41° CONGRESSO
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CENTRO CONGRESSI
LINGOTTO
TORINO - ITALY
6-8 LUGLIO 2016
SVINT
(Skull Vibration Induced Nystagmus Test)
Fundamental Bases- Examination Technique- Stimulus Optimization- Interpretation of Clinical main Results

(Dumas Test: PhD University Thesis. Nancy Sept 2014)

Georges DUMAS MD; PhD
Lecture Torino 8 th July 2016

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Ecole Doctorale BioSE (Biologie-Santé-Environnement)

Thèse

Présentée et soutenue publiquement pour l'obtention du titre de

DOCTEUR DE l'UNIVERSITE DE LORRAINE

Mention : « Sciences de la Vie et de la Santé »

par Georges DUMAS

Influence de stimulations vibratoires appliquées au crâne et aux muscles cervicaux sur la fonction d'équilibre. Interprétations physiologiques et applications à la pathologie. Développement et validation d'un nouveau test d'exploration vestibulaire : le test de Dumas.

19 septembre 2014

Membres du jury :

Rapporteurs :
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M. Pierre DENISE Professeur, Université de Caen – Basse-Normandie, INSERM U1675
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M. Sébastien SCHMERBER Professeur, Université de Granoble, Co-Directeur de thèse

Membre invité :
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EA 3450 DevAH – Développement, Adaptation et Handicap. Régulations cardio-respiratoires et de la motricité (Directeur : Ph. Perrin) – Université de Lorraine
Faculté de Médecine et UFR STAPS de Nancy
What is a VIN?

**Ex:** TUVL Left Lesion. (10 years post op)

Similar results in compensated, neglected Temporal Bone fractures

VIN IS REVEaled **INSTANTANEOUSLY** BY VIBRATIONS

VIN is not influenced by vestibular compensation mechanisms

Benefit in occupational Medicine or Medico-legal implications (forensic Medicine)
INTRODUCTION

• Von Bekesy (1935) : cranium vibrations induce vestibular réflex and motion illusions.

• Lücke K. (1973) : VIN accidental discovery (customary device) ; suggests clinical interest(100Hz)

• Hamann KF.: com.(1993;1995); pub.(1999) : VIN is frequent in V. Schwannomas and peripheral diseases; seldom in central cases; exceptionnal in BPPV. « VIN can replace the Caloric Test »

• Vibrations by other authors: motion illusions; postural sway; SVV; SHV; VIN: Lackner (1974); Michel(1995); Yagi(1996); Popov(1999); Strupp M (1998);Karlberg (2003); Ohki(2003); Magnusson (2006);Manzari(2008);Park H(2008);Nuti(2005);Koo JW(2011);Kawase T(2011);Kim;Lee SU(2015); Modugno; Tanzariello (Fev. 2016)

• Fundamental discoveries: Young (1977);Curthoys (2006;2013); Hudspeth(2003)

• Dumas G et coll.( Grenoble-Briançon-Nancy)com.(1997;1998);pub.(1999; 2000): topographic and frequency optimization; characterization; forces pressures Piezo E. sensors(ENSHMG).

A Vestibular Weber capable (liable)to reveal a vestibular asymmetry at high frequencies
INTRODUCTION

The Skull Vibration induced nystagmus test

- Acts as a high frequency Vestibular Weber Test (Dumas Test)
- Reveals instantly a vestibular asymmetry for frequencies around 100Hz
- Stimulates bilaterally and simultaneously vestibular structures (Dumas et al. 2007, 2008, 2011)
- Primarily the Utricle (500Hz) (Curthoys & Kim, 2006)
- Both SCC and otholith at 100 Hz (Curthoys 2013)

The Vibration induced Nystagmus (VIN)-100Hz

* G.Dumas; P.Perrin; S.Schmerber. Acta otolaryngol (Stokholm) 2008;128:255-62
* G.Dumas; S.Schmerber. Otol neurotol. 2011; 38: 1291-301
** I.S.Curthoys; J.Kim. Exp.Brain Res. 2006;175-67
** Curthoys I, Vulovic V, Sokalic L, Pogson J, Robins M, Burgess A. The neural basis of clinical vestibular responses to bone conducted vibration (BCV) and air conducted sound (ACS). In: Abstracts, editor. Association for Research in Otalaryngology (ARO); 2013; Baltimore. 2013.
FUNDAMENTAL BASIS: PERIPHERAL VESTIBULAR RECEPTORS

Cinetic Canalar Receptors (ampula CSC) sensitive to angular accelerations (2mrad/s²): accelerometer
Static Otolithic Receptors (macula Utr. and Sac.) sensible to linear accelerations and gravity (0,2m/s²).
Primary vestibular afferents with irregular resting discharge issuing from canal type I hair cells do not respond to sounds and vibrations at 500 Hz; Only irregular afferents issuing from otholith (Type I hair cells) respond.

**Guinea Pigs**: 80 animals recorded from single primary semicircular and otolithic afferents

**IS Curthoys et al.** The response of guinea pig primary Utricular an Saccular irregular neurons to bone-conducted vibration (BCV) and hair-conducted sound. Hearing Research 2016.331:131-43

With I. Curthoys courtesy 2016
Activation of a canal neuron by repeated bursts of 100Hz skull vibration (normal encased bony labyrinth)

neural response

Accelerometer records of the stimulus (VIBRATION)

With I. Curtoys permission 02/04/2016

Tuning responses with phase locking discharges of a canal irregular afferent at 100 Hz BCV
The 2 TYPES of SENSORY CELLS

- **Type I.** Phylogenetically more récent
  - Top of ampullar crests, striola.
  - Aff. Syst. Calix ending fibres big calibre (8 à12µm)
  - Irregular Phasic Discharges
  - Respond to High frequencies Stimulations.
  - Important Adaptation and gain.
  - Responses for high speed movements.

- **Type II.** Cresc Ampullary Basis, macula
  - Punctual contact aff syst; direct contact eff syst
  - Small caliber fiber (3µm), tonic cells
  - Respond to low frequency stimulations
  - Large amplitude of modulation
  - Vestibular static function.

- Contractile actine, myosine tropomyosine fibres : Active phenomenon (stereocils).

Neurobiotine Staining traces back neurons to Type I Hair cells of the Striola) (Curthoys 2015)

With I. Curthoys courtesy 2016-(from Vestibular Research Laboratory, School of Psychology, the University of Sydney, NSW, Australia). (The labeling of type I inner ear hair cells by Neurobiotin after BCV stimulations)

Curthoys I; Vulovic V et al. The response of guinea pig primary utricular and saccular irregular neurons to bone-conducted vibrations (BCV) and air-conducted sound (ACS). Hearing Research Bulletin. 2016; 331:131-143
The 2 types of sensory hair cells (Utricle Macula).

**HOW are Hair Cells stimulated at High Frequencies?**

Hair Cells type II (long hairs)  
Hair Cells type I (short, stiff hairs)

---

A similar disposition can be observed between Apex and basis of cupula  
Classic mechanical ampulla crest mobilization- cut off 60 Hz (Hermann 1980)  

---

Inner ear pressure Waves.  
frequencies >100 Hz  
(Vibration induced fluid pressure directly activate vestibular hair cells)

---

From Spoon & Grant 2012  
With Curthoys courtesy 2016
BONE CONDUCTION
(Stenfeld S; Goode RL. 2005)

- Transcranial Transfer Reduction attenuation (mastoid to mastoid):
  For $F<0.2\text{kHz}$: direct with low reduction or even negative; (almost infinite transmission velocity)
  For $0.25<F<4\text{kHz}$: $10\text{dB}$; For $F>8000\text{Hz}$: $15\text{dB}$

- Vertical Transfer (Vertex- mastoid): stimulation front-cochlea (11 dB) < stim mastoïd-cochlea contralatéral. (Muffling, damping, reduction).

SVINT (DUMAS Test)
Bedside Examination Technique (Dumas)

• Upright Sitting Position

• Stimulus : 30, 60 et 100 Hz

• Location : each mastoid in turn; vertex

• Stimulus Duration : 5 -10 seconds
Examination Technique: stimulus topography

The Examiner can be behind the subject

Level to the external auditory meatus (Behind the auricle)

The Examiner can be in front of the subject
FREQUENCY OPTIMIZATION

TOPOGRAPHIC OPTIMIZATION
AVAILABLE STIMULATORS-DEVICES

- Mechanical Vibrator: off axis rotation vibrator (masselotte)
  - Synapsys (Inc., Marseille, France) Inventis (Biomedica, Padova, Italy)
    SV VIB 3F (30- 60- 100 Hz)
    SV 100 Hz - 1mm amplitude

- Electromagnet Stimulators
  - ISV 1 Amplifon (Inc., Paris, France) 40-115Hz -0.6mm constant pressure
  - ABC (Germany) 100 Hz - 0.8mm
  - Stimulator 3S (ENSHMG)(Grenoble, France): 20 à 150 Hz (0,1 à 0,9mm ampli) (prototype)
  - VVSED 500 (Euroclinic Italy): 100 Hz; NC70209 (North Coast Medical, USA)

- Portable Stimulator
  - (Magnusson, Lund, Sweden) 85 Hz: fixed élastic strap or rubber band (Postural studies)
  - Vibrasens (7.5 cm/ 3.5cm. 80 Hz)(Techno Concept France)

- Mini-shaker 4810 or 2810 (Bruel and Kjaer, Denmark) 10 à 800 Hz (10-10000 Hz)
STIMULATION VERY HIGH FREQUENCIES PROTOCOL (B&K)(Mini shaker 4810)(15 UVL-SPV Analysis)
FREQUENCY OPTIMIZATION (B&K)
MASTOIDS STIMULATIONS (N=15) LUVS
RESULTS VIN-SPV ANALYSIS

Not paramétric Tests : Hétérogénéity: Friedmann Test(p=0.0001); Comparison of populations 2/2 Wilcoxon.
Significant Différences 2/2 for Hor component (p< 0.001). No significant difference for Vertical component.
TOPOGRAPHIC OPTIMIZATION

Oscilloscope Philips numérique (PM 3335 60 MHz; Netherland): amplitude réponse en mV (pic à pic; constante de temps 10s; durée 5s)
Accéléromètres Capteurs Piézo-électriques (Bruei et Kjaer MG 53; Denmark)

G. Dumas; A. Lion; P. Perrin; E. Ouedraogo; S. Schmerber. Topographic analysis of the Skull Vibration Induced Nystagmus Test with piezo-electric accelerometers and force sensors. Neuro Report. 2016
Topographic Optimization (Protocol)
piezoelectric Sensors

Fig. 1 Piezoelectric Sensor and vibratory stimulus location

G.Dumas; A.Lion; P.Perrin; E.Ouedraogo; S.Schmerber. Topographic analysis of the Skull Vibration Induced Nystagmus Test with piezo-electric accelerometers and force sensors. Neuro Report. 2016
RESULTS

Test Friedman-Wilcoxon: *p<0.01; ***p<0.001   N=11

OPTIMIZATION on MEDIAN LINE (100 Hz) (n=26 LUVS)

- VIN SPV Vertex = 3.25 [2.12 - 7]
- VIN SPV FZ = 4 [1.06 - 8.5]
- P = 0.39 (N=26) NS (Wilkoxon Test)
- VIN SPV Vertex = 3.00 [2.50; 5]
- VIN SPV FZ = 2.00 [1.00; 5.50]
- VIN SPV Occip. = 1.75 [1.00; 3.75]
- P = 0.55 (Friedman Test) No heterogeneity

NO SIGNIFICANT DIFFERENCE for TOPOGRAPHIES: FZ; VX; Bregma; OCC; S/Occ. analysed
Statistics: A. Lion Sports Medicine Research Laboratory, Luxembourg Institute of Health. Luxembourg
There is an inter and intra experimenter significant difference

Skull Vibration Induced Nystagmus Test (SVINT)- Bone Conducted Vibrations (BCV)

What is the best topography?

Mastoid

(SPV: Mastoid response > cervical post > Vertex) (p<0.05)

(In common UVL)

What is the best frequency?

(Horizontal component)

100 Hz (60 - 120 Hz)


-G. Dumas; A. Lion; P. Perrin; E. Ouedraogo; S. Schmerber. Topographic analysis of the Skull Vibration Induced Nystagmus Test with piezo-electric accelerometers and force sensors. Neuro Report. 2016
TEST INTERPRETATION
MAIN CLINICAL RESULTS
Currently 19800 cases have been explored under Videonystagmoscopy in the last 18 years (VNG: 604 cases)

Dumas G. PhD Thesis Nancy 18 Sept. 2014 (18500 cases)
Available Common Device

- Mechanical off-axis rotating Vibrator
  - **Synapsys** (Inc., Marseille, France) **Inventis** (Biomedica, Padova, Italy)
    - SV VIB 3F (30-60-100 Hz)
    - SV 100 Hz - 1mm amplitude
Vibration Induced Nystagmus Characteristics (VIN)

- Starts and stops with the stimulation
- Sustained, continuous, slight or no habituation
- Repetable on both mastoids (Vertex)
- Slow Phase Velocity (SPV)
  
  Usually > 2°/sec
Modalities of Report of Dumas Test.
Exemple of a right Peripheral vestibular Lesion.

<table>
<thead>
<tr>
<th>Stimulation</th>
<th>30 Hz</th>
<th>60 Hz</th>
<th>100 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM</td>
<td></td>
<td>→ ++</td>
<td>→ +++</td>
</tr>
<tr>
<td>LM</td>
<td>→ +</td>
<td>→ +</td>
<td>→ +++</td>
</tr>
<tr>
<td>Vertex</td>
<td></td>
<td>↘ +</td>
<td>→ ++</td>
</tr>
</tbody>
</table>

VIN intensity is quoted, assessed, estimated by +, ++, +++ ou –.
VIN direction is indicated by an arrow (←, ↑, →, ↓, ↗, ↘, ↕, ↖, ↗, ↔).

By convention, a right beating nystagmus is indicated by an arrow ←
(by analogy to conventional audiometrical Weber indications).
Left Total Unilat Vestibular Lesion (TUWL) 100Hz
(Left VS, TL approach) 3D Recording

VIN components
TUWL N = 46
• Horizontal : 98%
• Torsionnal : 70%
• Vertical : 45%
CONTROLS (n= 95)

- Spécificity (Sp) : 94%
  6 false positive in elderly subjects (normal Caloric Test)

Mastoid Stimulations
  - No nystagmus : 70%
  - Nystagmus observed on one single mastoid - SPV<2°/s 19%
  - Direction Changing Nystagmus following the stimulated side 11% (60 Hz) (inconsistency)
SENSITIVITY

• **TUVL**  (n= 131)       **Se  98%**  
  (2 negative cases had a strong contralateral hypoexitability)  
  Nyst is always beating toward the safe side (100%)

• **PUVL**  (n= 84)       **Se  76%**  
  VIN beats toward the safe side in 91% cases

SVINT IS NOT INFLUENCED BY VESTIBULAR COMPENSATION MECHANISMS
Left TUVL (6 years post surgery)  
Translabyrinthine Approach
VIN is not influenced by vestibular compensation mechanisms (Medico legal or forensic Medicine interest or benefit)
IN TUVL SVINT IS NOT INFLUENCED BY VESTIBULAR COMPENSATION MECHANISMS AND VIN IS ALWAYS LESIONAL (beating toward the intact side)

- Right Vestibular Schwannoma operated on 23 years ago (translabyrinthine Approach)
- 3D Recording:
  The VIN 3 components (Horizontal, Torsionnal, Vertical) are visible
- Higher responses are observed: mastoid > trapèze > vertex stimulation

VESTIBULE MULTI-FREQUENCY ANALYSIS

Optimal Vestibular Compensation Frequency Interval

Left Partial Unilateral Vestibular Lesion (PUVL).

Otolithic recurrent symptoms after a Left complicated otitis

CALORIC TEST

Discordant Results SVINT/HST/CT are observed in 30% PUVL

Malingerer? Exageration?
Left Partial Unilateral Vestibular Lesion (PUVL).

Otolithic recurrent symptoms after a Left complicated otitis

Dumas TEST = SVINT
HST = head Shaking Test

Caloric Test

HST - SVINT

Discordant Results SVINT/HST/CT are observed in 30% PUVL
Recurrent unsteadiness
Seldom Left Tinnitus. Normal Audiogram

Recurrent majoration of unsteadiness + Seldom Left Tinnitus  
Recurrent « otolithic symptoms » unsteadiness-imbalance
Left Cochlear Hydrops + Main Left Saccular Hydrops
Right unilateral Partial Vestibular Lesion (Menière)(PUVL)

VIN Direction may depend on stimulus frequency

Discordant Results (SVINT 30Hz/100Hz) are observed in 10% of PUVL

VIN is lesional beating toward the safe side in 91% of cases.
Issues about Bilateral Vestibular Areflexies

• True complete bilateral Areflexia=
  • Caloric Areflexia (20°) + no responses at pendular rotatory chair (gain=0) + Halmagyi (+) + Normal SVINT + COR (+) OVAR
  • Very bad pronostic (disabled patients proposed for sensorial substitution devices; vestibular implants?)

• False bilateral Areflexia =
  • Calo + Sinusoïdal + HIT + SVINT (VIN+)
  • Better pronostic after rehabilitation

(Patients acting as unilat High-frequency pass filter patients)
UNSTEADINESS-
FALSE BILATERAL VESTIBULAR AREFLEXIA -
Mrs B. d’A. Marie 69 ans - BK VIRUS

Myélodysplasic Syndrome
Chemotherapy
Bone Marrow Transplant
Antimitotics: (Certican – Cellcept)
Infection BK Virus kidney; Meningo-neuritis
UNSTEADINESS - FALSE VESTIBULAR BILATERAL AREFLEXIA - Mrs B.d’A. Marie 69 years old-BK VIRUS

VHIT

SVINT 100Hz

UNILATERAL VESTIBULAR RESIDUAL RESPONSES AT HIGH FREQUENCIES- VESTIBULAR REHABILITATION
A VESTIBULAR WEBER TEST
A VESTIBULAR WEBER
(VIN-SPV: interaction stimulation location/lesion side)
TUVL

• VIN always beats toward the intact side in TUVL. The intact side is stimulated
• In Vestib. Unilatéral total and partial lesions (TUVL) the stimulation location side has no influence on the induced response (p=0,6; n= 17) (100Hz) (Wilkoxon not paramétric Test; CIC Grenoble)

Peripheral Unilateral Vestibular Lesion
Example of a Left UVL

- **TUVL** (VIN + in 98% cases)
- VIN beats toward the intact side 100% cases

- **PUVL** (VIN + in 72% cases)
- VIN beats toward the intact side 91% cases

Ramsay Hunt Syndrome (Sicard). Shingle Associated OTR (Ocular Tilt Reaction)
Left Superior Semicircular Canal Dehiscence

SVINT: Vertex Stimulation 60 Hz, then 100 Hz
Audiological WEBER: Left
Vestibular WEBER: Left
Normal Caloric Test - weber
Stim. Right mastoid; then L 60Hz then
Stimulation Vertex 60; then 100Hz
VIN DIRECTION and SPV in SCD and OS
(Horizontal and torsionnal components) (n=23/38)

Direction

SPV

Chi2 or Fisher exact Test: **p< 0.01; ***p<0.001
Superior Semicircular Canal Dehiscence Bone conduction facilitation- Third Window

ANIMAL MODEL

Modifications of Responses after SSCD

• It went from not being activated at all to being activated and phase locked up to 1000Hz with airconducted sound and 700Hz with BCV. A CANAL afferent responding at 1000Hz!!!!

• The dehiscence increases the fluid displacement by stapes movement

With permission from I. Curthoys
HUMAN MODEL– DUMAS TEST
Right SSCD - VIN

Vestibular frequency sensitivity is enlarged to higher frequencies
The antagonist responses of one side cancel the responses of the contra-lateral side.
Vestibular Asymmetry: Partial Deficit
Vestibular Asymmetry: partial (or total) Deficit

Lesional Syndrome (Vest.Hypofunction):
- Translabyrinthine Approach
- VS (Vestib. Schwannoma)
- VN (Vestibular Neuritis…)(DVPB)
- CL (Chemical Labyrinthectomy)

« Hyper excitability» syndrome:
- SSCD (Sup. Semicirc. Canal Dehiscence)
- MD (Menière’s Disease)
TOPOGRAPHIC INDICATION
BENEFIT OR INTEREST

VIN AXIS / LESION TOPOGRAPHY in LABYRINTHINE SCC MALFORMATIONS
VIN IN CENTRAL DISEASES

VIN IS NOT SPECIFIC OF A TOPOGRAPY ON THE VOR PATHWAY
Perfect adequation with Caloric test and VHIT results:
VHIT: no response for Hor. Canal
Caloric Test: Right ear areflexia
Mme R.P. 43 ans
ANGIOME CAVERNEUX
PROTUBERANTIEL
G.: grand vertige
Ménièreiforme + vomissements

BRAIN STEM (PONS) CAVERNOUS ANGIOMA
(Woman 43 years old: Menière’s like symptoms)
SVINT IS MORE RELEVANT TO REVEAL PERIPHERAL THAN CENTRAL LESIONS


SVINT Sensitivity is significantly higher to reveal peripheral lesions than Brain Stem Central lesions p=0.04

(Test exact de Fisher ou X² pour comparer des pourcentages)
CONCLUSIONS

• First Line Examination Test not modified by vestibular compensation
• Vestibular Weber: VIN beats toward intact side TUVL (100%); PUVL usually (91%)
  SSCD VIN is observed in 86%; beats toward lesion (BC facilitation)
• Complements other tests in the vestibule multifrequency analysis(CaT HST HIT)
• Optimal Frequency is 100 Hz (VIN SPV)
• Optimal Topography in frontal plane: common lesions (LUVP; LUVT): Mastoid
  SSCD: Vertex
• Optimal Topography in the sagittal plane : Vertex= FZ= Occipital
• Possible Responses to higher frequencies in SSCD
• It addresses type I sensory cells ( big caliber phasic fibers with irregular discharges).
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TORINO - ITALY
6-8 LUGLIO 2016
"Il test di DUMAS"

(Skull Vibration Induced Nystagmus Test)

"TEST VIBRATORIO OSSEO" (TVO)

10 cose da sapere

esperienza 8'500 pazienti

1. Test ambulatoriale rapido alla poltrona --> WEBER vestibolare
2. Frequenza ottimale stimolo 100 Hz sulla mastoide
3. Nessun effetto collaterale - basso costo/efficente metodo di selezione e screening pazienti vertiginosi
4. NEVRITE /NEURINOMA/ FOLLOW up post Labirintectomia /post Gentamicina
   IT : TVO Induce Nistagmo che batte dal lato sano in ¾ dei pazienti
5. INTERESSE MEDICO LEGALE: ripetibile/ stabile nel tempo / sempre
   Nistagmo verso il lato sano (anche dopo anni)
6. IMALFORMAZIONI LABIRINZO (Deiescenza Canale Anteriore) solo in questo caso Ny verso lato malato (effetto terza finestra)
7. In deiescenza in Nistagmo può essere rivelato anche sul vertice del (Nistagmo verticale superiore).
8. MENIERE'S: il TVO induce caratteristicamente un nistagmo variabile per direzione alle diverse frequenze (30/60/100 Hz)
9. MEDICINA DEL LAVORO: TVO non si modifica per la compensazione (screening per pazienti a cui chiedere prove caloriche).
10. TVO: in sintesi e' un test complementare nella valutazione multifrequenziale del labirinto ma per la facilità e rapidità e' ottimo strumento per orientare la diagnosi.

Georges Dumas
CHU Grenoble
ENT Departement

Adattamento e Traduzione: Flavio Perottino
Conclusions (1)

- Robust, not intrusive Test. Useful in vestibular multifrequential analysis. It complements:
  - Caloric Test (CT) (Low frequencies)
  - Head shaking test (HST) (Medium frequencies)
  - Head impulse test (HIT) (6Hz)

- Optimal Responses 60-120 Hz
- Optimal Topography: Mastoids > Cerv. > Vertex (UVL) (SCD excepted: Vertex)

- **Global Vestibular Stimulation**: both vestibules (100 Hz) (canalar and otolithic stimulation)
Conclusions (2)

- SVINT explores the vestibular pathway in any point of the VOR: Absence of localization interest.

- More sensitive to reveal peripheral than central lesions:

- VIN is not modified by vestibular compensation mechanisms (TUVL): medico-legal, forensic interest.

- SVINT does not modify posture in long lasting compensated profound unilateral lesions (EC)

- It addresses Phasic type I sensory cells (big caliber fibers with irregular discharges).
Conclusions (3)

- **TUVL**: VIN direction is *lesionnal*: the nystagmus is always beating toward the intact side whatever the stimulus frequency, and topography.

- **SCD**: VIN beats toward the lesion side in correlation with the BC facilitation and impedance diminution on the lesion side (3rd Window)

- **PUVL**
  - VIN direction *may depend on stimulus frequency*. Nystagmus direction is not always specific of the pathologic side.
  - Reveals asymmetrical responses at high frequencies *when other tests* exploring lower frequencies *may remain normal* or show a bilateral areflexia at low frequencies.

1st Line Bedside Examination Test.
Reveals instantaneously a vestibular Asymmetry.
Hi George

I attach the pdf of a poster presented at Society for Neuroscience in 2012.

100Hz vibration activates both otoliths and canals; 500Hz only activates otoliths.

Interestingly I have recently shown that in animals with SCD, anatomically identified irregular canal afferents are activated by vibration up to 700Hz.

My summary - I think you are exactly correct in your ideas.

Best regards

Ian
Right Lat Canal Malformation . Mlle M. Alexia 22 ans

SVINT 3D

Caloric Test

VHIT

cVEMP
Right Lat Canal Malformation .
Mlle MARTIN Alexia 22 ans

SVINT 3D

Caloric Test

VHIT
cVEMP
Technique d’Examen

• Sujet assis

• Stimulus : 30, 60 et 100 Hz

• Localisation : chaque mastoïde successivement

• Durée Stimulus : 10 seconds
Divers Systèmes disponibles

• Rotation autour axe excentré
  • Synapsys (Inc. France)
    SV VIB 3S (30-60-100 Hz)
    SV 100 Hz - 1 mm amplitude

• Systèmes Electromagnétiques
  • ISV 1 Amplifon 40-115 Hz - 0.6 mm constant pressure
  • ABC (Germany) 100 Hz - 0.8 mm

• Mini-shaker 4810 or 2810 (Bruel and Kjaer, Denmark) 100 à 800 Hz
Left TUVL
Stim. Right mastoid; then L 60Hz then
Stimulation Vertex 60; then 100Hz
Quelle meilleure topographie ?

- Stimulation **Mastoïde** > vertex ou cervicale postérieure (p<0.005) (n=45)

Acta Otolaryngol. (Stockh.) 2008; 128: 255-262
Une stimulation Efficace
interférence du TVOV avec le test calorique

Peut inverser le nystagmus obtenu au calorique

Left V.S

Right V.S

Acta Otolaryngol. (Stockh.) 2008; 128: 255-262
Hypothèse d’une stimulation utriculaire

• NIV de sens différent à 30 et 100 Hz dans 15% des LUVP

# MATERIEL ET METHODES

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Manuel</th>
<th>Autostatique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contrôles-Témoins</td>
<td>![Image of manual test setup]</td>
<td>![Image of autostatique test setup]</td>
</tr>
<tr>
<td>- yeux ouverts (YO)</td>
<td></td>
<td></td>
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<tr>
<td>- yeux fermés (YF)</td>
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<tr>
<td>Vertex</td>
<td>![Image of manual test at vertex]</td>
<td>![Image of autostatique test at vertex]</td>
</tr>
<tr>
<td>- YO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- YF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mastoïde</td>
<td>![Image of manual test at mastoid]</td>
<td>![Image of autostatique test at mastoid]</td>
</tr>
<tr>
<td>- Droite – YO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Droite – YF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Gauche – YO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Gauche – YF</td>
<td></td>
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</tr>
</tbody>
</table>
VIN RESPONSES at VERY HIGH FREQUENCIES
(On going Study for frequencies up to 500Hz)
First Results in TUVL: 2D Analysis of a Right Lesion (CL)
(Rosello Luigia)
VIN RESPONSES at VERY HIGH FREQUENCIES
(On going Study for frequencies up to 500Hz)
First Results in TUVL 2D Analysis of a Right Lesion (CL)

200 Hz Right Eye

200 Hz Left Eye
VIN RESPONSES at VERY HIGH FREQUENCIES
(On going Study for frequencies up to 500Hz)
First Results in TUVL 2D Analysis of a Right Lesion (CL)

The VIN Vertical component is identical whatever the side of recording (on the Right or Left Eye)
VIN RESPONSES at VERY HIGH FREQUENCIES
(On going Study for frequencies up to 500Hz)
First Results in TUVL 2D Analysis of a Right Lesion (CL)
VIN RESPONSES at VERY HIGH FREQUENCIES
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First Results in TUVL: 2D Analysis of a Right Lesion (CL)
VIN RESPONSES at VERY HIGH FREQUENCIES
(On-going Study for frequencies up to 500Hz)
First Results in TUVL 2D Analysis of a Right Lesion (CL)

- 400Hz Left Eye
- 500Hz Left Eye
What is the best topography?
(Study in TU VLC)

- **Mastoid** > vertex or posterior cervical.
- VIN (SPV) (n=131): 98% mastoid; 90% cervical; 68% vertex

LOCATION OPTIMIZATION ON CRANIUM MIDLINE

• Comparison in 13 patients stimulated at 100 Hz on Frontal (Fz), Vertex(Vx), Bregmatic (Bg), Occipital(Occ) and sub occipital regions did not reveal any statistical difference.

• Comparison at 60 Hz:
  • SPV Vx > Occ: (p= 0.008 ; n=13)
  • SPV Fz > Occ: (p=0.004 ;n=13)
  • No significant difference between Vx/Fz
STUDY of VIBRATION DIFFUSION (Piezo Electric Captors) - CRANIAL and CERVICAL STIMULATIONS

Différent cranial régions (vertex, mastoids, pariétal region or BAHA implant) and trapèzius muscles have been stimulated by a vibrator at 100 Hz in 9 normal subjects and 2 patients with a unilatéral BAHA implant (UBI). The stimulation efficiency (vibration transfer) was analysed in différents points (vertex, mastoids, pariétal region, BAHA prosthesis and postérior cervical région) by piezoélectric captors (PEC) and measured on an oscilloscope.

Poster Soc ONO Paris 2007 (ENSHMG)
What is the best topography?

**Mastoid** > vertex or postérieur cervical (p<0.005)(n=45) (VIN-SPV) (Not parametric WilcoxonTest or t-test)

Acta Otolaryngol. (Stockh.) 2008; 128: 255-262
What is the best frequency? PUVL (n=13)

- 30 Hz: SPV = 5.96 (SD = 1.26)  p = 0.0009
- 60 Hz: SPV = 8.67 (SD = 8.68)  p = 0.009
- 100 Hz: SPV = 10.0 (SD = 9.29)  p = 0.26


(Test de Wilcoxon non paramétrique; SigmaStat 2.03 software; SPSS, inc., Chicago, IL, USA)
VIN RESPONSES at VERY HIGH FREQUENCIES
(On going Study for frequencies up to 500Hz)
First Results in PUVL: 3D Recording CT Left Hypofunction+SCD
VIN RESPONSES at VERY HIGH FREQUENCIES
(On going Study for frequencies up to 500Hz)
First Results in PUVL: 3D Recording CT Left Hypofunction+SCD
Long Lasting Unilateral total Vestibular Lesion (TUVL)

Left Translabyrinthine Approach

Operated on Vestibular Schwannoma- Translabyrinthine Approach- 6 years ago
Left  TUVL (6 years after surgery)
Quelle est la meilleure fréquence ?

(Stimulateur: 3S )

Constante amplitude (3S=0.2mm)-NIV Analyse Horizontale composante

Stimulation Mastoïdes LUVT (n=11)
Amplitude constante 0.2 mm

VPL NIV (60-100 Hz) > VPL NIV (30 Hz ) p< 0.009 ( non paramétrique Wilkoxon Test ou t-test)


Examination Technique: stimulus topography

The Examiner can be behind the subject
Examination Technique: stimulus topography

The Examiner can be in front of the subject
ARE VERY HIGH FREQUENCY STIMULATIONS (UP TO 500Hz) USEFUL TO DIFFERENTIATE BETWEEN CANALAR AND OTOLITHIC LESIONS?

AN ONGOING STUDY

(Bruel & Kjaer Mini Shaker 4810)
Les 2 types de cellules sensorielles (Macule Utriculaire)

Cellules type II (cils longs)  
Cellules type I (cils courts, rigides)

Zone extra striolaire  
Striola

From Spoon & Grant 2012  
With Curthoys permission 2016 (courtesy)
What is a VIN?

**Ex:** TUVL Left translabyrinthine. (10 years post op)

VIN is not influenced by vestibular compensation mechanisms
Hypothesis of a utricular stimulation


G.Dumas; S.Schmerber. Communication Politzer Society Londres Sept. 2009
SVINT
(Skull Vibration Induced Nystagmus Test)

Influence of bone-conducted vibratory stimulations applied to skull and cervical Muscles on the equilibrium function. Physiological Interpretations and applications to pathology. Development and validation of a new vestibular Test.

(Le Test de Dumas: Thèse d’Université Nancy Sept 2014)

Georges DUMAS MD; PhD
Course Torino Septembre 18th 2015

Directeur de thèse Pr. Philippe PERRIN
Co-Directeur de thèse Pr. Sébastien SCHMERBER
RIGHT TEMPORAL BONE FRACTURE
What is a VIN?

**Ex:** TUVL Left translabyrinthine. (10 years post op)
Similar results in compensated, neglected Temporal Bone fractures

VIN is not influenced by vestibular compensation mechanisms
Benefit in occupational Medecine or Medico-legal implications (forensic Medecine)
Peripheral Unilateral Vestibular Lesion
Example of a Left **UVL**

- **TUVL** (VIN + in 98% cases)
- VIN beats toward the intact side 100% cases

- **PUVL** (VIN + in 72% cases)
- VIN beats toward the intact side 91% cases

Associated OTR (Ocular Tilt Reaction)
Peripheral Unilateral Vestibular Lesion
Example of a Left UVL

- **TUVL** (VIN + in 98% cases)
  - VIN beats toward the intact side 100% cases

- **PUVL** (VIN + in 72% cases)
  - VIN beats toward the intact side 91% cases

Associated OTR (Ocular Tilt Reaction)
CRANIAL BONE STIMULATIONS (front) in the Squirrel Monkey
Préférential Fréquences (0.05 à 1000Hz)  
YOUNG; FERNANDEZ; GOLDBERG 1977

Lateral Semi-circular Canal (LSCC)

Other semi circular canals and Sacculus

BC and AC tuning curves for the lateral SCC (250 Hz)

Results for SCC (150 à 300 Hz) and otolithic structures (500 Hz)

Young ED, Fernandez C, Goldberg JM. Responses of squirrel monkey vestibular neurons to audio-frequency sound and head vibration.  
Results at 500 Hz stimulation

Direct stimulation of hair bundle is generated by fluid pressures waves at high frequencies

Bone conducted vibration selectively activates irregular primary otolithic vestibular neurons in the guinea pig.‖ Exp Brain Res. 2006; 175(2): 256-67

The neural basis of clinical vestibular responses to bone conducted vibrations (BCV) and air conducted sound (ACS), Assosiation for research in ORL. Baltimore, 2013

Sensory cells hair bundle active Movements: transepithelial electrical high frequency stimulations entrained the motion of the bundle eliciting movements of a polarity direction opposite that of the stimulus)
A: 10 cycles stimulation 100Hz, inverted polarity, followed by declining damped oscillations at 7Hz after stimulation cessation
B: electrical pulses 1 ms duration elicit rapid mechanical responses of opposite polarity, followed by a slower oscillation at 16 Hz
Active Phenomena are suppressed by cyto and neurotoxic drugs (butanedione monoxime or gentalline)
I recorded from a single irregular anterior semicircular canal neurons – synapsing on TYPE I receptors, similar to Type I receptors in the otoliths. This neuron like almost all the other canal neurons, was not activated by BCV or ACS with the bony labyrinth intact (100-200-500Hz) but I then opened the bony wall of the anterior canal while still recording from this same neuron and...

With permission of Ian Curthoys (April 2016)
What is the best frequency?
(Stimulator: 3S)

Constant amplitude (3S=0.2mm)-VIN Horizontal component Analysis

Mastoid Stimulation in TUVL (n=11)
Constant Amplitude 0.2 mm

VIN SPV (60-100 Hz) > VIN SPV (30 Hz) p< 0.009 (not parametrical Wilkoxon Test or t-test)

Topographic Optimization- VIN slow Phase Velocity (SPV) Analysis at 100 Hz (TUVL; n=45)

EXPERIMENTER AND HANDEDNESS INFLUENCE

Regression Graph

EXAMINER 1 (GD)
(Most Experienced) (Coeff. variation 9.8%) 

EXAMINER 2 (EO)
(Less Experienced) (Coeff. Variation 29.4%)
LEFT COCHLEO- SACCULAR HYDROPS
UNSTEADINESS-
FALSE BILATERAL VESTIBULAR AREFLEXIA -
Mrs B.d’A. Marie 69 ans-BK VIRUS
UNSTEADINESS-
FALSE VESTIBULAR BILATERAL AREFLEXIA -
Mrs B.d’A. Marie 69 years old-BK VIRUS

• Myélodysplasic Syndrome
• Chemotherapy
• Bone Marrow Transplant
• Antimitotics: (Certican –Cellcept)
• Infection BK Virus kidney; Meningo-neuritis
UNSTEADINESS - FALSE VESTIBULAR BILATERAL AREFLEXIA - Mrs B.d’A. Marie 69 years old-BK VIRUS

- Myélodysplasic Syndrome
- Chemotherapy
- Bone Marrow Transplant
- Antimitotics: (Certican –Cellcept)
- Infection BK Virus kidney; Meningo-neuritis
Available Common Devices

• Mechanical off-axis rotating Vibrator
  • *Synapsys* (Inc., Marseille, France) *Inventis* (Biomedica, Padova)
    SV VIB 3F (30-60-100 Hz)
    SV 100 Hz - 1mm amplitude

• Electromagnetical Devices
  • *ISV 1 Amplifon* (Inc., Paris, France) 40-115Hz -0.6mm constant pressure
  • *ABC* (Germany) **100 Hz** - 0.8mm
  • *Stimulator 3S* (ENSHMG)(Grenoble, France): 20 à 150 Hz (0,1 à 0,9mm ampli) (prototype)
  • *VVSED 500* (Euroclinic Italy): 100 Hz; *NC70209* (North Coast Medical, USA)