Novel diagnostic tools in vision rehabilitation

Chair: Bianca Huurneman, PhD
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Bianca Huurneman (PhD) received her Master's degree in Clinical Neuropsychology in 2009 at the VU University in Amsterdam. In 2009, she started working as a PhD student at the Bartiméus Institute and the Radboud University Nijmegen, investigating a phenomenon called 'crowding' in children with visual impairment. Her research is highly interdisciplinary and stands at the interface between scientific innovations and rehabilitation practice. During her PhD-project (2009-2014) she used clinical and psychophysical tasks to measure the impact of crowding on visual performance in children with visual impairment. The crowding effect appeared to be stronger in children with visual impairment than in normal controls and related to factors such as the presence of nystagmus (involuntary, oscillating eye movements) and amblyopia. After determining stimulus and observer factors that are related to crowding, she developed a paper-and-pencil training that improves near visual acuity and reduces crowding in 4-8 year olds with a visual impairment. During her first post-doc project (2014-2016), she developed a computerized perceptual learning paradigm which combined near-acuity crowded letter training with visuomotor training to reduce visual impairment in 6-11 year old children with infantile nystagmus. During these projects she encountered great inter-individual variability in treatment outcome. In the upcoming years, she plans to identify predictors of inter-individual variability in perceptual learning outcome.

Symposium Abstract

New technologies continuously see the light of day, offering also new opportunities to improve vision screening. The ideal clinical test is sensitive, specific, and objective. Other criteria for clinical usefulness are: efficiency (measurements should not take too long), facility (they should be easy to adopt), and construct validity (Dobson, 1980). A critique on many vision tests is that they heavily rely on the subjective judgement of an observer, rendering the test results susceptible to the influence of inter-rater variability, and the observer's expertise. This problem can be resolved by

adopting computerized vision tests. More than 30 years ago, Davida Teller (1983) wrote that there would be developments towards the use of computerised vision tests to screen visual functions. Advantages of computerized measurements are that they are automated, faster, and offer control over key test parameters such as presentation time (Jones et al., 2014). In addition, magnetic resonance imaging (MRI) is also arising as a diagnostic tool in Ophthalmology.

In this symposium, four talks are planned that all revolve around the same theme: finding new tools that can be used in vision rehabilitation. The first and second talks are about the use of computerized tests to assess visual processing time in subjects with infantile nystagmus, children with visual impairment and normal controls. The third talk concerns the cognitive and perceptual functions that are involved in the Useful Field of View test (UFOV). The UFOV shows relatively strong relationships with everyday activities such as driving. The UFOV might be an interesting tool for clinicians who want to assess the impact of visual impairment on daily life functioning. The last talk of this symposium reflects on the clinical relevance of structural MRI as a diagnostic and evaluative tool in Ophthalmology. In sum, this symposium offers an overview of new state-of-the-art tools in vision rehabilitation.

Lectures:

- ‘Time to see’ in infantile nystagmus (Matthew Dunn)
- A speed-acuity test to determine delays in visual processing: normative data and application in children with visual impairments (Annemiek Barsingerhorn)
- Perceptual and cognitive functions involved in the Useful Field of View test (K. Woutersen)
- Structural brain MRI studies in glaucoma: are they clinically relevant? A review of current findings (Sandra Hanekamp)

1. ‘Time to see’ in infantile nystagmus

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Introduction/aim: Infantile nystagmus (IN) is a condition constant causing horizontal ocular oscillations. It is lifelong and there is no cure. We have recently shown that, when measured using a strict psychophysical protocol, changes in nystagmus intensity have only a small effect on VA. Yet, people with nystagmus report large changes in VA following treatments to dampen the eye movements. We have developed a new test of visual function that restricts the length of time available to view stimuli, in the hopes that this will more accurately represent the visual difficulties faced by patients.

Methods: Letter VA was measured at seven exposure durations in 22 individuals with nystagmus, as well as age-matched, normally-sighted controls.

Results: Preliminary analysis suggests that VA asymptotes at presentations lasting 1 second in subjects with IN. The optimum exposure duration to elucidate nystagmus-related changes in visual function appears to be around 0.5 seconds.

Conclusion: Time-restricted VA testing may be a more sensitive test of visual function in individuals with IN, than non-time-restricted VA. This test may provide a more reliable outcome measure for therapeutic interventions.

2. A speed-acuity test to determine delays in visual processing: normative data and application in children with visual impairments.

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Introduction/aim: Visual processing speed is never tested during ophthalmic examination. However, there are children who display symptoms of slowed visual perception. Thus far there were no clinical tests available to assess visual acuity and processing speed simultaneously to quantify slowed visual perception. Our first goal was to develop such a computerized test and to establish normative values for 5-12

year-old children. Additionally, the test was used to assess visual processing speed in children with visual impairments (VI).

Methods: 104 children with normal vision (9.4±2.0 years) were included to establish normative values. Additionally, 50 children with VI performed the speed-acuity test. Children had to indicate using button presses, as fast and accurate as possible, on which side the opening of a Landolt-C was located. The test consisted of 2x90 trials with nine sizes of the Landolt-C. The size ranged from below acuity threshold to at least 0.9 LogMAR above threshold. We used a decision-making model, the drift-diffusion model, to analyse the results of the speed-acuity test. This model assumes that the brain accumulates (noisy) sensory evidence over time until the 'evidence scores' reach a decision boundary.

Results: The normative data revealed that the acuity thresholds obtained with the new test are comparable to those obtained with acuity cards. They also show that optotype size has a significant influence on the reaction times, even if the optotype size is well above threshold; reaction times decrease further as optotype-size increases until they reach a minimum. The drift-diffusion model can account for these results. Additionally, we found that children become faster as they grow older. The results of the children with VI revealed that a substantial number of these children have slower visual processing.

Conclusion: The speed-acuity test is an effective tool to determine impairments in visual acuity and processing speed in clinical populations.

3. Perceptual and cognitive functions involved in the Useful Field of View test

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Introduction/aim: The useful field of view (UFOV) test is a computerized test that measures the amount of information someone can extract from a visual scene in one glance. It consists of three subtests and its scores show relatively strong relationships with everyday activities such as driving. UFOV performance decreases in higher ages and in several visual conditions but it can be improved with training. It is still unclear which specific perceptual and cognitive functions are involved in UFOV performance. Therefore, we performed a meta-analysis of the correlations between

UFOV scores and perceptual and cognitive functions that are available in scientific literature.

Methods: We included 19 peer-reviewed articles reporting 85 Pearson's correlation coefficients in total. We divided the correlations into ten perceptual and cognitive domains, performed random model analyses for each domain, and compared the results within and across UFOV subtests.

Results: All ten domains, i.e. attention, executive functioning, general cognition, memory, spatial ability, visual closure, contrast sensitivity, visual processing speed, visual acuity and remaining visual functions, correlated significantly with at least one of the UFOV subtest-scores. Estimated correlations ranged from 0.2 to 0.6. Averaged correlations were higher for the second and third subtest than for the first subtest. Furthermore, attention and executive functioning showed significantly stronger correlations with the second and third subtest than some other functions such as visual acuity and general cognition.

Conclusion: Almost all perceptual and cognitive domains that could be included in our study were significantly related to every UFOV subtest. Higher-level cognitive functions showed somewhat stronger correlations to the UFOV scores than lower-level perceptual functions, but none of the three UFOV subtests seems to measure one clear construct.

4. Structural brain MRI studies in glaucoma: are they clinically relevant? A review of current findings

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Introduction/aim: Glaucoma is the most common age-related neurodegenerative eye disease in western society. It is an insidious disease that, when untreated or detected too late, leads inevitably to blindness. An outstanding issue is whether glaucoma should be considered exclusively an eye disease or also a brain disease. For this reason, over the past several years, numerous structural magnetic resonance imaging (MRI) studies have examined the association of eye diseases with pathway and brain changes.

Method: Here, we will review structural MRI studies performed in human patients with glaucoma. We focus on two main questions. First, what have these studies revealed? Second, what is the potential clinical relevance of their findings?

Results: The common finding in MRI studies in glaucoma is that the pregeniculate (e.g. optic nerve, chiasm, optic tract), geniculate (e.g. lateral geniculate nucleus) and post- geniculate structures (e.g. optic radiation and visual cortex) are affected. In addition, some studies revealed changes in other parts of the brain as well. This latter finding in particular indicates degeneration beyond what can be explained straightforwardly as a propagated consequence of pre-geniculate damage.

Conclusion: In our view, this implies the involvement of an independent brain factor in glaucoma. Brain involvement in glaucoma suggests that the current clinical focus on treating the eye might have to be expanded to treating the brain as well. Future structural MRI studies can contribute to (i) further establish relationships between ocular and neurodegeneration disorders, (ii) investigate whether brain degeneration in eye diseases is reversible, (iii) evaluate the use of neuroprotective medication in ocular disease, and (iv) establish structural MRI examination as a diagnostic and evaluative tool in ophthalmology.