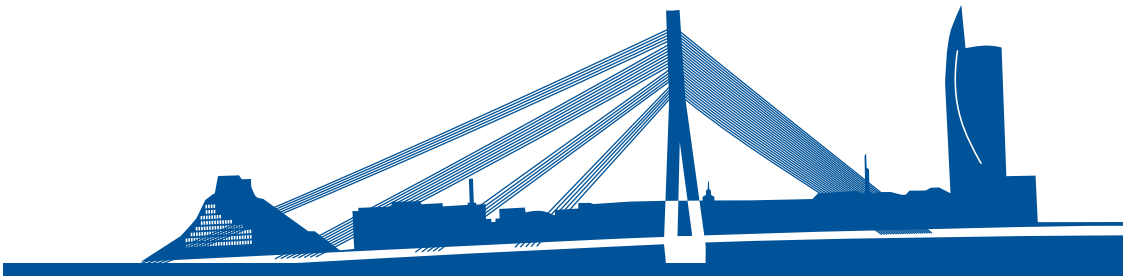
DEVELOPMENTS in Optics and Communications 2015

Book of Abstracts



Riga, Latvia, April 8 – 10, 2015

Accommodation lag under monocular and binocular conditions in symptomatic and asymptomatic emmetropes

Karola Panke[1,*], Aiga Svede[1], Wolfgang Jaschinski[2], Gunta Krumina[1]

[1] *1Department of Optometry and Vision Science, University of Latvia, Kengaraga 8, Riga, Latvia, LV-1063*

[2] *Leibniz Research Centre for Working Environment and Human Factors, Ardeystr. 67, D-44139 Dortmund, Germany*

[*] *E-mail:* karola.panke@inbox.lv

Introduction: Accommodation is the focusing mechanism that provides fast changes in the optical power of the eye in order to keep the image clear when changing the gaze from far to near distance. For each distance there is a constant theoretical accommodative demand, but real accommodation response maintain slightly lower. Difference between accommodative demand and accommodation response is called accommodative lag. The purpose of this study was to estimate the relationship between accommodation lag under monocular and binocular conditions in symptomatic and asymptomatic groups.

Method: Twenty participants (emmetropes) with mean age 24 $\pm$ 4 years participated in the study. Accommodative response was measured for dominant eye with open-field infrared autorefractometer (Shin-Nippon, SRW-5000) at 40 cm, 30 cm, and 24 cm (corresponding accommodative demands of 2.5D, 3.33D, and 4.17D) under monocular and binocular condition. Each accommodation measurement consisted of approximately 130 dynamic data points collected during consecutive 2 min time. Dissociated phoria for each distance was measured with Madox test. Convergence insufficiency symptom survey (CISS) score was used to distinguish symptomatic and asymptomatic group. Sequence of accommodation measurements were random order and all experiment was replicated twice within 7 $\pm$ 2 days.

Results: The two measurement sessions resulted in a test-retest correlation of r = 0,95 for accommodative response. To indicate reliability of accommodation response, we used the standard deviation of the difference between repeated measurements (0.22 D). For asymptomatic group monocular accommodative lag differed significantly across the distances from 40 cm to 30 cm (0.22 $\pm$ 0.19 D, p = 0.028) and from 40 cm to 24 cm (0.35 $\pm$ 0.25 D, p = 0.006), showing a tendency for accommodative lag to increase with closer distance (nonparametric ANOVA: p = 0.025). For symptomatic group monocular accommodative lag differed in similar way - from 40 cm to 30 cm (0.20 $\pm$ 0.32 D, p = 0.02) and from 40 cm to 24 cm (0.24 $\pm$ 0.31 D, p = 0.02), Binocular accommodation lag was significantly smaller than monocular accommodation lag (Spearman r = 0.77, p $<$ .001).

Conclusions: At close working distances (40 cm and closer), accommodation tends to be more variable and inaccurate for symptomatic patients both for monocular and binocular viewing conditions.

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The perception of coherent motion for the centric and eccentric fixation of a stimulus

B.Marcinkevica[1,*], E. Kassaliete[1], S. Fomins[1], I. Lacis[1]
[1]*Department of Optometry and Vision Science, University of Latvia, Riga, Latvia, LV1063*
[*]*E-mail:* beata.marcinkevica@gmail.com

Problem: The ability to perceive the motion of an object is one of the basics of visual perception. The constant change of retinal images depends not only on the movement of objects in various directions and at various speeds, but also on our movement relative to immobile objects. [1] The perception of motion is related to two terms – global motion and local motion. If a point changes its place, it is a local motion. If there are several points, and their vectors become integrated, the perception of a common motion occurs (global motion). [2] Neurones that perceive peripheral retinal information have bigger receptive fields than neurones that receive information from the centre of a retina only. The periphery of a retina allows recognising motion, high perceptibility of contrasts and low spatial frequencies. Central receptive fields recognize colours, low perceptibility of contrast and high spatial frequencies. [3]

Hypothesis: The thresholds of motion perception are lower for the eccentric parts of a retina.

Aim: To analyse, which type of fixation results in the lower thresholds of perception of coherent motion; to evaluate the inaccuracy.

Methods:*Participants*: The experiment involved 7 people. The average age of participants was 19,6 ± 0,6 years. *Methodology*: The thresholds of coherent motion were evaluated using RDK (random dot kinematogram). 160 black dots, 7' each (arcminutes), were displayed on a monitor in a 12˚x12˚ field. The working distance was 60 cm from the surface of the monitor. The motion speed of stimuli was 2˚/s with an exposition of 400ms. The evaluation of the threshold was performed using the adaptive staircase psychophysical method. Each participant was measured 5 times for both central and eccentric fixation (12˚ from the centre). The participant used their dominant eye to perceive the motion.

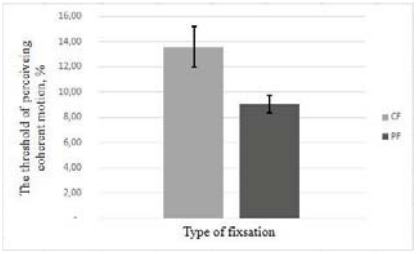

Figure 12: The mean thresholds of the perception of coherent motion for central (CF) and eccentric (PF) fixation.

Results: For two out of seven participants it was proven that the thresholds for central and eccentric fixations are statistically different. In others, a similar pattern was detected, but it could not be statistically proven. The analysis of the mean thresholds for

the perception of coherent motion shows that it is significantly lower (p<0,05) for the eccentric fixation. For central fixation the threshold is 13,6 $\pm 1,6$%, for the eccentric one – 9,1 $\pm 0,7$%. For the first and the fifth analysis using Bland-Altman, there is the effect of learning apparent for central fixation, but not for the eccentric one. The variation of results for 5 measurements is significantly higher for the thresholds for central fixation (2SD $= \pm 14,4$%) than it is for the peripheral one (2SD $= \pm 4,1$%) (p<0,05).

Conclusions: The results confirm the hypothesis that states that the peripheral receptive fields perceive the coherent motion better, showing lower thresholds and lower data variation, as well as for the eccentric fixation the effect of learning does not occur. For further research it would be advisable to increase the number of participants and change the methods in order to confirm that the methodology chosen does not affect the results.

Acknowledgement: This study is supported by ESF project No.2013/ 0021/ 1DP/ 1.1.1.2.0/ 13/ APIA/ VIAA/ 001.

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Influence of mental fatigue on visual grouping task

Diana Bete[1,*], Jurgis Skilters[2], Vsevolod Liakhovetckii[1,3], Gunta Krumina[1]
[1]*University of Latvia, Department of Optometry and Vision Science, Riga, Latvia*
[2]*University of Latvia, Center for the Cognitive Sciences and Semantics, Riga, Latvia*
[3]*Pavlov Institute of Physiology, Russian Academy of Sciences, St.Petersburg, Russia*
[*]*E-mail:* diana.bete.inbox.lv

Mental fatigue is a multi-dimensional perceptual and cognitive phenomenon interacting with and having impact on different perceptual and cognitive processes [1]. According to recent research evidence, mental fatigue impacts performance of perceptual and cognitive tasks, decreases the quality and increases the amount of errors [2]. In our study we investigate the impact of mental fatigue on the execution of visual grouping task in general and attentional processes that are implemented while doing it in particular. Visual grouping is usually executed according to different features, for example, colour or shape. The aim of our study is to assess the time for making visual attention task and to explore the correlation between the amount of mistakes and the level of subject's tiredness. Further, we also attempt to assess how a particular part of day (when the test is conducted) influences the performance of grouping task.

Research was conducted by using onscreen grouping task. Subjects did 4 grouping tasks, where the instruction was to find objects with aperture in the same direction. Every task consisted of 10x8 objects. 60 test subjects, between 18 and 32 years old, took part in research. Subjects also answered some general questions about their health and general feeling.

Results show, that grouping tasks can be completed faster, if there are more than one grouping feature – objects are in the same direction and in the same colours which might be interpreted as a result of additional configurational effects. But grouping task is performed slower if objects in the same direction are in different colours (which might be interpreted as a result of two different competing processes of grouping, i.e., similarity in shape and similarity in colour). Time for task execution more increases for those subjects who feel tired than those who indicated that they feel lively and are not tired. Tired subjects also made more mistakes. According to our results, the results of the test executed in the evening are the shortest if compared with other daytimes.

Mental fatigue has an impact on visual grouping task. Mentally fatigued subjects need more time to complete the test, and they also do more errors than those who are not tired. The results of our research also shows that the task is faster if conducted in the evening. Impact of the time if the test is conducted in the morning, at day and at night are not statistical significant for the test performance. Finally, according to our results, we can argue that grouping is better if there are more than one feature for grouping (i.e., configurational effects enhance the processes of grouping and attention).

The study was supported by ESF No.2013/0021/1DP/1.1.1.2.0/13/APIA/ VIAA/001.

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”Variantor” functional spectral filter that stimulates trichromats see as dichromats

Zane Jansone[1] and Maris Ozolinsh[1,2]
[1]*Dept.of Optometry and Vision science, University of Latvia, Kengaraga 8, Riga, Latvia, LV-1063*
[2]*Inst.of Solid State Physics, University of Latvia, Kengaraga 8, Riga, Latvia, LV-1063*
[*]*E-mail:* ozoma@latnet.lv,

”Variantor” functional spectral filter helps people with normal color vision to understand what the world looks like to color deficient people and which color combinations are confusing for these people [1]. In our study we tested the characteristics of these glasses: their spectrum of absorption; effectiveness of the color transfer and the patient response looking through the goggles on different color images. Their use was tested using color tests - Ishihara pseudoisochromatic plates and anomaloscope. The main goal was to test the ”Variantor” effectiveness in everydays life.

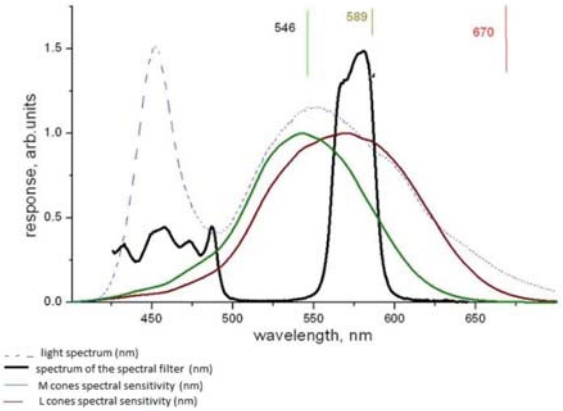

Figure 14: Spectral characteristics of filters and eye cone sensitivities

”Variantor” absorbed spectrum from 495nm till 555nm. In our research participated 3 observers: 1 thrichromat, a person with deiteroanomaly and a trichromatic person wearing glasses. During the studies (color discrimination of Ishihara plates) the results showed that person with ”Variantor” response was much slower and it was more difficult to distinguish different color objects. Results showed that anomaloscope can’t be applied to the test - are the patients trihromats or dichromats, because color stimuli used in anomaloscopes are monochromatic (see marks in the upper part of Fig.1); and they belong to the spectrum range which is absorbed the filter. Author M.O. was supported by ESF project No.2013/0021/1DP/1.1.1.2.0/13/APIA/VIAA/001.

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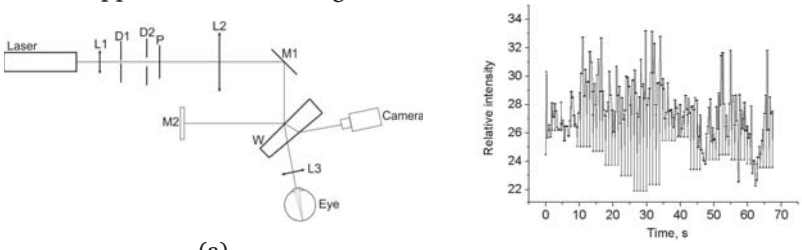
Measurement of the thickness of the corneal tear-film using a Twyman-Green interferometer

Varis Karitans[1], Inta Silina[2], Juris Lukjanovs[2], Gunta Krumina[2]
[1]*Department of Ferroelectrics, Institute of Solid State Physics, University of Latvia, Kengaraga street 8, Riga, Latvia LV-1063*
[2]*Department of Optometry and Vision Science, Faculty of Physics and Mathematics, University of Latvia, Kengaraga street 8, Riga, Latvia, LV-1063*
[*]*E-mail:* variskaritans@gmail.com,

Non-invasive optical methods such as the optical interferometry and reflectometry become increasingly popular for studies of the corneal tear-film [1, 2]. In this study, we develop a Twyman-Green interferometer that could be used to measure the thickness of the tear-film. The optical system shown in Fig. 21 makes use of interference of rays reflected from the surface of the tear-film and the tear-film and cornea interface.

However, apart from the study [1] the rays hit the surface of the tear-film at normal angle reducing influence of head and eye movements on the results. Fig. 15b shows the tear-film interference measurements of one subject. Periodical variations in the relative intensity can be noticed suggesting that the method used can be applied for measuring the tear-film thickness.



(a) (b)

Figure 15: (a)The optical system used in the study. **L** denotes lens, **M** denotes mirror, **D** denotes diaphragm, **P** denotes polarizer, **W** denotes wedge. (b) Variations in relative light intensity in time.

In Fig. 15b only a portion of all the trace of variations is shown. The data appears noisy and this is most likely due to low signal-to-noise ratio (SNR), various kind of noise etc.

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System for melanopsin related pupillometry

Sergejs Fomins[1], Brigita Zutere[2], Gunta Krumina[2,*]

[1]*Institute of Solid State Physics, Kengaraga 8, Riga, Latvia, LV-1063*
[2]*Biology Faculty, University of Latvia,Kronvalda bld. 4, Rīga, LV-1010*
[3]*Optometry and Vision Science Dept., University of Latvia,Kengaraga 8, Riga, Latvia, LV-1063*
[*]*E-mail:* sergejs.fomins@gmail.com

The retina of primates contains intrinsically photosensitive retinal ganglion cells. Pigment melanopsin originated in this cells is most sensitive to blue light and helps to controls the pupil reactions together with cones signal.[1] To investigate the contribution of melanopsin to daytime cycle and pupil response, we have developed the infrared pupil monitoring system. The system comprises wide field integrating sphere for efficient stimulation of the retina. The pupil is illuminated with 850 nm near infrared power led. Pupil is monitored with the high frame rate IR camera. Pupil tracking and diameter calculations are applied through C++ Open CV routines.

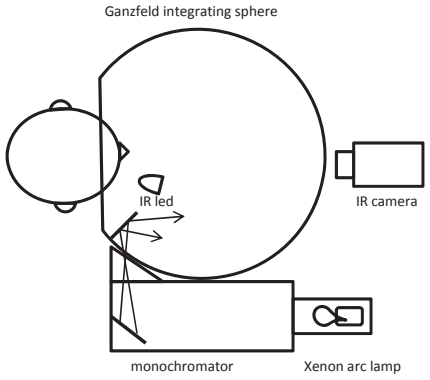

Figure 16: Diagram of the experimental electro-optical setup for eye pupil measurements. Eye pupil monitoring via infrared light. Visible stimuli is provided via monochromator.

Xenon arc lamp is used as a light source for monochromator. To introduce the modulation of light, mechanical switch is placed between the monohromator and integration sphere. The switch is a disk with holes shaped to produce the sinusoidal changes of the light intensity in the sphere.

Acknowledgement
This study is supported by ESF project No.2013/0021/1DP/1.1.1.2.0/13/APIA/VIAA/001.

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Perception of biological motion in central and peripheral visual field

Ilze Laicane[1,*], Jurgis Skilters[2], Vsevolod Lyakhovetskii[1,3], Elina Zimasa[1], Gunta Krumina[1]

[1]*Department of Optometry and Vision Science, University of Latvia, Kengaraga 8, Riga, Latvia, LV-1063*

[2]*Department of Communication Science/ Center for Cognitive Sciences and Semantics, University of Latvia, Lomonosova 1A, Riga, Latvia, LV-1019*

[3]*Pavlov Institute of Physiology, Russian Academy of Sciences, St.Petersburg, Russia*

[*]*E-mail:* ilze.laicane@lu.lv,

One of the most intriguing categories in motion analysis is the movement of a living organism. Swedish psychophysicist Gunnar Johansson (1973) was the first who noted that in order to perceive motion of the whole human body it was sufficient to demonstrate only the movement of its major joints [1]. Although biological motion has been widely studied, it is not entirely clear (a) whether the perception of biological motion is equally precise across all visual field [2,3] and (b) what is the underlying mechanism that determines central and eccentric motion perception of a biological object. The aim of this research work was to analyze the eccentric perception of visual motion when limited information of the movement is given.

In a psychophysical experiment the participants were instructed to determine whether the presented stimulus is a biological object walking in any of five different directions or a scrambled version of the object. The number of dots representing the motion varied from 1 to 13 according to staircase method. The stimulus demonstration sequence was generated based on adaptive staircase block up-down temporal interval forced-choice method BUDTIF [4].

Preliminary results indicate that perception of biological motion in the central visual field is highly individual (average thresholds range from 3.8-7.1 points, SEs range from 0.1-0.4 points). Perceptual learning is not observed during the performance of 10 sequential tests. The results demonstrate that the chosen experimental setting is applicable for the evaluation of perceptual processes of biological motion.

Study is supported by ESF project No.2013/0021/1DP/1.1.1.2.0/13/APIA/VIAA/001

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Impact of fatigue on spatial language and cognition

Evija Ziba[1], Jurgis Skilters[2], Vsevolod Liakhovetckii[1,3], Gunta Krumina[1]
[1]*University of Latvia, Department of Optometry and Optical Science*
[2]*Univerity of Latvia, Center for the Cognitive Sciences and Semantics, Riga, Latvia*
[3]*Pavlov Institute of Physiology, Russian Academy of Sciences, St.Petersburg, Russia*
[*]*E-mail:* ziba.evija@gmail.com,

Language is used to describe relations between objects in space. When describing these relations, speaker should chose the most appropriate linguistic representation to avoid increased comprehension time and ambiguities. In the present study we examined relationship between fatigue and spatial language. Although fatigue impacts various perceptual and cognitive processes, there are no studies exploring the relationship between fatigue and spatial language. There are also no studies on the representation of spatial relations in Latvian. The goal of our study was to evaluate the effect of fatigue on the spatial language. The main tasks was (1) to compare language-specific properties in Latvian and English spatial prepositions, (2) to discover possible differences between the results when conducting experiment at different times of the day, (3) to find possible differences in spatial perception in the conditions of fatigue.

56 subjects took part in experiment; 22 of them indicated that they feel tired in the beginning of tests, 18 were not tired and 16 participants were neutral in terms of fatigue. The test was conducted in four different times of the day. We used the acceptability rating task (modified from *Logan and Sadler*, 1996) with Latvian spatial prepositions. Picture with configuration of spatial objects and a corresponding sentence were shown on computer screen. Subjects were asked to rate how good the sentence describes the picture. Subjects rated also their fatigue before and after the test and answered some general questions about health, wake-up time etc.

Our results show that the effect of fatigue on the spatial perception differs according to the meaning of preposition. It was proper that tired subjects choose less acceptable ratings for prepositions ”virs” (above) and ”uz” (on), but for prepositions ”zem” (under), ”tuvu” (next to) and ”pa labi” (to the right) fatigued subjects choose more acceptable ratings. Results show that fatigue no impacts on spatial language and spatial cognition. Logan and Sadler (1996) in their study elaborated spatial templates for ten English prepositions. They determined the regions corresponding to good, acceptable and bad examples of each preposition. Results in present study in Latvian support *Logan and Sadler's* findings. The only difference is in case of Latvian prepositions ”virs” and ”uz” having different meanings than the corresponding prepositions in English. The region of acceptability is very small in case of ”uz” (on) which is different from the initial English version of the test. According to the data analysis we cannot observe any impact of the daytime (when the test is conducted) on the test results.

Acknowledgment
This study is supported by ESF No.2013/0021/1DP/1.1.1.2.0/13/APIA/VIAA/001.

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Speeded verification test in spatial perception under mental fatigue condition

Elina Vevere[1*], Jurgis Skilters[2], Vsevolod Liakhovetckii[1,3], Gunta Krumina[1]
[1]*University of Latvia, Department of Optometry and Vision Science, Riga, Latvia*
[2]*University of Latvia, Center for the Cognitive Sciences and Semantics, Riga, Latvia*
[2]*Pavlov Institute of Physiology, Russian Academy of Sciences, St.Petersburg, Russia*
[*]*E-mail:* elina-vevere@inbox.lv

Introduction

Mental fatigue occurs during monotonous work. It impairs physical performance, which may become apparent of sleepiness, lethargy, attention and concentration decline (*Marcora et al.*, 2009). Mental fatigue affects making decisions, performing tasks that require constant concentration. Our research aim is to determine how mental fatigue affects human visual spatial perception and reaction time.

Method

The research included 43 participants between the ages of 18-35 years. Participant's task was to give the shortest possible time response whether statement conform with image. The statement had two prepositions in Latvian - "virs" (above) and "zem" (below). Participants had to assess 192 steps - the statement and image. At the end they had to answer on a questionnaire about fatigue and health.

Results

The research assessed the impact of statement on human reaction time. When statement ("true") and the layout of objects are matching, participant gives faster response than if the statement is not coincide with picture. Assessing the effects of time of day, data shows longer response time at the morning and evening, and this relation is observed both at a "true" and "false" statement. The least mistakes (about 4%) of given replies, was in the morning hours. The other times of the day data did not differ statistically. If we appreciate the effects of fatigue on the reaction time and mistakes, then a strong correlation can't be observed. In preposition "below" case reaction time is longer than in the preposition "above" case, as well as mistakes have been realized in preposition "below" case.

Conclusion

Longer reaction time is in the morning, where fewer mistakes are made. During the day people faster bind together statement with image, but the mistake proportion increases. Shorter response reaction time and less mistakes are in response to the statement "above".

Latvian language prepositions have small impact on reaction time. Only still remain unexplained "above" and "below" prepositions statistically significant difference in reaction time and mistakes quantity.

Acknowledgement

This study is supported by ESF No.2013/0021/1DP/1.1.1.2.0/13/APIA/VIAA/001.

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Impact of mental fatigue on perception of biological motion

Liva Arente[1], *, Jurgis Skilters[2], Vsevolod Liakhovetckii[1,3], Gunta Krumina[1]
[1] *1University of Latvia, Department of Optometry and Vision Science, Riga, Latvia*
[2] *University of Latvia, Center for the Cognitive Sciences and Semantics, Riga, Latvia*
[2] *Pavlov Institute of Physiology, Russian Academy of Sciences, St.Petersburg, Russia*
[*] *E-mail:* liva.arente@inbox.lv,

Introduction

The drivers at the wheel must be able to assess what is happening on the road on different weather conditions to prevent traffic accidents. Fatigue affects the driver's attention. It could be decreased and it can improve the detection of biological motion. The purpose of our research is to evaluate mental fatigue impact on ability to detect biological motion. Our tasks were: (1) to evaluate effect of different noises on detection of biological motion, (2) to evaluate the effect of day-time on test performance, (3) to estimate the threshold of noises when biological motion is detected in the condition of mental fatigue.

Method

Stimuli consisted from biological and non-biological motion in noise presented on computer screen. Non-biological motion was close to human gait and moving in same frequency. 38 subjects in age 18-55 participated in this study. Test began with noise which is represented by 2000 dots. Points decreased gradually - 100 per second. Subject task was to perceive motion and to detect what kind of motion it was (normal or scramble). Biological or non-biological motion every time was presented on different areas of screen. There were biological motion (right, left, forward) and five noises (left-right in 45 degrees, right-left in 45 degrees, top-down, random and quasi-random). To make task more difficult contrast was reduced.

Results

Biological motion perception was dependent on time of the day. The threshold of noise when was possible to detect motion in evening was 1358 dots (+/-26 dots), while in other times average threshold was 1559 dots (+/-9 dots). The threshold of biological motion perception in random and quasi-random noises were lower than in top-down, left-right and right-left in conditions. We could not find the impact of fatigue on threshold of weather simulated noises, but in case of random and quasi-random noises the tired subjects showed better results as non-tired subjects. We could not find the difference between the detection of normal biological motion and scramble motion in different conditions of noises.

Acknowledgement

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The effect of blur adaptation on blur sensitivity

Anete Pausus*, Peteris Cikmacs, Gunta Krumina
Department of Optometry and Vision Science, University of Latvia, Kengaraga 8, Riga, Latvia, LV-1063
**E-mail:* anete.pausus@lu.lv

Blur perception is an important part of visual perception and accommodation control. [1] The source blurring method [2] was used to determine various thresholds of blur perception as blur level was increased (just noticeable blur and unrecognizable optotype perception threshold) or decreased (clear image perception, optotype orientation, recognition threshold). Gaussian low-pass filter with different blurring disc diameters was used to simulate image blurring. The effect of additional adaptation to optical defocus (1,0 D simulated myopia) was evaluated.

Results showed that thresholds decreased on average by 27 - 48 % for different blur perception aspects for myopic participants after adaptation. For emmetropic participants thresholds decreased on average by 10 - 42 % after adaptation (see Fig. 21).

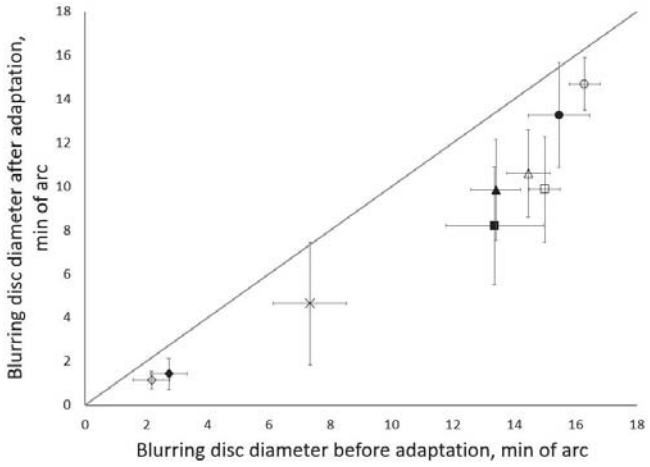

Figure 19: Blur perception thresholds for myopes (black markers) and emmetropes (white markers) before and after adaptation to 1,0 D simulated myopic optical blur. Circles - orientation, triangles - recognition threshold, squares - unrecognizable optotype, cross - clear image, diamonds - just noticeable blur threshold

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Acknowledgement

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Mental rotation test in condition of fatigue

Kristiana Ozola[1*], Jurgis Skilters[2], Vsevolod Liakhovetckii[1,3], Gunta Krumina[1]
[1]*University of Latvia, Department of Optometry and Vision Science, Riga, Latvia*
[2]*University of Latvia, Center for the Cognitive Sciences and Semantics, Riga, Latvia*
[2]*Pavlov Institute of Physiology, Russian Academy of Sciences, St.Petersburg, Russia*
[*]*E-mail:* ozola.kristiana@gmail.com

Introduction

Mental rotation is the ability to rotate two and three-dimensional objects in your mind. Mental rotation of three-dimensional objects have been experimentally studied since 1971 when R.Shepard and J.Metzler [1] found that if the angle of rotation increases, then the reaction time for detecting it increases as well. The aim of our study is to examine the possible impacts of fatigue on the ability of mental rotation. Our study has 2 main aims: 1) to estimate a possible correlation between the particular time of day and reaction time in mental rotation task of 2D and 3D objects; 2) to assess the possible impact of fatigue on the reaction time in mental rotation task.

Method

To evaluate reaction time for recognizing rotated objects (whether they do or do not match each other) we have constructed a special digitized test that consists of 256 object pairs (128 two- and 128 three-dimensional). When the pair of objects is shown on screen the participant has to indicate whether the object is the same (but rotated) or whether it is the mirror image of the same object.

Results

In case of 2D and 3D mental rotation reaction times are longer for mental rotation of mirrored objects. The error rate is higher in evaluating 3D objects than the 2D objects. We support Shepard and Metzler's (1971) observation that if the angle of rotation increases, the reaction time for evaluating object pairs increases as well. If the angle of rotation and the speed of detecting the rotation are compared in 2D object, reaction time for some types of figures is faster. According to our results rotation of 3D objects produces more errors if the test is conducted within the first 5 hours after waking up or since 15 hours of being awake. However, we are not able to observe any significant effects of fatigue on the mental rotation task.

Conclusion

The reaction time of 2D figures is longer in the morning, the 3D image has the longest reaction time in the morning and by night. The highest error rate occurs in the morning time (shortly after wakening up). We were not observe any impact of fatigue on the mental rotation task.

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Experiment session duration effect on chromatic sensitivity threshold

Renars Truksa[1,*], Janis Dzenis[1],Gunta Krumina[1]
[1] *Department of Optometry and Vision science, University of Latvia, Kengaraga 8, Riga, Latvia, LV-1063*
[*] *E-mail:* reenaars@inbox.lv,

Colour vision research results are useful for science and as well for everyday life. Studies with patients who have altered colour vision give opportunity to find more about mechanisms which governs our colour perception. Knowledge obtained in experiments allows develop methods to determine changes in chromatic sensitivity during the time which might be useful in medicine. Aim of current research to find out whether prolonged colour vision experiment sessions have any influence on chromatic sensitivity thresholds. In order to prove or reject hypothesis we offer two types of colour vision test designs. We suggest static and dynamic colour vision tests. Static colour vision test share design features with HRR colour vision test. Test stimuli are created digitalizing HRR test plates by employing picture segmentation and edge detection algorithms. Dynamic colour vision test shares some design features with Colour and Assessment colour vision test with exception that test background is created in way which doesn't allow artefact figures. Equal luminance clusters - artefact figures may draw patient attention from main task and lower chromatic threshold therefore artefact figures are excluded from test stimuli. Before each experiment session patient chromatic sensitivity is measured in 6 chromatic directions and corresponding chromatic thresholds are obtained. Testing procedure is designed in way that excludes possibility to adapt for specific type of colour stimuli either gain skills which might improve results. After mentioned procedures colour vision testing is continued by using constant stimuli method. When fixed number of stimuli are presented series of threshold stimuli are shown. Results obtained from these experiments hopefully will clarify whether experiment session duration have any effect on person colour vision performance.

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The Effect of Fatigue on Eye Movements and Metaphor Comprehension in Reading

Inga Jurcinska[1,*], Ilze Laicane[1], Jurgis Skilters[2], Gunta Krumina[1]

[1]*Department of Optometry and Vision Science, University of Latvia, Kengaraga 8, Riga, Latvia, LV-1063*

[2]*Department of Communication Science/ Center for Cognitive Sciences and Semantics, University of Latvia, Lomonosova 1A, Riga, Latvia, LV-1019*

[*]*E-mail:* ingaj114@gmail.com,

Two basic components of eye movements are the saccades and fixations. The average fixation duration in reading is 225-250 ms, whereas fixation durations can be extended between 150 ms and 500-600 ms (or even more). Skilled readers make about 10-15 percent eye movements as backward saccades, called regressions. Most regressions refer to the previous word, although when the text is exceptionally difficult, more long-range regressions can occur referring to previously read parts of the text [1]. Metaphors are different than the literal language in that they critically involve previous experience, which enables to understand the metaphoric meaning. Furthermore, metaphors help to express ideas that are difficult or impossible to express literally. Previous experiments with eye movement recordings show that more familiar metaphors are read faster than less familiar metaphors [2].

The aim of the current research is to analyze main characteristics of the eye movements (fixation duration, regressions and dispersion) and the effect of fatigue on the eye movements in reading and comprehending metaphors.

Three different texts containing simple, more complex metaphors and no metaphors were used. To analyze the comprehension and to motivate the participants, several questions about the context were asked after reading every text. Six (2 fatigued and 4 not fatigued) students participated in the experiment. All participants were native Latvian speakers with normal vision at near. Monocular eye movements were recorded with an iView HiSpeed video-based eye tracker. Data analysis was performed with BeGaze and Microsoft Excel.

The average fixation duration when reading texts without metaphors was 259ms, whereas the average fixation time when reading texts with complex and simple metaphors texts was respectively 254ms and 243ms. The results also demonstrate that fatigue had an impact on cognitive processing when reading all three texts. The comprehension was similar to both fatigued readers and participants who were not tired (83 and 77 percent of answers were correct) but the task execution time was increased in fatigued participants. Fatigued participants had almost twice as much regressions than the non-fatigued group. Most regressions were made to the previous word, although sometimes regressions were performed to the beginning of the row.

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