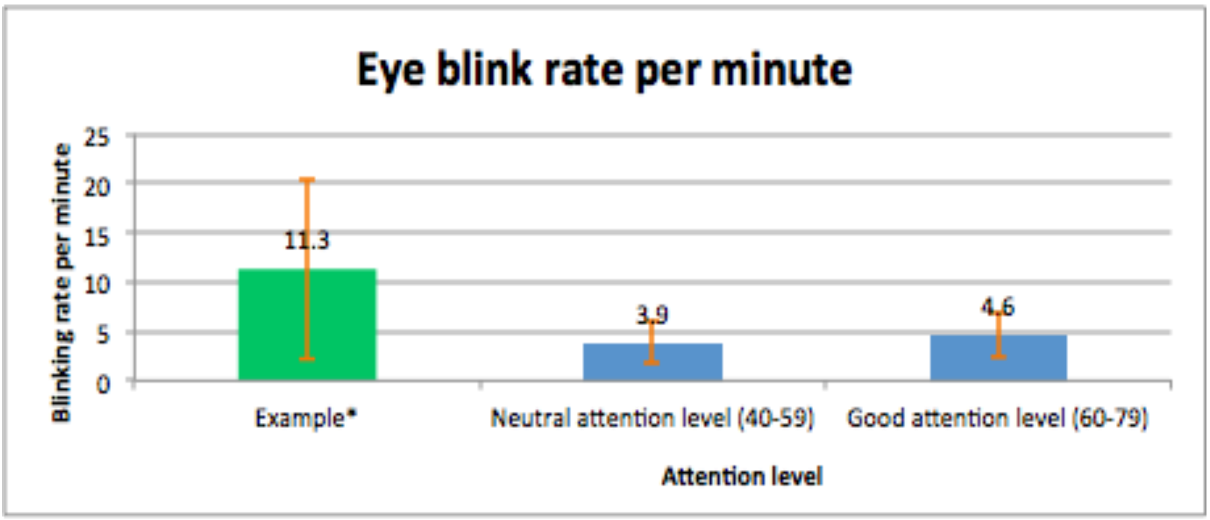


Figure 2: eye blink rate per minute in neutral and good attention levels in comparison with example value of eye blink rate given in the literature.

The Figure 3 shows the duration of each attention level and eye blink rate per minute in different attention levels. No significant differences of eye blink rate in different attention levels have been found.

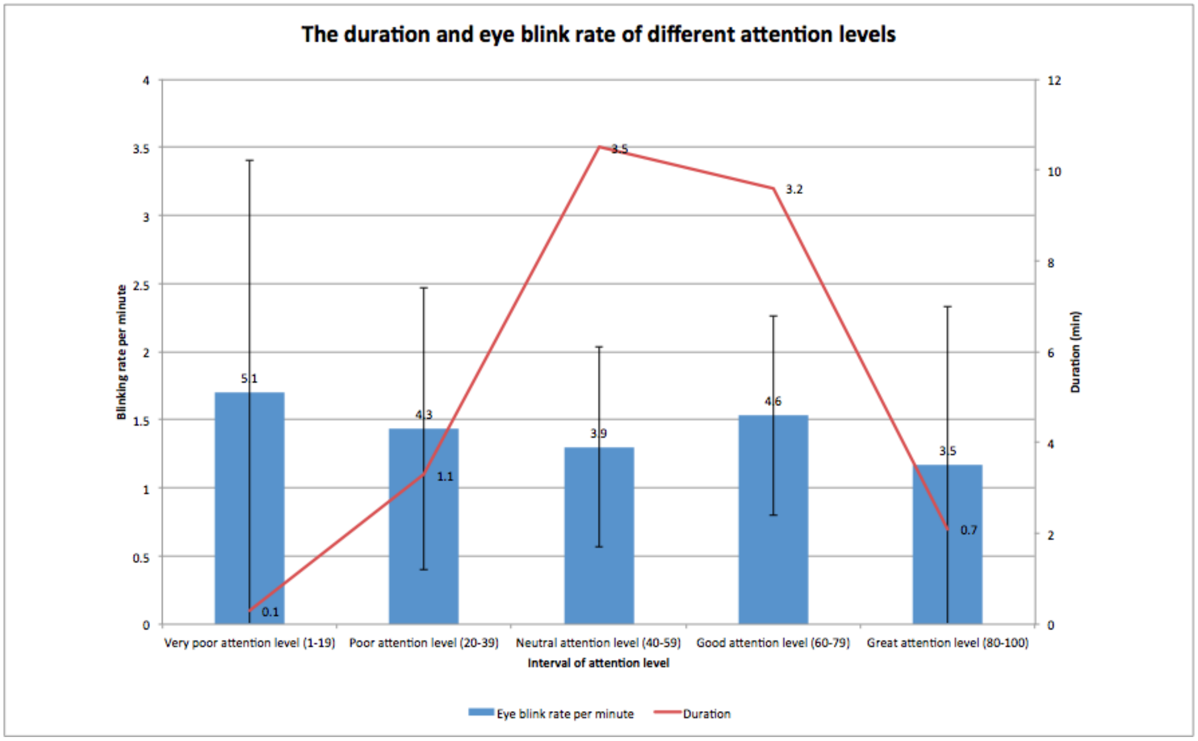


Figure 3: the duration and eye blink rate of different attention level.

CONCLUSIONS

The eye blink rate in different attention levels varies from 3,5 to 5,1 eye blinks per minute.

General eye blink rate per minute was 4,5 ± 2,2.

No significant differences of eye blink rate in different attention levels have been found.

DISCUSSION

According to the literature, the attention has a great impact on the eye blink rate. Previous studies have been performed by knowing the fact that there is a significant difference in blink rate in a variety of testing conditions (conversation, watching video, reading) because of changes in thought processes. In these studies the eye blink rate has been calculated in different testing conditions.

Our study shows, that possibly there is no significant relation between eye blink and attention level, when eye blink rate and attention level are assessed objectively.

However, there is still a problem of evaluating attention level correctly. The dry sensors of EEG and algorithms for analysis are not always accurate and have some deficiencies. An important problem in EEG is the recognition and suppression of artefacts (muscle movement, breathing, jaw movement), some of them can be similar to real EEG activity and have influence on the result. Overall recognition accuracy of both the concentration (attention) and relaxation (meditation) mental states of subjects were only 22.2% for the Neurosky device. [8]

There is a need to take into consideration that eye blink is detected because it has a specific biological artifact in EEG and could reduce the sensitivity of attention algorithms. This may lead to the cause, why our study shows absolutely different results on the relation between eye blink rate and attention.

Additionally, it is important to select a proper task. Our task, concentration grid, requires to maintain higher attention level during all duration of the task. Participants were in neutral and good attention level for most of the time. We suppose, that for appropriate evaluation of attention there is a need to design conditions where participants would be in all attention levels for a longer period of time.

We consider, that there is a reason to believe that in the near future we will be able to improve and repeat a study. One of the solutions could be the equipment consisting of several EEG sensors, where a separate electrode would be available for eye blink detection. Itis necessary to find the way how to optimize the methodology of the research, where attention and eye blink rate would be properly assessed, because this could help to standardize the eye blink rate.

It is important to resume the researches in this field and discover an accurate method for eye blink rate evaluation, suitable for clinical practice, since it could become a simple diagnostic criterion for Parkinson's disease.

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DISCLOSURES

All authors have approved the final article. Authors declare that there is no conflict.

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