# BSNO

British Society of Neuro-Otology

# ABSTRACTS

The 13th Meeting of the British Society of Neuro-Otology

11-12 NOVEMBER 2021

De Montfort University
Leicester
UK

www.bsno.org.uk

## About The British Society of Neuro-Otology (BSNO)

The British Society of Neuro-Otology (BSNO) aims to provide a forum for informal discussion and the opportunity to present research in related topics of neuro-otology, balance disorders and vestibular science.

## BSNO Committee

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Dr Louisa Murdin (Chair)
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# THURSDAY 11 NOVEMBER - BSNO Satellite Meeting 2021

## Acute vertigo & predictors of poor long-term outcomes

## SPEAKER ONE

**The HINTS Exam: Pearls & Pitfalls**
Dr Dan Gold, USA

Dr Gold is an Associate Professor of Neurology, Ophthalmology, Otolaryngology - Head & Neck Surgery, Neurosurgery, Emergency Medicine, and Medicine at The Johns Hopkins University School of Medicine. He is a neurologist with fellowship training in neuro-ophthalmology at the University of Pennsylvania and additional training in neuro-vestibular disorders at Johns Hopkins, and is the director of the Ocular Motor & Vestibular Oto-Neurology Fellowship within the Division of Neuro-Visual and Vestibular Disorders. Dr Gold maintains an active clinical practice, seeing patients with vestibular and neuro-ophthalmic conditions. He is also heavily involved in the education of residents and fellows, giving frequent lectures on topics related to his subspecialty expertise in addition to leading neuro-ophthalmology/ocular motor bedside teaching rounds. He has received awards for neurology resident teaching and clinical excellence, and for outstanding educational contributions to the Neuro-Ophthalmology Virtual Education Library (through the North American Neuro-Ophthalmology Society) via an ocular motor/vestibular collection. He has also written a Neuro-Ophthalmology & Neuro-Otology case-based guide which should be in print by the end of the 2021.

# ORAL PRESENTATIONS

**A Single Centre Audit of Managing Acute Dizziness by Non-Specialists**

*M Mahmud, M Prendergast, L Dixon, B M Seemungal*

Department of Brain Sciences, Imperial College London, United Kingdom

Introduction
The objective of this audit was to measure the quality of managing patients presenting with "dizziness", with an emphasis on stroke diagnosis and management.

Methodology
We conducted a retrospective case note analysis for all patients who had an brain MRI scan for acute dizziness at Imperial College Healthcare NHS Trust (ICHNT) between January to September 2020. Local research ethics permission was previously obtained.

Results
116 patient encounters were included (mean age of 62 ±18 years, 54% female). 23% of all MRI brain scans requested for acute dizziness were DWI-positive. Of the DWI-positive MRI scan patients, 23% had isolated vertigo with no additional neurological features recorded in the notes. The mean NIHSS score of isolated vertigo patients was 0 and none of the patients underwent thrombolysis. Only 14% of patients had a complete HINTS examination. The isolated vertigo patients with DWI negative MRIs had no definitive diagnosis in 45% of the patient encounters.

Conclusion
Emergency physicians are generally unaware that stroke can present with isolated vertigo. Most patients with acute dizziness were not systematically assessed, e.g. with the HINTS criteria.

**Prevalence of Acute Dizziness and Vertigo in Cortical Stroke**

*Y M Chan[1], Y Wong[2], N Khalid[1], A Flores-Martin[3], L A Frank[1], N Koohi[1], Q Arshad[4], I Davanagnam [2], P Castro[1,5,6], D Kaski[1]*

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Vertigo and dizziness may be symptoms of stroke, leading to an acute vestibular syndrome. Stroke presenting with vertigo or dizziness accounted for 2.7% and 3.2% of patients. In this study we explore the prevalence of vertigo and dizziness in acute stroke and evaluate the cortical distribution of these lesions in relation to the vestibular cortical network. We conducted interviews in adult patients admitted to the stroke unit. The questionnaire evaluates whether the patient was suffering from dizziness 1) before the onset of the stroke, 2) at the time of the stroke and 3) since the onset of the stroke. Data was acquired within 5 days of stroke onset. The MRI were retrospectively analysed by experienced consultant neuroradiologists and subsequently independently reviewed for inclusion for analysis by a radiologist blinded to the questionnaire results. In total, 173 questionnaires were collected. A total of 71 patients had cortical infarcts with appropriate imaging registration for further analysis. Of these, 50 patients did not report any dizziness symptoms, 21 patients reported acute dizziness. Out of the total 71 patients with cortical infarcts, 31 patients had lesions in the vestibular cortical areas distributed within the insular and parietal opercular cortices, but only eight patients had acute dizziness. We observed a low prevalence of vertigo in acute cortical strokes, with no single locus of lesion overlap. A possible lateralization of the vestibular cortex should be studied further. The variability in the prevalence of vestibular symptoms in stroke calls for a more novel framework to identify them.

**Acute, Prospective and Follow-Up of BPPV in Acute Traumatic Brain Injury**

*R M Smith, H Rust, B M Seemungal*

Department of Brain Sciences, Imperial College London, United Kingdom

Background
Benign paroxysmal positional vertigo (BPPV) is a common peripheral vestibular disorder following traumatic brain injury (TBI). Previous studies evaluating the type and frequency of BPPV in TBI have been limited to the sub-acute population or have employed dizziness screening tools prior to study inclusion. Currently there are no prospective data pertaining to the frequency and type of BPPV in
acute TBI.

Methods
Patients at a Major Trauma Centre (London, UK) were screened for a prospective study evaluating markers of balance recovery in TBI. Patients meeting the inclusion criteria (no previous TBI, active medical or psychiatric conditions) were assessed using a standardised vestibular-neurological examination.

Results
1287 patients were screened between August 2017 and December 2019; 177 patients were assessed clinically by the authors. 55% of the examined patients (98 of 177) had a positive Dix Hallpike (mean age 48±18 years; 63% male). Of the 98 patients diagnosed with BPPV, 72 patients (73% of BPPV total) had a unilateral posterior canal BPPV. Bilateral posterior or bilateral posterior and horizontal canal BPPV accounted for 26%. Critically a fifth of patients did not complain of vertigo prior to diagnosis, or during diagnostic or treatment manoeuvres. Of the 98 patients with BPPV, 18 were recruited into an on-going prospective study examining markers of balance recovery and currently, recurrence rate is 38% (7 patients) at 6 months.

Conclusions
Our data are the first acute prospective assessment of BPPV in TBI. We demonstrate that over half of acute TBI cases have BPPV. In our cohort a fifth of cases did not complain of vertigo (see Calzolari et al. abstract for study investigating the central disruption of vestibular perceptual mechanisms causing a vestibular agnosia). It is thought the presence of vestibular agnosia may hinder accurate diagnosis and treatment and thus have far reaching implications for patients and their families. Despite acute treatment, BPPV recurred in a significant proportion of patients and thus the optimum time to treat remains unknown. We are currently running controlled prospective treatment studies to assess this (https://www.isrctn.com/ISRCTN91943864).

**Clinician's Perspectives of Head Impulse-Nystagmus-Test of Skew for Acute Vestibular Syndrome**

*C L Barrett[1] BSc, L Bunn[2] PhD, N Koohi[3] PhD, G Schmidtmann[2] PhD, J Freeman[2] PhD, P Castro MSc[3, 4, 5], D Kaski[3,4] PhD.*

[1] North Bristol NHS Trust, University of Plymouth
[2] Faculty of Health, School of Health Professions, University of Plymouth
[3] Institute of Neurology, University College London, UK
[4] Department of Neuro-otology, Royal National ENT and Eastman Dental Hospitals UCLH, London, UK
[5] Neuro-Otology unit , Department of Brain Sciences, Imperial College London, London, UK

Background
Acute vestibular syndrome (AVS) features continuous dizziness and may result from a benign inner ear disorder or potentially life-threatening stroke. Misdiagnosis is common and can lead to poor long-term outcome. An oculomotor bedside assessment, the Head Impulse-Nystagmus-Test of Skew (HINTS) is more sensitive than brain Magnetic Resonance Imaging in identifying stroke as the cause of AVS within the first 48 hours, when applied by specialist clinicians. Clinicians' perspectives of the test in secondary care remains unknown. Here, we explore frontline clinicians' perspectives of use of the HINTS

Methodology
Clinicians from two large UK hospitals who assess AVS completed a short online survey, newly designed with closed and open questions. Results: Almost half of 73 total responders reported limited, or no experience (n=19), reflected in low rates of use (n=31) of HINTS. Whilst the potential utility of HINTS was recognised, many reported concerns about subjectivity, need for specialist skills and poor patient compliance. No clinicians reported high levels of confidence in performing HINTS, with 98% identifying training needs. A lack of formalised training was associated with onward specialist referrals and neuroimaging (p=.044).

Conclusions
We identified barriers to the application of the HINTS and training needs to improve rapid, cost effective and accurate clinical diagnosis of stroke presenting with vertigo

**Cerebral Small Vessel Disease in Vestibular Neuritis**

*F K Oussoren MD[1,2]; R B van Leeuwen MD, PhD[1]; T R Schermer, PhD[1]; T D Bruintjes, MD, PhD[1,2]*

[1] Apeldoorns Dizziness Centre, Gelre Hospital Apeldoorn, The Netherlands
[2] Departement of Otorhinolaryngology, Leiden University Medical Center, Leiden, The Netherlands

Background
Acute hearing or vestibular loss is a neurotologic emergency in which the aetiology is frequently unknown. In vestibular neuritis (VN) a viral genesis is expected, though antiviral therapy and corticosteroid use have not been proven sufficient.

A vascular etiology has been proposed in patients in elderly patients with sudden deafness, since cardiovascular risk factors are more frequently present and a higher risk of developing a stroke was seen compared to the general population. Cardiovascular risk factors have a positive correlation with cerebral small vessel disease (CSVD) on MRI. Also, white matter lesions and infarctions on MRI indicate a higher risk of developing a stroke. So far, very little research has been carried out on the possibility of a vascular origin in VN.

Aim
We investigated whether patients with VN have a higher prevalence of vascular lesions on MRI compared to a control cohort.

Method
Patients with VN of 50 years and older were retrospectively reviewed and compared to a control cohort. Outcomes were the difference in cardiovascular risk factors and CSVD on MRI imaging, which was assessed by the number of white matter hyperintensities using the ordinal Fazekas scale and the presence of brain infarctions.

Results
Patients with VN (N=101) had a an odds of 2.1 to receive a higher Fazekas score on imaging than the control cohort (N=203) (p=0.012), there was no difference in presence of brain infarctions between both cohorts (p=0.54).

# SPEAKER TWO

## Vestibulospinal Signs in the Differential Diagnosis of AVS

*Prof Sergio Carmona MD PhD*
Argentina

**Current positions**

- Chairman of Neurotology, INEBA (Instituto de Neurologia de Buenos Aires), Argentina
- Full Professor of Neurophysiology - School of Medicine – UNR (Universidad Nacional de Rosario) – Argentina
- President of FINO (Fundacio Iberoamericana de Neuro-otologia)

**Books**

- The New Neurotology – Springer (2019)
- Neuro-otologia IV Edition – Akadia, Buenos Aires (2018) Translated English & Italian
- Manejo del Sindrome Vestibular Agudo – Akadia, Buenos Aires (2016)

**Publications**

- More than 100 papers in peer review, from 2016 focused in the area of AVS, Director of the multicentric international study (Israel, Spain, Portugal and Argentina) of Truncal Ataxia in AVS
- RG Score 27.52 – h-index: 8 – Research Interest 234.4

**Recent Academic distinctions**

Visiting Professor

- Department of Neurology. University of Chicago at Illinois. August 20-23 2002
- Department of Neurology. Mayo Clinic. May 9-11 2006
- Vertigo 360o at Mumbai, Bangalore and New Delhi. India. July 2011
- Department of ORL. Universidad de Valencia. Valencia. Spain. November 2012
- Department of Neurology. University of Chicago at Illinois. March 2013
- an – Beijing and Hong Kong – China 2014
- Hospital Universitario Severo Ochoa 04/2018 – Madrid. Spain
- Lima - Perú – 2019
- Pune – India – 2019

Faculty

- Director Basic & Clinical Ocular-motor & Vestibular Research. Buenos Aires 2011
- President of the XXIV Bárány Society Meeting. Buenos Aires. 2014
- Congrex of the Italian ENT Society. Rimini. 2019
- XI Porto Vertigo Meeting May 2021

# FRIDAY 12 NOVEMBER
# The 13th Meeting of the British Society of Neuro-Otology (BSNO)

## KEYNOTE GUEST LECTURE

### PPPD and its Relationship to Other Functional Disorders

Professor Jon Stone, University of Edinburgh, UK

Professor Jon Stone is Professor of Neurology at the University of Edinburgh and Consultant Neurologist with NHS Lothian. He has collaborated on several articles on PPPD including one with Jeff Staab and Stoyan Popkirov. Professor Stone has been working for over 20 years in the field of functional neurological disorder (FND). Historically, this is a "no-man's land" between neurology and psychiatry which represents the second commonest reason for a neurological referral.

Professor Stone has promoted new transparent, pragmatic and multidisciplinary approach to understanding, diagnosing and communicating FND. In 2009 he made the first website for patients with FND at www.neurosymptoms.org which is now widely used across the world. He has published nearly 300 articles in the area including large cohort, mechanism and treatment studies. He has led on new diagnostic criteria for FND in DSM-5 and ICD-11 and the development of professional organisations for FND. In 2016 he co-edited, with Mark Hallett and Alan Carson, the volume 'Functional Neurologic Disorder' setting a new standard for a teaching and research curriculum. He is the first Secretary of the new international FND society (www.fndsociety.org) and is passionate about multidisciplinary collaboration and developing the next generation of health professionals in this field.

He graduated from the University of Edinburgh in 1992 and worked in Newcastle, Leeds, Oxford and New Zealand before returning to Edinburgh. A neurologist (Charles Warlow) and psychiatrist (Michael Sharpe) supervised his PhD, a case-control study of functional limb weakness. His awards include the Royal College of Physicians (London) Jean Hunter Prize for Nervous Disorders (2014), Royal College of Physicians (Edinburgh) Clouston Medal (2017), Royal College of Psychiatrist President's Medal (2017) and the Ted Burns Humanism in Neurology Award from the American Brain Foundation (2020). He has given invited plenary sessions at the American Academy of Neurology, World Congress of Neurology, and Movement Disorders Society as well as lectures in neurology department around the world including Harvard, St Louis and Stanford. In addition to his academic work, he remains a full-time clinician.

Weblinks: www.neurosymptoms.org; www.fndsociety.org; www.ed.ac.uk/profile/dr-jon-stone; Twitter: @jonstoneneuro; Email: Jon.Stone@ed.ac.uk

# FREE PAPERS SESSION ONE

## The Human Vestibular Cortex: Functional Anatomy, Connectivity and the Effect of Peripheral Vestibular Disease

*R T Ibitoye[1,2], E Mallas[1,3], N J Bourke[1], D Kaski[4], A M Bronstein[2], D J Sharp[1,3,5]*

[1] Computational, Cognitive and Clinical Neuroimaging Laboratory, Department of Brain Sciences, Imperial College London, London, UK.
[2] Neuro-otology Unit, Department of Brain Sciences, Imperial College London, London, UK
[3] UK Dementia Research Institute, Care Research & Technology Centre, Imperial College London, London, UK
[4] Department of Clinical and Motor Neurosciences, Centre for Vestibular and Behavioural Neurosciences, University College London, London, UK
[5] Centre for Injury Studies, Imperial College London, London, UK

Background
Area OP2 in the posterior peri-sylvian cortex has been proposed to be the core human vestibular cortex. We investigated its functional anatomy and connectivity.

Methods
We defined the functional anatomy of OP2 using spatially constrained independent component analysis of functional MRI data from the Human Connectome Project. OP2 responses to caloric irrigation and visual motion were then investigated in seventeen controls and seventeen age-matched chronic right vestibular neuritis patients.

Results
Ten subregions were identified, and most had significant connectivity to known vestibular areas. In controls, a posterior part of right OP2 showed: direction-selective responses to visual motion; and activation during caloric stimulation that correlated positively with perceived self-motion, and negatively with visual dependence. Patients showed abnormal OP2 activity, with an absence of visual or caloric activation of the healthy ear and no correlations with dizziness or visual dependence – despite normal brainstem responses to caloric stimulation (slow-phase nystagmus velocity). A lateral part of right OP2 showed activity that correlated with chronic dizziness (situational vertigo) in patients.

Conclusion
A posterior subregion of right OP2 shows strong functional connectivity to other vestibular regions and a profile of caloric and visual responses, suggesting a central role for vestibular

**Setting up a National Ménière's Disease Registry (MDR)**

*L Murdin[1], P Rea[2], J Harcourt[3], L Shepstone[4], E Sims[4], V Bion[4], J Phillips[5]*

[1] Guy's and St Thomas' NHS Foundation Trust
[2] University Hospitals of Leicester NHS Trust.
[3] Imperial College Healthcare NHS Trust
[4] Norwich Clinical Trials Unit, Norwich Medical School, University of East Anglia
[5] Norfolk and Norwich University Hospitals NHS Foundation Trust

Background
Meniere's disease (MD) is a difficult condition to research. This is partly due to the relapsing-remitting nature of the condition and uncertain natural history. National registries for other health conditions have been used to identify outcome predictors, disease subtypes, facilitate patient involvement in research and support clinical trials. We describe a pilot project to establish a registry for MD.

Methods
Patients with MD were invited to submit data on symptoms, comorbidity, treatment history and complete validated outcome measures directly into an electronic database or via postal questionnaires, supplemented by data from treating specialists.

Results
191 patients have been recruited to date (Males 46%, white ethnicity 95%).

| | Age at consent to study | Age when Meniere's symptoms started | Age at diagnosis with unilateral disease | Age at diagnosis with bilateral disease |
|---|---|---|---|---|
| n | 191 | 174 | 134 | 33 |
| Mean (SD) | 60 (14.7) | 47 (15.0) | 49 (14.8) | 56 (13.2) |
| Median (25%-75% IQR) | 63 (50-72) | 48 (35-61) | 49 (39-60) | 54 (48-67) |

Further data analysis to identify possible predictors for development of bilateral disease will be performed.

Conclusions
It is feasible, practical and acceptable to patients to establish a national database of patients with MD. Search functionality of secondary care patient management systems should evolve to support identification of potentially eligible patients for such projects.

This project was funded by the Ménière's Society.

**Migrainous and Peripheral Vertigo Differentially Modulate the Relationship Between Visual Conscious Awareness and Symptoms of Visual Hypersensitivity**

*Y Saman[1], A Bonsu[2], O Rea[1], A Kheradmand[3], P Rea[1], Q Arshad[1]*

[1] inAmind Laboratory, Department of Neuroscience, Psychology and Behaviour, University of Leicester, UK
[2] Neuro-otology Unit, Division of Brain Sciences, Imperial College London, UK
[3] Neurology Department, Johns Hopkins, USA

Normal balance function is mediated by sensory integration of visual, vestibular and proprioceptive cues. Previous research has shown that in patients with peripheral vestibular loss (i.e. bilateral vestibular failure: unilateral loss), they become increasingly reliant on visual cues, a concept termed visual dependency. Clinically, these patients report increase sensitivity to visual motion stimuli in busy and visually rich environments, such as train stations, supermarkets and patterned floors. Recent research has shown that these patients have associated changes in the visual cortex, including up-regulated activity and changes in functional connectivity. However, this phenomenon of increased visual sensitivity is not specific to peripheral vestibular disorders, but is also clinically encountered in patients with vertigo due to a central aetiology (i.e. vestibular migraine). Here, we sought to address whether in patients with visual hypersensitivity symptoms in association with vestibular migraine, manifest altered visual processing in higher, non-visual cortical areas. To address this we implemented a bi-stable visual perception stimuli (i.e. motion induced blindness), which is known to be mediated by activity in the parietal cortex, and can interact with vestibular processes in healthy individuals. In response to viewing the visual stimuli, we recorded the number of perceptual switches in 12 healthy controls, 12 vestibular migraine patients and 12 BPPV patients. Participants with vertigo (VM and BPPV) showed significantly more perceptual transitions when compared to healthy controls. Furthermore, we observed that in the VM patients, the perceptual switches were positively correlated with visual symptom scores (as assessed with the visual analogue scale), whereas in BPPV patients the perceptual switches were negatively correlated with visual symptom scores . Our findings suggest visual hypersensitivity is associated with altered visual conscious awareness in patients that is differentially modulated by vertigo.

**Insights into the Pathophysiology of Persistent Postural-Perceptual Dizziness (PPPD) from Brain Imaging**

*P Wodka[1], Z Britton[1] , N Koohi[1,2,3], P Castro[1,3,4] , M Bancroft[1] , Q Arshad[5] , D Kaski[1,2,3]*

[1] Centre for Vestibular and Behavioural Neuroscience, Department of Clinical and Movement Neurosciences, Institute of Neurology, University College London, London WC1N 3BG, UK.
[2] The Ear Institute, University College London, London WC1X 8EE, UK
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Persistent postural-perceptual dizziness (PPPD) is a common cause of chronic dizziness associated with significant morbidity. Observed risk factors include pre-morbid anxiety and neuroticism and increased visual dependence. Following a vestibular insult, patients with PPPD chronically adopt maladaptive strategies impairing behaviour. In this article, we review recent brain imaging studies that probe the pathophysiology of PPPD. Systematic searches yielded eight original research articles that used neuroimaging to study patients with PPPD: six studies used functional imaging techniques (five used functional magnetic resonance imaging; one used single-photon emission computed tomography) and two studies used structural imaging (one used grey matter volume; one used local gyrification index). The main findings across studies were altered activity, functional connectivity and structure in (i) core vestibular and visual cortices relating to a sense of self and movement in space; (ii) areas associated with regulation of mood and emotion; (iii) regions associated with higher executive functions; and (iv) motor effector areas. Taken together, the reviewed findings suggest that PPPD is a disorder of multisensory integration, with altered weighting of sensory cues that determine decision outcomes relating to posture and locomotion strategies

# FREE PAPERS SESSION TWO

## Risk Aversion in Persistent Postural Perceptual Dizziness

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[1] inAmind Laboratory, Department of Neuroscience, Psychology and Behaviour, University of Leicester, UK

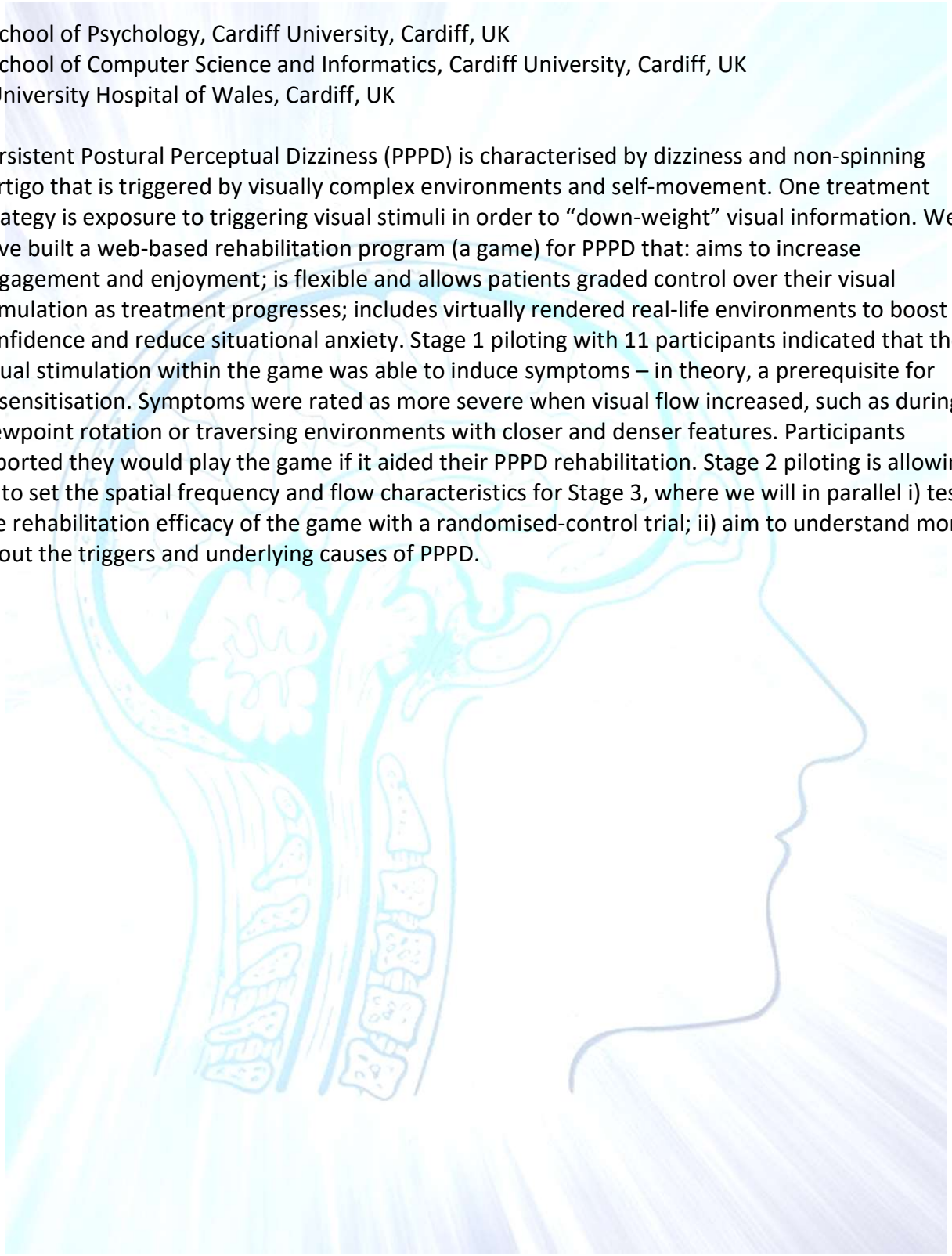
Persistent Postural Perceptual Dizziness (PPPD) is a newly defined functional vestibular disorder that unifies and reconciles three decades of research on previously described psychosomatic vestibular conditions including phobic postural vertigo, space-motion discomfort, visual-vertigo and chronic subjective dizziness. Clinically, patients with PPPD present with two key fluctuating or continuous symptoms; a) a dizzy, not-truly-vertiginous sensation, with patients reporting that their head is swimming and/or b) unsteadiness, such that patients report swaying, rocking or jelly legs. Typically, the development of PPPD is not attributable to the degree of otological dysfunction or failed ear recovery following balance dysfunction. Rather, psychological risk factors (anxiety related personality traits) and shifts in psycho-physical functioning (space-motion perceptual style and visual dependence) are strong predictive factors for determining which patients will develop PPPD following vestibular dysfunction. Under normal circumstances, humans are largely unaware of the details of sensory integration, motion perception and locomotor control, which operate outside of executive processes (fully conscious perception and action). These sensorimotor functions may transiently intrude into consciousness as when traversing an icy pavement, but even then, most aspects of locomotor dynamics (e.g. individual muscle movements) remain outside of direct executive control. Patients with PPPD, however, experience a consistently heightened, conscious awareness of space and motion stimuli, particularly an increased sense of error between predicted (conscious) and actual (subconscious) motions. Driven by their anxious temperaments, PPPD patients are suggested to exert unnecessarily increased executive control over locomotion, altering reflexive postural dynamics and normal weighting of sensory inputs, a mismatched behavioural response that paradoxically reduces the effectiveness of lower level systems. Research on heuristics in decision-making has described the adverse effects of undue emphasis on risk and the influences of emotional states induced by perceptual biases. In this study we directly probed generic risk assessment in 10 patients with PPPD using the IOWA gambling task. We observed that PPPD patients made significantly more riskier choices in the gambling task compared to controls, indicating that PPPD patients have a skewed assessment of risk and impaired learning to identify risky choices. Furthermore, the exhibited biases in patients were correlated with validated questionnaire measures of risk aversion that assess for conscientious personality types, indicating that the temperament of these patients in-part governs abnormal behaviour. These findings have functional significance for the rehabilitation of patients with PPPD, specifically how do we normalise risk assessment?

**Developing a Web-Based Clinical Rehabilitation Program for People with Persistent Postural Perceptual Dizziness (PPPD)**

*N Goodwin[1,2], P Sumner[1], F Loizides[2], H Derry-Sumner[3], G Powell[1]*

[1] School of Psychology, Cardiff University, Cardiff, UK
[2] School of Computer Science and Informatics, Cardiff University, Cardiff, UK
[3] University Hospital of Wales, Cardiff, UK

Persistent Postural Perceptual Dizziness (PPPD) is characterised by dizziness and non-spinning vertigo that is triggered by visually complex environments and self-movement. One treatment strategy is exposure to triggering visual stimuli in order to “down-weight” visual information. We have built a web-based rehabilitation program (a game) for PPPD that: aims to increase engagement and enjoyment; is flexible and allows patients graded control over their visual stimulation as treatment progresses; includes virtually rendered real-life environments to boost confidence and reduce situational anxiety. Stage 1 piloting with 11 participants indicated that the visual stimulation within the game was able to induce symptoms – in theory, a prerequisite for desensitisation. Symptoms were rated as more severe when visual flow increased, such as during viewpoint rotation or traversing environments with closer and denser features. Participants reported they would play the game if it aided their PPPD rehabilitation. Stage 2 piloting is allowing us to set the spatial frequency and flow characteristics for Stage 3, where we will in parallel i) test the rehabilitation efficacy of the game with a randomised-control trial; ii) aim to understand more about the triggers and underlying causes of PPPD.



**Saccadic Bradykinesia in Parkinson's Disease Preliminary Observations**

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[3] Department of Neuro-otology, Royal National ENT and Eastman Dental Hospitals UCLH, London, UK
4 Reta Lila Weston Institute, Department of Clinical and Movement Neurosciences, UCL Queen Square, Institute of Neurology, London, UK
[5] Queen Square Brain Bank for Neurological Disorders, UCL Queen Square Institute of Neurology, London, UK
[6] Neuro-Otology unit , Department of Brain Sciences, Imperial College London, London, UK

Bradykinesia and hypokinesia of limb movements are features of Parkinson's Disease (PD), exacerbated when patients perform self-guided, repetitive limb movements– the so-called 'sequence effect'. In the oculomotor system, both hypometria and slowing of voluntary saccades have been described in PD (1) but never as a change over time, which is the defining feature of this phenomenon. We examined six mildly- or moderately-impaired PD patients (Unified Parkinson's Disease Rating Scale: UPDRS motor part, 11±2.8 points; duration of illness, 2.2±0.4 years) aged 69±5 yrs (one female) and seven age-matched healthy control individuals (five female, 56±7 years). Voluntary and reflexive horizontal saccadic eye movements were recorded with infrared binocular videonystagmography (VNG) sampled at 250Hz. Voluntary horizontal saccades without visual targets led to a progressive decrease in PD saccadic amplitude over time (hypometria). Additionally, PD saccadic velocity progressively reduced over time, even when accounting for smaller saccadic amplitudes main sequence effect. Group (PD vs. Controls) and time (first six vs. final six saccades) interacted for both amplitude and velocity ($F(1,11)>6.1$; p0.110). PD saccadic velocity in the final six saccades was lower than normative amplitudematched velocities ($p=0.039$) whereas no difference was present in the first six saccades ($p=0.547$). Saccadic bradykinesia was apparent in all consecutive patients, but absent in age-matched controls. "Saccadic bradykinesia" may be a useful and early clinical sign of PD and future studies should confirm these findings and assess its specificity as a clinical biomarker of disease progression.

**The Effect of a Customized Vestibular Rehabilitation Programme With and Without Additional Dual-Task Training on Treatment Outcome in Persons with a Chronic Vestibular Disorder. A Randomise Controlled Trial**

*V Azoidou[1], L Murdin[2], D Bamiou[3], M Pavlou[4]*

[1] Centre for Human and Applied Physiological Sciences, King's College London, London, UK
[2] Audiovestibular Medicine Department, Guy's Hospital, Guy's and St Thomas NHS Foundation Trust, London, UK
[3] Neuro-otology Department, National Hospital for Neurology and Neurosurgery, and Ear Institute, University College London, London, UK
[4] Centre for Human and Applied Physiological Sciences, King's College London, London, UK

**BACKGROUND**
Dual-tasking (DT) training has been used in balance programmes for older adults at risk of falling, stroke patients and persons with Parkinson's disease. No studies have investigated the efficacy of DT training in persons with a vestibular disorder.

**METHODS**
A single-blinded randomized controlled trial investigates the effect of a 12-week customized vestibular rehabilitation (VR) programme incorporating cognitive DT exercises in 48 persons with chronic vestibular symptoms, aged 18-80 years old, who are randomly allocated to VR without (Group A) or with cognitive DT exercises (Group B). Treatment response is assessed at baseline and end of treatment. Primary outcome measure is Functional Gait Assessment (FGA) and FGA DT with numeracy, literacy and auditory tasks.

**RESULTS**
This study is ongoing. Group A includes 13 participants (8 females, mean age±SD=49.08±14.57 years) while Group B 15 participants (8 females, mean age±SD=45.53±16.95 years). Baseline FGA and FGA auditory mean±SD scores were within normal ranges, for Group A (26.23±2.35; 24.69±3.01) and Group B (24.07±4.96; 23.53±5.29), respectively. Baseline FGA DT showed increased falls risk for numeracy and literacy tasks; for Group A (20.15±3.55; 20.85±3.41) and Group B (17.27±5.20; 19.80±5.58), respectively.

**CONCLUSIONS**
The Groups have not been unblinded but in November pre-post VR findings will be presented.

**A 'Shoulder Tap' Test for Functional Gait Disorders: A Sign of Abnormal Anticipatory Behaviour**

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Objective
To describe the range of postural responses to the pull test in patients with functional gait disorders (FGDs) and explore the utility of the 'shoulder tap test' in these patients.

Methods
Patients with a diagnosis of FGD were identified from movement disorders clinics at two different hospitals. Reactions to being 'tapped' at the shoulders or pulled were retrospectively analysed using clinical records. For the shoulder tap test, patients were instructed that "on the count of three please try to keep upright if you are moved backwards" and that they were allowed to take as many steps as needed to avoid falling.

Results
Thirty-one patients with FGDs in whom responses were documented to either shoulder tap, pull test, or both were included in the analysis (mean age: 59.65 ± 15.27 years). All patients in whom a shoulder tap was performed (n=25) had an abnormal response, including taking multiple steps (n=9), significant body sway or a startle response (n=4), falling into the examiner's arms (n=7), or anticipatory body movement before being tapped (n=4). Abnormal responses to pull were documented in 14/17 patients (82.35%).

Conclusions
The 'shoulder tap test' was abnormal in all patients with FGD, even in those with a normal pull test, and may reflect postural hypervigilance and abnormal expectation in these individuals

# FREE PAPERS SESSION THREE

**Sensitivity and Specificity of the Persistent Postural-Perceptual Dizziness (PPPD) diagnostic criteria: a Synonym or Sub-type of Functional Dizziness?**

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Introduction
Persistent postural-perceptual dizziness (PPPD) is a diagnostic label, conceived by consensus expert opinion, for vestibular-related symptoms of functional aetiology. The term "functional dizziness" appears to be used synonymously with PPPD.

A prospective study was undertaken to investigate the diagnostic performance of the PPPD criteria against "Functional dizziness" as specified by the Functional Neurological Disorder diagnostic criteria.

Method
50 consecutive patients attending a tertiary vestibular physiotherapy service were screened for both PPPD and functional dizziness. Patients had had comprehensive vestibular assessment in a multidisciplinary balance clinic. At least two members of the research team had to reach consensus on the diagnoses for each patient.

Results
20% were diagnosed with PPPD and 64% with functional dizziness. Using the functional dizziness diagnostic criteria as the gold standard, the PPPD criteria had a sensitivity of 31% and specificity of 100% for identification of patients with functional dizziness. The most common reason for not meeting the PPPD criteria was identification of only a single-type motion intolerance, such as isolated positional dizziness.

Conclusion
These results suggest the PPPD criteria have low sensitivity for patients with dizziness of functional origin. Therefore the criteria may not capture the entire range of functional dizziness syndromes, and PPPD may represent a specific sub-type of functional dizziness. The development of an over-arching classification of functional dizziness should be considered.

**Safe Stability! The Importance of Multisensory Input for Balance Control in People with Intellectual Disabilities: a Pilot Study**

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Objectives
This pilot study aimed to explore the impact of (multi)sensory dysfunctions on the postural balance performance in adults with ID. Additionally, a comparison was made between the subjects with ID and a control group concerning the vestibular function and postural balance tasks.

Methods
45 adults with ID (18-61 years) participated to a vestibular screening protocol (cVEMP & vHIT) at the National Games of Special Olympics Belgium, of which 30 athletes (18-61 years) also completed an auditory (sequential protocol consisting of DPOAEs, tympanometry, and audiometry), visual (SVA), and postural balance evaluation (RS and SLS on a force platform, mFRT, and TUGT). Additionally, an age- and gender-weighted control group of 42 adults without ID (19-58 years) was subjected to the same vestibular screening protocol, of which 25 subjects (19-59 years) also underwent the postural balance evaluation.

Results
Compared to the control group, the occurrence of abnormal cVEMP and vHIT responses was significantly higher in the ID group, and the ID subjects performed significantly worse and/or showed more body sway for all balance tasks except the TUGT. Within the ID group, a significant positive correlation was observed between the number of failed sensory screening items and the number of failed balance tasks.

Conclusions
This study suggests an increased prevalence of peripheral vestibular deficits and postural balance problems in people with ID relative to the general population, and significant involvement of peripheral sensorial deficits in these postural balance dysfunctions.

Abbreviations

| | |
|---|---|
| ID | intellectual disabilities |
| cVEMP | cervical vestibular evoked myogenic potentials |
| vHIT | video head impulse test |
| DPOAEs | distortion product otoacoustic emissions |
| SVA | static visual acuity |
| RS | Romberg stance |
| SLS | single leg stance |
| mFRT | modified functional reach test |
| TUGT | timed-up-and-go test |

**Acquired Sex-Related Hormonal Differences in Motion Sickness Susceptibility**

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inAmind Laboratory, Department of Neuroscience, Psychology and Behaviour, University of Leicester, Leicester, UK

Previous research has illustrated strong hormonal related influences upon the evolution of dizziness and nausea in patients with vestibular migraine and during exposure to motion in healthy individuals respectively. Specifically, that is in females there is a close relationship between the menstrual cycle and episodic attacks of vestibular migraine as well as an enhancement in motion sickness susceptibly a few days preceding the mensuration period. However, whether acquired hormonal dysregulation can differentially modulate (males vs. females) motion sickness susceptibility remains unknown. To address this, we recruited 42 males and 42 females with adrenal insufficiency: matched for age, pre-morbid motion sickness susceptibility, aetiology, duration of disease, medication (steroid dosage) and co-morbidities (i.e. diabetes, thyroid disease) and assessed changes in motion sickness pre/post adrenal insufficiency utilising validated questionnaire measures. We observed that in females motion sickness susceptibility significantly increased ( almost doubling) following the development of adrenal insufficiency, whereas in males it remained unchanged. Our findings demonstrate that in individuals with acquired adrenal insufficiency, the dysregulation of sex hormones plays a pivotal role in governing susceptibility to motion sickness.

**Vestibular Agnosia Linked to Widespread Abnormality of Functional Brain Networks**

*Z Hadi, Y Pondeca, E Calzolari, M Chepisheva, H Rust, D J Sharp, M Mahmud, B M Seemungal*

Brain and Vestibular Group (BAVG), Neuro-Otology Unit, Imperial College London, UK

We recently reported a new condition - 'Vestibular Agnosia' - where acute TBI (aTBI) patients failed to perceive vertigo despite a manifest vestibular-ocular reflex (VOR) activation. In aTBI patients, vestibular agnosia was linked to impaired postural control via white-matter damage in the right inferior longitudinal fasciculus. Here we investigate the link between vestibular agnosia and resting state functional connectivity in aTBI, independent from postural control, and hence identify the brain regions specifically linked to self-motion perception. We assessed the functional differences revealed by analysing grey and white matter separately, using independent component analysis (ICA) and regions of interest (ROI). In 39 aTBI patients with intact peripheral and reflex vestibular function, we assessed self-motion perceptual thresholds during passive yaw rotations in the dark and analysed the scans of 25 aTBI patients following quality control. Using normative self-motion perceptual thresholds of 37 healthy controls, we classified 11 aTBI patients with vestibular agnosia (VA+) and 14 without vestibular agnosia (VA-). Grey-matter specific ICA showed that VA+ patients compared to VA- had: (i) decreased functional connectivity in right intracalcarine cortex in a resting state network composed of superior and mid temporal regions; (ii) increased functional connectivity in the left frontal pole in the rostral prefrontal cortex resting state network. White-matter specific resting state ICA showed that VA+ patients (vs. VA-) had increased functional connectivity in the right superior longitudinal fasciculus and right posterior thalamic radiation. ROI-to-ROI white matter specific analyses revealed a bilateral white matter network with increased functional connectivity in VA+ vs. VA-, with all connections originating from left anterior corona radiata. In conclusion, vestibular agnosia results in widespread abnormal white matter functional networks while grey matter functional changes are more specific to putative vestibular resting state networks, presumably reflecting low-order sensory processing. Abnormal prefrontal resting state networks could reflect abnormal perceptual 'ignition' of self-motion sensation.

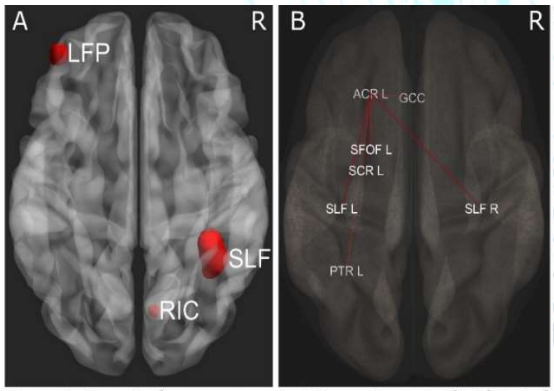


Figure A: Results from grey- and white-matter specific ICA. Left frontal pole (LFP; MNI: -42,48,00) and right superior longitudinal fasiculus (SLF; MNI: 39,-51,06) had increased while right intracalcarine cortex (RIC; MNI: 6,-72,12) had decreased functional connectivity in VA+ compared to VA-. Figure B: Group of connections in white matter specific ROI analysis showing increased connectivity in VA+ compared to VA- patients; connections originating from left anterior corona radiata (ACR) and terminating at right and left SLF, left posterior thalamic radiations (PTR), left superior corona radiata (SCR), genu of corpus callosum (GCC), and left superior fronto-occipital fasciculus (SFOF).

# KEYNOTE GUEST LECTURE

## Cognitive Functions and Vestibular Disorders

Professor Fred Mast, University of Bern, Switzerland

Fred Mast studied Psychology, Philosophy and Neurophysiology at the University of Zürich where he also obtained his PhD with his research on psychophysics of visual-vestibular interaction. He pursued his career in the US and spent four years at the Department of Psychology at Harvard University and at MIT.

He moved back to Switzerland and became Assistant Professor at the University of Zürich. In 2003, he became full professor for Cognitive Psychology at the University of Lausanne (2005-2008). Since 2008 he is full professor at the University of Bern where he is directing the section "Cognitive Psychology, Perception, and Research Methods". He served as Head of Department and Dean of the Faculty, and he was invited professor at York University in Toronto and at the Institute of Neuroscience of the Chinese Academy of Sciences in Shanghai.

His research is concerned with sensorimotor processing, in particular vestibular information, and how vestibular information is connected with higher order cognitive processes. He is using fMRI, EEG, galvanic and caloric stimulation, motion platforms, and eye movements for his research. He has ongoing collaborations with neuro-otologists and neurologists. neurology department around the world including Harvard, St Louis and Stanford. In addition to his academic work, he remains a full-time clinician.

# POSTER PRESENTATIONS

**PM01**

**The Visually Induced Motion Sickness Susceptibility Questionnaire (VIMSSQ): Individual Susceptibility to Symptoms of Motion Sickness using Visual Technologies**

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[2] KITE-Toronto Rehabilitation Institute, University Health Network, Canada
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Background
Widespread use of visual technologies increases the risk of visually induced motion sickness (VIMS). The 6-item short version of the Visually Induced Motion Sickness Susceptibility Questionnaire (VIMSSQ; also denoted as VIMSSQ-short) has been validated for predicting individual variation in VIMS. The aim of the current study was to investigate correlated factors for the VIMSSQ in the general population.

Methods
Participants (n=440, 201M+239F), mean age 33.6 (SD 14.8) years completed an online survey of various questionnaires including the VIMSSQ, Motion Sickness Susceptibility Questionnaire (MSSQ), Vertigo in City questionnaire (ViC), Migraine (scale), Social & Work Impact of Dizziness (SWID), Syncope, and Personality ('Big Five' TIPI).

Results
The VIMSSQ correlated (r) positively with MSSQ (.50), ViC (.45), Migraine (.44), SWID (.28), and Syncope (.15). The most efficient Multiple Linear Regression model for the VIMSSQ (adjusted R-Squared=0.4) included the predictors (beta) MSSQ (.32), Migraine (.27), ViC (.22), and Age (-.11). Factor analysis of strongest correlates with VIMSSQ revealed a single factor loading with VIMSSQ, MSSQ, ViC, Migraine, SWID, and Syncope, suggesting a common latent variable of sensitivity.

Conclusions
The set of predictors for the VIMSSQ in the general population has similarity with those often observed in patients with vestibular disorders. This may suggest the existence of continuum of underlying risk factors for sensitivity, from healthy population to patients with extreme visual vertigo and perhaps Persistent Postural-Perceptual Dizziness.

**PM02**

## Balancing Viral Transmission Risk with Falls and Detection Risks While Optimising Vestibular Rehabilitation Efficacy: the Judiciousness of a Novel Algorithm for Triaging Physiotherapy Referrals

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Introduction
Following the first wave of the COVID-19 pandemic, the physiotherapists at Guy's Hospital developed an algorithm to triage patients between face-to-face and remote consultations with the aims of (1) balancing viral transmission risk with falls and pathology detection risks, and (2) optimising the efficacy of vestibular rehabilitation (VR). This retrospective study was undertaken to determine the judiciousness of the algorithm.

Method
From October 2020 to March 2021, new patients were triaged to face-to-face consultations if referrals indicated a high falls risk and/or benign paroxysmal positional vertigo (BPPV). Otherwise, patients were triaged to video consultations by default. Telephone consultations were adopted if patients could not access the video platform. For follow-up appointments, the same triage criteria were applied, but video was no longer the default remote option. Face-to-face follow-up consultations were arranged if the initial appointment had been by telephone, enabling exercise technique to be scrutinised, or if sinister pathology was suspected at the initial remote consultation. Consultation types and adverse events were logged and descriptive statistics calculated.

Results
The proportion of face-to-face consultations dropped from 15% of new appointments to 8% of follow-up appointments. There were no known COVID-19 infections related to face-to-face consultations and no other adverse events.

Conclusions
The triage algorithm led to low proportions of face-to-face consultations. It may have prevented falls in those patients being treated for BPPV or imbalance, and optimised detection of sinister pathology. We believe the algorithm was and is prudent given the circumstances.

**PM03**
**EEG Correlates of Vestibulo-Cortical Processing**

*J Edey*

University of Leicester

Background
The vestibular cortex is a widespread, bilateral network across the parietal, temporal, and occipital cortices, involved in postural control. Cortical localisation studies have revealed an asymmetrical vestibular network which is lateralised to the non-dominant hemisphere, but electroencephalography (EEG) evidence is conflicting, and topographical localisation during caloric vestibular stimulation (CVS) is limited to functional MRI studies. Furthermore, previous literature has focussed on the structural organisation of the vestibular cortex, however, this does not translate to understanding of vestibulo-cortical processing. Using EEG, we measured cortical activations and functional connectivity during CVS in vestibular cortical regions. We aimed to identify whether neural processing of vestibular signals is lateralised to the non-dominant hemisphere, and to further understand vestibulo-cortical processing mechanisms.

Methods
Eighteen healthy, right-handed individuals underwent cold and warm caloric irrigation with eyes closed. EEG was recorded from 32 electrodes, data was processed in Minimum Norm Estimate (MNE) Python. Spectral power, node connection strength and connectivity correlation during CVS were analysed in the alpha frequency range (8-12 Hertz).

Results
During warm CVS, cortical activations in the right parietal lobe were significantly greater during right hemisphere stimulation than left, but the reverse was not seen in the left parietal lobe during left hemisphere stimulation. Symmetrical cortical activations were seen during cold CVS, however functional connectivity was greater during right hemisphere activation than left, significant in the left parietal, temporal, and occipital cortices. Functional connectivity in vestibular cortical regions was symmetrical during warm irrigations.

Conclusion
Our results demonstrate greater cortical activations and functional connectivity during some right hemisphere activations, supporting the notion that vestibulo-cortical processing is bilateral, with a degree of lateralisation to the non-dominant hemisphere. Alpha-band connectivity in the left hemisphere during right hemisphere activation could reflect interhemispheric inhibition of the inactive side by the dominant, activated hemisphere, potentially indicating dynamic interhemispheric competition.

**PM04**

## Frontal White Matter Integrity and Idiopathic Dizziness in Cerebral Small Vessel Disease

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Background
Three in ten older people (>60 years) complain of persistent dizziness which often remains unexplained despite specialist assessment and vestibular tests. We investigated if idiopathic dizziness was associated with vascular injury to white matter tracts relevant to balance or vestibular self-motion perception in sporadic small vessel disease.

Methods
We prospectively recruited 38 vestibular clinic patients with idiopathic dizziness (median 77 years) and 36 asymptomatic controls (median 76 years) who underwent clinical, cognitive, balance, gait and vestibular assessments, and structural and diffusion brain MRI.

Results
Patients had more vascular risk factors, poorer balance and worse executive cognitive function in association with greater white matter hyperintensity in frontal deep white matter, and lower fractional anisotropy in the genu of the corpus callosum and the right inferior longitudinal fasciculus. Vestibulo-ocular reflex and perceptual vestibular function was similar in patients and controls, though a white matter network involved in vestibular perception had lower connectivity in patients.

Conclusion
Our results show a relationship between lower microstructural integrity in frontal balance-relevant white matter tracts in cerebral small vessel disease, poorer balance and idiopathic dizziness. This suggests cerebral small vessel disease may be involved in the pathogenesis of dizziness in some older people.

**PM05**

## Multisensory Contribution in Visuospatial Orientation: An Interaction Between Neck and Trunk Proprioception

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[2] Neuro-otology unit, Department of Brain Sciences, Imperial College London, UK
[3] inAmind laboratory, Department of Neuroscience, Psychology and Behaviour, University of Leicester, UK
[4] Department of Neurology, The Johns Hopkins University School of Medicine, Baltimore, USA
[5] Centre for Vestibular and Behavioural Neuroscience, Department of Clinical and Motor Neurosciences, University College London, UK
[6] Universidad del Desarrollo, Facultad de Medicina Clínica Alemana. Santiago, Chile

Background and aims
A coherent perception of spatial orientation is key in maintaining postural control. To achieve this the brain must access sensory inputs encoding both the body and the head position and integrate them with incoming visual information. Here we isolated the contribution of proprioception to verticality perception and further investigated whether changing the body position without moving the head can modulate visual dependence- the extent to which an individual relies on visual cues for spatial orientation.

Method
Spatial orientation was measured in ten healthy individuals (6 female; 25-47yrs [SD 7.8yrs] using a virtual reality based subjective visual vertical (SVV) task. Individuals aligned an arrow to their perceived gravitational vertical, initially against a static black background (10 trials), and then in other conditions with clockwise and counterclockwise background rotations(each10 trials). In all conditions, subjects were seated first in the upright position, then with trunk tilted 20° to the right, followed by 20° to the left while the head was always aligned vertically.

Results
The SVV error was modulated by the trunk position, and it was greater when the trunk was tilted to the left compared to right or upright trunk positions ($p<0.001$). Likewise, background rotation had an effect on SVV errors as these were greater with counterclockwise visual rotation compared to static background and clockwise roll motion ($p<0.001$).

Conclusions
Our results show that the interaction between neck and trunk proprioception can modulate how visual inputs affect spatial orientation.

**PM06**

## Benign Paroxysmal Positional Vertigo in the Elderly with an Increased Risk of Fall Incidents

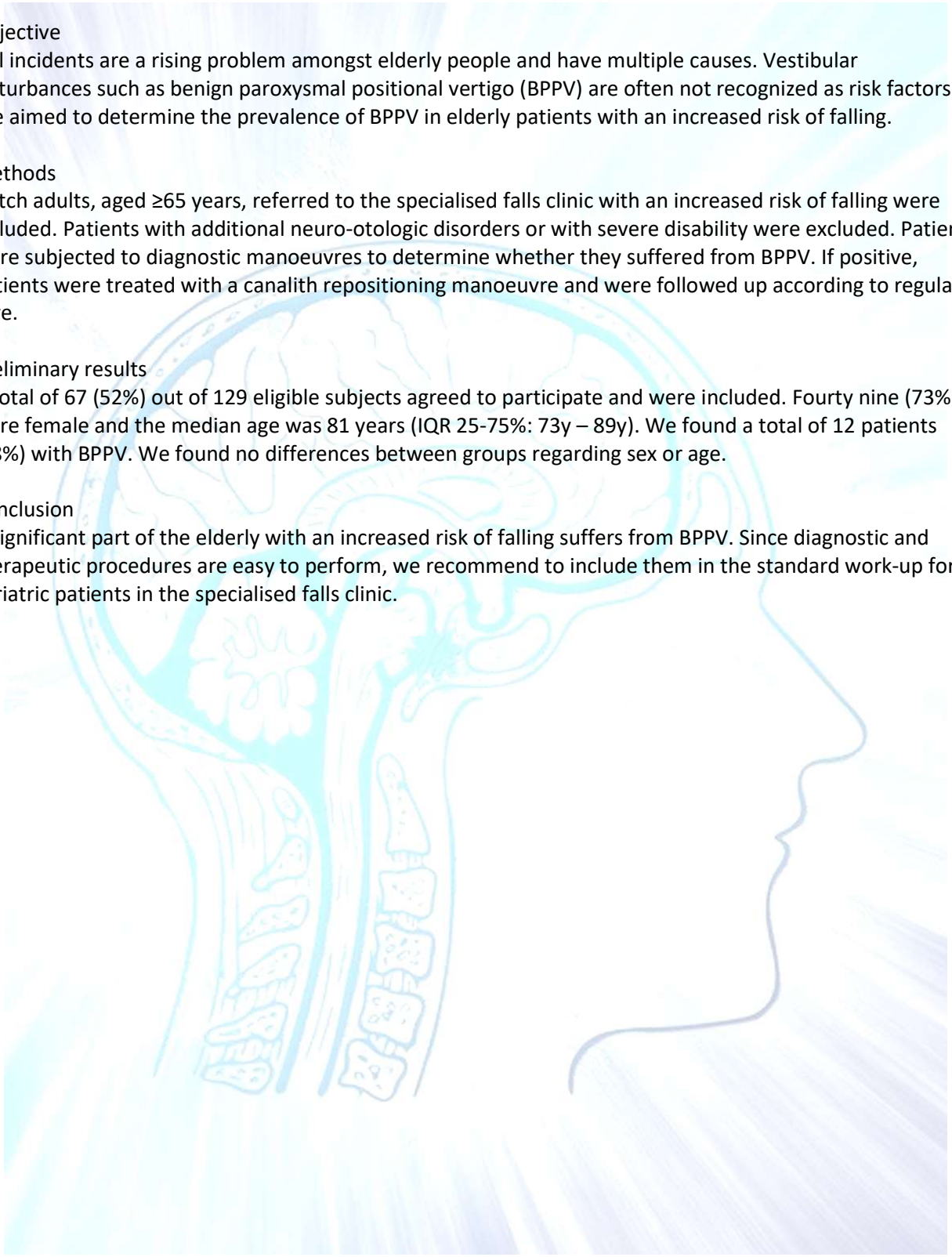
*B Maas*

Objective
Fall incidents are a rising problem amongst elderly people and have multiple causes. Vestibular disturbances such as benign paroxysmal positional vertigo (BPPV) are often not recognized as risk factors. We aimed to determine the prevalence of BPPV in elderly patients with an increased risk of falling.

Methods
Dutch adults, aged ≥65 years, referred to the specialised falls clinic with an increased risk of falling were included. Patients with additional neuro-otologic disorders or with severe disability were excluded. Patients were subjected to diagnostic manoeuvres to determine whether they suffered from BPPV. If positive, patients were treated with a canalith repositioning manoeuvre and were followed up according to regular care.

Preliminary results
A total of 67 (52%) out of 129 eligible subjects agreed to participate and were included. Fourty nine (73%) were female and the median age was 81 years (IQR 25-75%: 73y – 89y). We found a total of 12 patients (18%) with BPPV. We found no differences between groups regarding sex or age.

Conclusion
A significant part of the elderly with an increased risk of falling suffers from BPPV. Since diagnostic and therapeutic procedures are easy to perform, we recommend to include them in the standard work-up for geriatric patients in the specialised falls clinic.



**PM07**
**EEG Correlates of Illusory-Self Motion During Passive Rotation**

*Z Hadi, Y J V Pondeca, H M Rust, B M Seemungal*

Brain and Vestibular Group (BAVG), Neuro-Otology Unit, Imperial College London, UK.

Background
Perceived self-motion is typically induced when the head is accelerated by a suprathreshold stimulus that activates the peripheral vestibular apparatus. Illusory-self motion ('Vection') may be induced through moving large-field visual or less reliably via moving auditory stimuli. When assessing subjects at low yaw-plane angular acceleration vestibular thresholds (on a vibration-free rotating chair in dark), some subjects may perceive compelling illusory movement despite no real movement, providing a paradigm to assess the neurophysiological correlates of self-motion perception without the artefacts provoked by actual movement.

Objectives:
1. To determine EEG correlates of perceived rotation during real and illusory rotations.
2. Assess whether inter-hemispheric coherent activity correlates with perceived self-motion during actual and illusory rotation.

Methods
Subjects comfortably sat on a chair with 8 channel wireless EEG device. The chair was rotated at discrete triangular velocity waveform profiles at constant acceleration titrated according to individual perceptual thresholds determined at the start of the session. To induce illusory sensations of self-rotation, we used 240 trials of which 65% were real rotation trials and 35% had no rotation of chair. The start of each trial was indicated with a beep and a second beep sounded before the end of the acceleration phase (or identical time, since in no movement trials there was no confound of peripheral vestibular stimulation) requiring subjects to indicate their direction of movement (right or left), and then to indicate how compelling was their sensation of self-motion (1-5 scale).

Results
Our current data from 7 subjects show suppression of power (up to 3.5dB) in higher delta (3-4.5 Hz), theta (5-7.5 Hz), and low alpha (7.6-9 Hz) frequency ranges when the subjects perceived illusory self-motion. Similar effects are also observed during actual rotation trials; however, the suppression of frequency power is comparatively lower (1.5 dB). Slight increase in higher alpha (9-13 Hz) frequency power is also observed when subjects did not perceive movement in no rotation trials.

Discussion
Our preliminary data show clear EEG rhythm differences between epochs with perceived self-motion versus no self-motion. In addition to increasing our sample size, we are running additional experiments to control for the effects of vigilance.

**PM08**
**Brain Network Markers of Impaired Dual Task Postural Control in TBI**

*Y J V Pondeca, M Mahmud, Z Hadi, B M Seemungal*

Brain and Vestibular Group (BAVG), Neuro-Otology Unit, Imperial College London, UK

Background
Imbalance following acute TBI is associated with poor return-to-work rates at follow-up, and impaired dual-tasking may be implicated. Specifically, the ability to execute a cognitive task while balancing, may increase falls in TBI. Conversely, impaired balance aggravates cognitive performance. Hence, studying the neural mechanisms mediating imbalance during cognitive tasks (dual-tasking) may uncover why TBI patients with imbalance are twice as likely to be unemployed than those without balance issues. Herein, we will study the neurophysiological markers (using electroencephalography- EEG) of dual-tasking while balancing. The aim is to determine a clinically useful neurophysiological biomarker (via EEG) of TBI patients who are at increased risk of falls, and to link dual-tasking and postural control with an underlying rhythmic controller that may influence task performance. I will correlate EEG markers of abnormal dual-tasking in TBI patients – which we predict will relate to reduce inter-hemispheric coherence in EEG activity – which will correlate with loss of cortical connectivity on brain imaging. Linking neuro-imaging with neurophysiology will both validate the 'connectivity hypothesis' as well as provide a mechanistic insight in TBI-related imbalance during dual-tasking. The results from this investigation, have the potential to classify at-risk patients and thus enable targeted therapy to alleviate symptoms and ensure a timely return to work.

Hypothesis
TBI will disrupt networks that rely on rhythmic and interhemispheric connectivity, which mediate dual-tasks that involve simultaneous balance and a simultaneous cognitive task.

Methods
This study will combine posturography, neuroimaging , neurophysiological and neuropsychological techniques to assess neuromarkers of dual-task postural control and thus discriminate between healthy controls and TBI patients.

Conclusion
This research project, using a portable EEG device, will assess the EEG markers of deficient dual-task performance involving postural control in the TBI cohort. All things considered, if the findings of this study prove successful, there is great potential for a novel development of side-line assessment of TBI-associated postural instability, both within and outside clinical settings (e.g. sports with high concussion rates, such as rugby). Moreover, the linking of dual-task and postural control with a rhythmic controller may bring light to the functional architecture of dual-tasking, with close consideration of the impact of the periodic fluctuations of neuronal excitability.

**PM09**
**Therapist Referrals for Post Traumatic BPPV in a Major Trauma Centre**

*R M Smith, H Rust, N Marroney, J Beattie, B M Seemungal*

Brain and Vestibular Group (BAVG), Neuro-Otology Unit, Imperial College London, UK.

Purpose
We show that 55% of acute traumatic brain injury (TBI) patients have benign paroxysmal positional vertigo (see Smith et al. abstract). We investigated the factors that may affect trauma ward therapy staff recognising and referring TBI cases for BPPV treatment. We also assessed the impact of training upon referral rates for BPPV.

Methods
We examined referrals for BPPV to a specialist vestibular neurology service from the neurotherapy team at a Major Trauma Centre (St Mary's Hospital, London, UK). Training was provided on BPPV assessment and treatment over a 3-month period. Referrals were subsequently re-audited. Therapists were also made aware that over a fifth of acute TBI cases with BPPV do not complain of vertigo due to the disruption of vestibular-perceptual mechanisms, a syndrome called 'vestibular agnosia'(See Calzolari et al., abstract).

Results
Referral data was recorded from August 2017 to December 2019. Prior to training, of 76 patients with BPPV, 41 patients were referred by therapists (a recognition rate of 53%; on average 3.6 patients referred per month). Clinicians were five times more likely to refer patients with intact vestibular perception compared to patients with vestibular agnosia. Post-training, recognition rate was unchanged despite a drop in referral rates to 2.8 patients per month (of 22 patients with BPPV, 8 were referred). Therapists assessed and treated 23% of patients themselves, accounting for the drop in referral rate. The impact of vestibular agnosia on referrals however, was unchanged.

Conclusions
We demonstrate trauma ward therapists are motivated to assess and treat BPPV following TBI. Following training, referrals to specialists reduced markedly. However, recognition rates of BPPV remained unchanged, primarily due to the presence of vestibular agnosia. Although this suggests a pro-active screening and treating approach is needed in this population, the relatively high recurrence rate of BPPV in acute TBI indicates that the optimal time to treat is currently unknown. A prospective study to assess this question is on-going (https://www.isrctn.com/ISRCTN91943864).

**PM10**

## Prevalence and Impact of Dizziness, Unsteadiness and Falls in Adults Positive for COVID-19. An Online Anonymous Survey

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Background
Vertigo/dizziness and unsteadiness have been recently described as some of the main clinical manifestations of coronavirus disease of 2019 (COVID-19). Currently, it is not known how many adults positive for COVID-19 have been affected by dizziness, unsteadiness and/or falls and the impact these have on their lives.

Methods
An online anonymous survey delivered via Jisc platform aims to explore the prevalence and impact of vertigo/dizziness, unsteadiness and falls in adults aged 18-95 years' old who have had a positive test for COVID-19. The recruitment is performed via social media, community and patient organisations representing people with COVID-19, vertigo/dizziness, unsteadiness and falls.

Results
This study is currently ongoing. There are 360 respondents (296 females, mean age± SD=30.58±14.28 years) of whom 82 persons had symptoms due to COVID-19 that made them unable to work or had to change jobs while 32 were unable to work for over a year or established a permanent disability. Moreover, 196 persons experienced dizziness, 206 unsteadiness and 82 falls after having COVID-19.

Conclusion
Updated findings will be presented at the conference. Anonymised research data may help better understand appropriate assessment protocols and treatment strategies for persons who have had COVID-19 and experienced dizziness, unsteadiness and/or falls.

**PM11**

## Safety and Acceptability of Remote Consultations in the Neuro-otology e Clinic

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### Background

The COVID19 pandemic encouraged clinicians to maximise the use of remote consulting, including video and telephone consultations. However, the safety and patient acceptability of this pathway is not well understood.

### Methods

A prospective study was carried out at two centres, evaluating diagnostic stability, adverse events and patient feedback on remote consultation experience.

### Results

Data was collected on 59 consecutive new referrals. 69% were female and average age was 54 (range 24 to 83). In those who had a further clinical review (n=28), initial diagnosis was unchanged in 18 (64%) and revised for 10 (36%). Adverse events (falls) were reported in 4/59 patients (7%). Significant new pathology was identified at examination in 2/59 patients (3%); (central positional nystagmus n=1, POTS n=1). 38 (64%) patients rated the consultation as useful or very useful. In free text feedback, patients identified numerous practical advantages of remote consultations, but also that they found it easier to discuss sensitive issues and build rapport when seen in person.

### Conclusions

Many patients are satisfied with remote consultations, but clinicians need to be prepared to evaluate face-to-face promptly in order to allow timely intervention and recognition of less common conditions. Further research should aim to identify in which cases remote consultations are most effective.

**PM12**

**Vestibular Rehabilitation Service Performance Audit: Ascertaining the Impact of the Significant Reconfiguration of Therapy Delivery Necessitated by the Pandemic**

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Introduction

The rapid implementation of a hybrid vestibular rehabilitation (VR) service at Guy's Hospital, offering remote and face-to-face consultations, posed a threat to the service's mission to deliver judicious, responsive, effective and favourable care to balance-disordered patients. An audit was undertaken to determine whether VR service standards were met between October 2020 and March 2021.

Method

The following data were collected: (1) number of adverse incidents [judiciousness; standard=0], (2) number of new patients scheduled per month [responsiveness i; standard=84], (3) median monthly NP waiting time [responsiveness ii; standard=6 weeks], (4) 12-week change in DHI score [effectiveness; standard=8], (5) monthly follow-up DNA rate [favourability; standard=10%].

Results

While two adverse incidents were logged during the audit period, both were historic. The number of new patients scheduled per month increased from 21 in October to 58 in March as the service opened up after the first wave. Correspondingly, median waiting times dropped from 11 to 4 weeks. Very little DHI score data were captured throughout the period. The monthly follow-up DNA rate stabilised at 5%.

Conclusions

Some aspects of the VR service's mission had been accomplished. Although there were missing data, no concerning performance trends were detected. The hybrid VR service appears suitable for long-term implementation.

**PM13**

## An Acute Vertigo Pathway: the Interface of an ENT Multidisciplinary Balance Clinic with Acute Medicine

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Background
Acute vertigo is common in primary and emergency care settings. However, most specialists in neuro-otology within the UK work primarily in ambulatory care settings. Hence there is a potential disconnect between those treating acute vertigo and those who are most specialist in accurate diagnosis. Additionally, it is believed that long waits before diagnosis and correct treatment may facilitate the development of conditions such as persistent posturo-perceptual dizziness, PPPD. We hypothesised that the creation of a specific defined pathway (HOT vertigo pathway) for patients with acute vertigo could improve service provision.

Methods
Two groups of fifteen patients with vertigo were compared for diagnosis, waiting time and outcome. 1) patients referred via the HOT vertigo pathway (HOT group) 2) patients referred via other routes (control group)

Results
Patients referred via the HOT pathway were appropriately selected for the service, with no inappropriate patients referred via this route (main diagnoses BPPV 60%, acute unilateral peripheral vestibulopathy 10%, migraine 20%). However, the waiting times were not significantly different between the two groups (p=0.076).

Conclusions
The HOT clinic pathway has demonstrated that emergency care services can identify and refer appropriate patients to a rapid review vertigo service. Rapid access to such appointments remains challenging.

**PM14**
**Attentional Network Dysfunction in Vestibular Migraine**

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Background
Despite vestibular migraine being amongst the commonest causes of episodic vertigo, the pathophysiology remains largely unknown. Given the common complaint of spatial disorientation in vestibular migraine patients, we postulated that this may be mediated by a dysfunctional attentional network.

Methods
We used the Attentional Network task, where participants were instructed to indicate the direction (right/left) of a target arrow in the upper or lower visual hemifield presented on a laptop screen placed 25cm away. Targets were preceded by 1 of 4 possible cue types: none, double, central, or spatial and participants were required to detect the direction of a “target arrow” that allows interrogation of three attentional networks, alerting, orienting and executive control.

Results
Vestibular dysfunction induces a global deficit in attentional processing as reflected by significantly increased reaction time, irrespective of stimulus condition, when compared to controls. Furthermore, a clinically relevant and domain specific deficit is observed within the executive control network of VM patients.

Conclusions
Our findings revealed a specific and clinically relevant deficit in the executive control network of vestibular migraine patients.

**PM15**

## Impaired Subjective Visual Vertical and Increased Visual Dependence in Older Adults with Falls

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Aging affects the vestibular system and may disturb the perception of verticality and lead to increased visual dependence (VD). Studies have identified that abnormal upright perception influences the risk of falling. The aim of our study was to evaluate subjective visual vertical (SVV) and VD using a mobile virtual reality-based system for SVV assessment (VIRVEST) in older adults with falls and evaluate its relationship with clinical balance assessment tools, dizziness, mental state, and depression level. This study included 37 adults >65 years who experienced falls and 40 non-faller age-matched controls. Three tests were performed using the VIRVEST system: a static SVV, dynamic SVV with clockwise and counter-clockwise background stimulus motion. VD was calculated as the mean of absolute values of the rod tilt from each trial of dynamic SVV minus the mean static SVV rod tilt. Older adults who experienced falls manifested significantly larger biases in static SVV ($p = 0.012$), dynamic SVV ($p < 0.001$), and VD ($p = 0.014$) than controls and had a greater risk for falls. The increase in static SVV (odds ratio = 1.365, $p = 0.023$), dynamic SVV (odds ratio = 1.623, $p < 0.001$) and VD (odds ratio = 1.460, $p = 0.010$) tilt by one degree significantly related to falls risk in the faller group. Fallers who had a high risk of falling according to the Tinetti test exhibited significantly higher tilts of dynamic SVV than those who had a low or medium risk ($p = 0.037$). In the faller group, the increase of the dynamic SVV tilt by one degree was significantly related to falls risk according to the Tinetti test (odds ratio = 1.356, $p = 0.049$). SVV errors, particularly with the dynamic SVV test (i.e., greater VD) were associated with an increased risk of falling in the faller group. The VIRVEST system may be applicable in clinical settings for SVV testing and predicting falls in older adults

**PM16**

**Living with a Vestibular Disorder During the Covid-19 Pandemic: An Online Survey Study**

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Objective
To assess the impact that the Covid-19 pandemic has had on vestibular symptoms and key aspects of everyday life amongst people living with a vestibular disorder.

Methods
A cross-sectional online survey was completed by over 100 people in the UK with a vestibular disorder. The survey covered health status, symptomology, healthcare received, social interactions, and employment during Covid-19.

Results
The Covid-19 pandemic and social distancing restrictions affected perceptions of wellbeing, with over 50% rating their health as worse now than before the pandemic. Tinnitus, loss of concentration/memory, dizziness/disorientation, and headaches were the most commonly exacerbated symptoms. Respondents reported lifestyle changes including reduced social contact, worse exercise habits, and fewer recreational activities. Barriers included difficulty communicating, feeling anxious about future setbacks, and self-managing symptoms. Unintended benefits of the pandemic were also reported including; avoiding busy environments, accessing remote support, and less pressure to socialise.

Conclusion
These findings highlight the diverse effects of the pandemic. Clinical services should be mindful that Covid-19 can exacerbate vestibular symptoms and offer support to improve the wellbeing of people with vestibular disorders, who are vulnerable to the negative effects of the pandemic on their lifestyle and social interactions. Flexible remote support could offer some benefit.

**PM17**

**A Case-Controlled Study: Cognitive Performances in Vestibular-Impaired School-Aged Children**

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Background
Converging evidence suggests that besides balance deficits, vestibular-impaired patients may develop cognitive impairment as a result of their vestibular dysfunction. In contrast to studies in adults, studies about the impact on cognitive performances in vestibularimpaired children are scarce.

Methods
Thirteen uni- (n=5) and bilateral (n=8) VI children (6- 13 years old) were recruited from the audiology department of the Ghent University Hospital, and were matched for age, gender, and hand preference to thirteen typically developing children. All participants underwent an extensive protocol of audiovestibular, visual, and cognitive tests. Preceded by an intelligence screening, response inhibition, emotion recognition, visuospatial memory, selective and sustained attention, visual memory and visual-motor integration performances were assessed.

Results
For the domains 'social cognition' ($p=0.003$), 'executive functions' ($p<0.001$) and, more specifically, 'response inhibition' ($p=0.001$), 'complex attention' ($p=0.027$), and 'perceptual motor functioning' ($p=0.005$) significantly (or a strong trend towards) more difficulties were observed in the vestibular-impaired group, compared to their healthy peers. For the visual and visuospatial short term and working memory parameters no significant group differences or suggestive trends were found.

Conclusions
These preliminary cognitive results correspond with the findings in the adult population and underpin the importance of future studies characterizing the impact of vestibular dysfunction.

**PM18**

## Modelling Risk of Falls through Lab Assessment of Postural Control and Home-Monitoring in Parkinson's Disease

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Background
Falls are common in the elderly people and patients with neurodegenerative disorders such as Parkinson's Disease. Risk of falling is currently assessed through subjective measures, however, even measuring objective balance function is non-linearly related to falls frequency. For example, a patient with poor balance may choose to stay in bed all day and with few falls while a patient with good balance may hill walk having regular falls. Balance function can be quantified as a hybrid control systems model composed of proportional-integral-derivative (PID) control and an intermittent control system. We will combine laboratory measures of postural control with home measured activity to attempt to predict patients' absolute falls risk.

Objectives
1. Use a combination of intermittent and PID control systems to model postural control in patients with balance problems in the lab.
2. Estimate the type of activity (A) and quantity of activity (Q) using wearable home-monitoring devices.
3. Combine A and Q in the lab-model (PID and Intermittent) of postural control to estimate risk of falling.

Methods
We will assess patients on a posturography platform on hard and soft surface to test for their balance and use a hybrid model composed of PID and intermittent control systems as an objective measure of postural control. Wearable home-monitoring devices will be given to patients for 2 weeks to record their activity. The recorded activity will then be categorized using advanced machine learning techniques. The features from the patient's activity will be included in lab model in order to estimate risk of a fall.

Discussion
Using the above approach, we are currently assessing patients with Parkinson's Disease in a prospective fashion.

**PM19**
**Modulating Balance with Galvanic Vestibular Stimulation in Traumatic Brain Injury Patients**

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Background and Aims
Impaired balance, mainly a vestibular ataxia, affects 80% of patients with moderate-tosevere acute traumatic brain injury (TBI). Although vestibular ataxia improves over time post-TBI, no interventions have yet been shown to accelerate patient's balance recovery. Neuromodulation by galvanic vestibular stimulation (GVS) may itself or in conjunction with physical therapy, accelerate the balance recovery of TBI patients. We performed a mechanistic, randomised and double-blinded, sham-controlled study exploring the effect of GVS on imbalance in TBI patients.

Methods
We administered bipolar noisy GVS (frequency 0-30Hz) through anodes and cathodes placed on the mastoids of seven TBI patients and four healthy controls (HC). Subjects stood on a soft-foam surface, placed upon a 'balance' or force platform for 120 seconds, with eyes closed. Either anodal or sham stimulation was applied for the first and last 30 seconds of the balance task, in randomised order.

Results
The sway parameters of six TBI subjects reduced when compared to sham, with amplitudes between 100- 300uA (n=4) and 500–600uA (n=2). The average sway RMS, path and 95% confidence ellipse area of the subject's movement reduced compared to sham by (Mean (± SEM; p-value) 28.86% (2.57; p0.05) and 41.21% (5.07; $p<0.05$), respectively.

Conclusion
This is the first demonstration of noisy GVS in patients with TBI. Our work demonstrates GVS may have a role in balance modulation in TBI. Future work will assess possible brain mechanisms involved in noisy GVS upon patients' balance.

Disclosure
Nothing to disclose.

**PM20**

**Meta-Analysis and Systematic Review of Galvanic Vestibular Stimulation on Postural Control in Parkinson's disease**

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Background and aims:
Subthreshold Galvanic Vestibular Stimulation (GVS) may improve postural control in Parkinson's disease (PD) patients. This systematic review and meta-analysis investigate the effects of GVS on motor and non-motor outcomes in PD patients.

Methods
Six separate databases as well as ongoing trial and research registers were searched for randomised, controlled trials with a parallel or cross-over design that evaluated the effects of GVS on gait and balance in PD. Inclusion criteria were outcome measures of functional mobility, subjective balance, motor tasks, reactive balance and static balance. We excluded non-peer reviewed literature, conference proceedings and studies where it was not possible to extract results due to missing information. We used standardized mean difference (Hedges' g) as a measure of effect size in all studies.

Results
A total of 223 studies were screened and 14 included of which six qualified for the meta-analysis. A random effects model meta-analysis found GVS to be more effective than sham GVS for the improvement in postural outcome measures. The overall effect size was 1.28 (95% CI 1.02–1.61) and had low heterogeneity (Q=20.05, df=11, p=0.04, I^2=33.2%). However, the random effects model found no significant effect of GVS within each subgroup. A trim and fill funnel plot showed publication bias to be unlikely.

Conclusion
GVS may enhance gait and balance in patients with Parkinson's disease, but better powered studies that assess clinically useful outcome measures are required.

Disclosure:
Nothing to disclose.

**PM21**

## Saccadic Oscillations as a Cause of 'Refixation Saccades' with Normal Gain on Video-Head Impulse Testing

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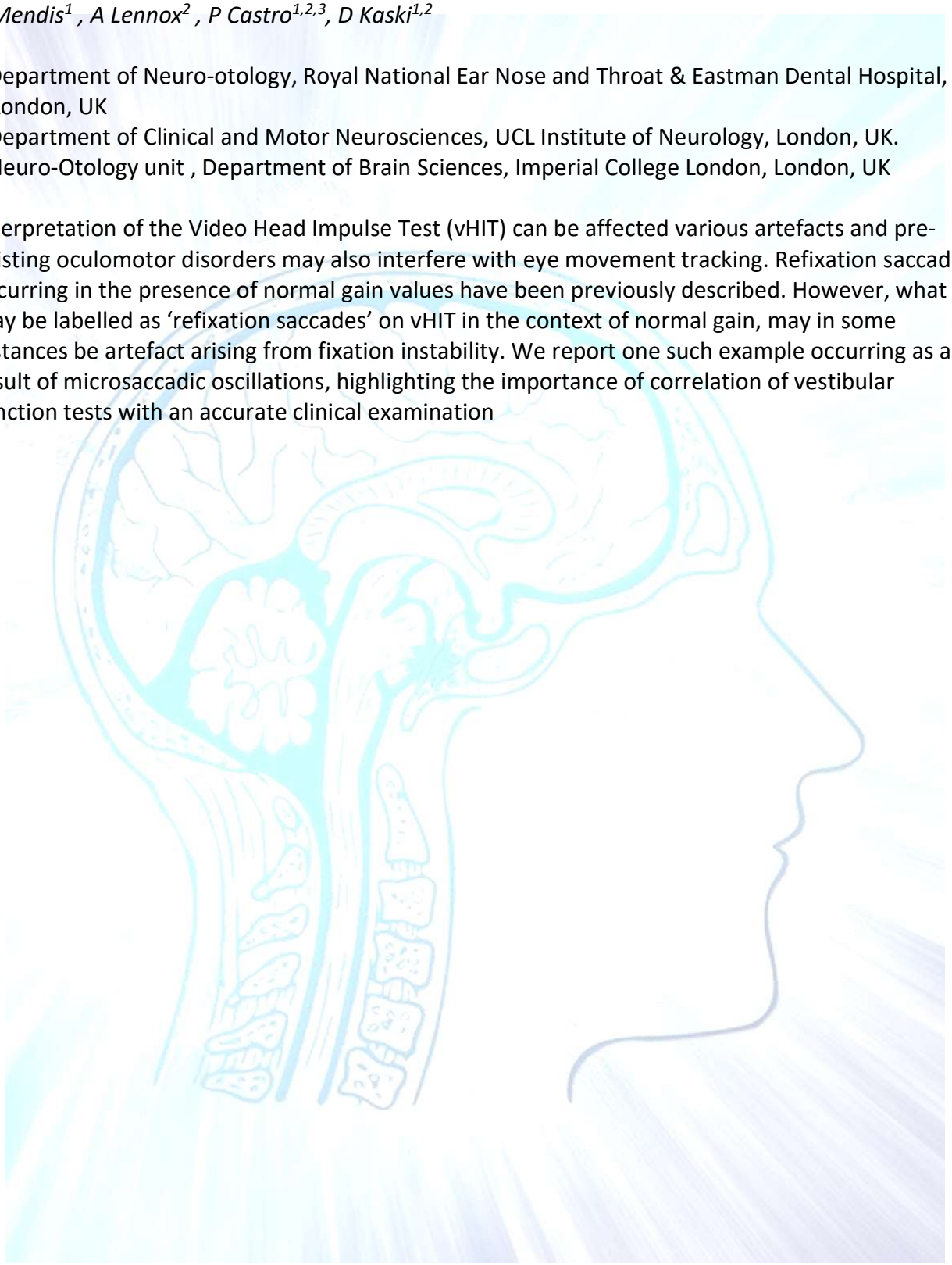
Interpretation of the Video Head Impulse Test (vHIT) can be affected various artefacts and pre-existing oculomotor disorders may also interfere with eye movement tracking. Refixation saccades occurring in the presence of normal gain values have been previously described. However, what may be labelled as 'refixation saccades' on vHIT in the context of normal gain, may in some instances be artefact arising from fixation instability. We report one such example occurring as a result of microsaccadic oscillations, highlighting the importance of correlation of vestibular function tests with an accurate clinical examination



**PM22**

## Consciously Processing Blance Leads to Distorted Perceptions of Instability in Older Adults

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Background
Persistent dizziness without a clear cause is common in older adults. We explored whether an anxiety-driven preoccupation with consciously processing balance may underpin the distorted perceptions of unsteadiness that characterises 'unexplained' dizziness in older adults.

Methods
We experimentally induced anxiety about losing one's balance (through a postural threat manipulation) in a cohort of asymptomatic older adults and evaluated associated changes in perceived stability, conscious movement processing and postural control. These outcomes were also assessed when performing a distracting cognitive task designed to prevent anxiety-related conscious movement processing, in addition to during baseline conditions (ground level).

Results
Despite a lack of increase in postural sway amplitude ($p = 0.316$), participants reported reductions in perceived stability during postural threat compared to baseline ($p < 0.001$). A multiple linear regression revealed that anxiety-related conscious movement processing independently predicted perceptions of instability during this condition ($p = 0.006$). These changes were accompanied by alterations in postural control previously associated with functional dizziness, namely high-frequency postural sway and disrupted interaction between open- and closed-loop postural control ($ps < 0.014$). While the distraction task successfully reduced conscious processing ($p = 0.012$), leading to greater perceived stability ($p = 0.010$), further increases in both postural sway frequency ($p = 0.002$) and dominance of closed-loop control ($p = 0.029$) were observed.

Conclusion
These findings implicate the role of conscious movement processing in the formation of distorted perceptions of unsteadiness, suggesting that such perceptions may be modifiable by reducing an over-reliance on conscious processes to regulate balance.

**PM23**

## Customised Vestibular Rehabilitation with the Addition of Virtual-Reality-Based Therapy in the Management of Persistent Postural-Perceptual Dizziness

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Abstract

Objective. Visual-vestibular mismatch patients experience persistent postural and perceptual dizziness. Previous studies have shown the benefit of vestibular rehabilitation for visual desensitisation using gaze stabilisation exercises and optokinetic stimulation. This study assessed the benefit of customised vestibular rehabilitation with visual desensitisation and virtual reality based therapy rehabilitation in the management of patients with persistent postural-perceptual dizziness.

Methods

This retrospective study included 100 patients with Situational Characteristic Questionnaire scores of more than 0.9. All patients received virtual reality based therapy along with usual vestibular rehabilitation using gaze stabilisation exercises with a plain background followed by graded visual stimulation and optokinetic digital video disc stimulation. Patients' symptoms were assessed before and after vestibular rehabilitation using the Situational Characteristic Questionnaire, Generalised Anxiety Disorder Assessment-7, Nijmegen Questionnaire and Dizziness Handicap Inventory.

Results

There were statistically significant improvements in Situational Characteristic Questionnaire scores, Nijmegen Questionnaire scores and Dizziness Handicap Inventory total score. However, there was a statistically insignificant difference in Generalised Anxiety Disorder Assessment-7 scores. There was a significant positive correlation between post- rehabilitation Situational Characteristic Questionnaire scores and other questionnaire results.

Conclusion

Incorporating virtual reality based therapy with customised vestibular rehabilitation exercises results in significant improvement in persistent postural-perceptual dizziness related symptoms.