From practice to progress: vision research in Scandinavia

The current issue of the Scandinavian Journal of Optometry and Visual Science (SJOVS) contains three papers and one scientific meeting abstract collection. These contributions present strong clinical and registry-based research and add updated knowledge for clinicians and researchers alike. This focus is also evident in the Kongsberg Vision Meeting abstracts, which span neuro-visual consequences of acquired brain injury, service development in primary eye care, and large-scale initiatives such as the SNOW school vision testing project, which has involved around 3,700 children.

Wehling et al. (2025) show that structured screening for visual deficits early after stroke is feasible in a stroke rehabilitation setting, and that visual impairment is common. Their findings support more systematic pathways for identifying vision- and neglect-related problems.

W. Sheppard et al. (2025) quantify functional costs of monocular viewing using online visuomotor tasks, highlighting the potential of scalable digital paradigms for studying visual deficits and everyday performance.

Gyllén et al. (2025) use data from the Paediatric Cataract Register (PECARE) to examine visual acuity testing after childhood cataract surgery, underscoring how variation in methods across ages and clinics complicates scientific evaluation of visual development and why harmonisation of outcome measures matters.

We, the editors, continue to prioritise efficiency and quality. In 2025, SJOVS received several new submissions, and the average time to first editorial decision was 25 days. We also implemented a change in our publication schedule, moving from two issues per year to one annual issue. We thank the authors for submitting their work to SJOVS and the reviewers for their invaluable contributions to improving manuscripts and ensuring the quality of the material we publish, while maintaining SJOVS' **free-to-publish model with no author fees**.

We also continue to strengthen the journal's outreach, for example through SJOVS' LinkedIn page, which has gained hundreds of followers. Over the past year, we have expanded the editorial board, broadening the range of expertise supporting peer review and helping us further develop the quality of the journal. We take this opportunity to thank our new editorial board members for supporting SJOVS.

Looking ahead, we will continue to develop SJOVS as an open, free-to-publish, community-driven journal with strong Scandinavian roots. We look forward to publishing your research in 2026.

We wish all authors and readers a Happy New Year,

Karthikeyan Baskaran, Co-Editor-in-Chief
António Filipe Macedo, Associate Editor
Rigmor C. Baraas, Editor-in-Chief

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Wehling, E., Vikane, E., Betten Lysgård, S. H., Taule, T., Pedersen, S. K., Jacobsen, A. H., & Kordt, E. A. (2025). Screening for visual deficits at a rehabilitation unit early in the rehabilitation process after stroke. *Scandinavian Journal of Optometry and Visual Science*, *18*(1), 1–7. https://doi.org/10.15626/sjovs.v18i1.4223

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One eye on the prize: The impact of monocular vision on aiming responses

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Abstract

The ability to move one's hand quickly and accurately towards a target is an essential skill that underpins many activities of daily living, such as writing or threading a needle. In-lab research has previously demonstrated that the time taken to complete an aiming task is proportional to task difficulty; however, the strength of this relationship appears to reduce as the quality of visual input becomes degraded (Wu et al., 2010). There is also evidence that when compared to full vision, monocular vision leads to a general increase in movement time during aiming tasks (Sheppard et al., 2021). Despite these valuable findings, logistical challenges (e.g. recruitment from hard-to-reach populations) make in-lab testing difficult or even impossible. These potential challenges could be overcome by introducing online tests if they are sufficiently sensitive to capture visual deficits accurately. The present study aimed to test (i) whether monocular vision was associated with increased response time and (ii) the feasibility of using simple, online tasks to probe the relationship between visual and motor function.

Using a computer mouse or touchpad to move to targets as quickly as possible, 65 participants (aged 18–77) completed (i) a visual search task (moving to a 34 target embedded amongst a grid of distractors) and (ii) a basic visual-motor aiming task (moving to individual targets of varying size/distance). Participants completed both tasks online, either with full vision or monocular vision.

Visual search time and aiming task response time increased significantly under monocular vision (≈1.8 s and ≈40 ms, respectively).

These results suggest that a simple, online aiming task can be suitable for testing the effects of a visual deficit on motor function.

Keywords: monocular vision, aiming, visual search, online testing

Introduction

For an individual to efficiently complete an aiming task, e.g. moving their hand to a target (Coull et al., 2000), they must estimate the positions of the hand and the target (Crawford et al., 2004) before estimating a path between the two (Flanagan et al., 2006) that balances the need to minimise movement time and energy expenditure depending on the demands of the task (Lyons et al., 2006). Once the hand is in motion, the participant uses vision to monitor the position of the hand and correct errors in a "feedback" loop (Elliott et al., 2010; Fukui & Inui, 2013). Aiming forms the basis of many essential activities of daily living (ADLs); for example, to thread a needle, one must accurately align the thread with the eye of the needle, and to write a sentence, one must accurately move their hand to the desired position on the page.

This ability to accurately move one's hand to a target has been shown to be significantly impaired by monocular vision (Loftus et al., 2004); therefore, it stands to reason that monocular blindness may impair one's motor function. Approximately 3.7% of the population experience monocular blindness, with the most common causes being optic atrophy (13%), amblyopia (11%), and phthisis bulbi (10%) (Mirza et al., 2021). In a study involving 65 individuals who had monocular vision loss, 50% reported changes in their ability to perform sports/hobbies, such as sewing, and 23% reported a change in their employment status (Coday et al., 2002), potentially due to changes in their ability to perform tasks essential to their role, such as writing. For example, monocular vision has been shown to significantly impair basketball performance (Vera et al., 2020).

Before completing a reach, an individual must generate a motor plan using an estimate of the hand's position and the desired endpoint. An accurate motor plan facilitates the movement's initial "feedforward" portion. Once the hand is in motion, the visuomotor system exploits vision and proprioception to monitor and correct the hand position in a "feedback" loop until it reaches the endpoint (Loftus et al., 2004). The time taken to execute the movement to the target (movement time or MT) is proportional to the index of difficulty (ID) of the movement, which is a product of the distance from the start point of the movement to the target (A) and the width of the target (W). Fitts first summarised this relationship with the equation:

$$\mathrm{ID} = \log_2\left(\frac{2A}{W}\right) \tag{1}$$

A linear function can approximate the linear relationship between ID and MT:

$$\mathrm{MT} = a + b \times \mathrm{ID} \tag{2}$$

Where a and b are empirical constants, this pair of relationships has become known as Fitts' law (Fitts, 1954; Fitts & Peterson, 1964).

Notably, the linear relationship between ID and MT appears robust to visual impairments, i.e., the relationship remains linear with a large effect size, even when visual input is degraded. For example, Wu et al. (2010) asked participants to complete a pointing task under four monocular visual conditions: full feedback, no-hand-movement (once the trial begins, the participant can see the position of the target but not the movement of the hand), no-target-location (once the trial begins, the participant cannot see the target) and no-vision (once the trial begins, the participant cannot see the target and the hand). ID and MT had a robust linear

relationship, with ID explaining much of the variance in MT irrespective of the visual condition ($R^2 = 0.99, 0.99, 0.98$, and 0.96, respectively). At the same time, however, the strength of the relationship between ID and MT decreased with degrading visual feedback, as shown by the standardised coefficient in each condition ($\beta = 67.49, 53.80, 58.20$, and 46.89, respectively).

Degrading vision is also associated with slower movements and, consequently, longer execution times. In a study investigating the participants' performance on a tablet-based aiming task (i.e., with 2D stimuli on a screen), monocular vision significantly increased MT compared to binocular vision (Sheppard et al., 2021). Monocular vision, relative to binocular vision, was also associated with increased MT in a similar study where the participants were required to point at 3D blocks rather than 2D stimuli on a screen (Loftus et al., 2004). In this study, visual feedback was manipulated in three experiments. Experiment 1 (fully lit) showed that monocular vision increased MT and reduced peak velocity and deceleration time. Experiment 2 (self-illuminating target in a dark room) did not show these effects. In experiment 3 (initially fully lit with the lights switching off after movement initiation), monocular vision was linked to a decrease in the time to peak velocity and an increase in maximum grip aperture, suggesting that binocular advantage is related to improved motor planning and feedback.

There are several possible mechanisms through which binocular vision improves the quality of visual input compared with monocular vision, including binocular summation and vergence. Binocular summation occurs when each eye's independent signals are combined, increasing the signal-to-noise ratio (Baker et al., 2018; Campbell & Green, 1965). Binocular summation is particularly beneficial when planning movements and is associated with faster initiation of rapid eye movements to the target, also known as saccades (González et al., 2013; Niechwiej-Szwedo et al., 2010). When an individual has moved their eyes to a target, they use the target's position on the retina to encode its position relative to the observer (Crawford et al., 2004). The individual then uses this signal to guide the movement direction during the initial phase of the movement (Niechwiej-Szwedo et al., 2023). Vergence signals also provide information on the target's depth and distance from the observer. These signals are derived from the muscular effort of both eyes to fix the gaze at a particular distance. During monocular vision conditions, the direction of the uncovered eye deviates (phoria), reducing the reliability of these vergence signals, which in turn produces planning and movement onset errors proportional to the magnitude of the phoria (Gonzalez & Niechwiej-Szwedo, 2016; Ono, 1979; Ono & Mapp, 1995).

Monocular vision also directly affects visual search performance. When moving the hand towards a target in a cluttered environment, an individual must visually scan the scene to identify the target's location. Researchers have tested the effect of monocular vision on visual search performance in individuals with amblyopia. This neurodevelopmental disorder reduces visual acuity (VA), typically occurring unilaterally and degrading binocular vision (Birch, 2013). Research has found amblyopia to increase visual search times in children and adults compared to controls with normal or corrected-to-normal vision (Black et al., 2021; Nagarajan et al., 2022; Tsirlin et al., 2018).

Studying the effects of monocular vision on motor function in a laboratory setting allows the researchers to take complete control of environmental and lighting conditions. However, this is not always possible. During the COVID-19 pandemic, the United Kingdom was placed into an emergency lockdown, restricting travel and social interaction. The lockdown reduced the opportunities for in-person research, and alternative research methods had to be explored. Presenting experiments online is naturally less controlled than when using the laboratory; on the flip side, advantages include mass testing a broad sample of individuals, which is diverse in terms of age, education, ethnicity, and nationality. Once the limitations of online testing are better understood and minimised, it will become possible to utilise the benefits of online testing. For example, remote clinical testing makes diagnosing and testing individuals quicker and more accessible for those living in remote rural communities (Li et al., 2021).

The present study investigates the potential for using simple online tasks to detect changes to the motor system associated with changes to the visual system across a range of people using their computers/laptops. Specifically, whether monocular vision produced changes to performance in an online aiming task. We designed two tasks to be performed under two visual conditions: binocular vision (with both eyes open) and monocular vision (with one eye covered). The tasks were: (i) a visual search task requiring participants to find the letter "Y" in a grid otherwise populated with "X"s and move the mouse to click on it and (ii) a motor task requiring participants to move the mouse to click on targets of various sizes and positions around the screen.

In the visual search task, we predicted that monocular vision would be associated with an increase in search time (ST), the time from the presentation of the search grid to the participant clicking on the target.

In the aiming task, we anticipated that response time (RT) would increase as the ID increased, following Fitts' law. RT is defined as the time it takes between the presentation of the target and the participant clicking on it using the mouse. It includes the time the participant takes to locate the target on the screen, plan the movement, and execute it. It is important to note that Fitts' law focuses on the effect of ID on MT, which is the time taken from starting the movement to reaching the target. However, our study could not directly test this due to technological limitations. To account for the expected increase in search and planning time associated with monocular vision, we included each participant's recorded ST from the visual search task as a control in the analysis.

Based on the study conducted by Wu et al. (2010), we expected that there would be a difference in the strength of the relationship between ID and RT across different visual conditions. To test this prediction, we hypothesised that a significant two-way interaction between visual condition and ID would indicate this difference.

Methods

Participants

An opportunity sample of 75 individuals was recruited to participate in the present study. However, the researchers excluded 10 participants after a general health screening. Three participants reported untreated cataracts, one reported uncorrected astigmatism, one reported uncorrected myopia, one had a right-eye

stroke, two were waiting for or had recently had ocular surgery, and two reported having osteoarthritis but did not specify the affected joints.

The remaining 65 participants' ages ranged from 18 to 77 (M = 36.97 years, SD = 20.07). The sample was 69.23% female. Most participants (95.38%) reported using the mouse right-handed. Most (61.50%) of participants reported being educated to the undergraduate level or higher. All remaining participants self-reported normal or corrected-to-normal vision.

Participants under 18 or who did not understand written English were excluded. The University of Leeds School of Psychology Ethics Committee granted ethical approval on 08/11/2021 (Ethics Reference Number: PSYC-344).

Design

The present study employed a within-subjects, experimental design, whereby participants completed four tasks (including an aiming task and a visual search in that order) across two visual conditions (monocular vision, full vision); however, two tasks are not reported in this manuscript. The order of the tasks was the same for all participants; however, the order of the visual conditions was counterbalanced between participants.

Procedure

The participants were sent a link to the study by email. They were presented with a digital information sheet and given the opportunity to contact the researchers with any questions before accessing a digital consent form. After agreeing to the terms of consent, the participants completed the demographics questionnaire and the eye dominance test. The participants established their dominant eye using an "alignment test" (Rombouts et al., 1996). A video embedded in the experiment provided all the instructions; the written instructions followed this. The participants then made a small triangle with the thumb and forefinger of both hands. Their arms were straight, and they framed an object on a wall with a gap in the triangle. The participant then closed their right eye; they could no longer see the object through the gap between their hands; the participant was deemed right-eye dominant; otherwise, they were categorised as left-eye dominant (Rombouts et al., 1996).

Having successfully established eye dominance, the participant was randomised to perform the monocular or binocular condition first. In the binocular condition, both eyes remained open. In contrast, in the monocular condition, the participant covered their non-dominant eye with any material they could not see through and which would not fall off or move during the tasks (for example, a scarf or an eye mask). The participant then completed the four tasks. After completing the tasks, they changed their visual condition and repeated the tasks before being debriefed.

Materials and Apparatus

The participants completed a demographics questionnaire, reporting their gender, height, weight, highest educational level, which hand they used to control a computer mouse, any relevant medical conditions or visual impairments, and whether they required a carer.

The experiment was hosted using the online experiment builder Gorilla (https://gorilla.sc) and completed in a place convenient to the participant. Gorilla estimates RT measures using JavaScript's `performance.now` which is independent of the system clock, thus making the timing estimates resistant to errors such as changing connection speed, system clock adjustments, and system clock skew (Barnhoorn et al., 2015). These estimates are accurate to at least the millisecond level and have an average precision of ±8.25 ms (Anwyl-Irvine et al., 2021; Barnhoorn et al., 2015).

Stimuli

In the visual search task, the participants saw one of four possible 14 (vertical) × 10 (horizontal) grids populated with 139 black distractor letters "X" and one black target letter "Y"; see Figure 1.

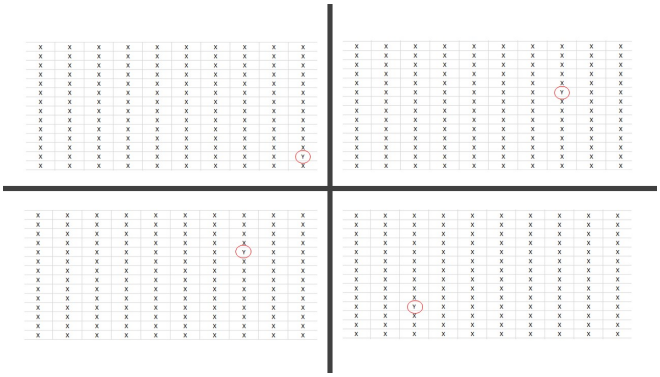

Figure 1: *The four visual search grids were presented to the participants. Red circles (not shown to the participant) locate the target letter "Y" in each grid.*

Before beginning the task, the participants were instructed to use the mouse and click on the "Y" as quickly as possible. Each trial started with a fixation cross visible at the centre of the screen for 250 ms. After a 100 ms pause, the first of four grids appeared. Having clicked on the first grid, there was a 100 ms pause and the process repeated for the remaining three girds. The grids were presented in a random order, and the participants completed all four grids. Each grid was 640 by 280 pixels (width by height), each cell was 64 by 20 pixels, and each letter was 8 by 9 pixels. After completing the trial (i.e., after responding to all four grids in succession), participants clicked a button to move on to the subsequent trial, which began 100 ms later.

In the aiming task, participants saw a yellow box in the top corner of the screen: the top left for right-handed participants (see Figure 2) and the top right for left-handed participants. The participant was then required to click the yellow box with the mouse cursor. Once the participant clicked the yellow box, a red box appeared on the screen, and the participant moved the cursor to this target using the mouse. The yellow box reappeared once they clicked the red box, and a new trial began. The red box would appear in one of five positions; see Table 1 for details. The red target boxes could be one of three sizes: 5×5, 10×10 or 20×20 screen units. The yellow home box was always 5×5 screen units in size. The displayed size of each screen unit in pixels was dependent on the dots-per-inch of a participant's monitor. The participants repeated each combination of position and size eight times for a total of 120 trials, which were presented in random order.

Statistical analysis

Due to the repeated measures design, a multilevel approach (using a Generalised Linear Mixed Model; GLMM) was used to ac-

count for dependencies in the data (Maas & Snijders, 2003).

For the visual search task, the mean ST in milliseconds (ms) was modelled as a function of one fixed factor (visual condition, two levels: monocular versus binocular).The maximal model included the main effect of the visual condition, two random intercepts and a random slope. Two random intercepts were estimated, one at the participant level to account for individual differences in vision and coordination and another at the grid level to account for random differences in the difficulty of each grid. The grid was not entered as a fixed factor as the grids were not generated with a systematic difficulty gradient. A random slope for each visual condition was estimated at the participant level to account for individual variability due to anisometropia.

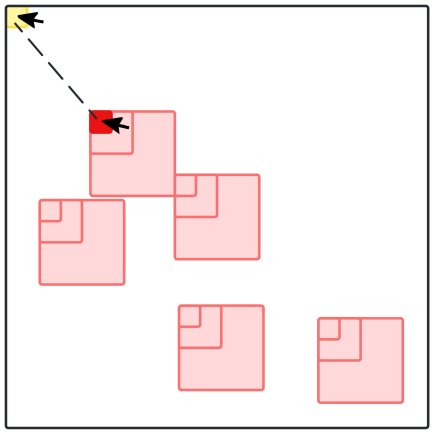

Figure 2: *Relative positions and sizes of the home (yellow square) and target squares (red squares). The targets were presented to the participants one at a time.*

Table 1: *The X and Y positions of the targets in the aiming task.*

	Right		Left	
	X	Y	X	Y
Position 1	40	40	60	40
Position 2	20	25	80	25
Position 3	41	71	59	71
Position 4	74	74	26	74
Position 5	8	46	92	49

Note: The coordinates of each target represent the position of the top left corner of the target relative to the top left corner of the participant's screen. These positions were measured in screen units. The top left of the screen is at (0, 0), and the bottom right is at (100, 100).

For the aiming task, the mean RT (in ms) was modelled as a function of two fixed factors (visual condition, two levels, and ID). ID was a numeric value, which is the product of the distance from the start point of the movement to the target (A) and the width of the target (W, see equation 1). ID was then standardised to have a mean of 0 and an SD of 1.

The maximal model included the two main effects, the two-way interaction of these factors and ST as covariate (the participant's performance in the visual search task under each visual condition). These values were standardised to have a mean of 0 and an SD of 1. ST was entered into the model as a covariate to isolate the effect of visual condition and ID on the MT of the task rather than the time taken for the participant to find the target. A random intercept was estimated for each participant to account for individual differences in vision and coordination. A random slope for the two-way interaction between visual condition and ID was also estimated at the participant level.

For all models, if the model failed to converge, starting with the random effects, the factors with the lowest variance were removed. All fixed effects from all models are reported in the results section, as each corresponds to a hypothesis being tested.

For the aiming and visual search models, performance was compared with two distributions: Inverse Gaussian and Gamma. The Gaussian distribution was not fitted to the aiming task and visual search data as both will use reaction time as an outcome variable. Reaction time data are zero bound and typically have a long, right-sided tail, meaning they are more likely to fit the Inverse Gaussian and Gamma distributions (Wagenmakers & Brown, 2007).

Performance was assessed by comparing each model's Bayesian information criterion (BIC), where a low BIC indicated a better fit, favouring models with lower numbers of factors. A BIC difference greater than 10 gives "very strong" evidence favouring the model with the lower BIC value (Bauldry, 2015; Raftery, 1995). These data are stored in the GitHub repository [https://github.com/willsheppard9895/OneEyeOnThePrize] in the files: aiming task (`motorTable.html`) and visual search (`vsDistTable.html`).

For each random effect, the heterogeneity of the effect was assessed by comparing the relative size of the random and fixed effects, for example, the random slope calculated for the visual condition and the fixed effect of the visual condition. In the present case, this took the form σ/β, where σ is equal to the magnitude of the random effect, and β is equal to the magnitude of the fixed effect. When this value exceeds 0.25, we concluded that the data are heterogeneous, as a participant at the 2.5th percentile would have a score equivalent to 0.5 of the mean, and a participant at the 97.5th percentile would have a score 1.5 times the mean (Bolger et al., 2019). These results were only reported if the effect was heterogeneous.

Standardised Beta (Std. β) coefficients were estimated using a standard procedure, whereby the outcome variables were scaled (with a mean of 0 and SD of 1) before being made positive by adding the minimum possible integer (scaled ST + 1 and scaled RT + 3), to fit the Gamma and Inverse Gaussian distributions. The continuous predictor variables were also scaled. The effect of visual condition was made numeric with binocular vision equal to zero and monocular vision equal to one (Lorah, 2018).

All analyses were performed using R Statistical Software (v4.3.1, R Core Team (2021)). GLMMs were estimated using the `lme4` package (Bates et al., 2015), and p-values were estimated using Satterthwaite's approximation through the `lmerTest` package (Kuznetsova et al., 2017).

Results

Visual Search Task

Depending on the visual condition, participants took approximately 11–13 seconds to complete the visual search (see Figure 3). Given an estimated MT of ≈1 second (the average MT in the aim-

ing task), this suggests an average processing time of ≈140–170 ms per search item based on an average target location in the middle of the array and a systematic search method.

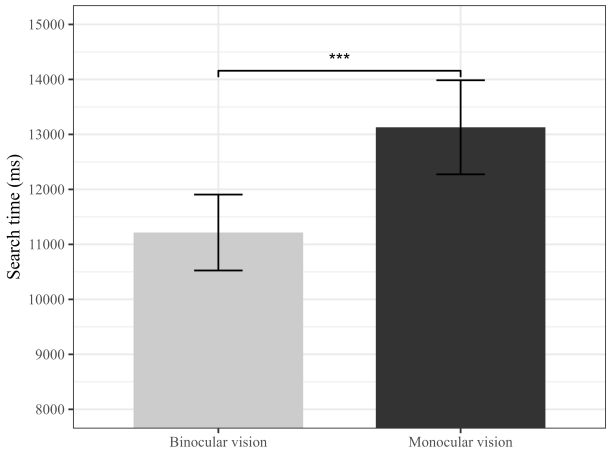

Figure 3: *The effect of visual condition on mean search time (ms). $p<.05$ (*), $p<.01$ (**), $p<.001$ (***), not significant (ns).*

The coefficients (β) in Table 2 predicted the average ST (μ_{ST}, in ms) and were fitted using an inverse Gaussian function. The intercept (β_{0ST}) estimated the average predicted performance in the binocular vision condition was 12509 ms. The standard deviation for its random effect (σ_{0ST}), which indicates the variability in the intercept across different participants, was equal to 2917 ms.

Table 2: *Multilevel modelling estimates of the fixed and random effects of the visual condition on mean search time (ms).*

Fixed effects					
Paramater	Description	*M* [95% CIs]	*SE*	*t*	*SD* β
β_{0ST}	μ_{ST} intercept. The estimated ST under binocular vision	12510*** [12380, 12640]	66.59	187.9	–
β_{STvc}	The effect of monocular vision on μ_{ST}	1880*** [1750, 2010]	64.87	29.0	0.15
		Random intercepts	Random slopes		
σ_{STpp}	SD of random intercept associated with each participant	2920	–		
σ_{STmv}	SD of random slope associated with the effect of monocular vision	–	510		
σ_{STgrid}	SD of random intercept/slope associated with the four grids	690	–		
R^2 marginal	Variance attributed to fixed effects	0.08			
R^2 conditional	Variance explained by fixed and random factors	1.00			

Note: $p<.05$ (*), $p<.01$ (**), $p<.001$ (***).

There was a main effect of visual condition, β_{STvc}, whereby monocular vision increased ST by 1881 ms (see Figure 3). This suggests that monocular vision was associated with an increase in processing time of 27 ms per search item based on an average target location in the middle of the array and a systematic search method (see discussion for further details). A random slope for the effect of visual condition was estimated for each participant, with the standard deviation of these slopes being 509 ms. Therefore, in the present case, we concluded that the effect of visual condition on ST was heterogeneous between participants as the standard deviation of the random slope was 27% of the fixed effect estimate for the visual condition. Further evidence for the heterogeneous nature of this effect comes from the relatively large size of the R^2 conditional compared to the R^2 marginal, i.e., 11.5 times as much variance is attributed to between participant factors compared with the fixed effect of the visual condition. The variability in the random intercepts of the four grids had an estimated standard deviation of 688 ms.

Aiming task

Participants took approximately 130 seconds to complete the task (120 trials), which varied depending on the visual condition (see Figure 4).

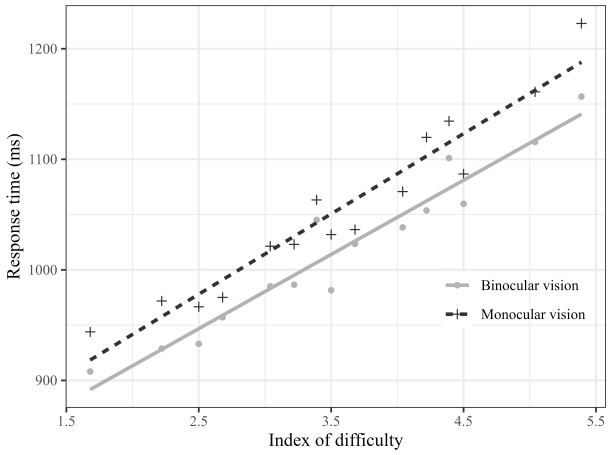

Figure 4: *The effect of visual condition on mean response time (ms) in the aiming task across the index of difficulty (ID).*

The coefficients (β) in Table 3 predicted the mean RT (μ_{RT}, in ms) and were fitted using a Gamma function. The intercept (β_{0RT}), estimating the average predicted performance in the binocular vision condition with a mean ID and RT, was 1062 ms. The standard deviation for its random effect (σ_{RTpp}), which indicates the variability in the intercept across different participants, was equal to 86 ms.

There was a significant main effect of visual condition, β_{RTvc}, whereby RTs increased by 40 ms under monocular vision (see Figure 4). A random slope for the effect of visual condition was estimated for each participant, with the standard deviation of these slopes being 55 ms.

Discussion

The present study investigated whether a pair of simple online tasks could accurately measure the effects of monocular viewing on motor function. Monocular vision impaired performance in simple visual search and visuomotor aiming tasks. Performance in the visual search task (ST) was associated with performance on the aiming task (RT), whereby longer STs were associated with longer RTs. Therefore, ST was entered as a covariate when esti-

mating the effect of the visual condition on RT in the aiming task. Results showed that, after controlling for ST, monocular vision was associated with increased RT. An increase in the ID was also associated with increased RT. There was no significant interaction between visual condition and ID.

Table 3: *Multilevel modelling estimates of the fixed and random effects of the visual condition, target distance and target size on mean response time (ms).*

Fixed effects					
Paramater	Description	*M* [95% CIs]	*SE*	*t*	*SD* β
β_{0RT}	μ_{RT} intercept. The estimated RT under binocular vision	1060*** [1060, 1070]	1.79	593.82	–
β_{RTvc}	The effect of monocular vision on μ_{RT}	40*** [30, 40]	1.57	26.75	0.11
β_{RTid}	The effect of the index of difficulty on μ_{RT}	70*** [70, 80]	1.29	56.66	0.19
β_{RTst}	The effect of the search time on μ_{ST}	30*** [20, 30]	1.39	27.73	0.10
$\beta_{RTvc*id}$	The interaction of monocular vision and ID	0 [0, 0]	1.21	-0.46	–
		Random intercepts	Random slopes		
σ_{RTpp}	SD of random intercept associated with each participant	90	–		
σ_{RTvc}	SD of the random slope associated with the visual condition	–	60		
σ_{RTid}	SD of the random slope associated with the index of difficulty	–	10		
R^2 marginal	Variance attributed to fixed effects	0.43			
R^2 conditional	Variance explained by fixed and random factors	1.00			

Note: $p<.05$ (*), $p<.01$ (**), $p<.001$ (***).

Therefore, we can conclude that the effect of the visual condition on RT was heterogeneous between participants, as the standard deviation of the random slope was 138% of the fixed effect estimate for the visual condition. Also, similar to the visual search task, further evidence for the heterogeneous nature of this effect is evidenced by the relatively large size of the R^2 conditional compared to the R^2 marginal, i.e., 1.3 times as much variance is attributed to between participant factors compared with the fixed effects (including visual condition) entered into the model. There was also a significant main effect of ID, where each additional increase of one *SD* was associated with a 73 ms increase in RT, β_{RTid}. The random slope associated with the ID had an *SD* of 14 ms. There was no significant interaction between visual condition and ID. Additionally, there was a main effect of ST, β_{RTst}, whereby each increase of one *SD* was associated with a 28 ms increase in RT.

In the visual search task, monocular vision increased ST by 1881 ms, or 15.0%, compared to the full vision condition. This effect is approximately half the size reported in previous studies, 22% to 37% (Black et al., 2021; Nagarajan et al., 2022). The difference in the effect size between the present study and previous work may be due to task characteristics (e.g. in the present task, the participants searched for the letter "Y" in a grid of "X"s compared with creating a path through ascending numbers (Black et al., 2021) or searching for a specific part of a real-world image (Nagarajan et al., 2022)). However, it seems more likely that this effect is due to the differences in participant characteristics. The present study used individuals with normal binocular vision with one eye covered. In contrast, the cited studies used individuals with amblyopia, a condition that begins at an early age and can impact the development of the individual's visual processing system. The idea that interindividual differences can cause differences in performance on a visual search task is supported in the present study, as demonstrated by the relatively large size of the SD of the random intercepts associated with each participant, σ_{STpp}, and the R^2 conditional compared to the intercept, μ_{ST}, and the R^2 marginal.

Nagarajan et al. (2022) found that the performance deficit associated with amblyopia relative to the controls persisted when both groups used only their fellow / dominant eye despite no difference in the average VA of the groups. This effect suggests that amblyopia may also be associated with higher-order visual processing deficits beyond the change to the clarity of their vision. In order to complete a visual search task in the minimum amount of time, participants would complete the task with a minimum number of saccades and brief fixations. Eye tracking data revealed that whilst the average fixation duration of the two groups was similar, the amblyopia group would, more often than the controls, fixate on the target before performing a saccade to, and fixation upon, the extra-target area before performing another saccade to the target, seemingly to perform a confirmatory fixation. A similar pattern of eye movements has been reported when investigating the effect of amblyopia on children's reading performance (Kelly et al., 2017). Nagarajan et al. (2022) proposed that the need for individuals with amblyopia to make additional confirmatory fixations is linked to a reduction in "visual span" (the amount of information that can be collected in one fixation (Frey & Bosse, 2018)). Evidence for this comes from studies showing that performance on a perceptual learning task by individuals with amblyopia is better when the visual environment is less crowded, i.e., individuals with amblyopia retain more task-relevant visual information when there is less demand on the individuals' visual processing systems.

While the participants in the present study all reported healthy vision, this is not to say that they all performed equally. When considering the effect of visual condition on ST, the magnitude of the random effect was equal to 27% of the fixed effect, suggesting that the effect of visual condition was heterogeneous across the sample (Bolger et al., 2019), whereby monocular vision increased ST by 1750 ms to 2010 ms in 95% of the participants. This variability is most likely due to each participant having different levels of anisometropia, which is the difference in VA between the eyes (Vincent et al., 2014). As monocular vision was induced by asking the participant to cover the non-dominant eye, it is logical that participants with low levels of anisometropia show a larger visual deficit and, therefore, would also show a greater performance deficit in the monocular vision condition, i.e., the STs of the participants with lower levels of anisometropia will increase by a greater amount in the monocular vision condition compared to those with

high levels of anisometropia. To confirm levels of anisometropia in the sample as the cause of variability in task performance, we need to develop reliable and validated tests of clinical measures of vision for use online. The 2D nature of the online tasks limits the stereoscopic aspects of the stimuli. Tests for contrast sensitivity and visual acuity will provide additional insight into the effects of visual conditions on motor function.

In the aiming task, monocular vision increased RT by 40 ms. This small but significant effect suggests that online testing provides a valuable method for assessing the effects of visual deficits on motor function. However, the pattern of results appears to differ from the work completed by Wu et al. (2010). They presented evidence that the association between ID and MT weakened as vision degraded. When the researchers further degraded vision, MTs were shorter when the ID was larger (compared with full monocular vision). The present study found no evidence that the gradient associated with ID differed between binocular and monocular vision.

There seem to be two possible explanations for this: (i) different metrics or (ii) different task difficulty. To describe these in turn, first, the aiming task in the present study used a measure of RT, which also contains some time before the initiation of the movement and is not a pure measure of MT. Despite controlling for the effect of the visual condition on the participant's performance in the visual search task (ST) on RT, there will be some additional variability in RT that is not present in the results presented by Wu et al. (2010), which may be masking a possible interaction. Second, Wu et al. (2010) found that the differences in slope between the visual conditions emerged at IDs equal to 5 and 6; the present study had a maximum ID of 5.39, and the effect may have emerged if the present study used stimuli with a higher ID.

When considering the main effect of ID on RT, rather than the interaction effect between ID and visual condition on RT (as discussed in the previous paragraph), as predicted, RT increased with ID; however, the effect size was far smaller than those reported in pure Fitts' law type tasks (for example, Wu et al. (2010)). Given that the standardised beta of ID was 0.19, approximately 19% of the variance in RT can be explained by ID. This is less than one-quarter of what is typically reported in the literature for Fitts' law-type tasks. This reduction is most likely due to the measurement of RT used in the present study, which also included the time taken for the participant to acknowledge the presentation of the target stimuli, find the target on the screen, plan the movement and execute the movement, rather than simply executing the movement to the target, as per a typical Fitts' law task. However, the finding of a significant relationship between ID and RT does confirm that online testing is a valid method for assessing the effects of visual deficits on motor function. Including ID in the model also assesses the effect of the visual condition on motor function more robustly since this isolates variance in RT due to task characteristics, which otherwise may have been wrongly attributed to the effects of monocular vision.

It is worth noting that the present study does face some potential limitations. First, the ocular dominance test was conducted at a distance of approximately 2 m, whereas the experimental tasks were conducted at approximately 0.6 m; therefore, ocular dominance may have switched between the ocular dominance test and the experimental tasks. Second, screen resolution and, therefore, the image size will likely vary between participants. However, the present study explored the feasibility of detecting visual effects on motor function in an online setting where such variability is inherent. By employing a within-subjects design, alongside multilevel modelling techniques and allocating each participant their intercept, we accounted for individual differences in setup. While this approach introduces variability, we believe it reflects the real-world conditions we aimed to study. However, future iterations of similar research paradigms may consider adding a calibration task to standardise the procedure further, although the choice to add additional tasks to future research must be balanced against the accessibility demands of the present research program.

Online testing presents opportunities not only in research, where it allows us to test individuals from a broad range of ages, educational backgrounds, ethnicities and nationalities but also in healthcare, where testing individuals remotely makes diagnosis and treatment quicker for those individuals who otherwise may struggle to access it (Li et al., 2021). To the authors' knowledge, this is the first time that Fitts' Law has been tested entirely remotely in an empirical study; therefore, presenting evidence that this phenomenon is robust to the reduced control associated with online testing provides robust evidence that online testing can be used to assess the impact of vision on motor function.

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Ett øye på premien: Effekten av monokulært syn på sikteresponser

Sammendrag

Evnen til å bevege hånden raskt og nøyaktig mot et mål er en grunnleggende ferdighet som er avgjørende i mange daglige aktiviteter, f.eks. når en skriver eller skal tre en nål. Laboratorieforskning har vist at tiden det tar å fullføre en sikteoppgave (responstiden) er proporsjonal med oppgavens vanskelighetsgrad; dette forholdet svekkes om kvaliteten på visuell informasjon blir forringet (Wu et al., 2010). Studier har også vist at når en bruker kun ett øye (monokulært syn) vil en bruke lenger tid på å bevege hånden når en utfører en sikteoppgave sammenlignet med når en bruker begge øynene (binokulært syn) (W. E. A. Sheppard et al., 2021). Til tross for disse verdifulle funnene, så er ikke laboratorietesting alltid mulig å gjennomføre pga. ulike logistiske utfordringer, f.eks. om en ønsker å rekruttere fra vanskelig tilgjengelige populasjoner. Slike mulige utfordringer kan en løse ved å introdusere nettbaserte tester, om testene er tilstrekkelig sensitive til også å registrere om personen som testes har et synsproblem som kan påvirke motorisk funksjon. Denne studien hadde som mål å teste (i) om monokulært syn fører til økning i responstid sammenliknet med binokulært syn og (ii) muligheten til å bruke enkle, nettbaserte tester for å undersøke forholdet mellom visuell og motorisk funksjon.

Ved å bruke en datamus eller pekeplate for å peke på objekter på skjermen så raskt som mulig, fullførte 65 deltakere (i alderen 18–77 år) (i) en visuell søkeoppgave (flytting ar musepeker til et objekt som var skjult i et rutenett av distraktorer) og (ii) en enkel visuell-motorisk sikteoppgave (flytting av musepeker til ulike bestemte objekter av varierende størrelse/avstand). Deltakerne fullførte begge oppgavene, binokulært eller monokulært, på sin egen datamaskin via en nettbasert tjeneste.

Resultatene viser at visuell søketid og sikteoppgavens responstid økte betydelig under monokulære forhold (henholdsvis ≈1,8 s og ≈40 ms). Dette viser at en enkel, nettbasert sikteoppgave kan være egnet for å teste effekten av synsforstyrrelse på motorisk funksjon.

Nøkkelord: monokulært syn, sikting, visuelt søk, nettbasert testing

Un occhio sul premio: L'Impatto della visione monoculare sui compiti di puntamento

Riassunto

La capacità di muovere la mano in modo rapido e preciso verso un bersaglio è un'abilità essenziale alla base di molte attività della vita quotidiana, come scrivere o infilare un ago. La ricerca di laboratorio ha precedentemente dimostrato che il tempo impiegato per completare un compito di puntamento è proporzionale alla difficoltà del compito; tuttavia, la forza di questa relazione sembra ridursi all'aumentare del degrado della qualità dell'input visivo (Wu et al., 2010). Inoltre, vi sono evidenze che, rispetto alla visione binoculare, la visione monoculare comporti un generale incremento del tempo di movimento nei compiti di puntamento (W. E. A. Sheppard et al., 2021). Nonostante queste preziose scoperte, le difficoltà logistiche (ad esempio, il reclutamento di popolazioni difficili da raggiungere) rendono i test in laboratorio complessi o addirittura impraticabili. Queste criticità potrebbero essere superate mediante l'adozione di test online, a condizione che essi siano sufficientemente sensibili nel rilevare con precisione i deficit visivi. Il presente studio si proponeva di esaminare (i) se la visione monoculare fosse associata a un aumento del tempo di risposta e (ii) la fattibilità dell'uso di semplici test online per esplorare la relazione tra funzione visiva e motoria.

Sessantacinque partecipanti (di età compresa tra 18 e 77 anni) hanno completato due attività online utilizzando un mouse o un touchpad per spostarsi il più rapidamente possibile verso i bersagli: (i) un compito di ricerca visiva (raggiungere un bersaglio all'interno di una griglia di distrattori) e (ii) un compito di puntamento visuo-motorio di base (raggiungere bersagli di dimensioni e distanze variabili). I partecipanti hanno eseguito entrambi i compiti sia in condizioni di visione binoculare che monoculare.

Il tempo di ricerca visiva e il tempo di risposta nel compito di puntamento sono aumentati significativamente con la visione monoculare (≈1,8 s e ≈40 ms, rispettivamente).

Questi risultati suggeriscono che un semplice compito di puntamento online può rappresentare uno strumento adeguato per indagare gli effetti di un deficit visivo sulla funzione motoria.

Parole chiave: visione monoculare, puntamento, ricerca visiva, test online

Screening for visual deficits at a rehabilitation unit early in the rehabilitation process after stroke

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Abstract

Stroke patients are not routinely screened for visual deficits despite recommendations on the importance of vision for safety and design of rehabilitation plans. The aim was to examine if it was feasible to expose rehabilitation patients to vision screening. Secondly, we aimed to examine the agreement between the vision screening and items from a neurological stroke screening tool specifically targeting vision and neglect.

Over a period of 6 months, patients arriving at a rehabilitation unit after having had a stroke were consecutively included. Data on aetiology, severity, and location of the stroke, time since the original admission, scores on the National Institutes of Health Stroke Scale (NIHSS), and results from a short screening/observation battery were registered. Cohen's kappa was calculated to examine the agreement between results from the screening/observation battery and NIHSS items.

Nighty-six percent of the patients were able to undergo screening of basic visual functions. Impairment was found in 52% of the patients, and 67% of these showed impairment in more than one function. Visual impairment occurred for all levels of stroke severity. Reduced distance visual acuity was found in 15% of all patients. Accordance between the screening/observation battery and NIHSS items varied between $\kappa = 0.36$ and $\kappa = 0.64$. Screening battery vs NIHSS items showed impairment in 31% vs. 21% of patients for oculomotor deficits, 31% vs. 34% for visual field deficits and 31% vs. 29% for neglect.

Results show that patients are assessable for basic visual functions early in the rehabilitation process. Items from the NIHSS cannot replace a dedicated vision screening tool because they exclude essential functions such as visual acuity, and oculomotor deficits may go undetected. Only the visual field assessment indicates substantial agreement and high sensitivity. Regarding stroke severity, agreement was substantial only in the severe group. In summary, we conclude that the NIHSS items cannot be recommended to replace systematic screening of visual function and neglect.

Keywords: visual impairment, stroke, vision screening, neurorehabilitation, NIHSS

Introduction

Impairment of visual function occurs in up to 60% of stroke survivors in the early subacute phase (Ali et al., 2013; Rowe, 2013; Rowe, Hepworth, et al., 2020). The importance of early visual assessment, preferably shortly after hospitalisation, is stressed by findings indicating that visual impairment increases the risk of falls, reduces participation in and the benefit of rehabilitation, and decreases independence in daily activities (e.g. dressing, manoeuvring wheelchairs, reading, using mobile phones) (Kerkhoff, 2000; Norup et al., 2016; White et al., 2015). Asking the patients themselves about visual impairment has been shown to be of limited value as answers do not provide reliable status descriptions due to the unawareness of deficits, denial of impairment, inability to describe impairment, or unspecific questions by staff (Berthold-Lindstedt et al., 2021; Falkenberg et al., 2020).

Despite the importance of visual functioning and recommendations in clinical guidelines, screening of functions is still not routinely applied in neither stroke nor rehabilitation units (NICE, 2013; Rowe et al., 2019; Schow et al., 2024). This may be due to time constraints, insufficient understanding of the impairment's impact, absence of brief and basic screening tools at rehabilitation sites, or uncertainty about which functions to prioritise when patients have complex needs and multiple impairments (Pollock et al., 2012; Rowe, Hepworth, Howard, Hanna, & Helliwell, 2022; Vancleef et al., 2022). Clinicians may further meet obstacles such as patients' fatigue, language impairment, postural difficulties, limited response capability, or cognitive impairment (Kerkhoff, 2000; Roberts et al., 2016; Schow et al., 2024; Wehling et al., 2024).

Warren (Warren, 1993a; 1993b) stressed the importance of extensive assessment of visual function after brain injury. Yet, she suggested that assessing basic visual skills, i.e. oculomotor function, visual fields and visual acuity, prior to higher level functions such as visual scanning, attention, pattern recognition, and visual memory, since deficits in basic skills could affect higher level functions (de Haan et al., 2020; Warren, 1993a; 1993b). This bottom-up approach could initiate referral to vision specialist to verify diagnosis and instigate treatment.

Upon admittance to stroke or rehabilitations units, patients are routinely examined for neurological deficits. A frequently used screening tool is applied; the National Institutes of Health Stroke Scale (NIHSS) (Brott et al., 1989), which contains items assessing visual domains, i.e. horizontal gaze disorders and visual field deficits. A third item assesses neglect/inattention, characterised by inattention towards the contra-lesional hemisphere, independent of the direction of gaze. Using the NIHSS, Ali et al. (2013) found that visual impairment was reported in 61% of stroke patients in the acute phase, with 28% still showing impairment at 30 days and 21% at 90 days follow-up. The NIHSS has been criticised

for not being usable as the only vision screening tool due to problems in detecting impairment of central vision and eye movement disorders (Hanna et al., 2017). Existing studies often report NIHSS findings focusing on location of the stroke (left versus right hemisphere, posterior versus anterior) or on sex differences (Barrett et al., 2007; Lyden et al., 1999; Tao et al., 2012). Regarding visual impairment, these studies either focus on one item or combine items based on factor analysis. Studies comparing NIHSS scores with subtests from more comprehensive screening tools such as the Brain Injury Visual Assessment Battery for adults (biVABA) (Warren, 2006), which is frequently available in rehabilitation settings, are still missing.

The aim of this study was to explore if it is feasible to expose patients admitted to inpatient rehabilitation to a short vision screening battery, including assessment of visual acuity, visual field and oculomotor functions. Screening of neglect/inattention was included due to the high occurrence in stroke patients and the overlap of symptoms with visual field deficits (Nyffeler et al., 2017; Ringman et al., 2004). The second aim was to analyse the agreement between the short vision screening/observation battery with results from the NIHSS. The results may help clinicians to decide which patients should be exposed to extensive assessment and referral to vision specialists as suggested by guidelines.

Methods

Participants

Patients admitted from two hospitals with acute stroke units were consecutively included after admission to the Department of Physical Medicine and Rehabilitation at the Haukeland University Hospital Bergen, Norway. Inclusion criteria were age ≥ 18 years and the ability to be awake and sit upright (wheelchair/chair) for approximately 20 minutes. Informed consent was obtained from the patient him-/herself or from a next of kin in cases where the patient's ability to communicate or their cognitive ability was reduced. The study was approved by the Western Regional Ethics Committee (REK 2018\903) and was conducted in accordance with the declaration of Helsinki (World Medical Association, 2018).

Measures

Medical data

Demographical and medical data were collected from each patient's medical journal, including age and gender, and aetiology, location and severity of stroke. Variables regarding visual function were registered, including ptosis, glaucoma, cataract, diabetic retinopathy, macular degeneration, strabismus, and use of visual aids/glasses/lenses before the stroke. The NIHSS (Brott et al., 1989) was scored upon arrival to the rehabilitation unit by the physician in charge.

Time of assessment

The time interval between stroke and vision screening was registered.

Vision screening procedure

Three short tests from the basic level of Warren's hierarchical model of visual-spatial abilities (Warren, 2006) were chosen, i.e. distance visual acuity, oculomotor control, and visual fields. Two experienced occupational therapists conducted the vision screening, which took approximately 15–20 minutes.

Vision screening battery

Visual acuity

Visual acuity was assessed using the Intermediate Acuity Test Chart from the biVABA (Warren, 2006). The patient sat one metre from the test chart wearing his/her own glasses, if indicated, and read the numbers on the chart aloud. The outcome was determined by the Snellen and metric fractions for the last row in which the patient accurately identified at least three out of five letters. Patients with aphasia were tested with the LEA-acuity test with symbols and pointed out the corresponding symbol on a sheet (Hyvärinen et al., 1980). Low vision was defined according to WHO's standards (Snellen acuity less than < 20/60) (Steinmetz et al., 2021).

Oculomotor control

Oculomotor control was assessed using the Binocular Smooth Pursuit Eye Movements from the biVABA (Warren, 2006). The penlight was held vertically, and the patient was instructed to focus on the light at the tip of the penlight. The penlight was moved slowly and smoothly in an arc through the nine cardinal directions of gaze (left, right, up, down and 45° diagonals) while maintaining approximately 40 cm distance from the patient. The results were recorded as "normal" when the patient was able to follow the pen in all directions, or "impaired" when the patient had difficulties following the pen or had a deviated eye position for more than approximately 2 seconds.

Visual field test

The patient sat vis-à-vis a staff member and was requested to focus on the person's face. A second staff member was positioned behind the patient. A red ball (the size of a tennis ball) was moved from behind the patient's head into his/her visual field at eye height until a 70° angle from fixation was reached (according to an angle meter fixed in the ceiling). The patient was instructed to indicate (by saying "now" or raising his/her hand) when he/she detected the ball. Three attempts for each side were registered. The results were recorded as "normal" (responding all three times to either side) or "visual field deficit" (VFD) when the ball was not detected two or more times (either left or right).

Neglect/visual inattention

Since brain injury often causes visual neglect co-occurring with visual deficits, and due to the timely assessment after admission and occurrence of hemiparesis of upper extremities, the presence of neglect was based on occupational therapists' observations. Neglect/inattention in at least two daily activities (e.g. dressing, eating, personal hygiene, colliding with/into objects) in addition to gaze deviation had to be observed for the presence of neglect to be registered.

National Institutes of Stroke Scale

The NIHSS is a systematic assessment tool providing a quantitative measure of stroke-related neurologic deficit. In this study, a 13-item Norwegian version was used to assess levels of consciousness, eye movements, visual-fields, motor strength (face, arm, leg), ataxia, sensory loss, language, speech, and neglect (Thomassen et al., 2011). Stroke severity was indicated by the fol-

lowing intervals: 1–4 = minor, 5–14 = moderate, 15–24 = severe, and ≥ 25 = very severe stroke.

For the analysis in this study, three items from the NIHSS relating to visual deficits and neglect were used. These comprised: *Best gaze* (item 2; Eyes open – patient follows examiner's finger or face; 0 = normal, 1 = partial gaze palsy, 2 = forced deviation), *Visual fields* (item 3: introduce stimulus/threat to patient's visual field quadrants; 0 = no visual field loss, 1 = partial hemianopia, 2 = complete hemianopia, 3 = bilateral hemianopia [blind]), and *Inattention/Neglect* (item 11; using Donders confrontation test, the patients covers his/her one eye with his/her hand). The examiner sits directly across from the patient and asks the patient to direct his/her gaze to the corresponding eye of the examiner. The examiner moves a target (finger/hand) from outside the visual field slowly into a central position until the patient reports seeing the target. Each eye is tested independently. Scores: 0 = no neglect, 1 = visual neglect, 2 = neglect occurred in visual and one other modality.

Data analysis

Analysis was conducted using IBM SPSS Statistics (Version 27). Descriptive statistics (Mean [*M*], Standard deviation [*SD*] and percentage [%]) were used to describe the sample characteristics and frequencies. Fisher's Exact Test was used to examine categorical data and Kruskal-Wallis tests were used for comparisons of continuous data. Cohen's kappa measure of agreement was calculated to evaluate the agreement between results from three items from the NIHSS and the vision screening/observation battery. The values of agreement have been defined as < 0.2 mild, 0.21–0.4 fair, 0.41–0.6 moderate, and 0.61–0.8 substantial. All analyses were two-tailed, and the alpha level was set at $p < 0.05$.

Results

In total, 52 patients were included. The average age was 67 years (SD = 9; range 49–83 years) and 56% of the sample were men. In 46% of the patients the lesion was located in the right hemisphere, in 50% it was in the left hemisphere, and 4% had bilateral lesions. For 77% of the patients the stroke was ischaemic and for 23% it was haemorrhagic. Thirty-five percent (n = 18) presented with language difficulties (aphasia and/or verbal apraxia). Based on NIHSS scores, 48% (n = 25) had a minor, 35% (n = 18) a moderate, and 17% (n = 9) a severe stroke. Sample characteristics are presented in Table 1.

Table 1: *Sample characteristics and clinical variables upon admission to the rehabilitation unit.*

		Range
Age (years), *M* (*SD*)	66.7 (9.1)	49–83
NIHSS total admission rehabilitation, *M* (*SD*)	7.6 (6.5)	0–24
Length of stay at acute ward (days), *M* (*SD*)	12 (9)	3–55
Time between ictus and visual screening/rehabilitation (days), *M* (*SD*)	22 (11)	6–61
Sex, *n* (male/female)	34/18	
Type of stroke, *n* (ischaemic/haemorrhagic)	40/12	
Location, *n* (left/right/bilateral)	26/24/2	
Aphasia, *n*	18	
Eye disease before admission, *n*	12	
Use of visual aids (glasses, contact lenses) before injury, *n*	47	

Screening visual functioning and neglect

Feasibility of assessment with vision screening battery

Fifty patients (96%) were able to undergo the complete vision screening. Two were not assessed with the visual acuity test, one who was not able to respond to stimulus material due to severe speech difficulties and one who expressed severe diplopia and was not able to focus on the Snellen chart. The timepoint for vision screening varied between 1 and 68 days (M = 21, SD = 11, Median = 20) after the stroke. Sixty-four percent were screened within the first week after arrival at the rehabilitation unit, all were screened within the first 12 days.

Vision screening results

Of the sample, 52% (n = 27) of patients showed deficits on any of the tests from the vision screening battery and the neglect identification. Fifteen percent of the sample (n = 8) had low vision (visual acuity < 20/60), 31% (n = 16) showed oculomotor deficits, and 31% (n = 16) had visual field deficits. Visual neglect occurred in 29% (n = 15). Analysis indicated no significant sex differences and no differences regarding lesion site for visual impairment. For patients registered with neglect, the stroke was more often in the right than in the left hemisphere (χ^2= 13.9; $p < 0.01$). Grouped by stroke severity, 48% (n = 12) with a minor, 44% (n = 8) with a moderate and 77% (n = 7) with a severe stroke demonstrated visual impairment. Sixty-seven percent of the patients demonstrated impairment in more than one function (see Figure 1). Analysis indicated that strokes with greater severity were more likely to cause some form of visual impairment (H = 5.48 [2], $p < 0.07$).

NIHSS score on three items

According to the three NIHSS items, 54% of the patients had deficits in any of the three selected items. Approximately 44% (n = 23) were scored to have visual field deficits, 37% (n = 19) had inattention/neglect, and 21% (n = 11) showed gaze deficits. Nineteen percent (n = 10) demonstrated impairment on one item, 23% (n = 12) on two, and 12% (n = 6) on all three items.

Agreement of NIHSS items and vision screening/observation battery

Table 2 shows the number of patients with impairment on the vision screening/observation battery and the NIHSS items for the three stroke severity groups.

The agreement for individual items and stroke severity groups are shown in Table 3. The overall agreement between NIHSS and the vision screening/observation battery had a kappa value of 0.5. This related to both high false negatives and false positives. Sensitivity was 77% and specificity 72%. For the individual items of the two methods, the highest level of agreement occurred for the visual field assessment (κ = 0.64). Neglect revealed a fair agreement (κ = 0.53). The lowest level of agreement occurred for oculomotor deficits (κ = 0.36). This related to a high number of false negatives, which means that patients did not show impairment on the NIHSS item, whereas they did on the vision screening/observation bat-

tery. The visual field assessment and the neglect assessment revealed a high number of false positives, which means the patients were scored as impaired with the NIHSS assessment but not with the vision screening battery.

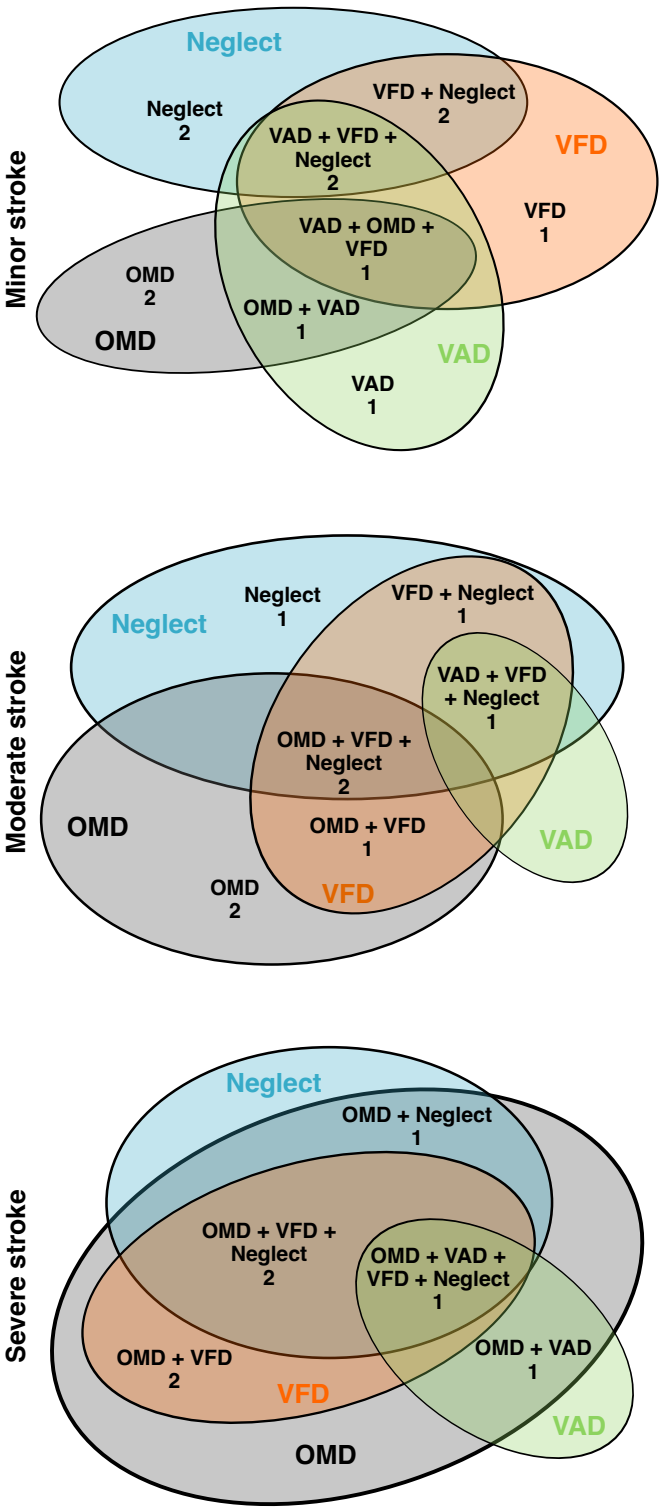

Figure 1: *Combination of visual deficits based on the visual screening/observation battery. VAD = Visual acuity deficit; OMD = Oculomotor deficit; VFD = Visual field deficit.*

Table 2: *Agreement between the visual screening/observation battery (VS/OB) and NIHSS items grouped by stroke severity.*

	Minor stroke (n = 25)		Moderate stroke (n = 18)		Severe stroke (n = 9)	
	NIHSS items	VS/OB	NIHSS items	VS/OB	NIHS items	VS/OB
Visual acuity deficit	–	5	–	1	–	2
Oculomotor deficit	1	4	3	5	7	7
Visual field defect	8	6	7	5	8	5
Neglect	4	6	8	5	7	4

Numbers refer to the number of patients.

For the stroke severity group, analysis revealed low agreement in the group with moderate severity ($\kappa = 0.24$) and fair agreement in minor and severe groups. In the minor stroke group reduced agreement was due to false negatives, whereas in the moderate stroke group low agreement was due to false positives. Sensitivity and specificity varied between 66% and 92%.

Table 3: *Summary of agreement between NIHSS and vision screening/observation battery for individual components and stroke severity (false positives and negatives, κ, sensitivity and specificity, and positive- and negative-predictive values).*

	Agreement	False neg.	False pos.	Kappa [95% CI]	Sens.	Spec.	PPV	NPV
Impairment	39	6	7	0.50 [0.26, 0.74]	77%	72%	75%	75%
Oculomotor deficit	39	9	4	0.36 [0.09, 0.63]	44%	89%	64%	78%
Visual field deficit	43	1	8	0.64 [0.43, 0.85]	94%	77%	65%	78%
Neglect	41	3	8	0.53 [0.29, 0.77]	80%	60%	60%	80%
Minor stroke	20	4	1	0.59 [0.28, 0.90]	66%	92%	88%	75%
Moderate stroke	11	2	5	0.24 [−0.18, 0.66]	75%	50%	54%	71%
Severe stroke	8	0	1	0.61 [0.06, 1.00]	100%	50%	88%	100%

Discussion

The aim was to examine the feasibility of a short vision screening/observation battery and to investigate the agreement of results from this battery with items from the NIHSS, a common neurological screening instrument that contains items of visual function and neglect.

Our results demonstrate that most patients were able to undergo vision screening using established methods in rehabilitation, i.e. subtests from the biVABA. Impaired visual function and neglect/inattention were found in about half of all patients using a vision screening/observation battery. Two thirds of these patients demonstrated deficits in more than one visual function. The agreement of results from the vision screening/observation battery and the NIHSS varied between fair and substantial. Likewise, sensitivity and specificity for individual items and stroke severity groups varied.

Our results, showing that vision screening was viable in 96%

of the patients admitted to rehabilitation units, even those with severe stroke or with aphasia, are notable and important for clinicians working in rehabilitation. More than half of the patients in our sample were screened within the first week after arriving at the rehabilitation unit, and all were assessed within the first fortnight. Due to this early screening, patients could be referred to vision specialists as soon as they were considered capable of undergoing an extensive assessment. Safety issues at the unit could be addressed, potentially preventing falls or bumping into objects. Moreover, the screening results could be considered in the interdisciplinary rehabilitation plan both at the inpatient unit and at follow-up after discharge. Although starting visual training is not recommended until after consultation with vision specialist (Roberts et al., 2016), for some patients the process of becoming aware of their visual impairment, learning about the consequences, and compensating for the deficit may be started immediately after the screening. Only two patients were not able to undergo distance acuity screening. One of these patients had aphasia which is often a barrier in assessments. The oculomotor and visual field assessments had instructions that were intuitive or could be supported by signs, which may have made them easier to perform than the visual acuity test.

The vision screening/observation battery indicated that more than half of the sample had some kind of visual impairment or neglect, and that most patients have impairment in more than one visual function. We found a trend indicating that the more severe a stroke was, the more likely it was to cause visual impairment. This is in accordance with earlier reports (Rowe, Hepworth, Howard, Hanna, et al., 2020) and the missing statistical significance may be explained by a small group size for patients with severe stroke.

The agreement between the NIHSS items and results from the screening battery varied considerably. Lowest agreement was found for the oculomotor item. Analysis revealed low sensitivity and a high number of false positives. This is important to consider. Eight patients who showed oculomotor impairment on the screening/observation battery were overlooked by the NIHSS. The shortcoming of detecting such impairment should be avoided, regardless of whether it occurs as the only impairment or in combination with others. Oculomotor function is highly important for all visual functioning and since these functions may improve through training (Watabe et al., 2019) the NIHSS item is not sufficient to satisfactorily assess this function and an extended screening as performed in the screening battery seems indicated.

The agreement for neglect and visual field varied between moderate (neglect) and substantial (visual field). The detection of VFD after stroke is important since it impacts grooming, feeding, work and family life, and is associated with fear, loss of confidence and avoidance (Hazelton et al., 2019; Rowe, 2017). Despite a high sensitivity for the visual field item (94%), specificity was somewhat low (77%) and for the neglect item, both sensitivity and specificity were low (≤ 80). For both items, there was a high number of false positives, indicating that impairment was found on the NIHSS item but not on the screening battery. Of these false positives, four showed impairments on a combination of other functions in the screening battery including neglect, oculomotor and visual acuity. One showed only a visual acuity deficit. This underlines the importance of further referral and clarification of multiple conditions through an orthoptic examination.

It is noteworthy that in both the NIHSS and the screening battery symptoms of visual field deficits and neglect co-occurred in almost half of the patients. Since neglect and visual field deficits are functionally distinct disorders, with differing lesion localisation, observable behaviour and prognosis (Halligan et al., 1990; Mueller-Oehring et al., 2010; Ting et al., 2011), comprehensive assessment and differential diagnosis are indispensable. This underlines that screening must be followed up with more extensive assessment which may be challenging in the early phase after stroke (Karnath, 2001; Karnath et al., 2001; Kerkhoff & Schindler, 1997; Mueller-Oehring et al., 2010).

Our final analysis examining the agreement between the vision screening/observation battery and the NIHSS regarding stroke severity showed considerable variation. Overall, agreement was low, and so were sensitivity and specificity with a high number of both false negatives and false positives. Agreement was substantial and sensitivity high only among the patients whose stroke was severe. In this case the NIHSS items could seem sufficient to determine impairment. Yet, the combination of impaired functions varied and thus the screening battery should be the preferred method of assessment. In the minor stroke group, agreement was high moderate, yet sensitivity was low, with a considerable number of false negatives.

In sum, we conclude that the NIHSS items for screening are not recommendable. The analysis revealed a considerable number of both false negative and false positives. The clinical consequences are of importance in that a false negative may mean that a patient is not referred for further assessment and subsequent treatment in a timely fashion. A false positive test may result in unnecessary further assessment for patients with limited capacity. The balance between these two types of errors needs consideration. In a rehabilitation setting like ours, repeated screening would be one way to collect consistent results since confounding factors such as fatigue, cognitive and communication disorders, or paresis may affect assessment.

We acknowledge that there are limitations to this study. We are aware that both the NIHSS and the tests from the biVABA are screening instruments and cannot compensate for detailed examination by vision experts. We argue that the methods enclosed in the biVABA are quite similar to validation tools such as Competence, Rehabilitation Of Sight after Stroke (KROSS) (Falkenberg et al., 2024) or Vision Impairment Screening Assessment (VISA) (Rowe, Hepworth, et al., 2020) and that it is a systematic method of screening for vision impairment in stroke patients. We chose to include screening of four functions but we are aware that there are many others of importance (Rowe, Hepworth, Howard, Hanna, & Currie, 2022). We based our approach on Warren's model for vision rehabilitation which is well-known in rehabilitation settings in Norway (Warren, 1993a; 1993b). Increased focus on interdisciplinary vision rehabilitation and functional vision including user perspectives may lead to changes in approaches and assessment of stroke patients in the future (Roberts et al., 2016; Rowe, Hepworth, Howard, Hanna, & Helliwell, 2022).

Conclusion

Screening of basic visual functions early in the rehabilitation process is feasible in most stroke patients. A systematic approach in the form of a short screening battery helps the interdisciplinary team and patients to differentiate type of impairment and potential impact on visual function. This study has found that a large proportion of stroke patients show multiple deficits and indicates that visual function should be considered along with language, speech, and motor disorders during assessment and rehabilitation after stroke. The use of a screening instrument in all patients is preferred compared to relying on items from the NIHSS.

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Declaration of interest

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Screening for visuelle vansker tidlig i rehabiliteringsprosessen etter hjerneslag

Sammendrag

Pasienter med hjerneslag blir ikke rutinemessig screenet for visuelle vansker til tross for anbefalinger om viktigheten av syn for sikkerhet og utarbeidelse av rehabiliteringsplaner. Målet med studien var å undersøke om det er mulig å gjennomføre synsscreening hos rehabiliteringspasienter. Videre ønsket vi å undersøke overenstemmelsen mellom resultatene fra synscreeningen med testledd om syn og neglekt fra et nevrologisk screeningsverktøy.

Over en periode på seks måneder ble pasienter med hjerneslag innlagt på en rehabiliteringsenhet fortløpende inkludert i studien. Data om årsak, alvorlighetsgrad og lokalisering av hjerneslaget, tid siden første innleggelse, skår på National Institutes of Health Stroke Scale (NIHSS), og resultater fra en kort screening-/observasjonsbatteri ble samlet inn. Cohens kappa ble beregnet for å vurdere overensstemmelse mellom resultatene fra screeningen-/observasjonsbatteriet og NIHSS-leddene.

Nittiseks prosent av pasientene var i stand til å gjennomgå screening av grunnleggende visuelle funksjoner. Synsvansker ble funnet hos 52% av pasientene, og 67% av disse viste nedsatt funksjon i mer enn én visuell funksjon. Visuelle vansker forekom for alle alvorlighetsgrader av hjerneslaget. Redusert visus (avstand) ble registrert hos 15% av alle pasientene. Overensstemmelsen mellom screeningen-/observasjonsbatteriet og NIHSS-leddene varierte mellom $\kappa = 0,36$ og $\kappa = 0,64$. Screeningbatteriet sammenlignet med NIHSS-leddene viste nedsatt funksjon hos 31% vs. 21% av pasientene for øyemotoriske vansker, 31% vs. 34% for synsfeltutfall, og 31% vs. 29% for neglekt.

Resultatene viser at pasienter kan screenes for grunnleggende visuelle funksjoner tidlig i rehabiliteringsprosessen. Ledd fra NIHSS kan ikke erstatte et dedikert synsscreeningsverktøy, fordi vesentlige funksjoner som synsskarphet er utelukket, og øyemotoriske vansker kan forbli uoppdaget. Kun kartleggingen av synsfeltet viser betydelig overensstemmelse og høy sensitivitet. Alvorlighetsgraden av hjerneslaget hadde kun betydning for overensstemmelsen i gruppen med alvorlig hjerneslag. Samlet sett konkluderer vi at NIHSS-ledd ikke kan anbefales som erstatning for systematisk screening av visuelle funksjoner og neglekt.

Nøkkelord: visuelle vansker, slag, synsscreening, NIHSS, nevrorehabilitering

Screening dei deficit visivi in una unità di riabilitazione nelle fasi precoci del percorso riabilitativo post-ictus

Riassunto

I pazienti colpiti da ictus non vengono sottoposti sistematicamente a screening per i deficit visivi, nonostante le raccomandazioni sull'importanza della visione per la sicurezza e per la pianificazione della riabilitazione. L'obiettivo dello studio era verificare la fattibilità di effettuare uno screening visivo su pazienti in riabilitazione. In secondo luogo, si mirava ad esaminare il grado di concordanza tra i risultati dello screening visivo e alcuni elementi di uno strumento neurologico di valutazione dell'ictus (NIHSS) specificamente rivolti a visione e neglect. Nel corso di 6 mesi, i pazienti che giungevano in una unità riabilitativa dopo un ictus sono stati inclusi. Sono stati raccolti dati sull'eziologia, gravità e sede dell'ictus, tempo trascorso dalla prima ospedalizzazione, punteggi alla scala National Institutes of Health Stroke Scale (NIHSS), e risultati di una breve batteria di test di screening/osservazione. L'indice kappa di Cohen è stato calcolato per esaminare l'accordo tra i risultati della batteria di screening/osservazione e gli elementi del NIHSS.

Il 96% dei pazienti è stato in grado di sottoporsi allo screening delle funzioni visive di base. Nel 52% dei pazienti è stato rilevato un deficit visivo e il 67% di questi mostrava alterazioni in più di una funzione. I deficit visivi si sono riscontrati a tutti i livelli di gravità dell'ictus. Una riduzione dell'acuità visiva da lontano è stata osservata nel 15% dei pazienti. La concordanza tra la batteria di screening/osservazione e gli item del NIHSS variava tra □ = 0.36 e $\kappa = 0,64$. Il confronto tra batteria di screening e NIHSS ha mostrato alterazioni nel 31% contro 21% dei pazienti per i deficit oculomotori, 31

I risultati indicano che i pazienti possono essere valutati per le funzioni visive di base nelle fasi iniziali del processo riabilitativo. Gli elementi del NIHSS non possono sostituire uno strumento dedicato allo screening visivo, poiché escludono funzioni essenziali come l'acuità visiva, e i deficit oculomotori possono non essere rilevati. Solo la valutazione del campo visivo mostra una concordanza sostanziale e un'elevata sensibilità. In relazione alla gravità dell'ictus, l'accordo è stato sostanziale solo nel gruppo con forme gravi. In sintesi, si conclude che gli elementi del NIHSS non possono essere raccomandati come sostituti di uno screening sistematico della funzione visiva e del neglect.

Parole chiave: deficit visivo, ictus, screening visivo, neuroriabilitazione, NIHSS

The Pediatric Cataract Register (PECARE): Challenges in scientific evaluation of visual development

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Abstract

The purpose of this study was to analyse visual acuity tests and methods used in children who have undergone cataract surgery in Sweden as well as the success rate of visual acuity testing, in order to improve current treatment.

Children registered in PECARE who underwent cataract surgery between 1st January 2007 and 31st July 2016 were included. Visual acuity test methods were analysed at the follow-up ages of 1, 2, 5 and 10 years.

A total of 424 children were operated, 209 girls (49%) and 215 boys (51%). The number of operated eyes was 584, of which 320 (55%) were bilateral cataracts and 264 (45%) unilateral. A total of 660 follow-up visits took place, and successful visual acuity measurements were achieved in 416 of these cases: 106/228 (46%) at 1 year of age, 128/226 (57%) at 2 years of age, 169/193 (88%) at 5 years of age, and 13/13 (100%) at 10 years of age.

Visual acuity test methods differed among the follow-up clinics, making comparisons challenging. The Kasper test was widely used before the age of 2, and has been validated, but not been published scientifically. The success rate was higher for Kasper than for other tests.

A challenging diversity of methods for testing visual acuity are used in Swedish paediatric cataract care. Age-related national guidelines regarding visual acuity tests methods are needed for the development and improvement of current treatment. Scientific evaluation of visual development is an important outcome in order to reach equal care. Furthermore, the Kasper test needs to be scientifically re-validated.

Keywords: paediatric cataract, congenital, visual acuity tests

Introduction

The aim of the Swedish National Quality Registries is to improve health care by continuously evaluating treatment results as well as patient reported outcome measures. Furthermore, they are tools in the national work for securing equal care between genders and age, independently of where you live in Sweden. The registries are funded by the Swedish Association of Local Authorities and Regions (SALAR), and regular reports of health care improvements are requested. The Pediatric Cataract Registry (PECARE) highlights several challenges when scientifically evaluating visual acuity among Swedish children in general. Therefore, it can be used as a scientific example of the challenge shared by other child-related quality registries and may be shared worldwide. For instance, there is no national, Scandinavian or European, agreement regarding age-related visual acuity tests. Another challenge is that for the youngest children, there is an acceptance of not achieving a result from visual acuity testing, justified by the lack of cooperation of the child due to their young age. However, the visual acuity result is always dependent on the interaction between three parties: the child, the parent and the professional.

Childhood cataract can be congenital or acquired, unilateral or bilateral, dense or partial. It is a very rare condition, but still one of the most common causes of blindness in children worldwide (Gilbert & Foster, 2001). In Sweden, about 40 children per year are born with congenital cataract (Haargaard et al., 2015). Newborns have an immature visual system and normal visual development requires, among other things, clear ocular media. If untreated, an eye with dense cataract will become severely visually impaired due to amblyopia and often requires surgery (within the first three months), followed by numerous visits to an ophthalmology clinic for several years during childhood to enable proper visual development. Early detection and surgery is essential (Gilbert & Foster, 2001). Unlike cataract surgery for adults, cataract surgery performed on children is associated with a significantly higher rate of complications in the form of glaucoma, inflammation, secondary visual axis opacification (VAO) and retinal detachment (Chan et al., 2012). Childhood cataract surgery is centralised by the Swedish National Board of Health and Welfare, and at present St Erik Eye Hospital (St Erik), Stockholm, and Sahlgrenska University Hospital (SU), Gothenburg, hold licences for National Specialised Medical Care for children under 3 years of age. They are called regions 1 and 2 in this study. One treatment goal for cataract surgery in children is visual acuity compatible with driving licence requirements where best corrected binocular visual acuity must be at least decimal 0.5 binocularly.

PECARE is a subdivision of the Swedish National Cataract Registry and collects data on aspects of cataract surgery and outcomes from all ophthalmology units in Sweden (Lundström et al., 2002; PECARE, 2025). One goal of PECARE is to strive for equality of care among children and adults, between children in different regions of Sweden, and to ensure early detection of paediatric cataract in new-borns by continuously evaluating and optimising

current screening strategies. Other goals are to reduce surgical complications, analyse unusual treatment outcomes on a national level, and to facilitate analysis of the underlying causes of childhood cataracts (PECARE, 2025). PECARE also works to evaluate and optimise collaboration with families as co-caregivers in the treatment of children with cataracts and to disseminate new knowledge on improving care.

At present, there is no general agreement as to which visual acuity test to use in paediatric ophthalmology (Anstice & Thompson, 2014). Choices are instead guided by knowledge and tradition. In the EU, a project called Euroscreen was carried out to collect data on vision and hearing screening programmes for children in all EU countries ("Euroscreen vision & hearing", 2023). In Sweden, various forms of preferential looking tests (PL tests) such as the Teller Acuity Cards (TAC) and the Cardiff Acuity Test (Cardiff) are mainly used from 0 to 2.5 years of age, and thereafter, the Lea Hyvärinen test (LH), the Hooper Visual Organization Test (HVOT) and the Konstantin Moutakis visual acuity chart (KM chart) (Adoh & Woodhouse, 1994; Moutakis et al., 2004; Rydberg, 2013; Teller et al., 1986). As a complement to TAC and Cardiff, a new variant of PL has been developed in Sweden: the Kasper PL vision test (Kasper), consisting of test cards with stylised faces in decreasing size, which are shown until the child no longer maintains fixation ("Kasper visual test chart", 2023). See Figure 1. In addition to visual acuity measurement, electrophysiology in the form of visual evoked potential (VEP) is also used for the youngest, non-verbal children (Lyons & Lambert, 2022).

Visual acuity measured with one test cannot be compared to a value measured with another method for the same age. Since visual acuity outcome is one of many important measures of success rates in paediatric cataract surgery, there is a need for agreement on visual acuity testing within the PECARE quality register, but also in our nation. Thus, the aim of the study was to analyse visual acuity tests used in children operated for cataract in Sweden as well as the success rate of visual acuity testing, in order to improve current treatment.

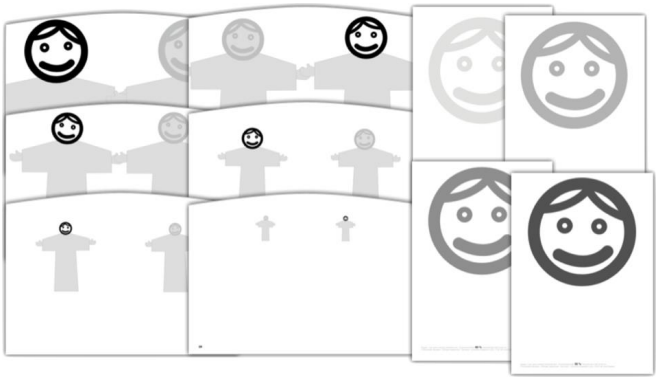

Figure 1: *Kasper PL visual test for children under 2 years of age.*

Methods

The PECARE registry was initiated in 2007 to gather data on postoperative outcome and aggravating factors among children undergoing cataract surgery before 8 years of age and has a coverage of 95% (PECARE). Demographic data, such as patient age and sex, age at time of diagnosis and surgery, surgical variables and reasons for patient referral, as well as who initiated primary contact, are reported to PECARE. Treatment outcomes as represented by visual development and occurrence of complications at 1, 2, 5 and 10 years of age are entered for each child. All measured visual acuity values are monocularly tested with glasses or contact lens correction for best corrected visual acuity (BCVA).

Children registered in PECARE who underwent cataract surgery between 1st January 2007 and 31st July 2016 were included in this study. During this period, 424 children were operated, 215 boys (51%) and 209 girls (49%), giving a M/F ratio of 1.03. Of these 160 had bilateral surgery, however, not all children with bilateral cataracts had both eyes operated. The number of operated eyes was 584 in which a total of 660 follow-up examinations were performed at the ages of 1, 2, 5 and 10 years. Of the total 584 operated eyes, 320 (55%) were bilateral cataracts and 264 (45%) unilateral. Please see Magnusson et al. (2018) for more detail.

The study was performed in accordance with the tenets of the Declaration of Helsinki as well as the General Data Protection Regulation (GDPR) and was approved by the Swedish Ethical Review Authority (reference numbers 2023–07821–02).

Results

Visual acuity tests were attempted for all children and results were achieved for 228 eyes (46%) at 1 year of age, 226 (57%) at 2 years of age, 193 (88%) at 5 years of age and 13 (100%) at 10 years of age, see Figure 2.

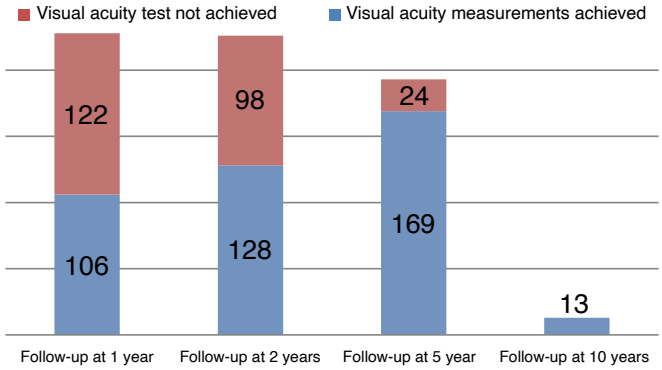

Figure 2: *Overview of the total number of visual acuity measurements achieved (blue) and not achieved (red) distributed over follow-up visits at 1, 2, 5 and 10 years of age n = 660.*

Table 1 shows the predominant visual acuity test methods at each follow-up age. At 1 and 2 years of age, the predominant methods in PECARE were TAC and what is referred to as an "other method". The "other method" is explained in free text when registering in PECARE, e.g. Cardiff, Kasper or Kay Picture tests. At the age of 5 years, the predominantly used methods were LH, HVOT and KM boards, and at the age of 10 years, KM and letter charts.

In the catchment areas of Region 1 and Region 2, i.e. the two operating clinics in Sweden, the choice of visual acuity test methods differed for the different follow-up ages. The proportion of successful visual acuity measurements at 1 year of age was slightly lower for Region 2 (38.0%) than for Region 1 (47.1%). For 1-year-olds TAC dominated in Region 1 and "other method" in Region 2. In Region 1 "other method" was in some cases described as "per-

ception", in others non-existent, i.e. "amaurosis", and for one eye the visual acuity method was not described. In Region 2 "other method" was described as Cardiff and Kasper tests, "perception", or non-existent, i.e. "amaurosis". The method was unexplained for four eyes.

Table 1: *Visual acuity tests used at different ages during follow-up visits registered in PECARE.*

	Age			
Test	1 year (%)	2 years (%)	5 years (%)	10 years (%)
Other	43.4	54.7	9.1	0
TAC	56.6	39	1.7	0
HVOT	0	0.8	32	0
LH	0	4.7	40	0
KM	0	0.8	16.6	30.8
VA letter chart	0	0	0.6	69.2

Note: VA = Visual acuity, LH = Lea Hyvärinen, HVOT = HVOT acuity chart, TAC = Teller Acuity Cards, KM = Konstantin Moutakis.

For 51.2% of the total number of eyes tested in 1-year-olds, the "other method" of the Kasper test was used.

In contrast to the follow-up at 1 year, for the 2-year-olds, the proportion of successful visual acuity measurements was higher in Region 2 (63.3%) than Region 1 (48.3%). Also, for following up the 2-year-olds TAC was predominant in Region 1 and "other method" in Region 2. The Kasper test was only used in clinics in Region 2. The total percentage of eyes in 2-year-olds measured with the Kasper test was 35.7%. In Region 1 four eyes were measured with LH, and in Region 2 one eye was measured with HVOT, two eyes with LH and one eye with KM. The "other method" was described in Region 1 as seven eyes that had "perception" or non-existent visual acuity, i.e. "amaurosis", as well as five eyes for which the method was left unexplained. In Region 2, in addition to Cardiff and Kasper, the "other method" was explained by eight eyes measured with Kay Pictures, three with KM symbols/charts, and four eyes were labelled amaurotic.

For the 5-year-olds, HVOT, LH and KM dominated with some differences between the clinics. In Region 2, HVOT dominated with 58.2%, followed by KM at 19.4%, and LH at 9.0%. In Region 1, the distribution was LH 63.4%, HVOT 12.9%, and KM 11.8%.

For follow-up of the 10-year-olds, KM and letter charts were the predominant tests. Too few follow-ups were recorded for this age group to detect possible differences between clinics.

The proportion of children with recorded developmental delay at the time of follow-up was 15.4% for 1-year-olds and 16.4% of all registered eyes at 2 years of age. In the group with unsuccessful visual acuity measurements, 22.1% had developmental delay at 1 year of age and 23.5% at 2 years of age.

No significant difference between girls and boys could be seen in this study, either in terms of the proportion of girls and boys with cataracts or in terms of the proportion that could or could not perform a visual acuity test.

Discussion

This study highlights the challenges of measuring, evaluating and comparing visual acuity in children when using a variety of different methods, especially during the first years of life. Our findings illustrate the problem that there are no European or Swedish guidelines for visual testing of children.

The strength of this study is that it is a geographically based cohort. Furthermore, the data represent all parts of ophthalmic healthcare for children in Sweden, which makes the study unique. Also, the success rate of visual testing of children under the age of 2 years in Sweden has not been investigated before, making this study an important contribution to the literature. One should bear in mind that one third of the children with cataract have a congenital syndrome or intellectual disability, which potentially could decrease the success rate.

In the PECARE register, visual acuity was successfully measured in 88% of eyes at the follow-ups of 5-year-olds, and in 100% of eyes at the follow-ups of 10-year-olds. The register only used scientifically evaluated tests at these follow-ups, which was not the case for the younger children. Visual acuity was successfully measured in fewer than 50% of the children under 2 years of age. Visual acuity measurement in children depends largely on the cooperation of the child, the skill of the examiner and the test method (Adoh & Woodhouse, 1994; Rydberg, 2013). To some extent, developmental delay can explain why visual acuity measurement was not possible in the younger children in this study, but not entirely. Nor does gender provide any explanation for the absence of visual acuity measurements. It can therefore sometimes be assumed that the age of the child determines how much visual acuity data can be collected. At the ages of 1 and 2 years, the general opinion is that children often will not accept occlusion of one eye and therefore do not cooperate in monocular visual acuity testing, which is shown in our analysis. Moreover, visual acuity testing is largely dependent on the child's ability to concentrate, which varies depending on factors such as stress, hunger and lack of sleep. It can also be speculated about whether examiners' experience and confidence in visual acuity testing of young children also vary in different parts of the country. The choice of visual acuity testing method is also likely to have an impact. Many attest to the difficulty of performing visual acuity testing on children aged 1 to 3 years, as they are easily distracted and grow tired of the examination (Adoh & Woodhouse, 1994; Rydberg, 2013). However, children with visual impairments have been found to be better at cooperating at this age than children with normal vision, probably due to the limited "visual attention area" of children with visual impairment (Rydberg, 2013). The difficulties of visual acuity testing in children under 2 years of age are reflected by the results of this study, where visual acuity was successfully measured in 46% of eyes at the 1-year-old follow-ups and 57% of eyes at the 2-year-old follow-ups.

Our study indicates that the Kasper test provides more successful visual acuity measurements in children at 1 and 2 years of age, possibly because it is more appealing for children. The test was designed with a face since newborns are better able to fixate on round shapes than straight ones and because children fixate on faces and stylised figures at an early stage (Maurer & Barrera, 1981; Morton & Johnson, 1991). Unlike many other PL tests, the test card does not have a grey half but instead has a grey low contrast face with a grey body of the same size as the black high contrast "test face". See Figure 1. The test is designed in this way to help the tester un-

derstand if the child has better visual acuity than the current card. Like the Cardiff test and the Harris stylised face test, the Kasper test is based on a stylised image, a more complex stimulus, and is thus a kind of hybrid of the striped pattern test and the single optotype test. This could possibly give more accurate visual acuity values than TAC and be better at detecting a lateral difference in visual acuity in a child with e.g. strabismic amblyopia (Harris et al., 1984; 1986).

At the eye clinic at Skåne University Hospital, the Kasper test was compared with VEP and was found to be equally sensitive in detecting as VEP. Several professionals at the clinic used the Kasper test and each detected the difference in visual acuity between the eyes. They also conducted a study comparing Kasper and TAC and found that, in general, visual acuity results were better by a line or two with TAC. However, none of these studies have been published. Furthermore, the Kasper test needs to be compared with other standardised tests and validated.

A national agreement on visual acuity testing is important for equal care, since the present study has mapped the differences found in PECARE in the choices of visual acuity measurement methods in the Swedish eye care system. The PECARE steering committee reached consensus in 2017 and has recommended the following choices of methods for visual acuity testing for different age groups: Kasper, TAC or another PL test method at < 2.5 years of age, LH at 2.5–3.5 (4) years of age, HVOT at 4–5 years of age and KM at 5–6 years of age. These recommendations are formulated in the instructions for performing the follow-up. Visual acuity is an important variable for evaluating cataract surgery in children as well as for vision rehabilitation, amblyopia treatment and evaluating the treatment of surgical complications. It is therefore of the utmost importance that there is agreement on the choice of visual acuity test method for these children. Since the present study represents all paediatric eye clinics in the country, it is likely that divergent methods are also used for children with other causes of visual impairment. The Swedish Health and Medical Care Act requires that the quality of healthcare provision must be systematically and continuously improved and assured (SFS 2017:30, 2017). To be able to conduct retrospective journal-based studies of good quality for diseases in addition to paediatric cataracts, it is desirable to have national agreement. It is likely that our findings will apply to visual acuity measurements in conditions other than paediatric cataract.

Clinical implications

Discussions should be had about which new strategies would be beneficial in minimising failures in visual acuity testing of the youngest ages. Optimising cooperation with parents is naturally of paramount importance. One strategy could be to send instructions to parents ahead of their first visit to the medical centre, asking them to prepare the child for the visual acuity test by referring to an instructional film. It is important to provide information to parents on how to minimise stress factors that reduce concentration in children during an eye clinic visit. For example, optimal food intake, leaving in good time for the visit, and preferably even having already played a game with one eye covered, as well as having played with the optotypes that will be presented during the visual acuity test, can make the situation one that is characterised by pleasure and recognition for the child. Cooperation within the healthcare team should also be optimised and should include standardised training in visual testing. Good interdisciplinary team spirit in combination with a test that is familiar to the examiner is certainly an important factor for successfully measuring visual acuity in children.

Conclusion

A challenging diversity of methods for testing visual acuity are used in Swedish paediatric cataract care. Age-related national guidelines regarding visual acuity tests methods are needed for the development and improvement of current treatment. Scientific evaluation of visual development is an important outcome in order to reach equal care. Furthermore, the Kasper test needs to be scientifically re-validated.

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Pediatric Cataract Register (PECARE): Utfordringer ved vitenskapelig evaluering av synsutvikling

Sammendrag

Formålet med denne studien var å analysere tester og metoder for måling av visus hos barn som har gjennomgått kataraktkirurgi i Sverige, samt å undersøke suksessraten for synsskarphetstesting for å forbedre dagens behandling.

Barn registrert i PECARE som ble operert for katarakt mellom 1. januar 2007 og 31. juli 2016 ble inkludert. Metoder for visustesting ble analysert ved oppfølgingsalder 1, 2, 5 og 10 år.

Totalt ble 424 barn operert, 209 jenter (49%) og 215 gutter (51%). Antall opererte øyne var 584, hvorav 320 (55%) hadde bilateral katarakt og 264 (45%) unilateral. Totalt fant det sted 660 oppfølgingsbesøk, og vellykkede visusmålinger ble oppnådd i 416 av disse tilfellene: 106/228 (46%) ved 1 års alder, 128/226 (57%) ved 2 års alder, 169/193 (88%) ved 5 års alder og 13/13 (100%) ved 10 års alder.

Metodene for visustesting varierte mellom de ulike oppfølgingsklinikkene, noe som gjorde sammenligninger utfordrende. Kasper-testen ble mye brukt før 2-årsalderen. Den er validert, men ikke vitenskapelig publisert. Suksessraten var høyere for Kasper-testen sammenliknet med andre tester.

Variasjonen i metoder for visustesting innen svensk pediatrisk kataraktomsorg er utfordrende. Alderstilpassede nasjonale retningslinjer for tester og metoder for måling av visus er nødvendig for å utvikle og forbedre dagens behandling. Vitenskapelig evaluering av synsutvikling er et viktig mål for å oppnå lik behandling. Videre må Kasper-testen vitenskapelig re-valideres.

Nøkkelord: pediatrisk katarakt, medfødt, visustester

Il Registro della Cataratta Pediatrica (PECARE): Sfide nella valutazione scientifica dello sviluppo visivo

Riassunto

Lo scopo di questo studio è stato analizzare i test di acuità visiva e i metodi utilizzati nei bambini sottoposti a chirurgia della cataratta in Svezia, così come il tasso di successo delle misurazioni dell'acuità visiva, al fine di migliorare il trattamento attuale.

Sono stati inclusi i bambini sottoposti a chirurgia della cataratta tra il 1° gennaio 2007 e il 31 luglio 2016 registrati in PECARE. I metodi di misura dell'acuità visiva sono stati analizzati alle età di follow-up di 1, 2, 5 e 10 anni.

In totale, 424 bambini sono stati operati, 209 femmine (49%) e 215 maschi (51%). Il numero di occhi operati è stato 584, di cui 320 (55%) cataratte bilaterali e 264 (45%) unilaterali. Complessivamente si sono svolte 660 visite di follow-up, e l'acuità visiva è stata misurata con successo in 416 di questi casi: 106/228 (46%) a 1 anno di età, 128/226 (57%) a 2 anni di età, 169/193 (88%) a 5 anni di età e 13/13 (100%) a 10 anni di età.

I metodi di test dell'acuità visiva differivano tra le cliniche di follow-up, rendendo le comparazioni difficili. Il test di Kasper è stato ampiamente utilizzato prima dei 2 anni di età, ed è stato validato ma non pubblicato scientificamente. Il tasso di successo è risultato più elevato per il test di Kasper rispetto ad altri test.

La gestione della cataratta pediatrica in Svezia è caratterizzata da un'ampia eterogeneità nei metodi impiegati per la valutazione dell'acuità visiva, elemento che rende complessa la comparazione dei risultati. L'elaborazione di linee guida nazionali, differenziate per fasce d'età, appare necessaria per favorire lo sviluppo e l'ottimizzazione dei protocolli terapeutici attuali. La valutazione scientifica dello sviluppo visivo rappresenta infatti un esito fondamentale per garantire uniformità ed equità di trattamento. Inoltre, il test di Kasper richiede una rinnovata validazione scientifica.

Parole chiave: cataratta pediatrica, congenita, test di acuità visiva

Kongsberg Vision Meeting: Abstracts 2025

Kongsberg Vision Meeting 2025 was held for the 17th time at the University of South-Eastern Norway in Kongsberg on October 20–21. The two-day event focused on clinical optometry and vision research, attracting more than 100 practicing optometrists, 60 final-year optometry students, and several commercial exhibitors, creating a dynamic arena for sharing knowledge and networking.

Keynote speakers included Jan Johannson (Karolinska Institute, Sweden), Hanne-Mari Schiøtz Thorud (University of South-Eastern Norway, Norway), Erik Roberstad (Interoptik Holt, Norway), and Eike Wehling (University of Bergen, Norway). The programme addressed vision problems following acquired brain damage, the expanding role and scope of optometrists in independent prescribing, and clinical approaches to headache management. A dedicated session showcased a decade of research on children's vision in Norway [The Southeast Norway Vision and Visuomotor Study (SNOW)]. Practical skills and applied research were central, with workshops on neurorehabilitation, tear duct irrigation, and binocular vision in schoolchildren. Two panel discussions addressed the evolving role of Norwegian optometrists as independent prescribers, and the importance of using diagnostic drugs in vision examinations in children and adolescents.

The Scandinavian programme was curated by Vibeke Sundling, Bente Monica Aakre, Rigmor C. Baraas, and Helle K. Falkenberg. Abstracts from invited and contributed talks are presented in the order they were given. The meeting reinforced the need for clinical innovation, evidence-based practice, and interdisciplinary collaboration to strengthen primary eye care services.

Visual function problems after brain injury

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Abstract

Neuro-optometry is a subspecialty within optometry that focuses on the connection between the visual system and the brain. It includes the assessment, identification, and management of visual disorders resulting from neurological conditions or brain injuries. The field covers areas such as eye movement control, accommodation, binocular function, visual-vestibular integration, visual perception and processing, as well as specific eye and brain-related effects seen in individuals with neurological impairment. The presentation provided an overview of visual function problems after acquired brain injury and linked them to patient needs and treatment opportunities. An important aspect is adapting the examination environment and communication style to the patient's cognitive and sensory condition. Treatment strategies are divided into two main categories: relief and restorative vision therapy. Relief aims to reduce visual strain through interventions such as tinted lenses, prism correction, and ergonomic adjustments related to visual tasks. Restorative therapy involves training to improve oculomotor control, binocular function, and visual endurance. Recent research emphasises the importance of early management of vision-related problems and the role of collaboration with other professionals involved in the rehabilitation process to optimise treatment outcomes.

The association between headaches and uncorrected vision problems in children and adolescents

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Abstract

Headaches and uncorrected vision problems are both common among children and adolescents. However, few studies have investigated the potential relationship between these two conditions. Existing research often lacks clear definitions of headache types and vision status, is not well-controlled, and frequently omits appropriate follow-up of participants. The evidence supporting a link between uncorrected vision and the development of headaches remains limited. Consequently, uncorrected vision is typically excluded from both international and national evidence-based clinical guidelines on headache management. However, cross-sectional studies suggest a possible association between uncorrected vision problems and headaches. This potential link warrants further investigation through high-quality, controlled research.

Diagnostics and Rehabilitation of post-stroke visual field loss using Innovative Visual field Evaluation — the impact of losing driving privileges (DRIVE-study) research protocol

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Abstract

It is challenging for healthcare professionals to recognise acute vision symptoms as signs of stroke. A structured vision assessment is essential to avoid stroke being identified by coincidence. Post-stroke visual field defects (VFD), without other stroke sequelae, are common after stroke, and affect stroke, survivors' right to drive. This represents a significant limitation in daily life. The driving ban is often perceived as a challenging consequence of

a stroke. In most parts of Norway, driving is essential for accessing healthcare, buying groceries, maintaining independence, and participating in society. Therefore, the loss of driving privileges poses substantial limitations to everyday life and quality of life. The Norwegian Stroke Care Guidelines recommend vision rehabilitation through compensatory scanning training to improve daily functioning by enhancing saccadic behaviour and visual search. However, there is a lack of knowledge about how vision rehabilitation protocols can be most effective, and furthermore, vision rehabilitation is not standard care offered to all stroke survivors. This study aims to gain knowledge about the effects of home-based compensatory vision rehabilitation in adult stroke survivors who have lost their driving licence due to VFD. The study is designed as a controlled, randomised, stratified trial with a semi-crossover design (ClinicalTrials.gov: NCT07147660). Participants will be randomised into either an immediate or delayed intervention group. Both groups will undergo objective and subjective baseline assessments (including vision assessments and questionnaires), followed by two post-intervention evaluations. Additionally, qualitative data will be collected through individual interviews to explore participants' experiences and expectations regarding vision rehabilitation.

Coping strategies in keratoconus

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Abstract

Keratoconus is associated with reduced quality of life, as evidenced by studies utilising patient-reported outcome measures. However, quantitative data alone may not capture the full complexity of the relationship. Qualitative research offers deeper insight into how individuals navigate the challenges of living with keratoconus. In this study, 13 individuals (six women and seven men) participated in semi-structured individual interviews to explore their experiences of living with keratoconus. The data was analysed using Systematic Text Condensation. Here, we present one of the main findings that emerged through the analysis which captured the participants' coping strategies and may influence their self-efficacy expectations. The strategies presented here reflect those most frequently described by the participants and do not constitute an exhaustive list. The first coping strategy involved the use of both optical and non-optical aids. In addition to primary vision correction, optical aids included computer and reading glasses, filters or sunglasses, and magnifiers. Participants mentioned a range of useful non-optical aids, including mobility sticks, car rear-view cameras, audiobooks, read-aloud software, and simple caps or hats for bright summer days. Other coping strategies included acquiring knowledge about keratoconus and one's own condition, as such understanding could help reduce emotional stress and worry. Participants accessed information through internet searches and YouTube videos, by consulting eye care professionals, or by reading their own patient records. Additionally, being open about keratoconus was often beneficial in the workplace, as it enabled necessary adjustments. In contrast, openness with family and friends was not always helpful, as they struggled to understand or tended to forget. Avoiding visually demanding situations and activities, such as reading, going to the movies or attending concerts, was also described as a strategy to cope. Finally, cultivating a positive outlook through personally meaningful and enjoyable activities emerged as an important strategy. These included hobbies such as knitting, listening to audiobooks, travelling, hiking, dining with friends, or riding a motorbike. While adopting a positive attitude came naturally to some participants, others described it as a continuous effort requiring daily commitment. Knowledge of coping strategies is essential for optometrists and other eye care professionals to enhance person-centred care and support individuals with keratoconus in managing their condition. Future research is needed to explore the relationship between quality of life and self-efficacy in this patient group.

Spectacles or treatment?

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Abstract

The challenges and burdens within the eye health sector are expected to increase in the years ahead. Waiting lists for treatment of common eye conditions such as cataract are growing; in some parts of Norway, the waiting time for cataract surgery is as long as 93 weeks. New treatments will further add to the workload in ophthalmology — for example, emerging therapies and medications for dry AMD, myopia, dry eye disease, and presbyopia. Eye diseases predominantly affect the elderly. Norway's population is aging, and the number of people over the age of 67 is projected to rise by almost 500 000 by 2043. In addition, the absolute number of working-age people will decline over the coming decades.

Norway already has a high and increasing number of doctors and nurses compared to neighbouring countries and the OECD average. The number of doctors and nurses per 1 000 inhabitants is 5.2 and 18.3, respectively, while the OECD average is 3.7 and 9.2. The number of ophthalmologists in Norway is also increasing (by 40% from 2012 to 2024).

The public report "Time for Action" (2023) concluded that the health sector must:

- increase the use of medical technology and digital solutions,
- enhance task sharing,
- use available competencies more effectively, and
- ensure that healthcare is delivered at the lowest safe and effective level

A report from Menon Economics concludes that optometrists can manage stable patients, particularly with glaucoma and AMD. Furthermore, task sharing with optometrists may reduce the need for travel, increase capacity in eye departments, and lead to

shorter waiting lists and better geographical coverage of ocular health services. National health service ophthalmologists and doctors currently perform around 1.6 million ocular consultations per year. Previous co-management projects within diabetes and cataract care have shown that optometrists can contribute successfully, significantly reducing both waiting times and travel burdens. A 2025 Kantar survey found that 75% of the Norwegian population believes optometrists should be allowed to prescribe topical eye drops for eye disease.

The Norwegian Optometric Association, the optometric industry, and the University of South-Eastern Norway have formed a therapeutics committee with the aim of enhancing patient care. Their goal is to develop educational programmes that empower optometrists to prescribe therapeutic medications, ensuring timely and effective treatment for individuals with eye diseases. The committee estimates that this initiative could significantly reduce the burden on ophthalmologists, potentially cutting up to one million consultations annually.

Digital co-management platforms are valuable tools for ensuring correct diagnosis and treatment for patients who require ophthalmological or interdisciplinary assessment. However, such platforms can also be time-consuming and incur extra costs for conditions that could have been managed safely and effectively at a lower level of care. In many cases, optometrists already possess the necessary skills to provide treatment independently.

Visual perception and cognition after acquired brain injury

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Abstract

Acquired brain injury (ABI) often leads to a range of visual deficits as well as associated perceptual and cognitive deficits that significantly impact the individual's daily functioning. Within rehabilitation settings, there is currently no consensus on when, or based on what symptoms, patients with visual deficits are referred to a vision specialist (ophthalmologist, orthoptist, optometrist) and how results from these examinations are integrated into rehabilitation processes. In 2016, an interprofessional model for comprehensive vision assessment and management was proposed, demonstrating how visual specialists and rehabilitation specialists could collaboratively address vision impairment; however, implementation remains insufficient.

Neuropsychologists are skilled at identifying specific visual perceptual deficits that may arise following brain injury or neurological conditions. Warren's hierarchical model of visual function emphasises the organisation of visual skills from basic to complex, i.e. from visual acuity, visual fields, and oculomotor control, up to higher-level skills such as visual attention, scanning, pattern recognition, visual memory, and visual cognition. This model underlines that understanding the interrelations of functions is crucial for neuropsychological assessment and the interpretation of results. Additionally, neuropsychologists can assess a patient's level of insight and awareness regarding their deficits. By collaborating closely with other professionals in the rehabilitation team, a neuropsychologist's knowledge can inform how interdisciplinary teams approach patients. By evaluating cognitive processes such as attention, learning and memory, neuropsychologists can provide recommendations for vision rehabilitation which may ultimately contribute to improved treatment for individuals with ABI.

A decade of research on children and vision in Norway

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Abstract

The Southeast Norway Vision and Visuomotor Study (SNOW) is a longitudinal and ongoing research study that was initiated in 2015 to investigate the development of refractive errors, visual function, and motor- and cognitive skills in children aged 7–16 years. In celebration of its 10-year anniversary, a medley of the various projects included in SNOW was presented.

Data are collected in 2nd, 5th and 10th grades within a school setting, and include cycloplegic refraction, ocular biometry, and comprehensive visual assessments. Fine motor skills (tracking, aiming, and tracing tasks) and cognitive performance (short-term memory, visuospatial memory, and processing speed) were assessed by a tablet computer that supported input through a digital stylus or finger touch.

To date, more than 3,700 children have participated, providing normative, longitudinal data across multiple time points. The results underscore the importance of cycloplegic refraction for accurate diagnosis and suggest that its omission often leads to an underestimation of hyperopia and an overestimation of myopia. The study also explores whether biometric parameters can predict cycloplegic refraction.

Overall, SNOW contributes to insights into the interaction between visual functions, motor skills and cognition in childhood, emphasising the clinical importance of accurate refraction and highlighting the broader implications of eye and visual health for learning and child development.