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Importance of binocular vision

In an executive function task using augmented reality head-mount display

Master's Thesis
Master Thesis MPRO5001-1
2024

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Parts of this master thesis have been written and submitted in previous assignments, in the courses MRES09-2 22H Research method and MPRO5001-1 23H Master Thesis.

Summary (English)

Introduction: The aim for this study was to investigate the importance of stereoscopic vision using augmented reality (AR). How a monocular reduction in visual acuity impact stereopsis and binocular vision. The impact on performance in the executive function task Tower of London, among young adults. With increasing implementation of virtual reality for different occupations, it is important to examine how different ocular conditions can affect performance and usability.

Methods: This is a cross-sectional study; participants were bachelor of optometry students at the university of southeast Norway, meeting the inclusion criteria of prescription within +/- 1D and previously scored 120” or better on TNO. In total 15 subjects participated; data was collected from October 2023 to March 2024. Testing was performed using the Tower of London (ToL) program with the augmented reality head-mount display HoloLens2. Bangerter foils 0.1 and 0.4 were used to induce reduction in visual acuity of the non-dominant eye. The study was approved by the Norwegian Agency for Shared Services in Education and Research (SIKT).

Results: When visual acuity in the non-dominant eye were reduced, we found a reduction in stereoscopic vision. Induced reduction in visual acuity and stereopsis did influence performance in the ToL task, suggesting it is important to consider binocular vision in tasks requiring executive functions and visuomotor coordination. However, because analysis of possible order effect suggest there is a learning effect of the task, we must be careful not to put too much emphasis on condition. ANOVA analysis suggested there only was significant difference between conditions for total testing time.

Conclusion: Reduction in visual acuity in the non-dominant eye with Bangerter foil provided a reduction in stereopsis. The subjects did show a reduction in performance with the different Bangerter foils. However, there might be an order effect, which suggest that experience might increase performance. Low data material might impact statistical significance or lack of significance, we therefore cannot rule out that a sufficient sample size might get different results. Further research analysing order effect by condition, can give us more information to understand how performance is affected, and what to take into consideration to optimize task performance in virtual reality.

Keywords: Augmented Reality, Tower of London, Executive function, Depth perception, Visual acuity, Bangerter foil, Cross-sectional study.

Sammendrag (Norwegian)

Introduksjon: Formålet med dette studie var å undersøke viktigheten av dybdesyn ved bruk av augmentert virkelighet (AR). Hvordan monokulær reduksjon i visus påvirker dybdesyn, binokulært syn og prestasjon i eksekutive funksjoner ved bruk av Tower of London programmet, blant unge voksne. Med økende implementering av virtuell virkelighet for ulike yrkesgrupper, er det viktig å undersøke hvordan ulike forhold i visus kan påvirke prestasjon og brukervennlighet.

Metode: Dette er en tverrsnittstudie; Deltagere var bachelor i optometri studenter ved universitetet i sør-øst Norge, som oppfylte inklusjonskriteriene for refraksjon innenfor +/- 1D og tidligere hadde prestert 120” eller bedre ved TNO testing. Totalt 15 personer deltok i studiet; data ble samlet inn fra oktober 2023 til mars 2024. Testing ble utført ved å bruke Tower of London (TOL) programmet ved bruk av HoloLens2 hodemontert skjerm for augmentert virkelighet. Bangerter foliene 0.1 and 0.4 ble brukt for å indusere reduksjon i visus og synsskarphet. Studiet var godkjent av Kunnskapssektorens tjenesteleverandør (SIKT) for samling og behandling av forskningsdata.

Resultater: Når visus i det ikke-dominante øyet ble redusert, fant vi en reduksjon i dybdesyn. Indusert reduksjon av visus og dybdesyn påvirket prestasjonen i ToL oppgaven. Dette tyder på at det er viktig å ta hensyn til binokulært syn i oppgaver som krever eksekutive funksjoner og visumotoriske ferdigheter. Imidlertid, fordi analysen av mulig order effekt antyder at det kan være en læringseffekt av oppgaven, må vi være forsiktige med å legge for mye vekt på prestasjon basert på synsskarphet. ANOVA analysen tydet på at det kun var signifikant forskjell mellom synsskarphet for total testtid.

Konklusjon: Reduksjon i visus i det ikke-dominante øyet ved bruk av bangerter folie, førte også til reduksjon i dybdesyn. Deltagerne viste en reduksjon I prestasjon med de ulike Bangerter foliene. Det kan også være en order effekt, som antyder at erfaring kan øke prestasjon. Lavt datamateriale kan påvirke statistikkens signifikans, eller mangel på signifikans. Vi kan derfor ikke utelukke at tilstrekkelig utvalgsstørrelse kan gi ulike resultater enn de som er funnet i dette studiet. Videre forskning som kan analysere order effekt og sammenheng med synsskarphet, vil kunne gi oss mer informasjon for å forstå hvordan prestasjon påvirkes, og hva som må bli tatt i betraktning for å optimalisere prestasjon og brukervennlighet ved bruk av virtuell virkelighet.

Nøkkelord: Augmentert virkelighet, Tower of London, eksekutive funksjoner, Dybdesyn, Visus, Bangerter folie, Tverrsnittstudie.

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Foreword

I want to thank my supervisors Trine Langaas and Ellen Svarverud for all their help, guidance and feedback. Without their faith in this project might not have been finished on time. I will also thank my family, friends and colleagues for being a listening ear when I needed. Both for listening to my complaints, and when I needed someone to discuss with to figure out my next move.

Krokstadelva/26.04.2024

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1 Introduction

Depth perception is made up of binocular and monocular cues, we use it to judge distance when driving, pouring a glass of water and when we give someone else a high five. Stereopsis is part of binocular cues and is the ability to see three-dimensionally and gain a perception of depth, based on retinal images and their disparity. By forming binocular vision to judge relative distance in space, even when there are no monocular clues. (Rabbetts, 2007, p.203)

For stereopsis to occur, there are three central conditions that need to be present: The field of vision needs a large binocular overlap, afferent visual fibers need to be partially crossed and for accurate eye movements, we need coordinated traction of the extraocular muscles. (Elliott, 2014, p. 190)

In this study we want to focus on binocular and stereoscopic vision. To get a good understanding of the binocular situation, it is important to assess stereopsis when we examine and evaluate binocular vision.(Snowden et al., 2012, p.247) Monocular cues depend more on familiarization and is usually less precise (Fulvio et al., 2020) Assessment of stereopsis and depth perception, as well as understanding the depth of binocular vision, will contribute to give further information, to better understand demands of stereovision in everyday life.

Stereopsis is commonly divided into two groups: fine stereopsis and coarse stereopsis. Coarse stereopsis is acquired from large retinal disparities, which produce diplopia. It is mature at around 4 years. coarse stereopsis is considered ≥1.0 degree of disparity, which equals to about ≥3600” (Giaschi et al., 2013). Fine stereopsis is obtained by small retinal disparities, fused together to a single image. Opposite to coarse stereopsis, fine stereopsis is still evolving and is maturing towards school-age. Normal fine stereopsis is considered as ≤40", but fine stereopsis is all levels of stereopsis <3600” (Elliott, 2014, p. 190) (Giaschi et al., 2013). This area that allows fusion and stereopsis is part of Panum´s fusional area. If we picture a semicircle, the stimuli close to the circle line that are fused and seen as one image is part of fine stereopsis, while the stimuli further away from the circle line that are seen as double is part of coarse stereopsis (Ansons & Davis, 2014, p. 406.).

Fine and coarse stereopsis are established by two distinctive, different systems in the V2 area of visual cortex. Magno cells from the thick stripe regions process motion and detect low spatial frequency to give us coarse stereopsis. Parvo cells in the interstripe and thin stripe regions process chromatic stimuli, luminance levels and detects high spatial frequency disparity giving us fine stereopsis (Stidwill & Fletcher, 2010).

There are suggestions that stereoscopic learning happens at different stages of this visual processing, and that the outcome depends on the targeted training site, first (fine)- or second(coarse)- order stereopsis mechanisms (Xi et al., 2021).

Anything that reduces visual acuity or inhibits fusion of the retinal images, such as refractive errors, strabismus or pathology can impact depth perception (Hess et al., 2015).

Today there are many different variants of virtual reality devices; Extended (XR), virtual (VR), augmented (AR) and mixed reality (MR). These devices have become highly popular in the last few years, for use in areas such as: manufacturing, design and medicine, marketing etc. (Y. Liu et al., 2020)(Schild et al., 2018). AR uses an optical see-thru display that is head-mounted, the virtual stimulus is thereby combined with real world surroundings. VR displays is a more closed in virtual experience using a screen and blocking out the real world. Depth matching tasks shows AR displays to have a higher depth estimation accuracy compared to VR displays (Ping et al., 2019).

With more use and implementation of these devices across different platforms, a need to understand how vision affect the usefulness arise. For 3D simulations to be effective, there is a need for good binocular and stereoscopic vision. If we do not consider common eye and visual problems, about 30% of the population will not be able to utilize these devices as intended. It is therefore important to examine how different binocular, ocular and vision problems can affect performance when using these devices. (Pladere et al., 2022).

The Tower of London procedure (ToL) is an executive function test, which requires vision, planning and analysis to interact with the AR system and perform a sequence of moves to complete the task. ToL consist of three rods, there are colored balls randomly distributed on the rods, and the procedure is to move the balls within a set number of moves to match a given sequence. Difficulty is increased by reducing the number of moves for the subject to complete the task. (Harsa et al., 2022)

2 Aims and research questions

The aim for this study was to investigate the impact stereopsis and binocular vision has on performance in an executive function task, among first year Bachelor of Optometry Students at the university of South-East Norway.

The research questions for this study are:

- How is stereovision affected when we reduce vision in the non-dominant eye with bangerter foil?
- Is there a difference in performance of the Tower of London task, with versus without unilateral bangerter foil?
- What is the importance of binocular vision when using augmented reality head-mounted display?

3 Methods

3.1 Study design

Because we do all the testing and measure the outcome at the same time for each subject, This project is a cross sectional study. (Setia, 2016). We want to examine young adults with close to normal stereopsis ≤120”, to measure execution and performance in a visuomotor and executive task.

3.2 Subjects and recruitment

The subjects in this study are first year Bachelor of Optometry Students, at the University of South-Eastern Norway (USN). The students have previously participated in another project where, among other things; Autorefractor with cyclopentolate and stereopsis were measured. The students that scored ≤120” on TNO and has given consent to be contacted for other research projects, will be invited to participate in this study by sending an E-mail. The age of our population is approximately 18-38, we want 20-30 participants for this project.

The study sample ended up with consisting not only of first year Bachelor of Optometry students, but second and third year students as well.

3.3 Exclusion criteria

For our subject group, we wanted no amblyogenic or suppression risks. Therefor we have set the following exclusion criteria for this project:

- LogMAR visual acuity >0.1 in one eye without correction
- Anisometropia >1,00D
- Uncorrected refraction > +1,00D and > -1,0D SER
- Stereopsis >120” measured with TNO stereo test.
- Tropia
- Uncompensated phoria

3.4 Data Collection

Recruitment period was from October 2023 to March 2024

For this project, we will use the Frisby test and TNO stereo test for near to measure stereopsis. All subjects will have an initial screening with some basic tests, to assess binocular status before the subjects perform the Tower of London task in AR. We will also use these data to compare the results of AR to see if any variables affect results. See Table 1 for the measurements thar are part of our initial data screening. These variables will also be used to exclude those subjects who should not be tested in AR. We will also ask the subjects for permission to get access to their refraction data performed with cyclopentolate and autorefractor.

Table 1: Shows data that will be collected as part of this study.

Measurement	**Data**
Refraction	Refraction measured with cyclopentolate eye drops by autorefractor (this data will be collected from the participants journals).
Visual acuity (VA) in LogMAR	Performed on each eye.
TNO	Performed at near.
Cover test	To look for phoria and tropia at distance and near.
OXO mallet	To examine if phoria is compensated or not. Performed at distance and near

Data will be collected in a Microsoft office excel spreadsheet; we will ensure participant anonymity by giving the subjects their own three-digit id-number. We will keep a separate document that links subject's birthday and their id-number. Along with this document, the written consent forms with names, will both be stored in a locked archive at the university of south-east Norway in Kongsberg. Testing will be performed over several days during fall 2023 and winter 2024. The documents will be stored until 01.06.2026, for further research. The subjects in our study will be bachelor students until 01.06.2026. After this date, the documents containing identification data will be shredded.

3.5 Variables

Outcome variable will be stereopsis results from random dot stereograms (TNO) and Frisby Test, predictor variables will be presence or absence of suppression, anisometropia and strabismus. Other variables will be visual acuity, refraction, sex and age see Table 2.

Table 2: Shows variables and what values they will be registered as

Variable	Value
Stereopsis	Numerical threshold value, measured in seconds on arc (“), grouped into 3 categories: 1= 15-120≥” (normal) 2= >120-480” (slightly reduced) 3= >2000” (poor) One measure for TNO stereo test and one for Frisby Test
Anisometropia	0= Absence 1= Prescence
Cover test	To identify if there are a compensated phoria. 0= Absence 1= Prescence
Visual Acuity	LogMAR decimal
Refraction	Noted in decimals, habitual refraction.
Dominance	Eye dominance measured with +1,00 Fog. L= Left R=Right
Sex	M= Male F= Female
Age	Numerical value

3.6 Tower of London

The ToL task will be performed using HoloLens 2 head-mount display where the programme has been downloaded. The subject will start by configuring the HoloLens to their eyes, then we will start testing tower of London, twice with bangerter foil over the non-dominant eye and once habitually. We will pseudo randomize testing, some will start with bangerter foil 0,1, others with bangerter foil 0,4 and some will start testing habitually. They will start by performing a demo, then they will have 12 levels to complete per trial. The Variables for Tower of London used in this study are Total testing time, initiation time, execution time and number of restarts. Total testing time is the time the subjects us from when they start level 1

until completing level 12. Initiation time is the time the subjects on average use per level, from when the level is precented until they make the first move. Execution time is the time the subjects use on average per level from the first move until the level is passed. Number of restarts is how many times the subjects had to restart one level because they made a mistake, and then added for all 12 levels. The levels is completed by moving a set of balls on a bracket to match an answer presented on a PC screen.

3.7 Bangerter Foil

Bangerter foil is a thin vinyl foil with a characteristic microbubble pattern, the microbubbles provide a scattering of the light that produce a degraded vision (Pérez et al., 2010). Density of the foil is estimated by the density of the microbubbles, they are available in density grades 1.0, 0.8, 0.6. 0.4, 0.3, 0.2, 0.1, >0.1 Light Perception (LP) and No Light (00) which corresponds to Snellen decimal expected visual acuity. The design of the foils provides a degraded visual acuity, which is independent of viewing distance (Then, 2010). For our study we chose to use the 0.4 and 0.1 bangerter foils, based on driving criteria for group 2 (heavy vehicles). The European standard is for visual acuity to be at least 0.1 LogMAR in the best eye and 0.3 LogMAR for the fellow eye (Van Rijn, LJ et al., 2005). The Norwegian standard is 0.1 LogMAR for the best eye and 1.0 LogMAR for the fellow eye (*Førerkortforskriften*, 2004, §9. The reason we chose the 0.4 foil instead of the 0.6 foil was to be sure we had enough of a reduction in visual acuity to be similar or just slightly worse, than the 0.5 decimal acuity for the European criteria of the fellow eye which translates to 0.3 LogMAR.

3.8 Equipment

- Occluder
- TNO stere test
- Frisby Test 6mm plate
- Polarized glasses
- String
- Opaque tape
- Microsoft office Word
- Private owned computer
- Tower of London Program
- Near point target
- Anaglyphic testing glasses
- Oxo Mallet
- Measuring tape
- Electrical tape
- Microsoft office Excel
- R-commander
- HoloLens 2 head mount-display

3.9 Testing set up.

We started by setting up two stations with one desk for each station, one desk for mirroring and recording of the tasks and one desk where the subjects sit to receive instructions and perform the ToL task. On the subject station, we use a 13 inch laptop to show instructions via PowerPoint, we marked the desk at 1 meter for where the laptop will be placed and 50cm for testing distance of the ToL. The laptop is remotely controlled with a mobile phone to change power point slides. The laptop used is a MacBook air M1.

Before testing with the HoloLens, we performed the Frisby test, TNO, visual acuity, oxo mallet and cover test, to make sure the subject was within the inclusion criteria. The Frisby test were performed against a white wall, where we used a string to measure distances of 40cm, 50cm, 75cm, 100cm, 150cm, 200cm and 250cm respectively, which were marked with tape, the 6mm plate were used for testing. Cover test was carried out at close range using a cover spade and fixation stick, the fixation stick was held at approximately 50 cm.

For visual acuity, we used the Good-Lite Near vision chart “2” IN LogMAR sizes for testing at 16 inches (40cm). Converted the numbers so that we could use this chart for testing at 1m. We measured 1m from the wall and made a mark in the floor so that the subjects could see where they should stand. The testing station where TOL, TNO and oxo mallet will be performed, were measured at 620 lumen.

Dominance was measured after visual acuity measurement at 1m using a +2.00D trial lens and asking the subject to rate their vision on a scale of 1-10, the eye with the lowest rating were noted as the dominant eye. Refraction was noted from the mini project with consent from the subjects. Refraction measured with Huvitz autorefractor with and without cyclopentolate. We marked up glasses, with 5 identical frames, two with Bangerter foil 0.4 and two with Bangerter foil 0.1, one for RE and one for LE. In addition to a frame without glass for "habitual" testing.

As mentioned previously, we chose to pseudo randomize what the subject should start with when using the HoloLens, where we rolled between testing habitually, 0.4 and 0.1 bangerter foil, next would test 0.4, 0.1 and habitually and so on.

All data were registered in a procedure form, we also used a procedure form for instructions on how to manage the HoloLens, calibrate and how to perform the Tower of London test, see attachments “data registration form” and Tower of London procedure.

3.10 Analysis

Statistical analysis is performed in R-commander. Descriptive analysis include mean, standard deviation, median as well as ranges and percentiles of fine and coarse stereopsis, for each test separately. We also want to look at the different variables and factors, to investigate what factors affect stereopsis the most. Data Analysis will be performed by Linear mixed models, Regression analysis, ANOVA analysis, independent sample t-tests, Principle-Components analysis, stepwise model selection and linear models.

Analysis was started by making a histogram to visualize the values for visual acuity for the nondominant eye (ND) for the different conditions. Stereovision measurements were analysed by performing a paired t-test between the results from TNO and Frisby. The Stereoscopic values were grouped into 3 categories: Normal (15-120≥”), slightly reduced (>120-480”) and Poor (>2000”) see Table 2. We categorized stereopsis into 3 groups to be able to analyse the data, as there is no value for not seeing the presented figures for stereoacuity measure.

Analysis of variance (ANOVA) was performed to test the assumption that all means are equal for the different conditions and for possible order effects.

Low recruitment issue made us choose to also contact possible subjects from the second-year bachelor students, who also had participated in a mini-project on campus and agreed to be contacted for future testing. We also sent a general message to the third-year students to contact us if they are interested in being part of the project, in the general message we have included that they must have prescription within +/- 1D and previously scored 120” or better on TNO.

We performed a Power analysis, using the University of Vienna sample size calculator for Analysis of variance with the data we had acquired.

3.11 Ethics

Possible subjects were contacted thru e-mail and invited to participate. with a short information about the study and informed consent form. All participation were voluntary, and they could withdraw at any time without having to explain why they want to back out and with no repercussion. Anonymity was ensured by providing the subjects unique id-numbers. Personal information, contact id and consent forms will be stored in a locked locker at university of south-east campus Kongsberg.

Because this study collects and store health related data of the subjects, we had to be approved by the Norwegian Agency for Shared Services in education and Research (SIKT). Approval was acquired October 2nd, 2023. The study also followed and were completed in accord with the WMA Declaration of Helsinki- ethical principles for medical research involving human subjects. Additionally, it was approved see attachment: for the SIKT application.

4 Results

4.1 Demographical data

A total of 16 subjects participated in this study. one subject was excluded because of an uncompensated phoria, 15 were included in the final analysis (see table 3). Mean(SD) age was 23.67(4.6) years, the age range was from 19 to 33 years. There was 12 females and 3 males, 7 did not have some prior experience with VR/AR while 8 did. 8 of the subjects did not were any refraction, while 7 used glasses. Mean(SD) refraction for the right eye was -0.13(0.5) D and -0.13(0.5) D for the left eye. Visual acuity mean(SD) -0.02(0.1) LogMAR OD, -0.04(0.1) LogMAR OS and -0.10(0.1) LogMAR OU. Stereopsis had a mean(SD) of 42(28) seconds of arc for TNO and 32(25) seconds of arc for the Frisby test.

Table 3 shows demographical data of the different subjects, Refraction of OD and OS is noted in Diopters, visual acuity is registered in LogMAR and stereoacuity for TNO and Frisby is registered in seconds of arc.

Table 3: Demographical data of the sample PE stands for Prior experience.

ID	Age	Sex	PE	Ref OD	Ref OS	VA OD	VA OS	VA OU	TNO	Frisby
1	27	f	no	+0,39/-0,32	+0,49/-0,41	-0,10	-0,20	-0,20	15	10
2	20	f	no	+0,38/-0,54	+0,50/-0,44	-0,02	0,00	-0,04	120	55
3	19	f	yes	+0,75/-0,64	+0,75/-0,50	0,04	-0,06	-0,06	15	15
4	21	m	yes	+0,40/-0,03	+0,07/-0,25	0,04	-0,02	-0,08	60	15
5	20	f	no	+0,44/-0,25	+0,34/0,13	-0,10	-0,10	-0,18	15	25
6	19	f	yes	-0,12/-0,64	-0,10/-0,45	0,08	0,04	-0,08	30	55
7	24	f	no	-0,75	-0,75-/0,25	0,06	0,02	-0,04	60	55
8	19	f	no	+0,53/-0,08	+0,67/-0,62	-0,04	-0,04	-0,04	30	95
9	31	f	yes	-0,87/-0,24	-0,68/-0,21	0,00	-0,08	-0,20	60	25
10	26	m	yes	-0,21/-0,40	+0,03/-0,81	-0,02	-0,04	-0,06	60	25
11	23	f	no	-0,93/-0,77	-0,84/-1,18	0,02	0,12	0,02	30	55
12	20	f	no	-0,87/-0,07	-0,67/-0,28	-0,08	-0,06	-0,12	30	15
13	24	f	no	-0,15/-0,29	-0,02/-0,39	-0,04	-0,06	-0,12	30	15
14	33	f	yes	+0,28/-0,47	+0,22/-0,12	-0,20	-0,18	-0,22	30	15
15	29	m	yes	+0,72/-0,68	+0,67/-0,73	0,02	0,02	-0,10	15	10

4.2 Visual acuity and Stereovision

Visual acuity and stereoacuity were measured habitually and with the 0.4 and 0.1 bangerter foils. The 0.1 and 0.4 foils are 0.4 and 1.0 LogMAR visual acuity respectively. Mean visual acuity in LogMAR for the nondominant (ND) eye where: -0.03 habitually with range min -0.20 and max 0.12. The 0.4 foil yielded a mean VA acuity of 0.15 with range min 0.00 and max 0.28, 0.1 foil had mean visual acuity of 0.78 with range min 0.36 and max 0.98. Mean(SD) binocular visual acuity were habitually -0.10(0.07) with range min -0.22 and max 0.02, 0.4 foil -0.07(0.07) with range min -0.20 and max 0.06 while 0.1 foil yielded -0.05(0.08) with min -0.20 and max 0.14. Testing showed a slight reduction in visual acuity with the 0.4 bangerter foil, the 0.1 foil has more of a reduction in visual acuity and more variability in the data. There is also an overlap in visual acuity between habitual and the 0.4 foil, as shown by Figure 1. Binocular visual acuity showed a slight reduction with the different foils, both mean, standard deviation and range were highly similar for the different condition, with mean VA only had 0.03 LogMAR difference in habitually compared to the 0.4 foil, and 0.05 LogMAR difference between habitual testing and 0.1 foil. Suggesting binocular visual acuity to not be statistically distinct for the different conditions.

TNO resulted in a mean(SD) of 42(28) seconds of arc with range min:15 and max: 120 when testing habitually, the 0.4 foil resulted in 347(702) with range min: 15 and max: 2000. The Frisby test yielded a mean(SD) of 32(25) seconds of arc when testing habitually with range min: 25 and max: 95, the 0.4 foil showed 52(49). With the 0.1 foil, 7 subjects did not see the butterfly with TNO, the mean(SD) of those who managed to see something were 893(925) seconds of arc. For the Frisby Test, 6 subjects could not tell where the circle were, those who manage to perform the Frisby test had a mean(SD) of 198(102) seconds of arc. Suggesting the subjects performed worse with the 0.4 and 0.1 bangerter foil. With the 0.1 foil yielding the poorest result. The results also suggest the subjects performed better with the Frisby test than TNO.

In Table 4, visual acuity is registered in LogMAR for the nondominant eye and binocular. Frisby and TNO are registered as seconds of arc and in categorized groups 1-3 based stereoscopic result.

Table 4: Visual acuity and stereovision for the different conditions

ID	condition	VA Nondominant	VA OU	TNO		Frisby	
1	hab	-0,20	-0,20	15	1	10	1
	0.4	0,10	-0,20	15	1	15	1
	0.1	0,60	-0,20	120	1	55	1
2	hab	0,00	-0,04	120	1	55	1
	0.4	0,28	-0,04	240	2	55	1
	0.1	0,86	0,00	not seen	3	not seen	3
3	hab	-0,06	-0,06	15	1	15	1
	0.4	0,16	-0,06	60	1	25	1
	0.1	0,90	-0,06	not seen	3	340	2
4	hab	-0,02	-0,08	60	1	15	1
	0.4	0,06	-0,04	120	1	15	1
	0.1	0,94	-0,02	2000	3	215	2
5	hab	-0,1	-0,18	15	1	25	1
	0.4	0,12	-0,16	240	2	55	1
	0.1	0,36	-0,10	not seen	3	215	2
6	hab	0,08	-0,08	30	1	55	1
	0.4	0,14	-0,08	60	1	55	1
	0.1	0,66	0,00	60	1	95	1
7	hab	0,06	-0,04	60	1	55	1
	0.4	0,24	0,00	60	1	55	1
	0.1	0,86	0,04	240	2	340	2
8	hab	-0,04	-0,04	30	1	95	1
	0.4	0,10	-0,04	30	1	215	2
	0.1	0,70	0,04	240	2	not seen	3
9	hab	0,00	-0,20	60	1	25	1
	0.4	0,20	-0,18	60	1	55	1
	0.1	0,80	-0,10	not seen	3	not seen	3
10	hab	-0,04	-0,06	60	1	25	1
	0.4	0,20	-0,04	2000	3	55	1
	0.1	0,72	-0,02	2000	3	215	2
11	hab	0,12	0,02	30	1	55	1
	0.4	0,20	0,06	2000	3	55	1
	0.1	0,80	0,14	not seen	3	not seen	3
12	hab	-0,06	-0,12	30	1	15	1
	0.4	0,14	-0,10	60	1	25	1
	0.1	0,98	-0,08	not seen	3	not seen	3
13	hab	-0,06	-0,12	30	1	15	1
	0.4	0,00	-0,10	60	1	26	1
	0.1	0,92	-0,10	2000	3	215	2
14	hab	-0,20	-0,22	30	1	15	1
	0.4	0,04	-0,14	30	1	55	1
	0.1	0,58	-0,14	480	2	95	1
15	hab	0,02	-0,10	15	1	10	1
	0.4	0,20	0,02	60	1	15	1
	0.1	0,98	-0,08	not seen	3	not seen	3

On average visual acuity in LogMAR for the nondominant (ND) eye were: -0.03 habitually, 0.15 with 0.4 foil and 0.78 with 0.1 foil. Table 4 and Figure 1 shows a slight reduction in visual acuity with the 0.4 bangerter foil, the 0.1 foil has more of a reduction in visual acuity, but also more dispersion in the data. From the results we can see that the histograms in Figure 1 are divided by the mean visual acuity for the different conditions, with the different columns portraying frequency for visual acuity below or over the mean the width of the column shows the minimum and maximum value acquired. For habitual and the 0.4 foil we can see that 8 subjects had better visual acuity than the mean and 7 subjects had worse visual acuity than the mean. The columns for the 0.1 foils shows that 3 subjects had better visual acuity than the mean with 1 subject in the first column on the left and 2 in the second column, while 12 subjects had worse visual acuity than the mean with 5 subjects in the third column and 7 subjects in the fourth column on the right.

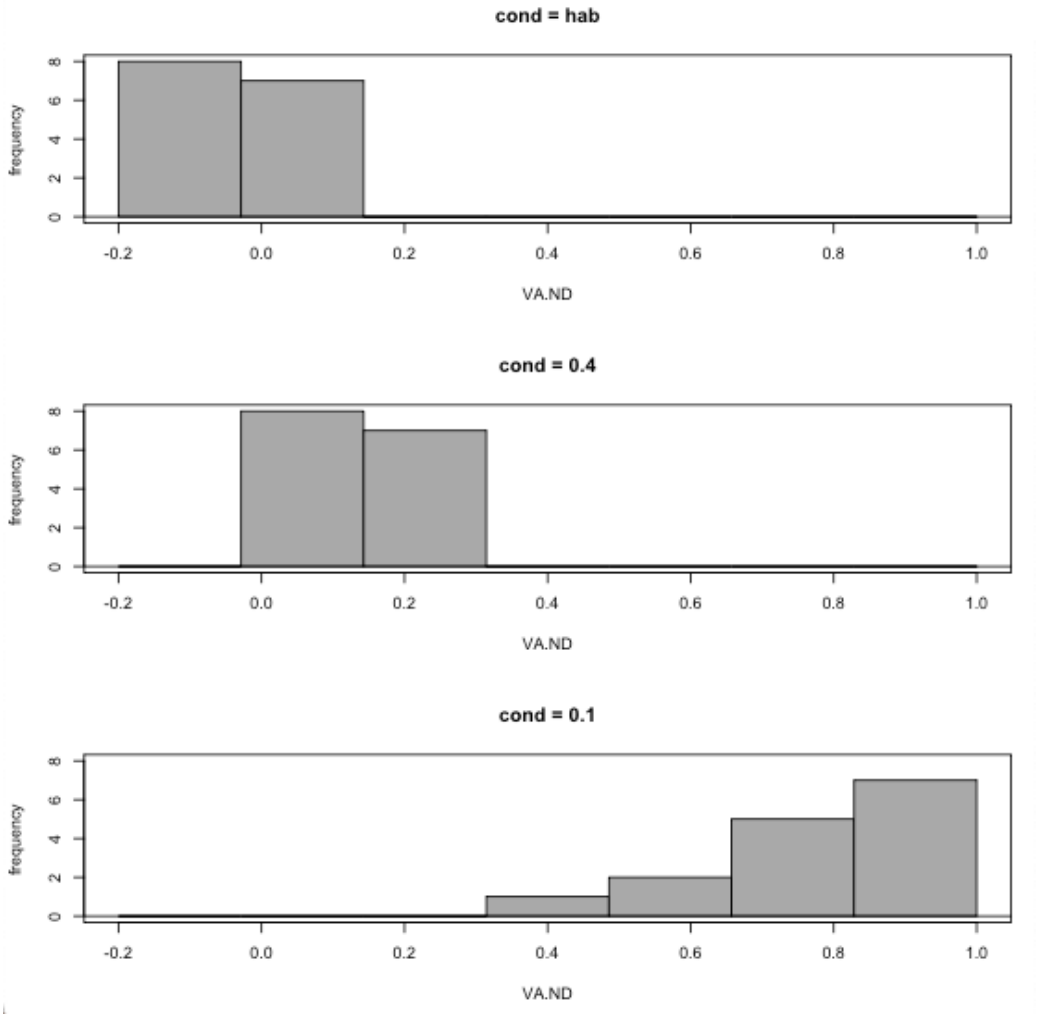

Figure 1: Histogram of Visual Acuity for the Non-dominant eye, for the different conditions.

Visualizing visual acuity of the none-dominant eye and the results from stereoscopic testing, see Figure 2 for TNO and Figure 3 for Frisby. The X axis represent the groups of stereoscopic values, while the Y axis represent visual acuity of the nondominant eye, the plot and whiskers represent mean and standard deviation. When analyzing Figure 2 and Figure 3, we can see that stereoacuity reduces with reduced visual acuity, these results are independent from the foils, as this shows reduction in visual acuity and the obtained stereoacuity, not the foil that provided the reduction. Paired t-test to compare the stereoscopic measurements, yielded a p-value of 0.10, which is significant at an alpha level 0.05. Suggesting there is a difference in stereoscopic values between Frisby and TNO.

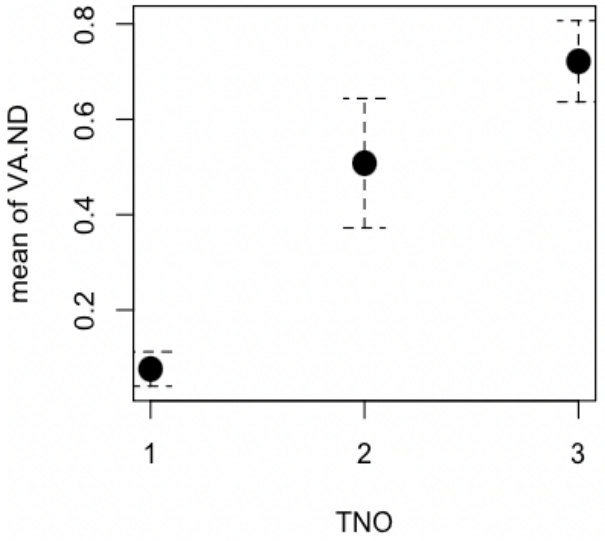

Figure 2: Visual acuity of the nondominant eye and TNO stereoscopic results grouped in 1-3.

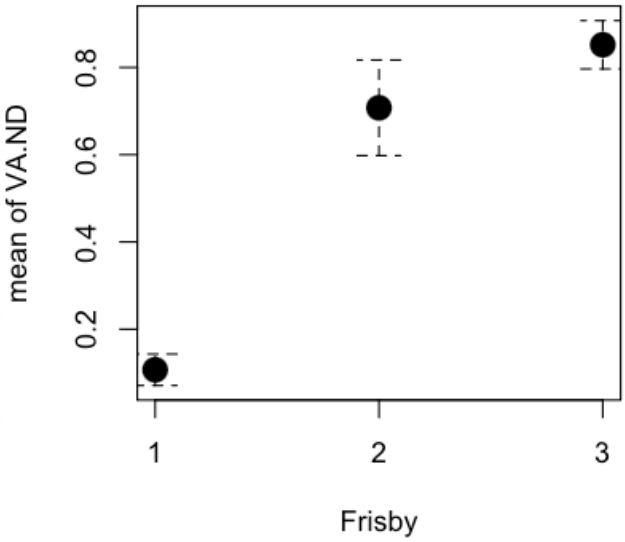

Figure 3: Visual acuity of the nondominant eye and Frisby stereoscopic results grouped in 1-3.

Linear model analysis for visual acuity (VA) if the nondominant (ND) eye and TNO yielded the p-value: 9.406e-11, Multiple R-Squared: 0.6669 and Adjusted R-Squared: 0.6511. For nondominant visual acuity and Frisby p-value was 0.1661e-8, Multiple R-Squared: 0.6181 and Adjusted R-Squared: 0.5999. None of the P-Values are significant at an alpha level 0.05, multiple R-Squared shows that both models account for approximately 60% of the variance with adjusted R-squared and multiple R-Squared, which does not indicate a linear correlation between visual acuity and stereoacuity for either test.

4.3 Tower of London Results

Tower of London was performed habitually and using the bangerter foil 0.4 and 0.1. Variables are Total testing time (ToTime), Initiation Time (InTime), Execution Time (ExTime) and number of restarts (NoRestart). Time is registered as minutes and seconds (min:sec). Total testing time is the time the subjects us from when they start level 1 until completing level 12. Initiation time is the time the subjects on average use per level, from when the level is precented until they make the first move. Execution time is the time the subjects use on average per level from the first move until the level is passed. Initiation time and Execution time were only calculated for successfully completed levels; levels that was restarted were not included in this calculation. Number of restarts is how many times the subjects had to restart one level because they made a mistake, and then added for all 12 levels. The Tower of London task is in this study repeated for the different conditions, noted as testing order. Starting filter were pseudo randomized.

ANOVA Analysis

There were significant differences between conditions for Total testing time $\chi^2(2)=8.27$, $p=0.02$, but not for the other variables (all $p > 0.05$). Execution time was $\chi^2(2)=4.31$, $p=0.12$, initiation time was $\chi^2(2)=0.01$, $p=0.99$ and number of restarts was $\chi^2(2)=4.62$, $p=0.10$.

ANOVA analysis testing for order effect did not show any significant difference between trials (all $p > 0.05$). Execution time was $\chi^2(2)=2.96$, $p=0.23$, initiation time was $\chi^2(2)=0.68$, $p=0.71$, Total testing time was $\chi^2(2)=4.26$, $p=0.12$ and number of restarts was $\chi^2(2)=0.69$, $p=0.70$.

Analysis of possible order effect

Because a randomised order between conditions was used, it was necessary to analyse for possible order effect. There was no statistical order effect, but based on the data we cannot rule this out, due to low data material. We therefore choose to present the data.

Execution time

Mean(SD) Execution time in seconds for the first trial was 14(6) with range 8 to 29, for the second trial 14(5) with range 7 to 27. 12(3) for the third trial with range 8 to 16. Results show mean to be similar for trial one and two and faster for the third trial. Minimum time is similar for each trial while maximum time shows improvement for each trial. Figure 4 also suggest that the subjects performed faster for each trial. The X axis in the plot shows trial order and the Y axis shows mean execution time in seconds.

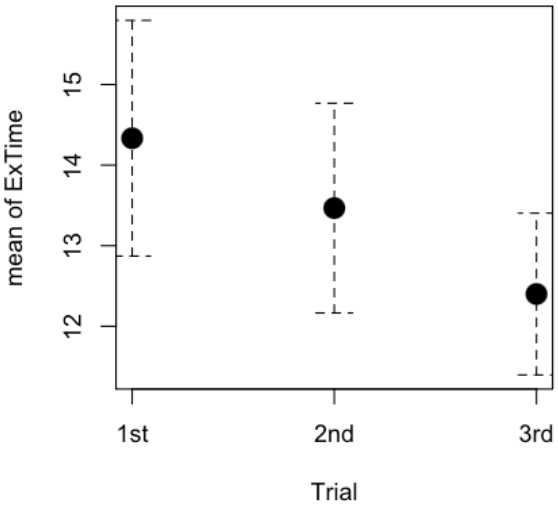

Figure 4: Shows Plot of means for Execution time for each trial.

Initiation time

Mean(SD) Initiation time in seconds was 10(4) for the first trial with range 4 to 21. Second trial was 9(3) with range 5 to 18. For the third trial results was 12(3) with range 8 to 16. Mean initiation time and maximum time used, shows an improvement for each trial. Standard deviation and minimum time is similar for the different trials. Figure 5 shows that the subjects was fastest on the second trial, first trial were the slowest. The X axis in the plot shows trial order and the Y axis shows mean initiation time in seconds.

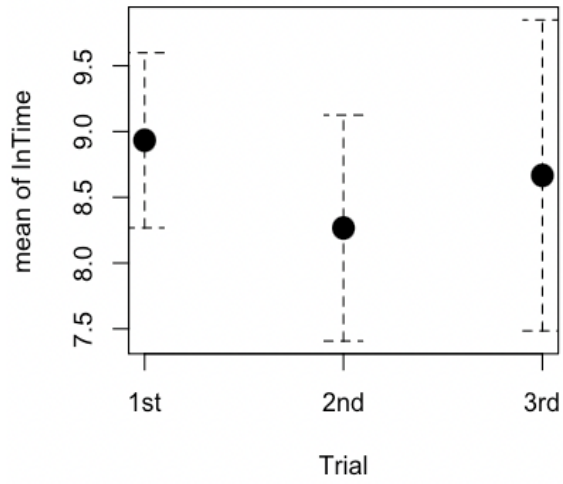

Figure 5: Shows Plot of means for Initiation time for each trial.

Total Testing time

Mean(SD)Total testing time in seconds for the first trial was 538(276) with range 233 to 1118. For the second trial 423(173) with range 216 to 797. The third trial was 368(136) with range 191 to 646. The results show that mean, standard deviation, minimum time and maximum time all provides faster results with each trial. Figure 5

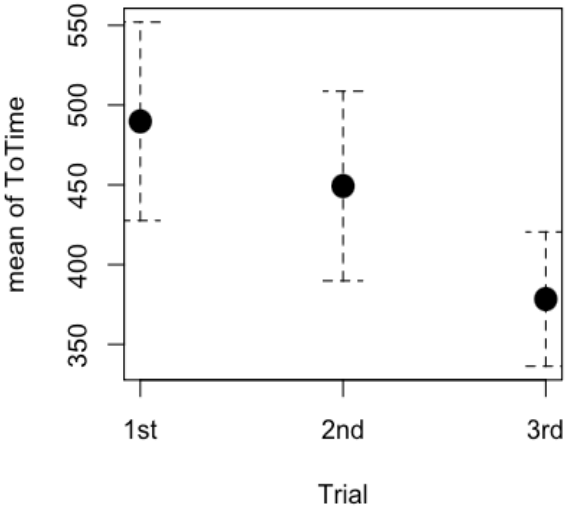

Figure 6: Shows Plot of means for Total testing time for each trial.

suggest that the subjects performed faster for each trial. The X axis in the plot shows trial order and the Y axis shows mean total time in seconds.

Number of restarts

Mean(SD) Number of restarts was 7(7) times for the first trial, with max range of 24, for the second trial 6(6) with max range of 23. The third trial was 5(6) with max range of 22. For each trial the minimum range of restarts were 0. Mean, standard deviation and maximum number of restarts, all show a reduced number of restarts for each trial. Figure 7 Shows the second trial to have the most restarts while the third trial had the least restarts. The X axis in the plot shows trial order, while the Y axis shows number of restarts.

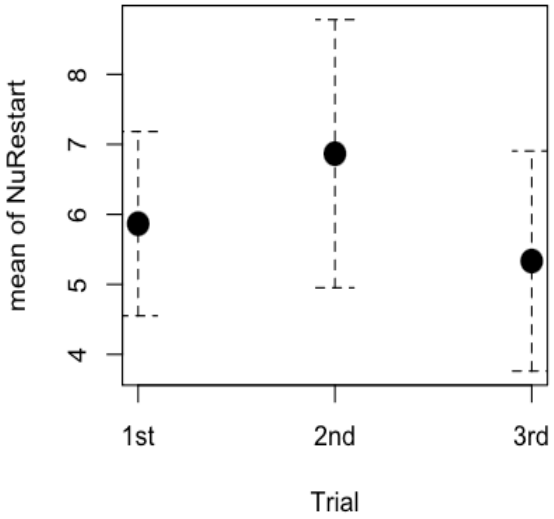

Figure 7: Shows Plot of means for Total Number of restarts for each trial.

Analysis by Condition

Execution time

Mean(SD) Execution time in seconds was 12(4) for habitual testing with range 8 to 24, the 0.4 bangerter was 14(5) with range 7 to 29 and 14(5) for the 0.1 foil with range 8 to 27. Execution time were on average 2 seconds faster habitually compared to the 0.4 and 0.1 foil which had the same mean and standard deviation. Range was similar for all conditions. Figure 8 shows a reduction in performance with the foils, the trial with 0.1 foil provided the worst performance. The X axis in the plot shows condition, while the Y axis shows mean execution time in seconds.

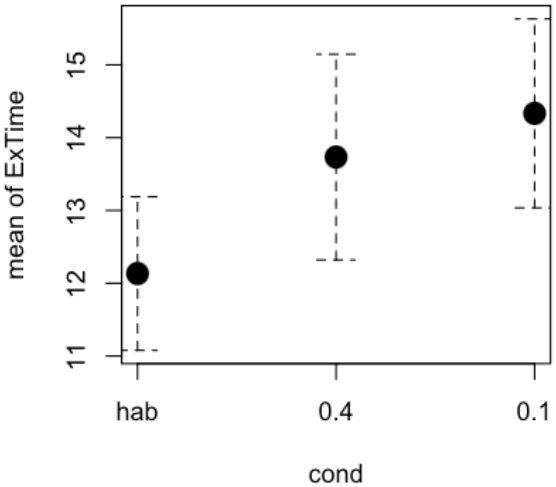

Figure 8: Shows Plot of means for execution time for each condition.

Initiation time

Mean(SD) Initiation time in seconds were 9(4) when testing habitually with range 5 to 21, 8(4) with the 0.4 foil and range 4 to 13.With the 0.4 foil results was 8(3) with range 4 to 18. Mean, standard deviation and minimum time was similar both foils, maximum initiation time were highest when testing habitually, also shown by Figure 9. The X axis in the plot shows condition, while the Y axis shows mean initiation time in seconds.

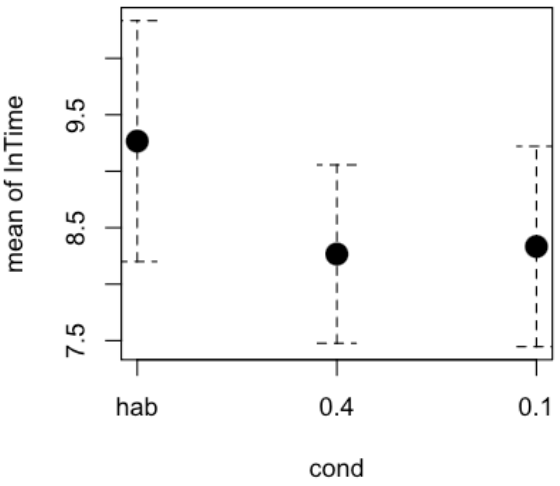

Figure 9: Shows Plot of means for initiation time for each condition.

Total testing time

Mean(SD)Total testing time in seconds was 377(125) with range 191 to 635. For the 0.4 foil results was 510(281) with range 216 to 1118. 0.1 foil result was 443(192) with range 228 to 870. The 0.4 bangerter foil yielded the longest testing time, highest standard deviation and maximum testing time. Habitual testing provided the fastest results, also shown by Figure 10. The X axis in the plot shows condition, while the Y axis shows mean total testing time in seconds.

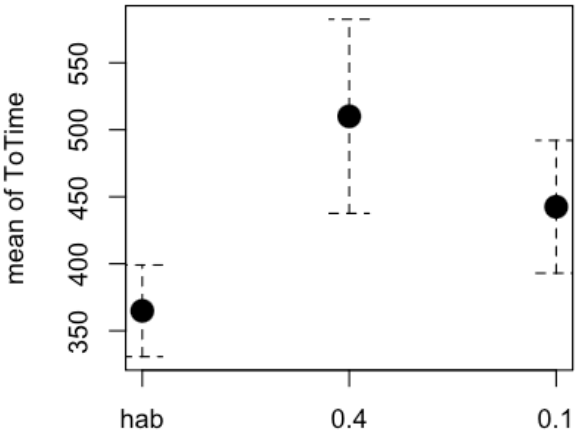

Figure 10: Shows Plot of means for Total testing time for each condition.

Number of restarts

Mean (SD) Number of restarts were 5(5) times for habitual testing with max range of 23 restarts. With the 0.4 foil 9(8) restarts with max range of 24. The 0.1 foil result was 4(4) restarts with max range of 15 restarts. All conditions had a minimum range of 0 restarts. The 0.4 foil had the highest average of restarts and maximum number of restarts, while the 0.1 foil had the lowest average and maximum number of restarts. Figure 11 shows the 0.4 foil to have

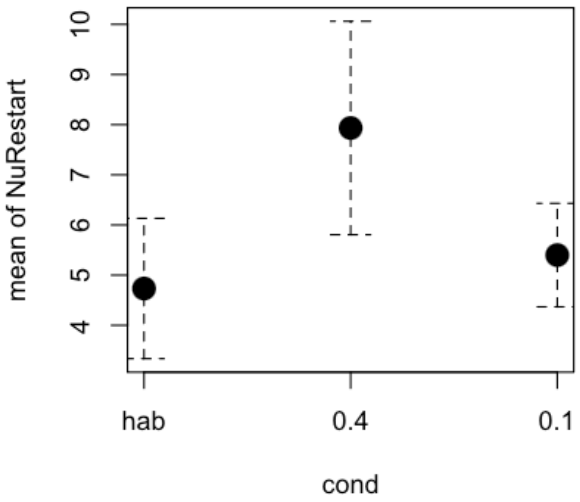

Figure 11: Shows Plot of means for Number of restarts for each condition.

the highest number of restarts, while the subjects had less restarts when testing habitually. The X axis in the plot shows condition, while the Y axis shows number of restarts.

Figure 12 suggest that level 8, 10 and 12 had the most restarts regardless of condition. However, it also suggest that the subjects had a tendency of more restarts with the 0.4 foil. The x axis shows level, while the Y axis shows number of restarts.

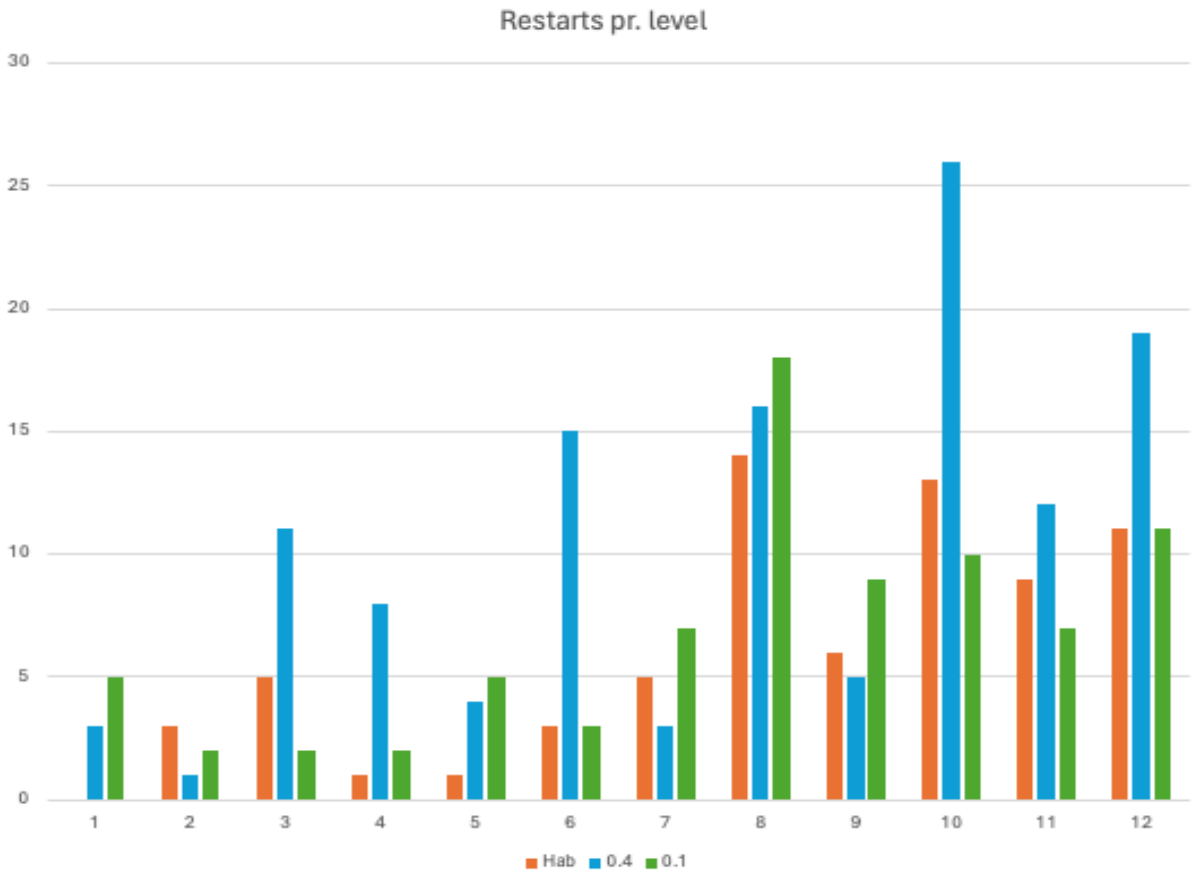

Figure 12: Shows histogram of restarts per level for the different conditions.

Table 5: Shows the Tower of London results.

ID	cond	ToTime	InTime	ExTime	NoRestart	Foil order
1	hab	03:53	00:05	00:08	4	1
	0.4	03:36	00:05	00:07	2	2
	0.1	04:59	00:04	00:08	5	3
2	hab	07:09	00:15	00:16	2	3
	0.4	18:38	00:12	00:29	17	1
	0.1	13:17	00:18	00:27	5	2
3	hab	05:40	00:08	00:11	6	2
	0.4	03:46	00:05	00:11	1	3
	0.1	06:27	00:08	00:13	5	1
4	hab	06:05	00:08	00:12	3	1
	0.4	09:46	00:07	00:21	8	2
	0.1	04:51	00:05	00:13	2	3
5	hab	03:11	00:06	00:09	0	3
	0.4	05:11	00:13	00:10	0	1
	0.1	03:48	00:06	00:11	0	2
6	hab	05:04	00:10	00:10	2	2
	0.4	03:57	00:10	00:08	0	3
	0.1	06:09	00:10	00:10	3	1
7	hab	05:13	00:06	00:12	6	3
	0.4	07:43	00:04	00:14	12	1
	0.1	08:10	00:06	00:14	12	2
8	hab	05:24	00:07	00:10	4	2
	0.4	09:59	00:04	00:12	22	3
	0.1	06:09	00:08	00:14	4	1
9	hab	04:38	00:08	00:09	2	1
	0.4	04:09	00:08	00:10	1	2
	0.1	04:19	00:07	00:09	3	3
10	hab	05:07	00:11	00:13	1	3
	0.4	07:37	00:08	00:15	1	1
	0.1	05:03	00:07	00:13	2	2
11	hab	10:35	00:06	00:11	23	2
	0.4	10:45	00:08	00:15	15	3
	0.1	14:30	00:09	00:18	15	1
12	hab	08:35	00:21	00:14	2	1
	0.4	06:23	00:11	00:13	3	2
	0.1	06:16	00:07	00:16	3	3
13	hab	07:23	00:08	00:15	6	3
	0.4	17:17	00:07	00:16	24	1
	0.1	10:39	00:09	00:22	9	2
14	hab	09:46	00:09	00:24	4	1
	0.4	06:49	00:09	00:14	4	2
	0.1	08:36	00:08	00:16	6	3
15	hab	06:30	00:11	00:08	6	3
	0.4	11:55	00:13	00:11	9	1
	0.1	07:25	00:13	00:11	7	2

Power Analysis

Power analysis calculated the necessary sample size, for reproducibility when registering the mean of total testing time for the different conditions; hab: 377 seconds, 0.4 foil: 510 seconds and 0.1 foil: 443 seconds, with the standard deviation for all the variables: 212 seconds. The result showed a necessary sample size of 50 subjects. The sample size acquired in this study of 15 subjects is over three times lower.

5 Discussion

In this study we investigated the impact reduction in visual acuity has on stereopsis, binocular vision and performance in an executive function task using augmented reality. We used bangerter foils 0.4 and 0.1 to provide optical blur. Results showed that the foils provided a reduction in visual acuity and stereopsis. We also discovered a learning effect when performing the Tower of London task.

5.1 Bangerter foils and degradation in vision

The results in this study revealed a reduction in visual acuity with both bangerter foils. The 0.1 foil had the most dispersion in reduction of visual acuity. From this we can see that there is a significant reduction between the different foils. However, the 0.4 bangerter foil is supposed to reduce vision down to 0.4 decimal acuity, which corresponds to 0.4 LogMAR acuity, while the 0.1 foil corresponds to 0.1 decimal visual acuity and 1.0 LogMAR acuity (Then, 2010). From our testing, this was not the case.

A Study testing the optical characterization and effectiveness of the bangerter foils (Odell et al., 2008). Showed that the 0.8 and 0.4 foils did not show a reduction in visual acuity which were statistically significant, this was also the case for the 0.6 foil. For the foils of 0.3 degradation and below there was a significant reduction in visual acuity. In this study the mean visual acuity of the subjects was 0.28 LogMAR for the 0.4 foil and 0.93 LogMAR for the 0.1 foil. They concluded that foil grade did not correspond with reduction in visual acuity as well. This study has a similar sample size and inclusion criteria to our study. There were 15 participants with no prior binocular issues, stereoacuity of at least 40 seconds of arc and corrected visual acuity of 20/25 Snellen or better.

Another study (McCulloch et al., 2011) testing the effects of visual degradation of face discrimination using the bangerter foils, found visual acuity to be 0.74 LogMAR when using the >0.1 grade foil. This Study also discovered that the 0.4 and 0.1 foils had a great overlap in visual acuity and contrast sensitivity. The foils also had the least significant difference compared to the 0.8 and >0.1 foils.

5.2 Effect on stereopsis

Figure 2 and Figure 3 showed a reduction in stereopsis when visual acuity were reduced for both Frisby test and TNO. Linear model analysis was not significant, not indicating a correlation between visual acuity and stereoacuity. However, even if the correlation is not linear, we can see that there is an association between visual acuity and stereopsis. Analysis of TNO and Frisby test showed a reduction in stereoacuity for both tests with the 0.4 and 0.1 foils, the 0.1 foil had the most reduction in stereoacuity and several of the subjects were not able to see any figures. This highlights the importance of adequate visual acuity for maintaining optimal stereopsis. The subjects performed better with Frisby test compared to TNO for all conditions.

Paired comparisons between Frisby test and TNO, showed a significant difference in obtained stereoacuity, which is also shown when observing the data in Table 4. This is also supported by (Mehta & O'Connor, 2023) who tested the retest variability of stereoacuity measurements. They found that even though both Frisby and TNO independently have good reliability and repeatability, they cannot be used interchangeably. TNO and Frisby test are both random dot stereograms that test for global stereopsis, however the procedure and method of testing is different (Zhao & Wu, 2019). The Frisby test, is one of the few stereopsis tests that are a "free space test" with real depth perception (Kaye, 2005). Because of this we chose to include this in our project, as we expect this to be the closest to the cues given by the augmented reality headset. The Frisby test consist of a transparent plate with four squares, each square has a pattern of triangles randomly presented, in one of the squares there is a stereogram which presents a circle that either is seen as protruding or descending from the plate (Ohlsson et al., 2001). However, because the Frisby test offers a real depth effect, there are also monocular clues (Elliott, 2014, p.192-194). To limit monocular clues, we fastened a string to a white wall, to ensure that the subjects stand directly in front, as well as correctly testing different distances. TNO on the other hand offers fine stereoscopic values ≤480 arc seconds, while also offering the butterfly which has a disparity of 2000 arc seconds (Elliott, 2014, p.192-193), this value is close to coarse stereopsis at a value of ≥3600 arc seconds (Giaschi et al., 2013). TNO is one of the most used screening test (Ancona et al., 2014), this is the reason we chose to include this in our project. One limitation for the TNO is the need for anaglyph red/green glasses in order to perform the test, the red/green glasses can produce dissociation and therefor a reduction in obtained stereopsis (Larson, 1988). Literature found monocular blur to reduce measured stereoacuity more in random dot tests as TNO and Stereo Fly compared to the Frisby test and Frisby-Davies 2 (Odell et al., 2009).

Which we also can see from our testing. The same values of stereoacuity were obtained by poorer VA with Frisby test than TNO.

In this study we placed the bangerter foil over the nondominant eye. Induced optical blur can affect stereoacuity, while the amount of reduction is not affected by ocular dominance (Nabie et al., 2017). However, as this study utilize augmented reality and an eye-hand coordinated task, it is still beneficial to test ocular dominance. Visuomotor skills can be important when interacting with the tower of London task (Carey & Hutchinson, 2013). If all subjects were tested with ocular blur on the same eye, analysis would not be able to tell if a change in performance is based on the change in visual perception or induced stereopsis (Crawford et al., 2003).

Induced reduction in visual acuity can give us an indication of how an actual visual impairment might affect vision. However, when artificially reducing, we already are working with healthy eyes that have fully developed visual systems, like normal stereoacuity and binocular vision. Because of this we can choose to only alter one aspect of vision, while keeping the other systems intact (Musa et al., 2022). Compared to congenital or acquired vision loss, where several systems often are affected and influence reduction in vision. For instance, amblyopia is a condition where someone has monocular reduced visual acuity from early childhood. They often don’t have any stereoacuity and some impairment in fine motor skills (Birch & Kelly, 2023). Subjects with some kind of reduced vision would therefore get different results on a test, compared to someone who is induced to have the same visual degradation in vision (L. Liu et al., 2024).

5.3 Tower of London Results

ANOVA analysis only showed Total Testing time to have significant difference between conditions, analysis of possible order effect were not significant. However, we cannot rule out that order effect is insignificant because of low data material. Figure 4, Figure 5 and Figure 6 suggests a possible order effect, also suggested by the numbers in Table 5. Because the bangerter foils did not provide the reduction in visual acuity we expected, this can also be a reason for ANOVA analysis not to be significant as there is a large overlap in data, especially between habitual testing and the 0.4 foil. However, we still choose to discuss the results for each variable, both accounting for possible order effect and condition.

Execution time

Execution time suggested an improvement with each trial, when considering possible order effect. When analysing for condition, both foils showed a reduction in performance compared to habitual testing. Execution time was one of the variables we were most interested in starting this study, because this is the average time the subjects used to complete each of the twelve levels. Execution time is measured from when the subjects grab the first ball after each level is presented and until they place the last ball at that level to match an answer. We considered this the variable that might show the highest correlation between visual acuity and performance, based on the need to accurately place the balls on the cylinders on the bracket. However, we cannot rule out that there is a possible order effect as both the results in Table 5 and Figure 4 suggest a correlation between trial order and performance. We cannot rule out a learning effect.

Initiation time

Initiation time did not show much difference between the different trials nor the different conditions. Tower of London is one of the most used executive function tasks, used to assess planning ability (Unterrainer et al., 2019). Our results suggests that even though there is a change in visual acuity, planning ability is similar despite the reduction in visual acuity, with minimal learning effect. This can be because we only included the levels that were passed and not those that were restarted, this can skew the data, as we do not take into consideration how many times each subjects tried to complete a level but had to restart. Giving them several attempts to plan and try to complete the level, and perhaps improved their time as well.

Total testing time

Total testing time seemed to have a slight increase in performance with each trial. This variable was also the only one who showed a significance of mean difference for conditions. When looking at the plot of means for total testing time, comparing the different conditions. The 0.4 bangerter foil yielded the longest testing time while the fastest performance were done habitually. It is interesting that the subjects performed the worst with the 0.4 foil, considering visual acuity only were slightly reduced in the nondominant eye compared to the 0.1 who had a greater reduction in visual acuity. One explanation might be that even though the reduction in visual acuity is minor, the difference between dominant and nondominant eye is enough to produce a small suppression (L. Liu et al., 2024). The subjects might not have felt much difference in their vision with the 0.4 foil, and therefor tried to use the same

binocular clues as they normally do. Not considering that there is an actual difference between the eyes. With the 0.1 foil, they would notice the difference between the eyes more and therefore might take more consideration to the difference in stereopsis when performing the task. To account for the change in technique, the subjects had around two minutes to perform the demonstration with the different conditions before starting the test. One limitation for total testing time is that there was a 3 to 4 second lag between what the subject saw and what the observer saw. This might have impacted the total time results as the subjects had to wait for the observer to change the matching answer for the different levels on a computer thereby adding extra seconds on time. This is not relevant for execution time or initiation time as initiation time is the time from the level is presented until the subject grab the first ball, while execution time is from when they have initiated the task until they play the last ball in that level, an average was then calculated for all twelve levels.

Number of restarts

Number of restarts seemed to show a slight improvement between the trials when looking at the numbers from Table 5. However, Figure 7 showed the second trial to have the most restarts, all trials showed to have a minimum number of restarts at 0 and maximum amount of over 20 restarts. Analysis by condition showed the 0.4 foil to provide the trial with most restarts, while all conditions had a minimum number of restarts of 0. The maximum number of restarts were over 20 for habitual and the 0.4 conditions, and slightly less restarts for the 0.1 round. Because the subjects repeated the ToL task. They might have underestimated the task and change in vision, thereby trying to complete the task too fast, becoming sloppy in the process and having to restart the levels. From Figure 12 we could see that several of the levels suggested to have been restarted several times regardless of condition. A limitation is that the repetitiveness of the task can affect performance due to fatigue and boredom (Pan et al., 1994)(Rana et al., 2013). Especially considering the 0.4 foil provided only a small reduction in visual acuity and stereoacuity. One confider in this study is that the system sometimes failed a level even though it was performed correctly, which resulted in the subject having to restart the level. However, most of the restarts were based on poor planning and wrong moves.

Condition versus trial order

Condition suggest an acquired effect is because of degradation in visual acuity and stereopsis, trial order on the other hand suggest effect is based on than learning and experience might increase performance more than condition. From observing the data, we

can see that induced reduction in visual acuity and stereopsis did influence performance, suggesting it is important to consider binocular vision in tasks requiring executive functions and visuomotor coordination. However, because the Analysis of possible order effect suggest there is a learning effect of the task, we must be careful not to put too much emphasis on condition. If the sample size had a significant statistical power, it might have been possible to perform an analysis of order effect by condition. however, because our sample size is over three times the necessary size for statistical power, this is not possible. This analysis could provide further research and into effect on task performance and give insight into optimizing performance in consideration to visual impairments.

5.4 Ethics and sample size

Our target sample of this project were first year Bachelor of optometry students, at the University of South-Eastern Norway. Recruitment was difficult within the allotted time. We contacted the subjects by sending them an email, inviting them to respond if they were interested in participating. In this study we had a strict set of exclusion criteria, to try to make the sample group as homogenous as possible. The reason for this is that we wanted possible effects to be because of either trial run or conditions and not because of subject differences. These exclusion criteria made recruitment especially difficult.

Because we ended up with a lower sample size then planned, we calculated the necessary sample size for reproducibility. The calculation showed our subject sample is less than one third of the needed size to provide scientific reproducibility. An insufficient sample size is important to consider when analysing the data. Firstly, a significant or insignificant result, can be the result of deficient data. The results therefore cannot with certainty be given scientific reliability. Rather it gives us a possible indication on where the results may be leaning towards (Pandis et al., 2011).

For example, we found in our analysis no significance in execution time for either trial order or condition, even though plot of means suggested a correlation. This might be because of the low sample size, if someone were to perform the same test with an adequate sample size, they might get a different result. (Faber & Fonseca, 2014).

As we discovered the foils do not necessarily have a proportional reduction. The variety of reduction with the bangerter foil might also have contributed in a spread and overlapping of the data, making it hard to analyze cause and effect.

If the results did not suggest a slight learning effect for the different trials when accounting for possible order effect, we could have performed a paired t-test if we only had two conditions

and only chosen one foil to use. To ensure similar testing conditions with the bangerter foils, if one were to only have one condition, it may have been beneficial to select the different foils independently per subject, to ensure that they get the same level of reduction in visual acuity.

6 Conclusion

Our study investigated the impact of reduced visual acuity on binocular vision and performance in an executive function task using augmented reality. The results in this study revealed an intended reduction in visual acuity with two different bangerter foils, however the reduction was not proportional to the density of the foils. Testing suggested an association between induced visual acuity in the non-dominant eye and the obtained stereopsis, with the TNO and Frisby test. In terms of performance in the Tower of London task, our results indicated mixed findings, possibly because of the limited number of participants. We cannot exclude the possibility of a learning effect rather than an effect based on condition and reduction in stereovision. Further research analysing order effect by condition, can give us more information to understand how performance is affected, and what to take into consideration to optimize task performance.

References

Ancona, C., Stoppani, M., Odazio, V., La Spina, C., Corradetti, G., & Bandello, F. (2014). Stereo tests as a screening tool for strabismus: Which is the best choice? *Clinical Ophthalmology*, 2221. https://doi.org/10.2147/OPTH.S67488

Ansons, A. M., & Davis, H. (2014). *Diagnosis and management of ocular motility disorders* (p. 406).

Birch, E. E., & Kelly, K. R. (2023). Amblyopia and the whole child. *Progress in Retinal and Eye Research*, *93*, 101168. https://doi.org/10.1016/j.preteyeres.2023.101168

Carey, D. P., & Hutchinson, C. V. (2013). Looking at eye dominance from a different angle: Is sighting strength related to hand preference? *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, *49*(9), 2542–2552. https://doi.org/10.1016/j.cortex.2012.11.011

Crawford, J. D., Henriques, D. Y. P., Medendorp, W. P., & Khan, A. Z. (2003). Ocular kinematics and eye-hand coordination. *Strabismus*, *11*(1), 33–47. https://doi.org/10.1076/stra.11.1.33.14094

Elliott, D. B. (2014). *Cinical Prosedures in primary eye care* (fourth edition, pp. 190–192). Saunders Elsevier.

Faber, J., & Fonseca, L. M. (2014). How sample size influences research outcomes. *Dental Press Journal of Orthodontics*, *19*(4), 27–29. https://doi.org/10.1590/2176-9451.19.4.027-029.ebo

Førerkortforskriften. (2004). Forskrift om førerkort m.m. https://lovdata.no/dokument/SF/forskrift/2004-01-19-298/*

Fulvio, J. M., Ji, M., Thompson, L., Rosenberg, A., & Rokers, B. (2020). Cue-dependent effects of VR experience on motion-in-depth sensitivity. *PLOS ONE*, *15*(3), e0229929. https://doi.org/10.1371/journal.pone.0229929

Giaschi, D., Narasimhan, S., Solski, A., Harrison, E., & Wilcox, L. M. (2013). On the typical development of stereopsis: Fine and coarse processing. *Vision Research*, *89*, 65–71. https://doi.org/10.1016/j.visres.2013.07.011

Harsa, P., Břeňová, M., Bezdíček, O., Kališová, L., Heidingerová, J., Schönová, K., & Michalec, J. (2022). Tower of London test—Short version. *Neurologia i Neurochirurgia Polska*, *56*(4), 365–370. https://doi.org/10.5603/PJNNS.a2022.0037

Hess, R. F., To, L., Zhou, J., Wang, G., & Cooperstock, J. R. (2015). Stereo Vision: The Haves and Have-Nots. *I-Perception*, *6*(3), 204166951559302. https://doi.org/10.1177/2041669515593028

Kaye, S. B. (2005). Testing Distance Stereoacuity With the Frisby-Davis 2 (FD2) Test. *American Journal of Ophthalmology*, *140*(2), 346–347. https://doi.org/10.1016/j.ajo.2005.03.016

Larson, W. L. (1988). Effect of TNO Red-Green Glasses on Local Stereoacuity: *Optometry and Vision Science*, *65*(12), 946–950. https://doi.org/10.1097/00006324-198812000-00005

Liu, L., Xu, L., Yu, B., Zhao, L., & Wu, H. (2024). The influence of simulated visual impairment on distance stereopsis. *Journal of Vision*, *24*(2), 1. https://doi.org/10.1167/jov.24.2.1

Liu, Y., Sun, Q., Tang, Y., Li, Y., Jiang, W., & Wu, J. (2020). Virtual reality system for industrial training. *2020 International Conference on Virtual Reality and Visualization (ICVRV)*, 338–339. https://doi.org/10.1109/ICVRV51359.2020.00091

McCulloch, D. L., Loffler, G., Colquhoun, K., Bruce, N., Dutton, G. N., & Bach, M. (2011). The effects of visual degradation on face discrimination. *Ophthalmic & Physiological Optics: The Journal of the British College of Ophthalmic Opticians (Optometrists)*, *31*(3), 240–248. https://doi.org/10.1111/j.1475-1313.2011.00828.x

Mehta, J., & O'Connor, A. (2023). Test retest variability in stereoacuity measurements. *Strabismus*, *31*(3), 188–196. https://doi.org/10.1080/09273972.2023.2252853

Musa, A., Lane, A. R., & Ellison, A. (2022). The effects of induced optical blur on visual search performance and training. *Quarterly Journal of Experimental Psychology*, *75*(2), 277–288. https://doi.org/10.1177/17470218211050280

Nabie, R., Andalib, D., Amir-Aslanzadeh, S., & Khojasteh, H. (2017). Effect of artificial anisometropia in dominant and nondominant eyes on stereoacuity. *Canadian Journal of Ophthalmology*, *52*(3), 240–242. https://doi.org/10.1016/j.jcjo.2016.11.008

Odell, N. V., Hatt, S. R., Leske, D. A., Adams, W. E., & Holmes, J. M. (2009). The effect of induced monocular blur on measures of stereoacuity. *Journal of AAPOS: The Official Publication of the American Association for Pediatric Ophthalmology and Strabismus*, *13*(2), 136–141. https://doi.org/10.1016/j.jaapos.2008.09.005

Odell, N. V., Leske, D. A., Hatt, S. R., Adams, W. E., & Holmes, J. M. (2008). The effect of Bangerter filters on optotype acuity, Vernier acuity, and contrast sensitivity. *Journal of American Association for Pediatric Ophthalmology and Strabismus*, *12*(6), 555–559. https://doi.org/10.1016/j.jaapos.2008.04.012

Ohlsson, J., Villarreal, G., Abrahamsson, M., Cavazos, H., Sjöström, A., & Sjöstrand, J. (2001). Screening merits of the Lang II, Frisby, Randot, Titmus, and TNO stereo tests. *Journal of AAPOS: The Official Publication of the American Association for Pediatric Ophthalmology and Strabismus*, *5*(5), 316–322. https://doi.org/10.1067/mpa.2001.118669

Pan, C. S., Shell, R. L., & Schleifer, L. M. (1994). Performance variability as an indicator of fatigue and boredom effects in a VDT data-entry task. *International Journal of Human-Computer Interaction*, *6*(1), 37–45. https://doi.org/10.1080/10447319409526082

Pandis, N., Polychronopoulou, A., & Eliades, T. (2011). Sample size estimation: An overview with applications to orthodontic clinical trial designs. *American Journal of Orthodontics and Dentofacial Orthopedics*, *140*(4), e141–e146. https://doi.org/10.1016/j.ajodo.2011.04.021

Pérez, G. M., Archer, S. M., & Artal, P. (2010). Optical Characterization of Bangerter Foils. *Investigative Opthalmology & Visual Science*, *51*(1), 609. https://doi.org/10.1167/iovs.09-3726

Ping, J., Liu, Y., & Weng, D. (2019). Comparison in Depth Perception between Virtual Reality and Augmented Reality Systems. *2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, 1124–1125. https://doi.org/10.1109/VR.2019.8798174

Pladere, T., Svarverud, E., Krumina, G., Gilson, S. J., & Baraas, R. C. (2022). Inclusivity in stereoscopic XR: Human vision first. *Frontiers in Virtual Reality*, *3*, 1006021. https://doi.org/10.3389/frvir.2022.1006021

Rabbetts, R. B. (2007). *Bennett & Rabbett´s Clinical Visual Optics* (4th ed., p. 203). Butterworth Heinemann Elsevier.

Rana, R., Singhal, R., & Singh, V. (2013). Analysis of repeated measurement data in the clinical trials. *Journal of Ayurveda and Integrative Medicine*, *4*(2), 77. https://doi.org/10.4103/0975-9476.113872

Schild, J., Misztal, S., Roth, B., Flock, L., Luiz, T., Lerner, D., Herkersdorf, M., Weaner, K., Neuberaer, M., Franke, A., Kemp, C., Pranqhofer, J., Seele, S., Buhler, H., & Herpers, R. (2018). Applying Multi-User Virtual Reality to Collaborative Medical Training. *2018 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, 775–776. https://doi.org/10.1109/VR.2018.8446160

Setia, M. (2016). Methodology series module 3: Cross-sectional studies. *Indian Journal of Dermatology*, *61*(3), 261. https://doi.org/10.4103/0019-5154.182410

Snowden, R., Thompson, P., & Troscianko, T. (2012). Basic Vison, an introduction to visual perception. In *Basic Vision* (2nd ed., Vol. 2, p. 208). Oxford university press.

Stidwill, D., & Fletcher, R. (2010). *Normal Binocular Vision: Theory, Investigation and Practical Aspects*. John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118788684

Then, R. (2010). The Effect of Bangerter Occlusion Foils on Blepharospasm and Hemifacial Spasm in Occlusion-Positive and Occlusion-Negative Patients. *The Open Ophthalmology Journal*, *4*(1), 1–6. https://doi.org/10.2174/1874364101004010001

Unterrainer, J. M., Rahm, B., Kaller, C. P., Wild, P. S., Münzel, T., Blettner, M., Lackner, K., Pfeiffer, N., & Beutel, M. E. (2019). Assessing Planning Ability Across the Adult Life Span in a Large Population-Representative Sample: Reliability Estimates and Normative Data for the Tower of London (TOL-F) Task. *Journal of the International Neuropsychological Society: JINS*, *25*(5), 520–529. https://doi.org/10.1017/S1355617718001248

Van Rijn, LJ, Beaten, G., van den Berg, T., Gomez de Liano, R., Hedin, A., Lianoros, Major, H. G., Mäntyjärvi, M., Mouterde, P., Tant, M., Wilhelm, H., & Valmain, J. (2005). *New standards for the visual functions of drivers* (p. 3). Eyesight Working Group.

Xi, J., Wang, G.-T., Zhao, J., & Huang, C.-B. (2021). General and Specific Effects of Stereo Learning. *Frontiers in Human Neuroscience*, *15*, 535512. https://doi.org/10.3389/fnhum.2021.535512

Zhao, L., & Wu, H. (2019). The difference in stereoacuity testing: Contour-based and random dot-based graphs at far and near distances. *Annals of Translational Medicine*, *7*(9), 193–193. https://doi.org/10.21037/atm.2019.03.62

List of figures and tables

Annexes

Annex 1: Tower of London procedure, Language: Norwegian

Tower of London Procedure (Norwegian)

Mens vi utfører TOL, vil jeg gå igjennom en liste med instruksjoner, slik at vi er sikre på at du får riktig informasjon.

1. Ta opp hånden din, du vil da få opp et windows flagg ikon→ trykk på dette.
2. Hjemskjermen vil da dukke opp → trykk på alle apper på siden til høyre → instillinger.
3. Trykk så på system → Kalibrering som du finner i menyen på venstre side → Run eye calibration.
4. Det vil komme opp en firkant med følgende tekst: Adjust device fit, Make sure the visor is pushed fully down and inn, so you kan see all four corners → Trykk så på next.
5. «Lets adjust the hololens for your eyes» → Trykk next.
6. Nå kommer det opp teksten «Hold your head still and follow the gems with your eyes", du trenger ikke gjøre noe, bare vent til «juvelene» dukker opp og følg disse med øynene. Når kalibreringen er ferdig:
7. Ta opp hånden din og trykk på windows ikonet igjen.
8. Hjemskjerm → alle apper → finn så tower of london som er nederst ved siden av instillinger.
9. Det kommer nå opp tre søyler og to knapper, Blå: start game, Rød: Start demo
10. Trykk på rød knapp: start demo, øv på å flytte på kulene. Anbefaler å slippe kulen når du har fått den på søylen, istedenfor å føre kulen helt ned. Den kan da ha en tendens til å bli med opp igjen/dette av. Det er plass til 3 kuler på den høyeste søylen til venstre, 2 kuler på den midtre og 1 kule på den minste til høyre.
11. Det du skal gjøre i denne oppgaven er at du skal matche kulene til en fasit gitt på en skjerm. Du vil ha et begrenset antall trekk du får på å utføre oppgavene på. Det er 12 ulike nivåer som du skal prøve å fullføre. Dette skal vi gjøre to ganger, en gang med et filter foran det ene øyet og en gang uten noe foran øynene. Dersom du gjør feil, trykk på orange knapp: Restart. Den blå knappen viser hvor mange trekk som gjenstår.
12. Når du føler deg klar så kan du trykke på start, så starter vi, si ifra når du har fullført et nivå, trykk så på blå knapp, da vil du få neste sekvens som du skal prøve å matche.
13. Når ferdig → Trykk på quit, Kryss ut Tower of London programmet → ta av hololensen.
14. ta på/av bangerter filter → ta på hololensen igjen
15. Ta opp hånden din og trykk på windows ikonet igjen.

16. Hjemskjerm → alle apper → finn så tower of london som er nederst ved siden av instillinger igjen.
17. Utfør tower of London en gang til → Når ferdig, kryss ut Tower of London programmet
18. Utfør tower of London en gang til → Når ferdig, kryss ut Tower of London programmet
19. Ta av hololens. Du er nå ferdig

Annex 2: Testing registration form

ID					
Age					
Gender	☐Male ☐Female				
Prior experience with VR	☐Yes ☐No				
Measurement	**Result**				
Autorefraction	OD:		OS:		
Autorefraction Cyclo	OD:		OS:		
Refraction type	☐None ☐spectacles ☐Contact lenses				
Visual acuity 1m	OD:	OS:	OU:		
Stereopsis TNO	☐Butterfly ☐480 ☐240 ☐120 ☐60 ☐30 ☐15				
Stereopsis Frisby Davies	☐40 ☐50 ☐75 ☐100 ☐150 ☐200 ☐250				
Cover test	☐Ortho ☐Tropia ☐Phoria				
OXO mallet	☐Compensated ☐Not compensated				
Dominance	☐Right ☐Left				
With Bangerter filter	☐Right ☐Left				
Starting filter	☐Habitually ☐0,4 ☐0,1				
Visual acuity 1m	☐0,4	Non dominant:	OU:		
	☐0,1	Non dominant:	OU:		
Stereopsis TNO	☐0,4	☐None ☐Butterfly ☐480 ☐240 ☐120 ☐60 ☐30 ☐15			
	☐0,1	☐None ☐Butterfly ☐480 ☐240 ☐120 ☐60 ☐30 ☐15			
Stereopsis Frisby Davies (cm)	☐0,4	☐None ☐40 ☐50 ☐75 ☐100 ☐150 ☐200 ☐250			
	☐0,1	☐None ☐40 ☐50 ☐75 ☐100 ☐150 ☐200 ☐250			
TOL	☐Calibration ☐Demo				
Habitual **Time starting:**	Initiation Time	Execution Time	Total Time	Moves	Number of restarts
With Bangerter filter ☐0,4 ☐0,1 **Time starting:**	Initiation Time	Execution Time	Total Time	Moves	Number of restarts
With Bangerter filter ☐0,4 ☐0,1 **Time Starting:**	Initiation Time	Execution Time	Total Time	Moves	Number of restarts

Annex 3: SIKT application, Language: Norwegian

Sikt

Meldeskjema

Referansenummer
977145

Hvilke personopplysninger skal du behandle?

- Navn
- Fødselsdato
- Nettidentifikator
- Helseopplysninger

Prosjektinformasjon

Tittel
Viktigheten av binokulært syn ved en visumotorisk test ved bruk av mixed reality hodemontert display

Sammendrag
Virtuell virkelighet (VR og AR) har blitt veldig populært de siste årene, og brukes i dag i blant annet medisin, produksjon, vedlikehold, design og mer. Ved mer bruk og implementering av ulike VR instrumenter i ulike plattformer er det viktig å forstå hvordan synet kan påvirke brukervennlighet. For at disse 3D systemene skal kunne være effektive og bli brukt slik de ofte er tiltenkt, vil man trenge godt binokulært syn og dybdesyn. Dersom vi ikke tar hensyn til vanlige synsproblemer, vil rundt 30% befolkningen ikke kunne bruke disse instrumentene slik de er tiltenkt. Det er derfor viktig å undersøke hvordan ulike binokulære, okulere og visuelle problemer kan påvirke ytelse ved bruk av VR. I dette studiet ønsker vi å fokusere på binokulært syn og dybdesyn og hvordan dette kan påvirke hvordan vi kan utføre visumotoriske oppgaver i VR.

Hva er formålet med behandlingen av personopplysninger?
Vi vil samle inn fødselsdato for beregning av alder og signatur for samtykke. E-post adresse for kommunikasjon med deltaker. Helseopplysninger vedrørende sykdom, skade eller operasjoner som kan påvirke synet og/ eller binokulært syn må innhentes for å forsikre at deltagerne tilfredsstiller inklusjonskriteriene. Optometriske data som synsstyrke, refraksjon og binokulær status er en del av prosjektbeskrivelsen og journalføres.

Dersom personopplysningene skal behandles til flere formål, beskriv hvilke
Ettersom dette prosjektet er en del av et masterstudium, og deltakerne er studenter ved samme universitet og fagfelt, vil det kunne være av interesse for masterstudenter senere og se på målinger vi har gjort i dette prosjektet for å sammenligne med målinger funnet senere. Dette vil i såfall gjelde masterstudenter som fullfører sin masteroppgave våren 2025 eller våren 2026, mens studentene som er brukt som subjekter i vårt prosjekt fortsatt vil være studenter og mulige subjekter ved senere prosjekter.

Prosjektbeskrivelse

Research protocol Draft 1.pdf

Ekstern finansiering
- Andre

Annen finansieringskilde
Dette prosjektet har ingen ekstern finansiering, men vil bli finansiert privat av de som utfører prosjektet.

Type prosjekt
Master

Kontaktinformasjon, student
Ida Marie Knudsen, ida.marie.knudsen@gmail.com, tlf: 99530472

Behandlingsansvar

Behandlingsansvarlig institusjon
Universitetet i Sørøst-Norge / Fakultet for helse- og sosialvitenskap / Institutt for optometri, radiografi og lysdesign

Prosjektansvarlig
Trine Langaas, Trine.Langaas@usn.no, tlf: 31008934

Er behandlingsansvaret delt med flere institusjoner?
Nei

Utvalg 1

Beskriv utvalget
1.års studenter ved bachelor i optometri. Vi ønsker 20-30 studenter til dette prosjektet.

Beskriv hvordan du finner frem til eller kontakter utvalget
Rekrutering vil skje av 1 klasse studenter ved bachelor i optometri ved Universitetet i Sørøst-Norge. Vi vil rekruttere studenter som har gitt samtykke til at de kan kontaktes for deltagelse i forskningsprosjekt og som på et tidligere tidspunkt har testet stereosyn og fått resultat på minimum 120 buesekunder.

Aldersgruppe
18 - 38

Hvilke personopplysninger vil bli behandlet om utvalg {{i}}? 1

- Navn
- Fødselsdato
- Nettidentifikator
- Helseopplysninger

Hvordan innhentes opplysningene om utvalg 1?

Medisinsk undersøkelse og/eller fysiske tester

Lovlig grunnlag for å behandle alminnelige personopplysninger
Samtykke (Personvernforordningen art. 6 nr. 1 bokstav a)

Lovlig grunnlag for å behandle særlige personopplysninger
Uttrykkelig samtykke (Personvernforordningen art. 9 nr. 2 bokstav a)

Begrunn valget av behandlingsgrunnlag

Informasjon til utvalg 1

Mottar utvalget informasjon om behandlingen av personopplysningene?
Ja

Hvordan mottar utvalget informasjon om behandlingen?
Skriftlig (papir eller elektronisk)

Informasjonsskriv

informasjonsskriv-samtykke Ida Marie Knudsen.pdf

Tredjepersoner

Innhenter prosjektet informasjon om tredjepersoner?
Nei

Dokumentasjon

Hvordan dokumenteres samtykkene?
- Manuelt (papir)
- Elektronisk (e-post, e-skjema, digital signatur)

Hvordan kan samtykket trekkes tilbake?
Ved å ta kontakt med med (masterstudent) eller veiledere i form av brev, e-post eller SMS. Også muntlig, det vil da sendes en skriftlig bekreftelse til deltageren som trekker tilbake samtykket.

Hvordan kan de registrerte få innsyn, rettet eller slettet personopplysninger om seg selv?
Dersom en av de registrerte ønsker innsyn i personopplysninger, bes de ta kontakt på e-post, slik at vi kan dele det som er notert og de kan komme med tilbakemelding om noe skal slettes eller redigeres.

Totalt antall registrerte i prosjektet
1-99

Tillatelser

Vil noen av de følgende godkjenninger eller tillatelser innhentes?
Ikke utfyllt

Sikkerhetstiltak

Vil personopplysningene lagres atskilt fra øvrige data?
Ja

Hvilke tekniske og fysiske tiltak sikrer personopplysningene?
- Fortløpende anonymisering

Hvor blir personopplysningene behandlet?
- Maskinvare
- Private tjenester

Hvem har tilgang til personopplysningene?
- Student (studentprosjekt)
- Prosjektansvarlig

Overføres personopplysninger til et tredjeland?
Nei

Avslutning

Prosjektperiode
01.10.2023 - 01.06.2024

Hva skjer med dataene ved prosjektslutt?
Persondata lagres midlertidig 01.06.2026

Hva er formålet med lagringen av persondata?
Forskningsformål

Vil enkeltpersoner kunne gjenkjennes i publikasjon?
Nei

Tilleggsopplysninger

Annex 4: Written information and consent form, Language: Norwegian

Vil du delta i forskningsprosjektet:

Viktigheten av binokulært syn ved en visumotorisk test ved bruk av mixed reality hodemontert display

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å Undersøke og vurdere samsynet (3D synet) til 1.års studenter ved bachelor i optometri. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål

I forbindelse med dette masterprosjektet, vil vi gjennomføre flere binokulære målinger, hvor vi gjør en vurdering av binokulær status og gjør en grundig måling av stereosyn (3D syn). Formålet med disse målingene er å se hvordan binokulært syn påvirker gjennomførelse av en oppgave ved bruk av VR briller.

Hvem er ansvarlig for forskningsprosjektet?

Instituttet for optometri, radiografi og lysdesign ved USN Kongsberg er ansvarlig for prosjektet.

Masterstudent: Ida Marie Knudsen
Veiledere og behandlingsansvarlige: Trine Langaas og Ellen Svarverud

Hvorfor får du spørsmål om å delta?

Rekrutering vil skje ved å ta kontakt med 1. års studenter ved bachelor i optometri, som har gitt samtykke til å bli kontaktet for deltagelse i forskningsprosjekt. Som tidligere har oppnådd godt resultat ved testing av dybdesyn.
Studentene vil gå igjennom flere poster, hvor det vil bli uført flere undersøkelser av synet. Alle studentene som kontaktes oppfordres til å delta.

Hva innebærer det for deg å delta?

I forbindelse med masterprosjektet vil vi gjennomføre flere binokulære målinger, hvor du vil bli testet individuelt. Vi vil bruke frisby davies test og TNO med rødgrønn brille for å måle stereosyn. Testing vil påberegnes og ta ca. 1 time. Du vil kanskje kunne oppleve lett hodepine etter testing, da enkelte av testene krever en del konsentrasjon. Men du vil ikke oppleve noen vedvarende hodepine.

Vi vil innhente refraksjon målt med cycloplentolate i autorefraktor fra database som finnes i forskningslabben ved USN Kongsberg.
Resultater vil bli notert ned i Excel, dataene vil bli behandlet og anonymisert.

Det er frivillig å delta

Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Alle dine personopplysninger vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg. Dersom du trekker deg vil dine data bli slettet og ikke inkludert i prosjektet. Deltagelse er ikke et krav i forbindelse med undervisning, selv om rekrutering skjer på universitetet.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger

Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket. Dermed vil det ikke være mulig og spore noe informasjon tilbake til deg ved publisering av masterprosjektet.

Dataene som blir samlet inn vil kun være tilgjengelig for meg (Ida Marie Knudsen) og mine veiledere (Trine Langaas og Ellen Svarverud)
Personlige opplysninger er begrenset til fødselsdato, navn og kjønn. Dette prosjektet vil kunne samle inn helseopplysninger som sykdom, skade eller operasjoner som kan påvirke synet og/ eller binokulært syn. Hvert subjekt vil få en anonymisert tresifret tallkode, personidentifiserende data vil bli notert i et separat dokument som vil bli oppbevart i et låsbart arkivskap på USN Kongsberg, sammen med signerte samtykkeskjemaer.

Masterprosjektet skal leveres og avsluttes innen juni 2024. Det vil ikke bli delt noen informasjon ved fremleggelse og publikasjon av masterprosjektet, som vil kunne spores tilbake til deg som deltager. I publikasjonen vil det kun fremkomme kjønn og alder i år. Annen informasjon vil ikke bli fremlagt/delt gjennom dette prosjektet.

Hva skjer med personopplysningene dine når forskningsprosjektet avsluttes?

Prosjektet vil etter planen avsluttes juni 2024. Etter prosjektslutt vil datamaterialet med dine personopplysninger bli oppbevart for eventuell videre forskning av andre masterstudenter ved insituttet for optometri, radiografi og lysdesign, frem til juni 2026. Dette vil korrespondere med når du etter planen vil være ferdig med din bachelor i optometri. Dette gjøres for at andre skal kunne bruke vårt forskningsmateriale dersom det blir forsket mer på samme tema, mens du fremdeles er student. Etter juni 2026 vil datamaterialet med dine personopplysninger bli permanent slettet.

Hva gir oss rett til å behandle personopplysninger om deg?

Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra *Universitetet i Sørøst-Norge ved insitutt for optometri, radiografi og lysdesign* har Sikt – Kunnskapssektorens tjenesteleverandør vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Dine rettigheter

Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke opplysninger vi behandler om deg, og å få utlevert en kopi av opplysningene
- å få rettet opplysninger om deg som er feil eller misvisende
- å få slettet personopplysninger om deg
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger

Hvis du har spørsmål til studien, eller ønsker å vite mer om eller benytte deg av dine rettigheter, ta kontakt med:

Ida Marie Knudsen (masterstudent) for spørsmål om studiet, E-Post: 147456@usn.no

Eller:
Trine Langaas, førsteamanuensis ved institutt for optometri, radiografi og lysdesign: Trine.Langaas@usn.no
Ellen Svarverud, førsteamanuensis ved institutt for optometri, radiografi og lysdesign: Ellen.Svarverud@usn.no

Vårt personvernombud: Paal Are solberg, kontakt: Paal.A.Solberg@usn.no telefon: 35 57 50 53

Hvis du har spørsmål knyttet til vurderingen som er gjort av personverntjenestene fra Sikt, kan du ta kontakt via:

- Epost: personverntjenester@sikt.no eller telefon: 73 98 40 40

Med vennlig hilsen

Trine Langaas	Ellen Svarverud	Ida Marie Knudsen
(Forsker/veileder)	*(Forsker/veileder)*	*(Masterstudent)*

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet *Undersøkelse og vurdering av fint og grovt stereosyn*, og har fått anledning til å stille spørsmål. Jeg samtykker til:

- ☐ å delta i *testing av binokulær status*
- ☐ å delta i *testing av stereosyn*
- ☐ *Innhenting av refraksjon målt med cycloplentolate hentes fra forskningslabben ved universitetet i sørøst norge ved fakultetet for Optometri*
- ☐ *at mine personopplysninger lagres etter prosjektslutt, til andre masterprosjekter innen samme forskningsfelt*

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet

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(Signert av prosjektdeltaker, dato)