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## Characteristics of Benign Positional Vertigo Tested on the Epley Omniax Chair

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**Purpose:** To describe the spatiotemporal characteristics of BPV and its variants.

**Methods:** We studied 2559 consecutive patients referred to a neuro otology clinic dedicated to the management of BPV. Patients were tested on the Epley Omniax Rotator, a positioning device which allows alignment of the patient in the plane of any given canal and simultaneously display and records video oculography. Video data was extracted and analysed offline using a custom written LabVIEW programme. Nystagmus onset, duration and slow phase velocities were analysed.

**Results:** BPV was diagnosed in 1207 subjects: 814 had unilateral posterior-canalithiasis while 167 had bilateral posterior-canal involvement and 72 patients had more than 2 canals affected; 96 patients had horizontal-canal BPV. In 11 patients anterior-canal BPV was found. In PC BPV, nystagmus onset occurred before 1second in 73% subjects. Nystagmus duration was 13.4 sec (median). The median peak-SPV was 32.4/sec. In horizontal-canalithiasis with the affected ear down, nystagmus onset was <1s in nearly all subjects. Nystagmus lasted for 22.5 sec (median) and peaked at 56.8/sec(median). When the unaffected ear was lowermost the nystagmus duration was similar 25 s (median) and peak-SPV 18.1/sec. In all subjects with canalithiasis, the time taken for the peak-SPV to halve (T50) was <60s. In contrast, subjects diagnosed with vestibular migraine (n=334) had persistent vertical or horizontal positional nystagmus with a T50 that exceeded 60s.

**Conclusions:** Canalithiasis uniformly demonstrated a crescendo decrescendo SPV profile. Symptomatic horizontal or vertical positional nystagmus recorded in canalithiasis could be separated from horizontal positional nystagmus recorded in vestibular migraine

## **BBPV App**

Anne Burston, MHealSc (Rehab), MPNZ

BPPV Relief is an App developed as an educational tool for Health Professionals who treat BPPV and teach other Health Professionals. It can be used to educate patients about BPPV and for patients to more easily follow repositioning manoeuvres given as home exercises under the guidance of a Health Professional.

The tests and treatments are all commonly used and follow evidence based recommendations by the Clinical Practice Guideline for BPPV updated in 2017 by the American Academy of Otolaryngology- Head and Neck Surgery Foundation. They are presented in easy to follow and interactive animations.

Animations show how to perform The Dix-Hallpike, Side Lying and Roll tests to test the posterior and horizontal canals. Each animation shows the correct direction of nystagmus seen with a positive test.

Animations show how to perform the common treatment manoeuvres for posterior and horizontal canals. They also show the semicircular canals moving in the same plane as the head with the crystals moving around and out of the canal during each manoeuvre.

This App will help Health Professionals improve their diagnostic skills and clinical reasoning when treating BPPV.

BPPV Relief has been developed by a New Zealand Physiotherapist with 18 years experience treating BPPV and her son who is an App developer.

## Vestibular Migraine presenting with Acute Peripheral Vestibulopathy: clinical, oculographic and vestibular test profiles.

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**Objective:** To describe clinical, oculographic and vestibular test profiles of eight subjects with vestibular migraine who presented with acute peripheral vestibulopathy.

**Methods:** Vestibular migraine was diagnosed according to Neuhauser and the Bárány Society criteria. A history, neuro-otological examination, video head impulse testing (vHIT), cervical and ocular VEMPs (cVEMP/oVEMP) to air-conducted clicks and bone-conducted vibration, subjective visual horizontal (SVH), audiometry and Magnetic Resonance Imaging (MRI) were undertaken in all subjects.

**Results:** Six subjects presented to the Emergency Room and two to a rapid access neurology outpatient facility with vertigo that exceeded 24 hours in duration. Seven had a history of previous episodes of vertigo associated with headaches. Two reported monaural high-pitched tinnitus. None had hearing loss. All had primary position unidirectional horizontal spontaneous nystagmus (slow phase velocity 4-36 deg/s). On vHIT, all had horizontal semi-circular canal dysfunction with reduced gain (0.56-0.8). CVEMPs were normal in 71% and asymmetric in 29% (average asymmetry ratio=28.4%). OVEMPs were normal in 12.5% and asymmetric in 87.5% (average asymmetry ratio =76.2%). SVH showed an abnormal bias in 57% (range 3.3°-5.9°). Audiometry and MRI brain were normal in all. Subjects were followed up over 1-7 years with no change in the final diagnosis.

**Summary:** Vestibular Migraine can sometimes present as an acute peripheral vestibulopathy with findings that mimic vestibular neuritis and should be considered in the differential diagnosis of acute prolonged vertigo.

## **Episodic Ataxia type 2 causes combined cerebellar ataxia and bilateral vestibulopathy**

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**Objective:** To quantify bilateral vestibular loss in Episodic Ataxia type 2 (EA2).

**Method:** Eye movement was recorded with video-oculography in 4 patients from the same family with genetically confirmed EA2. We recorded gaze-evoked nystagmus at horizontal 20° eccentric gaze, determined individual semicircular canal function (SCC) as evoked by the head impulse test (HIT), and visually enhanced vestibulo-ocular reflex (VVOR).

**Results:** Gaze-evoked, direction changing nystagmus was present in all patients. Individual SCC function, particularly horizontal canal function, was variably and bilaterally impaired. Both covert and overt catch up saccades were present. VVOR was affected, with bursts of multiple catch-up saccades.

**Conclusion:** EA2 causes combined cerebellar ataxia and bilateral vestibulopathy. It should be considered as a key differential diagnosis of cerebellar ataxia with neuropathy and vestibular areflexia syndrome.

## **Single dose gentamicin vestibulotoxicity: one hit disaster**

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### **Abstract**

Gentamicin vestibulotoxicity (GV) causes variable degree of bilateral vestibulopathy (BV)(1) and is not related to dose or serum level. GV after single dose of gentamicin is rare, occurring in about 5% of GV(2). We describe 4 cases of BV after single dose of gentamicin, confirmed by medication chart review and video head impulse test evidence of bilateral loss of semicircular canal function. All patients were given gentamicin non-emergently, often prophylactically during planned, elective surgical procedure. All noticed symptoms after treatment of gentamicin. Time to diagnosis was variable, but typically months to years. Whilst one-hit GV is uncommon, clinician should discuss this potential yet devastating complication before planned, elective surgical procedure where prophylactic gentamicin is routinely administered.

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## Virtual Reality for Vestibular Education, Testing, and Rehabilitation

Hamish MacDougall and Elodie Chiarovano

Virtual reality has a long 50 year history but is currently undergoing an explosion in development, investment and publicity due to the convergence of various technologies which capitalise on the developments in smart phone and computer gaming technology. High resolution and low persistence displays, tiny inertial motion sensors, powerful graphics processing units and clever algorithms have solved the problems of visual-vestibular mismatch which previously caused motion (cyber) sickness. Head mounted displays, hand controllers and tracking systems are now manufactured for the domestic mass-market and provide compelling emersion with wide field-of-view, spatially localised sound and some haptic feedback. With the economies of scale prices have dropped to a few thousand dollars for room-scale systems and just a few hundred dollars for portable stand alone solutions.

In the Virtual Reality OpenLab at the University of Sydney we have developed free Virtual Reality applications for vestibular education, testing and rehabilitation that use readily available consumer VR equipment rather than the specialised hardware interfaces that have previously hampered distribution at scale.

For education we use virtual reality to visualising complex 3D data for anatomy, physiology and virtual surgical planning, and to improve understanding and empathy through exposure to simulated vestibular attacks for those that support patients. For vestibular testing we have developed virtual versions of the subjective visual vertical test, visual perturbations useful in balance testing, etc. For rehabilitation, we have made visual stimuli including optokinetic clouds (for balance training), striped rotating drums (potentially useful in the treatment of MDDS), and modelled various environments that vestibular patients find challenging (to develop coping mechanisms and strategies with gradual and controlled exposure). In this presentation we will demonstrate with live virtual reality, many of these exciting now applications and free downloadable applications.

Debate The caloric test has been superseded by the vHIT and is no longer of value except for Meniere's disease

Retrospective data analysis of the Activity-Specific Balance Confidence Scale across vestibular diagnostic groups with a focus on the comparison of patients with PPPD.

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**Background:** The Activity-Specific Balance Confidence Scale (ABC) is a subjective measure of balance confidence that has been well validated in individuals with vestibular disorders but not yet compared across specific vestibular diagnoses. A score of 0% indicates the individual has no confidence in performing a task without falling or becoming unsteady, whilst a score of 100% indicates complete confidence. Lower ABC scores correlate with higher fear of falling and higher falls risk.

**Objectives:** The purpose of this study was to compare admission ABC scores across diagnostic groups and sites for patients presenting to three vestibular physiotherapy clinics. The study also aimed to evaluate the balance confidence of individuals with Persistent Postural Perceptual Dizziness, PPPD compared to other diagnostic groups to see if this patient group showed lower scores, reflecting the complex nature of the condition.

**Design:** Retrospective sample at multiple sites

**Participants:** Individuals presenting to the vestibular physiotherapy outpatient services at three separate metropolitan public hospitals in south east Queensland. Referrals were made directly to vestibular physiotherapy, or diverted from specialist outpatient waiting lists (ENT and Neurology). Individuals were categorised into a vestibular diagnostic group at completion of bedside examination and/or vestibular function testing. Inclusion criteria: individuals who had completed the ABC on admission.

**Method:** Participants completed self-administered questionnaires prior to their initial physiotherapy appointment. Retrospective data from 2012-2018 was compiled based on recorded diagnosis, site and ABC scores. Comparison across sites was completed for each diagnosis initially using both ANOVA and nonparametric Independent Sample Kruskal-Wallis Testing (KWT). Since the results for mean ABC scores across sites were found to be statistically the same, the means were pooled in One Sample t testing to consider the mean ABC scores of the PPPD patients in comparison to those of the other diagnostic groups.

**Results:** A total of 790 patient records were obtained and grouped according to site: Gold Coast University Hospital [GCUH] (n = 101), Logan Hospital [LGH] (n = 388) and Royal Brisbane and Women's Hospital [RBWH] (n = 301). Of these 790, 597 patients met inclusion criteria (GCUH n = 101; LGH n = 213; RBWH n = 283) and were included in the analysis. The following seven diagnostic categories emerged: Benign Paroxysmal Positional Vertigo [BPPV] (n = 180), Unilateral Vestibular Hypofunction [UVH] (n = 224), Persistent Postural Perceptual Dizziness [PPPD – functional disorder] (n = 52), Meniere's Disease [MD] (n = 31), Bilateral Vestibular Hypofunction [BVH] (n = 26) and Other (n = 399). No significant difference in mean ABC scores was found across the sites for either diagnostic group.

When considering PPPD specifically, given that the ABC scores were considered statistically the same across the three sites ( $p=0.836$ ), the means were pooled and compared to other diagnoses. A statistically significant difference was shown between PPPD and all the alternate diagnoses except for BVH ( $p = <.001$ ).

**Conclusion:** A significant difference was identified in comparing the pooled mean ABC scores of PPPD patients with all other identified diagnostic groups, with the exception of BVH. The findings of our study therefore support our hypothesis that patients with PPPD (and BVH) typically require more extensive intervention compared with other diagnoses, given the complex nature of the condition and the increased risk of falls. Based on these findings, we can report that the ABC score is a helpful tool in diagnosing PPPD especially once the diagnosis of BVH has been eliminated.

## Are the late bone-conducted cVEMP peaks stretch reflexes?

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**Introduction:** While the early, vestibular-dependent peaks of the bone-conducted (BC) cervical vestibular evoked myogenic potential (cVEMP) have been well-studied, the origin and response characteristics of the longer latency components of the waveform are not known. It has been suggested that the late peaks represent a vibration- or tap-evoked stretch reflex of the sternocleidomastoid (SCM) muscle. We tested this hypothesis in a group of normal subjects.

**Methods:** We tested 12 normal subjects using three main BC stimuli: tendon hammer taps and 5 ms tone bursts delivered at 100 Hz and 500 Hz with a Minishaker. We compared two stimulation sites, forehead and sternum - aiming to produce differential stimuli for the vestibular and non-vestibular peaks. We expected forehead stimulation to activate both vestibular and stretch receptors, while sternum stimulation should preferentially activate stretch receptors. cVEMPs were recorded from the SCM muscles and triaxial acceleration was measured from behind the right ear and over the lower third of the right SCM. We also looked for differential effects of frequency (100, 200, 500 and 1000 Hz tone bursts), muscle contraction strength (at rest, medium and strong contractions) and the Jendrassik manoeuvre (a technique used to enhance stretch reflexes) on the early and late cVEMP peaks using forehead stimulation. Threshold was measured in 2 subjects.

**Results:** Mean acceleration measured behind the ear was greater following forehead than sternum stimulation (e.g. 0.16 vs 0.02 g for 100 Hz), suggesting that the experimental paradigm provided differential stimulation to the vestibular receptors. Forehead stimulation produced an early positive-negative wave (p1-n1, i.e. cVEMP) followed by a negative-positive wave (n2-p2, i.e. putative stretch reflex), while sternum stimulation produced a series of six peaks beginning with a small negativity. The initial peak produced by forehead stimulation (p1) was larger than that produced by sternum (n1) stimulation (ratio = 4.3-4.8, effect size  $d = 2.1-2.5$  across stimuli). In contrast, the same comparison performed on putative stretch peaks at both stimulation sites (n2 vs n2) showed a similar, but smaller, difference (ratio = 1.1-2.6,  $d = 0-1.7$ ). Comparison of the peaks at a matched level of mastoid acceleration (0.125V stimulus at the forehead vs 1V at the sternum) showed similar amplitude for the initial, presumed vestibular, peaks. In contrast, the late, presumed stretch, peaks were much larger following sternum stimulation. There were no differential effects of frequency, muscle contraction strength or Jendrassik manoeuvre on the early and late cVEMP peaks.

**Conclusion:** The late peaks were less affected by stimulus location than the early peaks, but were still larger following forehead stimulation, suggesting that they are somewhat mediated by vestibular activation. The results suggest that the later BC cVEMP peaks are likely to be a combination of stretch and vestibular reflexes.

## Isolated positional vertigo of vascular origin

G. M. Halmagyi, Royal Prince Alfred Hospital, Sydney

A male 62 without vascular risk factors, tying his kayak to the roof of his car experienced brief isolated vertigo. That night he awoke with vertigo and vomiting. In the emergency room no abnormalities were found; the diagnosis was BPV. Two days later he had more vertigo, now spontaneous, with vomiting and headache. He now had total horizontal ophthalmoplegia. CT angiogram showed total occlusion of the left intracranial vertebral artery. He then developed hemiplegia and apnea. MRI showed bilateral medial medullary and dorsal pontine infarcts. After a month in ICU and 3 months in rehabilitation he went home.

A male 61 with pulmonary fibrosis developed vertigo while drinking from a can. In our emergency room he had, sitting upright, right-beating spontaneous nystagmus. Three hours later the vestibular examination was normal. CT angiogram showed stenoses in both distal vertebral arteries and the proximal basilar. LDL cholesterol was high. With atorvastatin+clopidogrel+aspirin and has had no further cerebrovascular symptoms after 18 months.

Isolated vascular vertigo, positional or spontaneous is rare but dangerous. Patients are rarely seen by a neuro-otologist during the attack so the diagnosis is based on history. They are difficult to distinguish from common benign aural causes isolated vertigo attacks. Once the attacks start there is a stroke is likely within a week; the patient who has had many attacks and is only seen weeks later is unlikely to have this problem.

A case presentation. imelda hannigan imeldahannigan@hotmail.com

From the clinic of Dr. Shaun Watson, Sydney.

Presented by Imelda Hannigan Clinical nurse specialist

A sixty one year old lady presented to our neuro-otology clinic for vestibular function tests, after 2 weeks of vertigo, which she described as worse lying to the right in bed. She had vomiting on and off in the first few days but now complains of nausea and severely off balance. She reports a left sided headache, that seemed to begin at the same time as the vertigo. The pain radiates to her neck and left scapular region and is significantly worse when she brushes her teeth. About 3 months earlier, purely by chance, she noticed her left hearing had decreased but really didn't know how long it had been like this. She reported some minor tinnitus at that time and it seemed to resolve over the subsequent 2-3 days. No associated otalgia or aural fullness reported. No audiology had been performed at that time.....

**Kim Hawkins**, Ian Curthoys, Elodie Chiarovano, Hamish MacDougall, Serene Paul.

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### **Background.**

People with Parkinson's disease (PD) have been shown to have a higher falls risk than age matched controls [1, 2]. As postural instability is one of the cardinal motor features of PD (along with tremor, freezing, bradykinesia and rigidity), understanding whether vestibular dysfunction plays a role in postural instability and falls in people with PD may help to inform more targeted falls prevention and management strategies. Previous studies have found increased rates of vestibular dysfunction in PD as measured by calorics [3] and more recently by cervical and ocular vestibular evoked myogenic potentials (cVEMP and oVEMP) [4]. Vestibular dysfunction thus may be one of the multiple non-motor features of this neurodegenerative disease which could be contributing to the PD population's elevated falls risk.

**Methods:** This prospective observational study will include 40 people with idiopathic PD and 40 healthy age matched controls (aged 50-79 years). A 12-month retrospective falls history and Falls Efficacy Scale will be recorded. Vestibular function and balance assessment will be quantitatively assessed using a 'mobile balance laboratory' including oculomotor function, vHIT (all 6 canals) and SHIMPS;  $\mu$ VEMP oVEMP and cVEMP (clicks and tendon hammer taps); SVV using Curator App[5]; BalanceRite balance assessment with virtual reality with visual mismatch[6]; gait speed, presence of orthostatic hypotension and lower limb joint position matching test. Parkinson's Disease specific measures, the MDS-UPDRS section 3, Hoehn & Yahr Stage (H&Y), New Freezing of Gait Questionnaire and Levodopa daily equivalent dose will also be recorded.

**Results:** Data has, so far, been collected for 15 subjects with PD (MDS-UPDRS 3 scores range 16- 63, H&Y 1-3) and 20 age matched healthy controls. Preliminary data suggests that horizontal canal vHIT gains are similar in both groups, in contrast to Lv et al (2017)[7], and that participants with PD have a tendency to fall at lower amplitudes of visual mismatch via VR stimulation compared to healthy controls, especially those PD subjects who experience freezing of gait when walking. Some of the challenges of vestibular testing in older subjects and participants with PD will be discussed.

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## Abstract

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### Tone Burst Electrocochleography to Separate Meniere's Disease and Vestibular Migraine

Meniere's disease and vestibular migraine are the most common causes of recurrent vertigo attacks. There is a long controversy as to whether they are separate or co-causal conditions. There is no diagnostic test for vestibular migraine. Transtympanic tone burst electrocochleography (TB EcochG) to detect cochlear endolymphatic hydrops is the simplest, quickest, cheapest and most sensitive test for Meniere's disease. In general TB EcochG and MRI inner ear imaging show that in Meniere's disease there is inner ear hydrops and in vestibular migraine there is not. A case is presented of vestibular migraine where TB EcochG disproved Meniere's disease in a patient who had been given 5 intratympanic treatments of dexamethasone and gentamycin for an assumed diagnosis of Meniere's disease.

Evaluation of nonorganic vestibular symptoms using both neuropsychological and posturography assessment

Andrea Kilgour PhD

Beth Lange MD FRCSC

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Suresh Subramaniam MD FRSCSP

Abstract:

Accurate diagnosis depends on patient ability to report symptoms and demonstrate clinical signs in a valid manner. Performance validity testing for both domains of neuropsychological and posturography testing is well established. The purpose of this study was to compare scores on two measures of performance validity across cognitive and balance paradigms. 67 patients underwent both neurovestibular and neuropsychological assessment. We present our results which agree with previously published research, that if symptom magnification occurs within one clinical domain, other domains may also show exaggeration, and should be independently evaluated

## **Biomarker-enhanced virtual reality-based platform for assessing motion sickness susceptibility**

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**Introduction:** Motion sickness (MS) is a relatively common occupational hazard in aviation and space exploration. One reason for this is a lack of simple and cost-effective method of assessing MS susceptibility that could be used during recruitment; MS desensitization programs are expensive and time-consuming. Exposure to provocative VR content readily elicits MS (“cybersickness”), and it may be that VR technology could be used for both identification of MS-susceptible individuals and for MS desensitization. To advance this idea, two issues should be first clarified: i) whether sensitivity to VR provocations reflects sensitivity to vestibular provocations; and ii) whether cybersickness is clinically identical to a “classic”, motion-induced motion sickness. Consequently, our aim was to fill these gaps of knowledge.

**Methods:** A cohort of 30 young healthy volunteers was exposed to both vestibular (Coriolis cross-coupling) and VR (virtual ride on a roller coaster) provocations in a counter-balance order on different days. Nausea scores were recorded during the exposure, and Motion Sickness Assessment Questionnaire (MSAQ) was used to profile subjective symptoms. Tonic and phasic forehead skin conductance level (SCL) was measured before and during exposure.

**Results:** Nausea onset times and maximum nausea ratings correlated during both provocations ( $r=0.40$ ,  $p=0.03$  and  $r=0.56$ ,  $p=0.0012$ , respectively). Symptom profiling with the MSAQ revealed substantial and significant correlations between total symptom scores ( $r=0.69$ ,  $p<0.0001$ ) and between 15/18 individual symptoms assessed in both conditions. Both provocations caused increase in tonic and phasic SCL activity associated with nausea, with a reasonably close correlation between the conditions ( $r=0.48$ ,  $p=0.04$ ).

**Conclusions:** Similarities in sensitivity to both provocations, and in clinical profile and physiological changes occurring during VR-induced and “classical” motion sickness suggest that using VR technology might be a promising approach for identification of MS-susceptible individuals and for MS desensitization.

# The video Head Impulse vs the Suppression Head Impulse, compared to visual dependency in Normal Subjects.

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## Purpose

In the sHIMP paradigm, the visual system is working against the VOR driven by the vestibular system. The purpose of this experiment was to determine if the gain reduction seen in some normal subjects, between the HIMP and sHIMP, was related to visual dependency. In this case, a measure of static visual dependency was determined by the effects of a tilted visual frame on the static visual horizontal (or BIAS) test.

## Methods

12 Normal subjects were tested with horizontal HIMPs and sHIMPs at the standard target distance of 120 cm. The vertical LARP and RALP impulses were also carried out to ensure normal function.

A measure of visual dependency was obtained by placing the 12 subjects in a totally dark room and testing their subjective visual horizontal settings in response to a leftward and rightward, 15 deg tilted, faint visual frame made with luminous tape.

## Results

At 120 cm target distance, there was a significant decrease in horizontal gain between the HIMP and the sHIMP gains (eg 6% decrease for leftward impulses in the 180 to 220 deg/sec band).

However, the data also showed great individual variability, with some subjects having no difference between HIMP and sHIMP responses.

Likewise, there was a large variation in the SVH settings, ranging from no effect to 8 degrees of offset in response to the tilted visual frame. But there was no clear relationship between the amount of SVH offset and the amount of visual suppression of the impulse gain during the sHIMP.

## Conclusions

The static “visual dependency” indicated by the SVH offset does not predict the amount of gain reduction between the HIMP and the sHIMP in a given individual. This may be due to the SVH being a static task versus the dynamic nature of the HIMP/sHIMP interaction.

# The video Head Impulse vs the Suppression Head Impulse in a patient tracked over 500 days during recovery from a second Neuritis attack.

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## Purpose

To examine the interaction between the HIMP and sHIMP gains, and the complementary catch-ups, as the patient's peripheral function levels recover and to compare these results to the data from normal subjects.

## Methods

A male subject (D.O.B. 1967) presented in October 2014, when a 3-d vHIT and SVH (Bias test) were used to diagnose left Neuritis. The subject presented again in March 2017 with a right sided loss. He was then tracked until the end of July 2018, after which he left the country.

## Results

The primary result is that the recovery of peripheral function, as measured by the tests, can occur over very different time scales for different aspects. For example, the SVH (Bias) returns to normal within 6 weeks, while the higher head velocity HIMP responses to the affected side were still increasing at the end of the monitoring period. Catch-up saccade patterns varied with the changes in peripheral gain.

Horizontal impulses (189 to 220 deg/sec) towards the left (the side with the 2014 problem), consistently produced a gain of between 0.5 to 0.6, with a reduction in gain between the HIMP and sHIMP of 25%. To the right, however, while the HIMP gain climbed from 0.14 to 0.67, the sHIMP gain reduction decreased from an initial 50% to 25% at 500 days.

During the final year of testing, the subject was also tested at a target distance of 50 cm as well as 120 cm, which exposed an interesting asymptote in the distance mediated gain change.

## Conclusions

The primary conclusion to be taken from this study is that aspects of peripheral function can continue to improve over a long time scale and, as such, the patient will continue to feel "that they are not right yet". Stability of function seems to be a major prerequisite for a feeling of "recovery".

# Vestibular Event Monitoring in the Emergency Room

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**Aims:** To assess the merits of a structured assessment and vestibular event monitoring in the emergency room

**Methods:** We present 100 non-consecutive patients presenting to a tertiary hospital emergency department with acute vertigo, during a 6 month period. Each patient was assessed using a structured history, neuro-otological examination and video nystagmography by the neuro-otology fellow. Patients with acute spontaneous vertigo also underwent video head impulse test, vestibular evoked myogenic potentials, subjective visual horizontal and an audiogram. Data was compared against retrospective analysis of the records of 114 consecutive vertiginous subjects who underwent assessment as per standard Emergency Room protocol.

**Results:** For the structured assessment group, mean age was 58.7 and 48% were female; 64% presented with acute vestibular syndrome (AVS), 18% with episodic vertigo syndromes (EVS), and 15% with recurrent positional vertigo (RPV).

For the AVS (n=64), 26.5% were diagnosed with stroke/TIA, 39.1% with vestibular neuritis, 17.2% with vestibular migraine; the remaining 6.3% were other diagnoses or undifferentiated. Spontaneous nystagmus was seen in 62.5% of cases. For VN, 100% of subjects had spontaneous horizontal nystagmus, mean ipsilesional and contralesional HC vHIT gains were 0.57 and 0.95 respectively. The average subjective visual horizontal value was 8.1 degrees, Mean AC cVEMP and BC oVEMP asymmetry were as 37.09% and 30.6%

For stroke (7 PICA, 1 AICA, 2 SCA, 2 paramedian pons, 3 DWI negative, 1 MCA) 44% subjects had spontaneous nystagmus (6 horizontal, 1 vertical), mean ipsilesional and contralesional HC vHIT gains were 0.97 and 1.01. The average subjective visual horizontal value was 3.7 degrees, Mean AC cVEMP and BC oVEMP asymmetry were 18.3% and 12.7% respectively.

For VM, 36% of subjects had spontaneous nystagmus, mean HC vHIT gains were 1.05 (right) and 0.96 (left). The average subjective visual horizontal value was 2.1 degrees. Mean AC cVEMP and BC oVEMP asymmetry were as 12.9% and 6% respectively.

For EVS group (n=18), the diagnoses were VM in 66.6%, uncertainty between VN and MD in 11.1% and other diagnoses in 22.2%. 6% had spontaneous nystagmus, 33% had positional nystagmus, mean vHIT gains on the right and left lateral canal were 1.02 and 0.89 respectively.

In the recurrent positional vertigo group, 69% had posterior canal BPPV (45% on right and 55% on left), 17.6% had horizontal canal, 11.8% had a normal examination and 5.9% had probable vestibular migraine. Overall in this group, a diagnosis was reached in 92% of cases.

There were 114 patients in the ED control group, 62.3% were female. Mean age was 51.9. In this group, 52.5% of patients were had vertigo lasting seconds or minutes, 25.4% lasting hours, 5.2% lasting days or longer and in 16.7% of cases the duration of vertigo was not specified. The diagnoses included BPV in 42.7%, Labyrinthitis/vestibular neuritis/peripheral vertigo in 11.3% and central vertigo in 1.7%. The diagnosis was uncertain in 43% of cases in this group. 57% of cases received a formal diagnosis. Half of the subjects diagnosed with Vestibular neuritis or labyrinthitis did not have a head impulse test. 12% of cases diagnosed with BPPV were not tested for positional nystagmus. When these were excluded, a final diagnosis was reached in 49%

## Conclusion:

A structured history, examination and event monitoring secured a diagnosis in 92% of cases compared with 49% for the Emergency Control group, reinforcing its value in frontline.

## Acute isolated vertigo due to vestibular nuclear infarction

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### Abstract

Acute central lesions can closely mimic peripheral vestibulopathy and present a diagnostic challenge (Kim & Lee, 2010) (Kim, et al., 2014). An unusual pattern of semicircular canal (SCC) deficit involves selective involvement of horizontal (HC) and posterior canals (PC), with sparing of the anterior canals (AC) (Kim, et al., 2014; Chen & Halmagyi, 2018). We report a case of an 84 year-old woman with a history of hypertension and paroxysmal atrial fibrillation, who presented to hospital with first attack of acute prolonged vertigo, gait ataxia and bilaterally abnormal head-impulse test (HIT). The spontaneous, right beating nystagmus was transient, resolving over hours. There was no skew deviation. She had no other focal neurological or audiological findings. MRI brain demonstrated acute infarct in the left lateral medulla, in the region of the medial vestibular nucleus. Video HIT demonstrated selective impairment of PC function, with preservation of HC and AC function. Small catch-up saccades were recorded during right HC impulses, despite normal gain. The AC afferents project to both superior and medial vestibular nuclei, so a selective lesion may “skip” AC afferents and present with only HC and/or PC deficit. Strategically placed small brainstem stroke can present with isolated vertigo, rapidly resolving spontaneous nystagmus and unusual pattern of SCC deficit, which can now be rapidly detected by portable video-oculography.

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## **Advanced Scope Practice of Vestibular Rehabilitation as an Alternative Pathway to Traditional Medical Models of Care**

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**Concept/Relevance:** In Queensland Health, Vestibular Rehabilitation by Physiotherapists practicing within an advanced scope of practice has been introduced and found to be effective. This nationally innovative practice manages referred patients with dizziness as an alternative to traditional medical pathways in public hospital settings.

**Background:** A 2013 Ministerial Taskforce prompted lead Queensland Health sites to develop innovative Vestibular Rehabilitation models of care to assist in driving specialist outpatient waits down. Two primary contact models of care were used by the Vestibular Collaborative Project to inform 12 Queensland Health implementation sites. These alternative Vestibular Pathways function to reduce outpatient waits and increase throughput, manage patients appropriately, and collect data for clinical/service justification, while achieving service sustainability through ongoing clinical education.

**Outcomes:** Data from the vestibular rehabilitation services of the Royal Brisbane and Women's Hospital, Princess Alexandra Hospital and Gold Coast University Hospital, using a combination of primary and secondary contact physiotherapy, demonstrates significant improvements in service outcomes, patient outcomes, and patient satisfaction. Considering the RBWH Vestibular Physiotherapy pathway for example, mean waits for outpatients reduced significantly from 415.3 days (442.53) in 2014 to 93 days (219.38) in 2017, while 95.2% of the 271 patients seen from 2013 to 2017 were discharged without needing an Ear Nose and Throat consultant review. Rated using a visual analogue scale, mean outpatient satisfaction scored 8.2 (3.01) in 2014, rising to 9.3 (0.86) in 2017. Clinical outcomes of the three metropolitan hospitals demonstrated safe clinical effect, in line with Cochrane Review evidence.

### **Take home messages:**

Pathways involving Vestibular Physiotherapy operating within an advanced scope of practice can safely divert public hospital outpatients from specialist outpatient waitlists, allowing earlier assessment and treatment. Patient subjective and objective outcomes demonstrate high patient satisfaction and clinical effectiveness.



# **A Systematic Review of the Reported Proportions of Diagnoses for Dizziness and Vertigo**

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## **Abstract**

**Objectives:** To determine the typical proportions of diagnoses for patients presenting with dizziness or vertigo based on clinical speciality and to assess the change in proportions of diagnoses over time.

**Data Sources:** Following PRISMA guidelines, systematic searches of PubMed and CINAHL databases and follow-up reference searches were performed for articles published in English up to October 2016.

**Study Selection:** Analysis of searches yielded forty-two studies meeting the criteria of case series of adult patients with dizziness and/or vertigo presenting to general practice, emergency departments or specialist outpatient clinics.

**Data Extraction:** Data comprising demographics, diagnostic cases, and the total number of cases were recorded and independently tested, followed by a risk of bias analysis.

**Data Synthesis:** Sample size weighted proportions expressed as percentages with confidence intervals were calculated and compared using Chi Squared analysis and a reference proportion formed by the combination of Ear Nose and Throat and Neurotology case series published between 2010 and 2016. Analysis of diagnostic trends over time employed Poisson Regression with consideration for overdispersion.

**Conclusions:** This systematic review of case series demonstrated significant differences in the proportions of diagnoses for patients presenting with dizziness or vertigo, depending on the specialty making the diagnosis. ENT proportions were dominated by BPPV, Psychogenic and Meniere's Disease diagnostic categories, whereas Emergency proportions were dominated by Other, Cardiac, and Neurological categories. Analysis of case series proportions over time revealed increases in diagnoses such as Benign Paroxysmal Positional Vertigo and Vestibular Migraine, and a corresponding decrease in the diagnoses of Meniere's Disease.

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## Title

Video head impulse gain and saccade characteristics in normal subjects

## Authors

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## Abstract

The video head-impulse test (vHIT) enables measurement of the smooth vestibulo-ocular reflex (VOR) and saccades in the clinic. We characterise in a normal population the smooth and saccadic response to three-dimensional head-impulses. Eighty subjects aged 16-84 years ( $47 \pm 19$ ) were studied using a right monocular vHIT system.

Overall, impulses towards the right lateral and anterior canal (mean; 0.97, 0.87) and left posterior canal (0.77) had slightly higher mean gains compared to their counterpart (0.92, 0.81, 0.72). All canal gains had a negative relationship with head-velocity ( $-0.2 - -0.11$  per  $100^\circ/\text{s}$ ). RALP gains were higher than LARP of the same canal type, however gains of the left posterior canal dropped 0.10 and anterior canal rose 0.06 in subjects  $>60$  years, so there was no side difference in this age-group. Comparison of five published gain calculation methods in the lateral canals found those with early narrow detection windows yielded lower gains than when a wide window was used.

Small refixation saccades (amplitude  $1.13 \pm 1.04^\circ$ ; peak velocity  $64 \pm 35^\circ/\text{s}$ ; onset latency  $266 \pm 98$  ms; frequency  $43 \pm 27\%$ ) were observed amongst all age groups. For the lateral canals saccade frequency, amplitude and peak velocity increased in older subjects. Impulses towards anterior canals showed the least frequent and smallest saccades; lateral and posterior canal impulses had similar frequencies; posterior canals showed the largest saccades. Saccade peak velocity ~ amplitude 'main sequence' slope from the vertical planes trended shallower compared to the horizontal plane ( $60^\circ/\text{s}$  vs.  $< 41^\circ/\text{s}$ ).

## **BPPB myth busters, how much of the BPPV dogma is actually correct?**

**Power, L., Murray, K., Szmulewicz, D.**

A review of the medical records of 314 patients who were diagnosed with BPPV by physiotherapists specialising in Vestibular Disorders. The records of patients who presented to the service in the months of September 2017 to June 2018 (n = 314) with a diagnosis of BPPV were included in this study. Patients were diagnosed by various clinicians with definite BPPV using the Barany society diagnostic criteria for BPPV using the Dix-Hallpike or supine roll test. Patients whose nystagmus did not confer with the diagnostic characteristics of BPPV (including those with VM or central positioning nystagmus) were excluded from the study. A successful treatment was defined by the presence of a negative Dix-Hallpike manoeuvre.

## Toward objective clinical diagnosis of ataxia

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**Background and Objective:** One of the most common and medically concerning manifestations of ataxia is gait imbalance. Imbalance represents one of the most prevalent medical complaints globally and in the developed world is as common a presentation as back pain or headache. With an overall incidence of 5-10%, imbalance affects 40% of people older than 40 years and the incidence of falls is 25% in those aged 65 and over. Diagnosis of dizziness or balance disorders is very often challenging, with no single cause accounting for more than 5–10% of cases. There has also been a lack of ‘tools’ for readily describing and measuring dysfunction in these systems.

This current program of work aims to instrument key aspects of the clinical examination that are utilized in the assessment of the imbalanced patient.

**Methods:** Customized inertial measurement units, speech recognition and visual-kinematic systems have been applied to a set of functional cerebellar domains. Instrumentation was chosen to allow movements to be assessed without preconception as to the best method. Following this, various forms of analyses to select the optimal instrumentation and algorithm, for each clinical test, that first gave the best diagnostic separation between controls and ataxics, and then gave the best scaling of severity of ataxia when detected as present. A sub-selection of appropriately instrumented clinical was made, that together provided the greatest accuracy in diagnosing the presence of ataxia and its severity.

**Results:** We present objective, stratified data on clinical metrics of ataxia

## **New concept of Visual cortical hypersensitivity to explain Visual Vertigo:** An alternative to Maladaptation/ Visual dependence concept.

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### **Back ground:**

Visual vertigo(VV) is defined as dizziness provoked by large sized repetitive or moving visual patterns such as in a supermarket or in crowds or when looking at traffics or clouds.(1) The explanation given for such symptoms is that these patients have mal adaptation and are visually dependent, abnormally preferring visual inputs, instead of using an optimal ratio of visual, vestibular and proprioceptive inputs. The treatments used for VV are vestibular rehabilitation with optokinetics stimuli and exercises involving visual- vestibular conflicts.(2)

### **Short comings of the Maladaptation/ Visual dependence concept:**

Many patients with VV also has associated photosensitivity and sensitivity to flickering lights like office fluorescent lights. They also show remarkable variation in their symptoms on a day to day basis or even within a day itself. These patients actually gets worse when habituation exercises are introduced as per the current treatment guidance. In my observation the treatment which works are antimigraine drugs like Amitriptyline and Sodium Valproate. The concept of Maladaptation/ visual dependence do not explain the association of photosensitivity, or reason for improvement with medications or the variation in severity.

### **New concept of Visual cortical hypersensitivity to explain VV:**

Wilkins et. al. ( 3) observed that individual who suffer from migraine are susceptible, even in between their acute attacks, to strong visual stimuli such as bright lights and certain visual patterns which brings on visual discomfort, perceptual illusions and dizziness. They coined the term **visual stress** to this observation. Visual stress can also be elicited by activities like reading, working with computers, watching television and seeing certain patterns. The stimuli that induces such discomfort have particular characteristics. They lie within two octaves of 3 cpd ( cycles per degree). This pattern is common in complex every day images, geometric patterns and art works which are seen to evoke visual stress in susceptible patients. The lines in text can also follow this particular stripe pattern making reading difficult.

The patterns and stimuli which produces visual stress are also in the range that usually produce the strongest visual stimuli in all of us. These particular stimuli are optimal for visibility and produce maximal interference with visibility to other stimuli and induces high amplitude visual -Evoked Potential.They are associated with greatest fMRI BOLD signal and may induce abnormal EEG patterns in visual cortex called Photoparoxysmal response (PPR)( 4).

They hypothesised that visual stress results from excessive neuronal activity in the visual cortex in response to these physiological stimuli possibly due to reduction in appropriate inhibition in the cortex. The hyperexcitable neuronal activity then could spread to other parts of the brain causing symptoms like perceptual illusions or distortions.

I feel that concept of visual stress observed by Wilkins et. al. can explains many of the symptoms associated with visual vertigo such as discomfort with particular patterns,

association of photosensitivity, difficulty in reading texts, and scrolling computers and phones. It also explains the variability observed in VV as hypersensitivity of visual cortex and other parts of cortex may vary with internal and external environment such as sleep deprivation, food triggers like coffee and chocolates, and menstrual cycle.

The concept of cortical hyperexcitability may also allows new treatment modalities like Precision Spectral Filters ( PSF)( 5), drugs like antimigraine medication and antiepileptics to treat VV. It also allows us to advise environmental modifications like avoiding flickering lights, high contrast patterns in the environment in work environment( 6).

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Photosensitivity: epidemiology, genetics, clinical manifestations, assessment, and management.

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A physiological basis for visual discomfort: Application in lighting design  
AJ Wilkins DPhil

TITLE: Do sinusoidal gaze stabilising exercises result in adaptation of the transient (head impulse) VOR?

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BACKGROUND: The vestibulo-ocular reflex (VOR) maintains stable vision during rapid transient head rotations. Vestibular rehabilitation includes active head rotation gaze stabilising exercises to improve postural control and possibly VOR adaptation. Currently, these consist of sinusoidal head rotations while looking at a space-fixed target.

OBJECTIVE: We sought to determine whether sinusoidal training leads to changes in the transient (high-frequency) VOR where its function is physiologically most relevant.

METHOD: We tested 8 normal subjects over 3 sessions. For protocol 1, subjects performed sinusoidal head rotations at 1.3 Hz while tracking a laser target whose velocity incrementally increased relative to head velocity so that the VOR gain (eye/head velocity) required to stabilise the target went from 1 to 2 over 15 minutes. For protocol 2, head rotation frequency incrementally increased from 0.5 to 2 Hz over 15 minutes, while the VOR gain required to stabilise the target was fixed at 2. Protocol 3 was the same as protocol 1 except that head rotations were at 0.5 Hz. We measured the active and passive, transient (head impulse) and sinusoidal (1.3Hz), VOR gains before and after each protocol.

RESULTS: Sinusoidal and transient VOR gains increased due to protocols 1 and 2 training, however, the sinusoidal gain increase was significantly larger ( $18.1\% \pm 2.3$  vs  $9.7\% \pm 1.4$ ,  $P < 0.0001$ ). Protocol 1 training affected the active VOR more than the passive, whereas protocol 2 affected both (interaction,  $P < 0.03$ ). Protocol 3 resulted in no gain adaptation. The transient VOR increase for protocols 1 and 2 was smaller than in studies where the training consisted of head impulses ( $16.2\% \pm 5.3$ ) rather than sinusoidal rotations.

CONCLUSION: Sinusoidal adaptation training is not as optimal as head impulse training to increase the VOR during rapid head movements where its function is most important.

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## Sound-evoked vestibular projections to the sternocleidomastoid, splenius capitis and trapezius muscles in humans

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**Introduction:** Vestibular-dependent reflexes have been characterised in several neck muscles in human subjects, including sternocleidomastoid (SCM) and splenius capitis (SC). In contrast, the nature of the projection (polarity, lateralization and strength) to trapezius (TRAP) is not known. Prior studies used a variety of surface electrode montages and found small reflexes with differing polarity. We used single motor unit recordings to unequivocally demonstrate the nature of projections to trapezius in normal volunteers. We then compared the strength of vestibular projection to the SCM, SC and TRAP muscles.

**Methods:** We recorded single motor unit and surface responses following vestibular stimulation with 2ms, 500 Hz tone bursts. Concentric needle electrodes (N=5 subjects) and active surface electrodes (N=10) were placed into or over the upper portion of trapezius, approx. midway between the shoulder and the neck, with reference surface electrodes on the wrist. Trapezius was activated by shoulder elevation and responses were compared to those in SCM in the same subjects. In four subjects, responses were compared across the SCM, SC and TRAP muscles.

**Results:** In ipsilateral trapezius we found significant short-latency changes in single motor unit activity in 60% (18/31) of units at approx. 15 ms and these were mostly excitatory (67%, 12/18) with median duration 1 ms. In contralateral trapezius there were responses in only 32% (8/25) of units, below the expected false positive rate of 40%. Short-latency biphasic surface responses with initial negativity were present only in ipsilateral trapezius (right ear: 7/10 subjects, left ear: 5/10), with mean amplitude  $17.7 \pm 15.2 \mu\text{V}$  at initial peak latency  $15.8 \pm 2.0$  ms, significantly smaller than those recorded in SCM in the same subjects ( $146.0 \pm 76.9 \mu\text{V}$ ,  $P < 0.001$ ). Comparison of single unit responses from all three muscles across subjects showed a pattern of declining strength of projection from SCM (88% response rate, 2.1 ms duration), to SPL (70% response rate, 1.8 ms duration) to TRAP (60% response rate, 1.3 ms duration). This pattern was also seen in the surface responses (SCM 86  $\mu\text{V}$  raw amplitude, 1.2 amplitude ratio; SPL 20  $\mu\text{V}$ , 0.4 ratio; TRAP 9  $\mu\text{V}$ , 0.1 ratio).

**Conclusion:** The vestibular projection to trapezius in humans is ipsilateral and predominantly excitatory, but much weaker than that found in SCM or SC, suggesting only a minor role for trapezius in the vestibulo-collic reflex. The projections to SCM and SC are complementary, and the polarity is consistent with a shared role in axial rotation, though the projection to SCM is stronger.



## **Evidence That The Otoliths Are Critical For Early Development In Mice**

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Earth's gravity is a fundamental mechanical constraint for living organisms against which we have adapted our strategies for posture and locomotion as well as metabolic and cardiovascular regulation. The otolithic part of the vestibular organs was the first sensory system to emerge in protochordates about 500 million years ago, encoding the effects of gravity in the brain. It makes sense, therefore, that the otoliths might serve a primary role in brain function. We have hypothesized that the vestibular perception of gravity might play a crucial role during the first stages of development in both sensorimotor and cognitive functions. For the first time, we have investigated an original mouse model (Head Tilted mice, B6Ei.GL-*Nox3*<sup>het</sup>/J) with selective congenital absence of otolith function (n = 27 *Het*<sup>-/-</sup>) and compared them with their heterozygote normal littermates (n = 36, *Het*<sup>-/+</sup>). Our data demonstrate that mouse pups without otolithic function exhibit a delay in the acquisition of sensorimotor reflexes (i.e., the righting reflex, the negative geotaxis test, the cliff drop aversion test, the forelimb stick grasping reflex), spatial olfactory guidance (the whiskers placing response), path integration (the home retrieval test), and ultrasonic communication (the ultrasonic vocalization test), while maternal care remained normal. We suggest that development on Earth involves a critical period dependent on the vestibular perception of gravity, at least between postnatal days (PND) 6 to 10 in rodents. Remarkably, the symptoms of our otolith-deficient mice investigated here are similar to the profile of validated mouse models of autism and emphasise the significance of vestibular graviception for the pathophysiology of autism spectrum disorders during development.

## **New Software dedicated to Virtual Mazes for Human NeuroCognitive investigations**

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Although current neuropsychological investigations with standard paper-pen tests limit the evaluation of high-level cognitive functions, 3-D virtual immersive technology may offer new tools for research purposes and for the diagnosis of patients, improving the early screening of cognitive impairment associated with vestibular dysfunction. We attempted to create new software based on rodent behavioural tests, which enables a full evaluation of spatial cognitive performance and is expanded to numerous cognitive functions in humans. We have created a virtual eight-arm radial maze, a Morris water maze and a reverse T-maze and tested them on 44 healthy subjects, showing sex differences in terms of navigation strategy. We have observed that the choice of benchmarks, instructions, and experimental parameters influence the performance. Current software is limited by the lack of standardization and calibration, is often homemade and not adaptable in terms of settings and parameters of analysis. Our solution provides a platform in order to choose preconfigured 3-D and 2-D tasks combined with validated neuropsychological tests and questionnaires or to create your own virtual environments and protocols associated with an automatic analysis for clinical use in patients. We suggest that the sensitivity of 3-D calibrated tasks combined with digitized current neuropsychological tests could surpass the paper-pen tests, providing new tools in order to improve evaluation during rehabilitation in patients.

## **The Neurobiological Basis of Spatial Memory Deficits Following Vestibular Dysfunction: Modulation of Hippocampal Long-Term Potentiation and NMDA Receptors**

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Vestibular dysfunction strongly impairs hippocampus-dependent spatial memory performance and place cell function. However, the hippocampal encoding of vestibular information at the synaptic level, remains sparsely explored and controversial. We investigated changes in *in vivo* long-term potentiation (LTP), using electrophysiology (n = 14), and N-methyl-D-aspartate (NMDA) glutamate receptor (NMDAr) density and distribution, using receptor autoradiography and flow cytometry (n = 100), after bilateral vestibular lesions (BVL) in adult rats. At day 30 (D<sub>30</sub>) post-BVL, the LTP of the population spike recorded in the dentate gyrus (DG) was higher in BVL rats, for the entire 3 h of LTP recording, while no difference was observed in the field excitatory post-synaptic potential (fEPSP) slope. However, there was an increase in EPSP-Spike (E-S) potentiation in lesioned rats. NMDAr's were upregulated at D<sub>7</sub> and D<sub>30</sub> predominantly within the DG and CA1 of the hippocampus. At D<sub>30</sub>, we observed a higher NMDAr density in the left hippocampus. NMDAr's were overexpressed on both neurons and non-neuronal cells, suggesting a decrease of the entorhinal glutamatergic inputs to the hippocampus following BVL. The EPSP-Spike (E-S) potentiation increase was consistent with the dorsal hippocampus NMDAr upregulation. Such an increase could reflect a non-specific enhancement of synaptic efficacy, leading to a disruption of memory encoding, and therefore might underlie the memory deficits previously reported in rats and humans following vestibular loss.

## **Two cases of reversible bilateral vestibular failure**

**Duncan Smyth, Stuart Mossman**

Department of Neurology, Wellington Hospital, Wellington

**BACKGROUND:** Bilateral vestibular failure (BVF) is an uncommon condition with a multitude of causes including medications, infections, autoimmune diseases, genetic conditions, Meniere's disease and thiamine deficiency. In the majority of cases, BVF causes progressive and insidious loss of balance, however BVF has recently been shown to be reversible in some cases of aminoglycoside toxicity and in thiamine deficiency.

**CASE REPORTS:** Two cases of BVF were identified, one due to sarcoidosis and the other a likely paraneoplastic syndrome, in whom BVF significantly improved over months to years in association with treatment of the underlying condition. The horizontal vestibulo-ocular reflex gain improved from an average of 0.13 to 0.71 in the first patient and from 0.57 to 0.80 in the second patient.

**CONCLUSION:** Diagnosis of the underlying cause of BVF is therefore important as it may improve with treatment.

## **Assessment of the cause of acute transient vestibular syndrome**

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Angela McDonnell, Department of Neurology, Wellington Hospital, Wellington, New Zealand

**BACKGROUND:** In the majority of cases of acute transient vestibular syndrome (ATVS), the diagnosis is unknown. The aim of this study was to see whether adequate investigation can define the cause of ATVS. We present the interim results of the study.

**METHODS:** Patients presenting with acute transient vestibular syndrome (symptoms lasting 1-24 hours) were recruited from Wellington Hospital Emergency Department. Patients with known vestibular disorders or with an obvious cause on examination, including abnormal video oculography of the horizontal semi-circular canal were excluded. Patients underwent a complete neurological and oculomotor examination, subjective visual vertical, video-oculography of horizontal and vertical canals, bithermal calorics, cervical vestibular evoked myogenic potentials and MRI brain with diffusion weighted imaging.

**RESULTS:** Eleven patients were included in the study. Five patients (45%) had significant abnormalities on at least one vestibular test, although the exact vestibular disorder was not able to be defined. No patients had evidence for cerebral ischaemia.

**CONCLUSION:** Extensive vestibular investigation may establish a peripheral vestibular cause in approximately half of patients with ATVS, although the exact nature of the presumed peripheral disorder remains unknown.

Abstract NOTSA 2018-10-07

**Vestibular Physiotherapy in the hospital setting: A PhD wrap-up, and future research plans**

Dr Vicky Stewart (BPHTY, PHD) Advanced vestibular physiotherapist (ENT/ Neurology) Gold Coast University Hospital.

Vestibular physiotherapy is a fast growing area with new permanent positions arising in the hospital setting. The recently completed PhD titled 'Improving screening and physiotherapy management of vestibular disorders in the hospital setting' includes four peer-reviewed papers published between 2015 - 2018.

Phase one of the thesis included the construction and validation of a new questionnaire, the Vestibular Screening Tool (VST), to guide referral to vestibular physiotherapy (N = 114). The 4-item VST had 83% sensitivity and 84% specificity for identifying non-emergent vestibular disorders (cut-off value  $\geq 4 / 8$ ). The VST was found to have concurrent validity against the DHI, across the continuum of care. The VST also demonstrated responsiveness to change after vestibular rehabilitation intervention.

Phase two of the thesis determined the immediate and longer-term clinical effectiveness of a new vestibular rehabilitation service within the hospital setting (N = 193). People had significantly reduced dizziness / vertigo symptoms and significantly improved mobility at discharge, which was maintained 3-months post discharge ( $p \leq 0.001$ ).

Phase two (Paper 4) also tested the outcomes of people immediately referred to the physiotherapy vestibular service; compared to those referred through a waitlist, delayed pathway. Both immediate and delayed intervention groups reported significantly reduced dizziness / vertigo impairment ( $p \leq 0.001$ ), but only the immediate group significantly improved in all mobility measures ( $p \leq 0.005$ ). Resultant symptoms and functional impact of a vestibular disorder did not significantly subside to normal without vestibular rehabilitation, even 3-weeks after presenting to hospital.

Findings from this research support the clinical effectiveness of a hospital-based physiotherapy vestibular service. Finally, results indicate immediate referral to physiotherapy vestibular services should be considered.

Future research plans include physiotherapy and ENT assessment concordance study, 5-year clinical outcomes of a ENT primary contact vestibular physiotherapy service; and prevalence of specific vestibular disorders presenting to emergency departments.

**Title:** Preliminary report of Third Party Disability resulting from Vestibular Dysfunction:  
Understanding the experiences of significant others

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**Background:** Ongoing Vestibular Symptoms (OVS) are common in cases of vestibular dysfunction, and can be debilitating for the person experiencing them. For example, OVS can impact an individual's daily function, participation and emotional wellbeing, and often requires significant support from others. As with many chronic conditions, it is anticipated that the consequences are also felt by an individual's significant other (SO); this phenomenon is known as Third-Party Disability. Understanding the nature of Third-Party Disability for chronic health conditions can greatly assist health professionals in providing effective, family-centred rehabilitation and management. To date, little is known about the nature and extent of Third-Party Disability in SOs of adults experiencing OVS.

**Aims:** This study aimed to gain a deeper understanding of the experiences of living with ongoing vestibular symptoms from the perspective of SOs. That is, it aimed to identify the nature and extent of Third-Party Disability in this group.

**Methodology:** In-depth, semi-structured qualitative interviews were conducted with SOs of people with ongoing vestibular symptoms. Thematic analysis was conducted based on interview transcriptions; themes that characterise impact on the lives of the SOs were identified. Thematic analysis is a widely used analysis method in health research that employs a systematic progression of analytic techniques to produce several themes across multiple sources of data.

**Preliminary results:** Participants reported numerous changes to their lives because of the vestibular condition that were sorted into common categories. These included experiences such as a quest for understanding of the condition, positive and negative interactions with healthcare professionals, and changes to their everyday lives. Throughout these categories, four predominant themes were revealed (to date):

- *Ownership* Participants reported varying levels of ownership of their family member's vestibular condition. Those who considered the vestibular condition as a joint problem were often more burdened by feelings of guilt and redundancy.
- *Journey* The progression of learning to understand, cope and adapt with a family member's vestibular condition is a unique journey. This indicates a need for tailored support.
- *Intangibility* The very nature of many vestibular conditions is that they are unpredictable, and differential diagnosis is often challenging. Participants reported inconsistent advice from healthcare professionals, struggles with understanding, and difficulty talking about the conditions within their own support networks.
- *Disempowerment* Not knowing what to do for a loved one when they experience vestibular symptoms, and not having a comprehensive understanding of the vestibular condition left SOs feeling powerless to provide support.

**Projected Outcome:** Results will inform and assist healthcare professionals to better provide effective family-centred rehabilitation and management which addresses the needs of the SO, in turn optimising capacity to support the person with vestibular dysfunction. Ultimately, this study will inform provision of optimal care and therefore improved clinical outcomes for adults with vestibular dysfunction.

# **Vergence increases the gain of the human angular vestibulo-ocular reflex during peripheral hyposensitivity elicited by cold thermal irrigation.**

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## **Introduction**

When viewing a far target, the gain of the horizontal vestibulo-ocular reflex is around 1.0, but when viewing a near target there is an increased response. It has been shown that while this convergence-mediated modulation is unaffected by canal plugging and clinically practical transmastoid galvanic stimulation, it is eliminated by a partial peripheral gentamicin lesion.

## **Objective**

The aim of this study was to determine if convergence increases the gain during peripheral hyposensitivity elicited by cold thermal irrigation.

## **Methods**

The high frequency gain of the vestibulo-ocular reflex was measured using video head impulse testing immediately after the cold caloric stimulus in 9 healthy human subjects with the lateral semicircular canals oriented approximately earth-vertical.

## **Results**

Before caloric irrigation, near viewing (15 cm) increased the gain of the reflex tested by head impulses in average from 1 to 1.28. Cold (24°C) water irrigation of the right ear decreased the gain to 0.66 (far viewing) and 0.82 (near viewing). Thus the vergence mediated ipsilateral gain increase was 28% before caloric stimulation and 22% immediately after. Although vergence also increased the gain for impulses to the left before caloric stimulus, the caloric irrigation itself (applied to the right ear) did not influence the gain for contralateral impulses.

## **Conclusion**

In our experiments vergence increased the gain of the human angular vestibulo-ocular reflex during peripheral hyposensitivity elicited by cold thermal irrigation. These results suggest that cold irrigation does not abolish the function of the nonlinear/phasic vestibular afferent pathway.



**New Zealand Society for Balance Dizziness and Vertigo (NZSBDV)**  
**Neuro-Otology Society of Australia (NOTSA)**  
*Combined Clinical and Scientific Meet, 23<sup>rd</sup>-25<sup>th</sup> November 2018*  
*Inter-Continental Hotel, 2 Grey Street, Wellington, New Zealand*

**Characteristics of crossed-sternocleidomastoid responses to monaural air-conducted sound**

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**Background:** Small, excitatory potentials can sometimes be recorded from the contralateral sternocleidomastoid muscle following monaural stimulation with high intensity sound. Little is known about the physiological properties of these crossed reflexes. In this study, we define the properties of crossed SCM responses and, through comparison with other myogenic potentials of known cochlear and vestibular origin, sought their likely receptor origin.

**Methods:** Sound-evoked myogenic potentials were recorded from ipsilateral and contralateral sternocleidomastoid (SCM) and post-auricular (PAM) muscles of 11 healthy volunteers, four patients with superior canal dehiscence and one with profound hearing loss. Air-conducted clicks of 105 dB nHL and tone bursts (250-4000 Hz) of 100 dB nHL were presented monaurally through TDH 49 headphones during head elevation from supine with masking presented to the non-test ear. Click-evoked responses were recorded under two conditions of gaze in random order: straight ahead and rotated hard towards the contralateral recording electrodes. Reflex amplitudes and latencies for crossed SCM responses were compared with vestibular (ipsilateral SCM) and cochlear (PAM) responses between groups and across the different recording conditions.

**Results:** Surface potentials were bi-phasic; positive-negative for the ipsilateral SCM, and negative-positive for crossed SCM and PAM. There were significant differences in amplitudes ( $p=0.004$ ) and latencies ( $p<0.001$ ) for click responses of healthy controls across recording sites. PAM responses had the largest amplitudes ( $2.3\pm 2.8$ ) and longest latencies ( $13.0\pm 1.2$  ms), compared with ipsilateral ( $1.6\pm 0.5$ ; 12.07 ms) and contralateral ( $0.8\pm 0.3$ ;  $10.3\pm 1.0$  ms) SCM responses. Amplitudes and muscle activation for PAM increased by 104.4% and 46.8% with hard lateral gaze respectively, whereas SCM responses were not significantly affected. Click responses of patients with superior canal dehiscence followed a similar latency, amplitude and gaze modulation trend as controls. SCM responses were present in a patient with profound hearing loss, yet all PAM were absent. Frequency tuning curves of healthy controls were flat for PAM and down sloping for both SCM responses. For SCD, they were rising for PAM and slightly down-sloping for SCM responses.

**Conclusions:** Properties of crossed SCM responses were similar, though not identical, to those of ipsilateral SCM responses and are likely to be predominantly vestibular in origin. They are unlikely to represent volume conduction from the PAM as they were unaffected by lateral gaze, were shorter in latency and had different tuning properties.

Not your case of typical vestibular neuritis

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#### Abstract:

A 34 year old male with no prior medical history or significant migraine history presented with increasing headaches followed by bilateral sequential (left then 4 weeks later right) lower motor neurone facial palsies over the next few weeks. At the time of facial weakness, he also intermittent left jaw pain and reported taste disturbance. He was prescribed high dose oral prednisolone, and valaciclovir over the next 6 weeks, and his facial weakness bilaterally had sequentially resolved. His headaches diminished somewhat but remained mild despite steroids and low dose amitriptyline. Initial studies of complete metabolic profile, ANA, ENA, dsDNA, ANCA, serum ACE (ACE on several occasions), and HIV/syphilis serology were all negative; he had a mild normocytic anaemia (Hb125, MCV 89). Antiganglioside GQ1b, GM1 antibodies were negative. His CRP peaked at 56 with a peak ESR of 18. His inflammatory markers declined over the next few weeks following treatment. His initial CSF revealed oligoclonal bands positive, CSF WCC <1, protein & glucose normal. An external MRI/MRA brain was reported as normal. MRI skull base with contrast (Aug 2016) found mild diffuse but predominantly basal, dural thickening/enhancement. There is also asymmetrical thickening/enhancement of the right facial nerve in its first genu and tympanic segments, and asymmetric thickening/enhancement of the V3 and V2 segments (left greater than right). Blink reflexes were within normal limits. Pure tone audiogram, speech audiometry, OAE and ABR within normal limits. Contralateral stapedius reflexes were abnormal and only elicited at 2kHz.

His CT chest had an incidental finding of a 33 mm mass in the right axilla. This was subsequently fine needle biopsy and then followed by a core needle biopsy and both were non-diagnostic. CT Abdomen revealed several mesenteric lymph nodes largest measuring up to 8 mm within the right iliac fossa with small mesenteric lymph nodes following the mesenteric vessels are more significant for their number than size. He did not report any B-symptoms of fever, night sweats throughout the course of follow-up. Flow cytometry was repeatedly normal. Serial MRI brain imaging showed persisting facial nerve enhancement bilaterally, with reduction in dural enhancement.

Exactly two years from his initial presentation he presents with an acute vestibular syndrome with acute persistent spontaneous vertigo with nausea and unsteadiness, without auditory symptoms. Frenzel examination revealed second degree left beating nystagmus, and was more conspicuous post-headshake. Head impulse test was positive to the right and video head impulse test revealed right VOR gain of 0.42 with overt saccades, and left VOR gain of 0.75. He also reported coincidentally a few months history of exertional syncope whereby a cardiac MRI and transthoracic

echocardiogram and Holter monitoring were non-diagnostic. An MRI brain revealed subtle hyperintensity and enhancement of the bilateral vestibulocochlear nerves together with persistent bilateral facial nerve enhancement, but without dural enhancement or thickening. A whole axillary lymph node excision was finally performed which confirmed IgG4 sclerosing disease. His serum IgG4 levels and IgG subpopulation levels were normal. He is now being considered for immunosuppression with high dose oral steroids with a steroid-sparing agent, and followed up in clinic.

## **Severe motion sickness - a possible rare presentation of vestibular migraine**

John Waterston

Alfred Hospital, Melbourne

**Purpose:** To describe a rare presentation of severe motion sickness due to possible vestibular migraine.

**Methods:** A retrospective review of patients presenting with severe motion sickness who responded to migraine prophylaxis was conducted. These cases were collected over a 20 year period and were analysed according to the medications prescribed, duration of symptoms, history of migraine and presence of migrainous features during bouts of motion sickness.

**Results:** A total of 16 patients with severe motion sickness were identified who responded dramatically to the use of migraine prophylaxis, with a greater than 50% reduction in symptoms of motion sickness, though most had a substantial or near total improvement in their symptoms. Medications used included pizotifen, topiramate, amitriptyline and propranolol. This collection was from a total cohort which included over 600 patients with a diagnosis of suspected vestibular migraine. Of the 16 cases, 7 had a history of motion sickness dating back to early childhood. Only 5 cases (31%) had a history of migraine according to IHS criteria. Nine cases (56%) had a history of headache or photophobia during bouts of motion sickness. No cases fulfilled the IHS criteria for the diagnosis of vestibular migraine.

**Conclusions:** Severe motion sickness may be a presenting feature of vestibular migraine. These cases responded dramatically to trials of migraine prophylaxis and this treatment should be considered in patients presenting with severe motion sickness. A trial of therapy may be indicated even when there is no other history to suggest a diagnosis of migraine.

### **Bilateral Vestibular Hypofunction: vestibular test characteristics.**

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We describe clinical and vestibular test characteristics of 173 subjects diagnosed with bilateral vestibular hypofunction recruited from a neuro-otology outpatient clinic over a 10 year period

The presenting symptoms included imbalance in 98%, falls in 19%, persistent dizziness in 26%. Two subjects with a history of childhood meningitis reported no imbalance.

Idiopathic BVL constituted the largest subgroup (n=98), with inflammatory/infectious /autoimmune disorders (n=19), Menieres Disease (n=2), ototoxic drugs (n=29), Head and Neck Radiation (n=4), Meningitis (n=9), Neurofibromatosis 2 (n=2), Superficial Siderosis (n=2), CANVAS (n=6), demyelinating neuropathies (n=4), sequential vestibular neuritis (n=2) and iatrogenic vestibular loss (n=2) accounting for a smaller proportion.

For the entire group, average head impulse gains for the Left and Right HC were  $0.35 \pm 0.15$  and  $0.38 \pm 0.22$ ; for the LARP canals  $0.45 \pm 0.22$  and  $0.50 \pm 0.28$ ; for the RALP canals  $0.33 \pm 0.20$  and  $0.37 \pm 0.22$ . Average corrected AC and BC cVEMP amplitudes were 0.47 and 0.51 (median amplitude=0 for both). Average BC oVEMP amplitudes were 4.78 (median=1.15). Absent or reduced air-conducted cVEMPs were commonly observed in the group with gentamicin toxicity (80%) compared with the idiopathic group (31%).

## Neuro-otology patients report significant levels of cognitive dysfunction

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**Introduction:** Patients with vestibular disorders sometimes report cognitive difficulties and there are documented effects of vestibular loss on cognitive functions such as visuospatial ability. Two studies recently found high levels of perceived cognitive difficulty in these patients, but there is no consensus about the cognitive functions affected. We therefore investigated subjective cognitive dysfunction in a broad range of neuro-otology patients and compared cognitive complaints to reports of emotional distress.

**Methods:** We asked 126 neuro-otology clinic outpatients whether they experienced difficulties with thinking, memory or concentration as a result of dizziness or vertigo. They (and 42 non-vertiginous control subjects) also completed several questionnaires, including the neuropsychological vertigo inventory (NVI), everyday memory questionnaire (EMQ), and depression, anxiety and stress scales (DASS).

**Results:** Many patients (60%) reported experiencing cognitive difficulties. As scores on the cognitive questionnaires were positively correlated with those on the DASS (NVI:  $r=0.63$  and EMQ:  $r=0.46$ , respectively,  $p<0.001$ ), we compared patients and controls on the NVI and EMQ using DASS scores (as well as age and gender) as covariates. Compared to controls, patients scored significantly worse on the EMQ and three of the four NVI subscales relating to cognition (assessing perceptions of space and time, and attention,  $p<0.05$ , but not memory). Patients also scored significantly worse on the NVI subscales assessing emotions, vision and motor function ( $p<0.05$ ).

**Conclusion:** Patients with dizziness and vertigo reported high levels of subjective cognitive dysfunction, affecting spatial ability, memory, attention and orientation in time. Although perceptions of cognitive dysfunction co-varied with emotional distress, they were significantly elevated in patients over and above the impact of depression, anxiety or stress.

## **Capturing acute vertigo with home-video oculography**

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**Purpose:** To facilitate the diagnosis of vestibular disorders by capturing ictal nystagmus in patients' home environment.

**Methods:** Adults from a Sydney neurology outpatient clinic reporting recurrent vertigo were convenience recruited prospectively (with informed consent) and were loaned home-video goggles and taught to record spontaneous and positional nystagmus while symptomatic. Patients with ictal video recording(s) and a final clinical diagnosis of Ménière's Disease (MD), Vestibular Migraine (VM) or Benign Paroxysmal Positional Vertigo (BPPV) were included in the study.

**Results:** Videos of 117 patients were analysed. Of 43 MD patients, 40 showed high-velocity spontaneous horizontal nystagmus (median slow-phase velocity (SPV) 39.7 degrees/second (°/s); Twenty-one showed horizontal nystagmus reversing direction within 12 hours (24 on separate days). In 44 of 67 patients with VM, spontaneous horizontal (n=28, 4.9°/s), up-beating (n=6, 15.5°/s) or down-beating nystagmus (n=10, 5.1°/s) was observed; Sixteen showed positional nystagmus only, and seven had no nystagmus. Horizontal spontaneous nystagmus SPV >12.05°/s had a sensitivity and specificity of 95.3% and 82.1% for MD. Nystagmus direction-change within 12 hours was highly specific for MD (95.7%). Spontaneous vertical nystagmus was highly specific for VM (93.0%). In the seven BPPV patients, spontaneous nystagmus was absent or <3°/s. Lying affected-ear down, BPPV patients demonstrated paroxysmal positional nystagmus. Median time for peak SPV to halve (T50) was 19.0s. VM and MD patients demonstrated persistent positional nystagmus (median T50; 93.1s, 213.2s). T50 <47.3s had a sensitivity and specificity of 100% and 76% for BPPV.

**Conclusion:** Patient-initiated vestibular event-monitoring is feasible and could facilitate rapid and accurate diagnosis of episodic vestibular disorders.

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