International Parkinson and Movement Disorder Society European Section

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5th Congress of the European Academy of Neurology

Oslo, Norway, June 29 - July 2, 2019

Hands-on Course 11

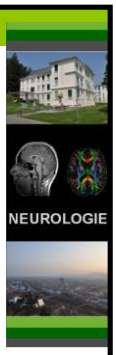
EAN/MDS-ES: Clinical neurophysiology for assessment of patients with movement disorders (Level 2)

Tremorous movements

Petra Schwingenschuh
Graz, Austria

Email: petra.schwingenschuh@medunigraz.at

Medizinische Universität Graz



CLINICAL NEUROPHYSIOLOGY FOR ASSESSMENT OF TREMOR

P. Schwingenschuh

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Contact Details:
Assoc. Prof. Dr. Petra Schwingenschuh
Department of Neurology, Medical University of Graz, Austria
Email: petra.schwingenschuh@medunigraz.at

Conflict of Interest

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In relation to this presentation and manuscript:

❑ the Author has no conflict of interest in relation to this manuscript.

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Outline

- The Rationales
- Types of Devices
- Outcome Measures
- Routine tremor analysis
- Characteristic findings and cases

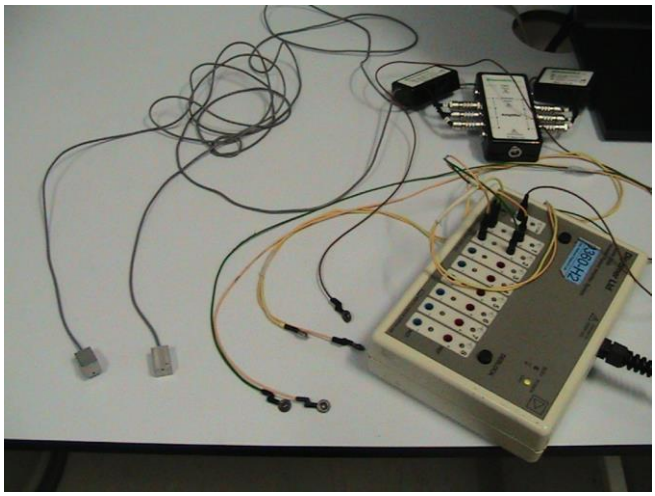
The Rationales

- May assist in making the correct diagnosis
- Provide quantifiable tremor data
- Research settings

Types of Devices

- Technology-based devices - equipped with one or more types of transducer → physical property of tremor → electrical signal
- Various transducer-based methodologies are currently used:
  - accelerometry, electromyography, gyroscopy, electromagnetic tracking, actigraphy, digitizing tablets etc. (Haubenberger et al. Mov Disord 2016)

Basic Kit for Tremor Studies

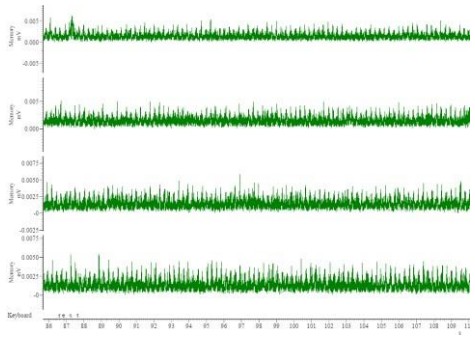


Routine tremor analysis protocol

- Rest tremor
- Postural tremor with and withoud loading
- Postural tremor in wing beating position
- Kinetic tremor
- Additional recordings in presumed functional tremor

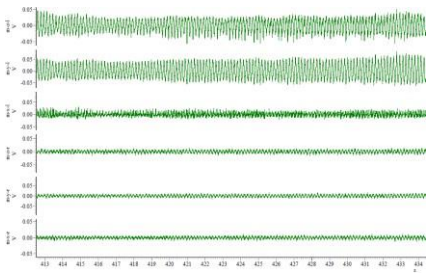
- Recordings include EMG of hand flexors and extensors (ECR, FCR) (± APB)
- Accelerometry of hand (10cm from wrist) or fingers

Routine tremor analysis



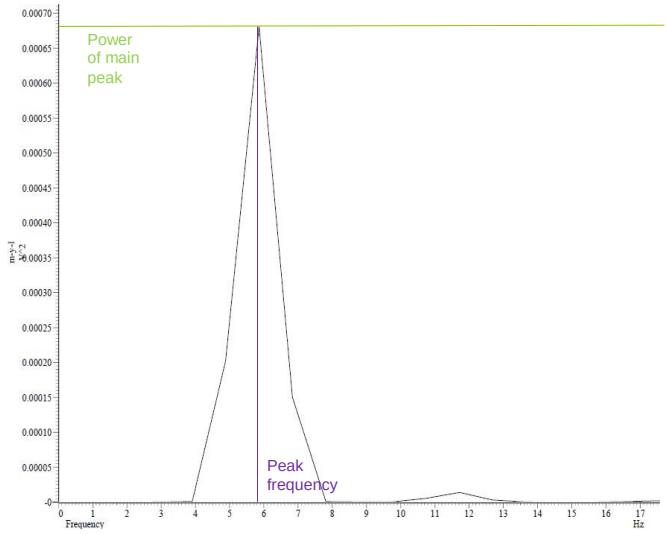
- **Analysis of EMG**
  - rectified and low pass filtered
- Rhythmic entrainment of motor unit discharge?
  - Pattern of activity in antagonist muscles?
- Spectral analysis (Fast Fourier Transformation)
  - Spectral peak?
  - Peak frequency?
  - Phase analysis (180? 360? Degrees)
  - Coherence analysis

Routine tremor analysis

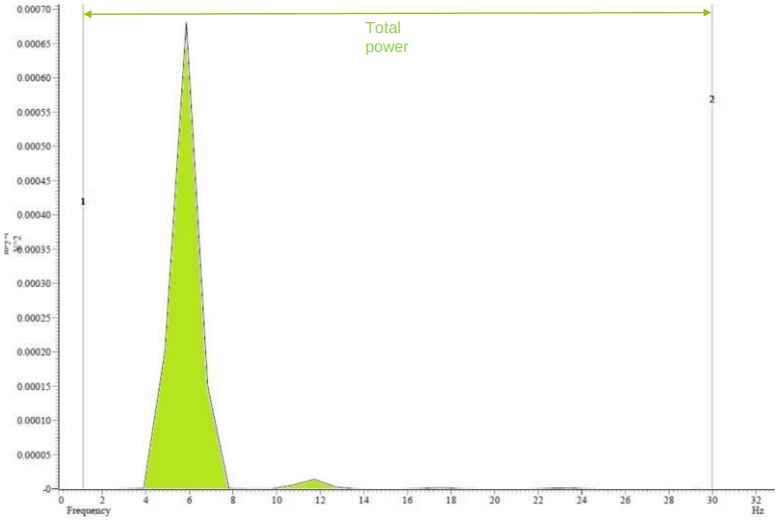


- **Analysis of accelerometry**
- Peak frequency
- Peak power, total power (surrogate for amplitude)
  - logarithmically correlated with clinical ratings
- Analysis in the various conditions
  - rest, posture, posture + loading (frequency stable component?), action
- Additional analysis in presumed functional tremor

Accelerometry



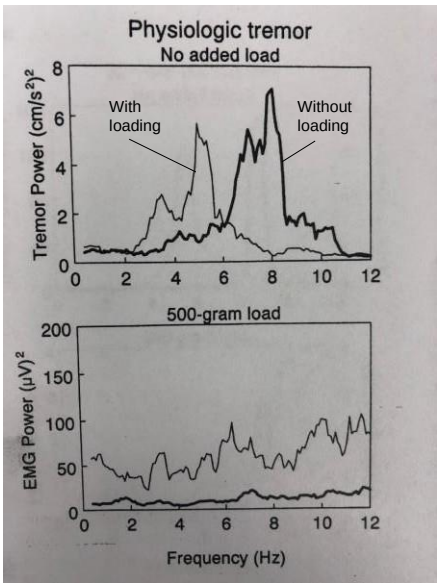
Accelerometry

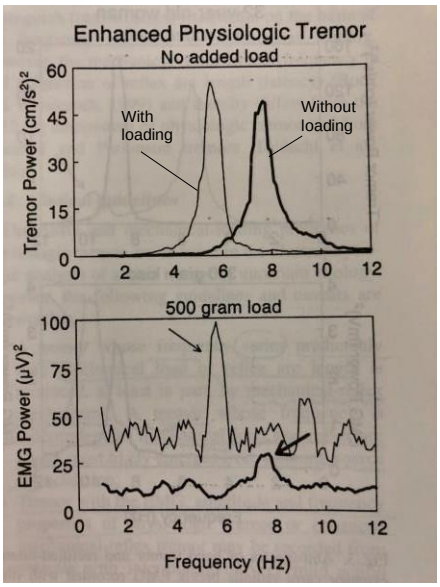


Case

- 50 years old woman
- Tremor of both upper limbs
- Noticable during all tasks
- Onset: 6 month ago
- Mild progression
- First only when anxious
- now all day
- Wheight loss
- Never drinks alcohol
- No relevant medical history
- No drugs

No associated EMG peak





Associated EMG peak

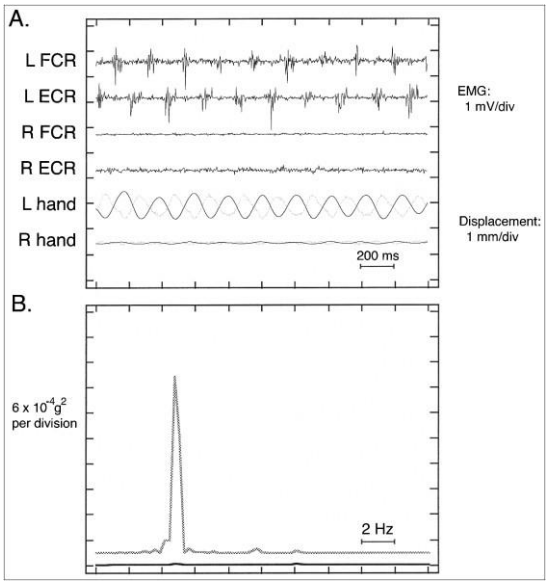
Adapted from Elbe R. Handbook of clinical neurophysiology 2003

Case

- Tremor Analysis:
  - Mild bilateral action tremor
  - EMG: Rhythmic bursts
  - Peak frequency in Acc + EMG spectra at 8 Hz
  - PF decreased with 500 g loading
- Work-Up: TSH decresed, FT3 + 4 increaesed
- Tremor cessastion after succesfull management of hyperthyroidism
- Diagnosis: Enhanced physiological tremor

PD

- PF classical rest tremor 4-7Hz (in early stages up to 9Hz)
- Sharp peak in EMG and accelerometry spectra at 4-7 Hz
- Invariant to load changes
- Poly-EMG: Pattern of activation in antagonistic muscles is mostly alternating in rest tremors (but all other patterns occur as well)
- PF of postural tremor may differ > 1.5 Hz; may have 7-12 Hz action tremor
- Suppression of tremor during movement onset

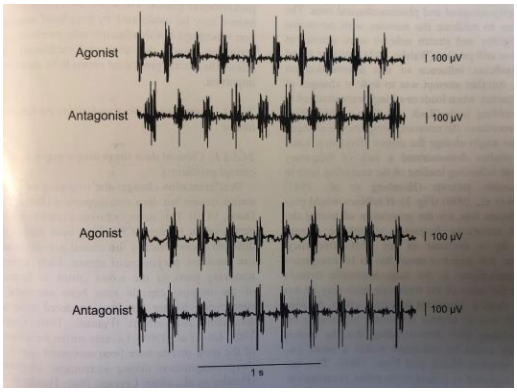


"Alternating pattern"

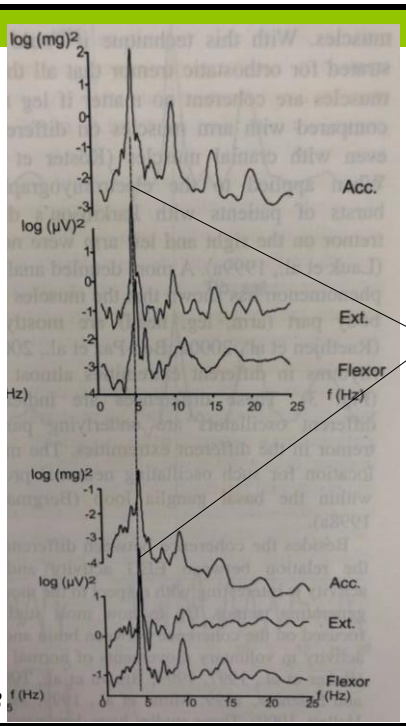
Hess & Pullmann TOHD 2012

PD

"Alternating pattern"



"synchronous pattern"



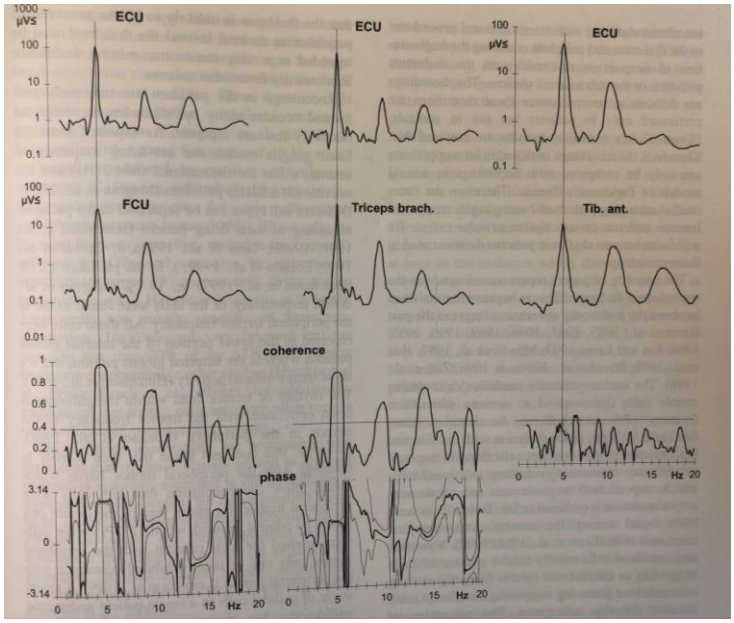
Without loading

PF invariant to load changes

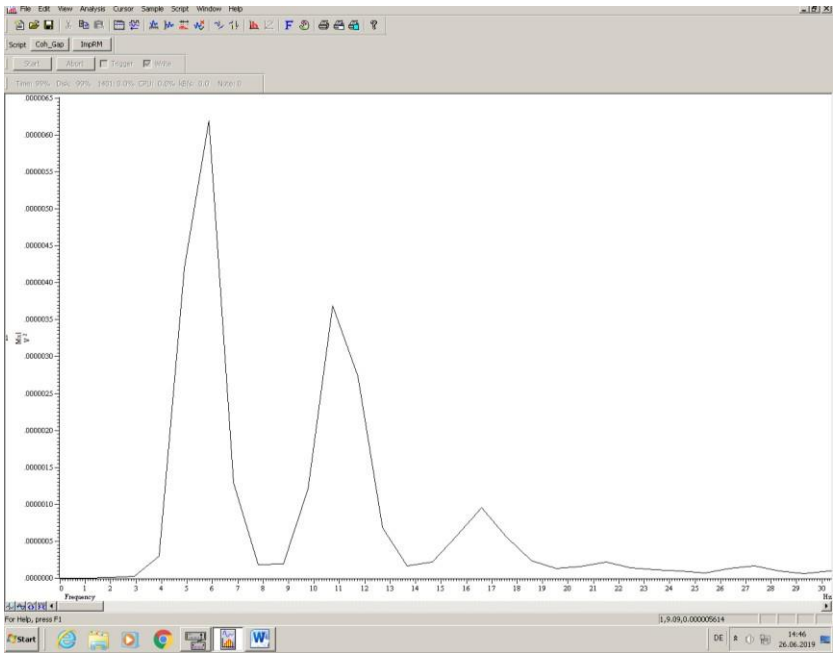
during loading

Deuschl G et al. Handbook of clinical neurophysiology 2003

Coherence analysis



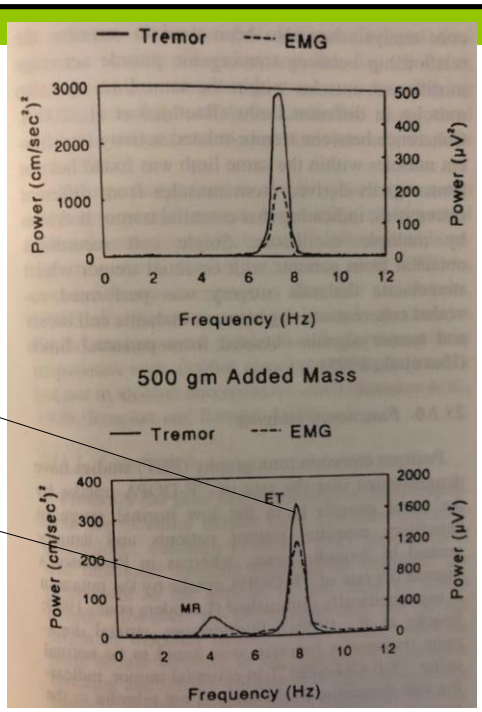
Deuschl G et al. Handbook of clinical neurophysiology 2003



ET

- Isolated tremor syndrome of bilateral upper limb action tremor with or without tremor in other locations
- Clear spectral peak in acelerometry and EMG
- PF not diagnostic, overlaps with many other tremors (4-12Hz)
- Relationship of bursts in agonist/antagonist muscle pairs is variable and varies even in the same muscle pair within an individual patient
  - Co-contraction, alternating, intermediate, switching from one to another

ET



Without loading

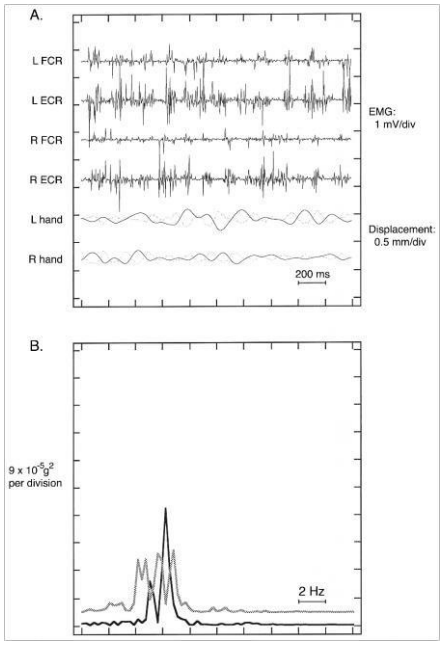
Frequency stable component

Mechanical reflex frequency component

during loading

Bain P. Handbook of clinical neurophysiology 2003

ET



Hess & Pullmann TOHD 2012

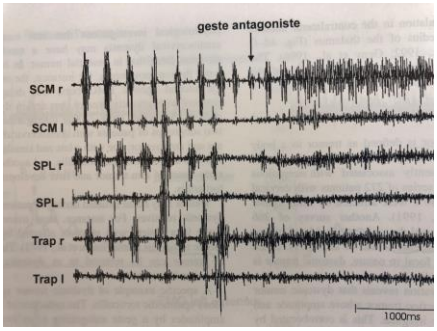
PD versus ET

- No fully reliable electrophysiologic tool is available for differential diagnosis
- Standard power spectral analysis (both accerermetry and EMG) inferior to clinical diagnosis
- Investigational: MHP + TSI
  - Mean harmonic power higher in PD compared to ET *(Muthuraman M et al. MovDisord 2011)*
    - ROC AUC 0.89
  - Tremor stability index lower in PD compared to ET *(di Biase L Brain 2017)*
    - ROC AUC 0.92
    - Independent of posture or recording device
    - 10s accelerometry recordings
    - TSI is quantitative; automatically estimated from tremor time series

DT

DT

- Mainly action tremor, amplitude and frequency (3-7Hz) may be irregular
- EMG: bursts variable (duration 50-300ms)
- Bursts of muscle activity in agonist/antagonists are typically imperfectly synchronized
- Abolished by geste antagoniste



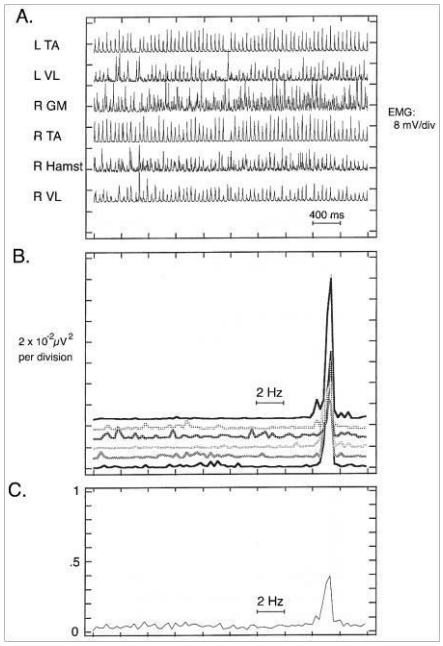
Lücking CH et al. Handbook of clinical neurophysiology 2003

Case

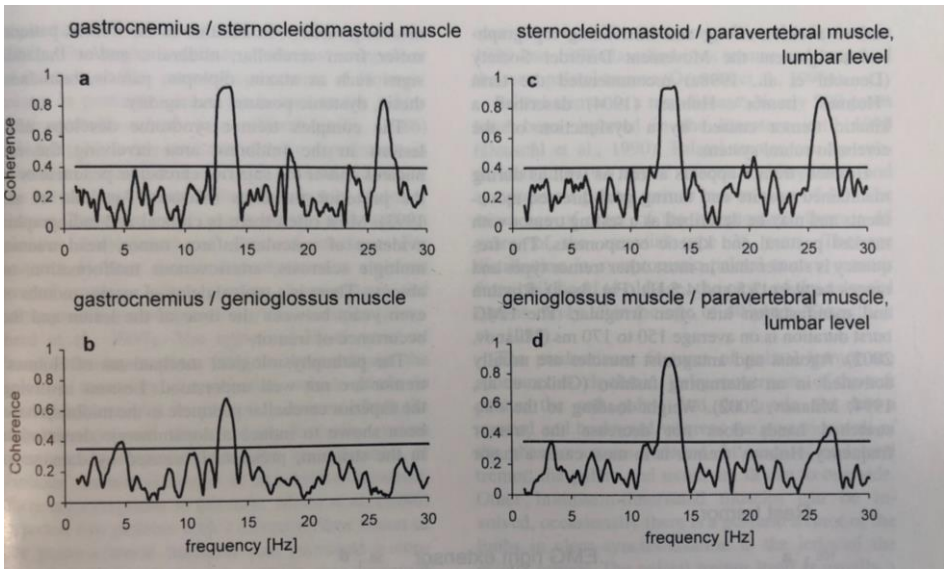
- 50 years old man
- Feeling unsteadyness in legs
- Fear of falling while standing
- Fine ripples of leg muscles when standing
- Walking unaffected

OT

- Highly synchronized EMG activity 13-18Hz
- EMG burst duration ranges betwen 10 and 80 ms
- Activation of agonist/ antagonists may be both alternating and synchronous
- Muscles of upper limbs and cranial muscles may also be involved
- All trembling muscles are coherent, no matter if leg muscles are compared with eachother or even with arm and cranial muscles
- Occurence of rhythmic EMG activity is not strictly related to stance (also during isometric muscle activation when sitting or lying)



Hess & Pullmann TOHD 2012



Lücking CH et al. Handbook of clinical neurophysiology 2003

Case

- 50 years old woman
- Tremor both hands, mainly on action
- Very distressed
- Sudden onset 6 months ago
- Diagnosed with ET
- Fluctuating
- Sometimes distractable

Tremor analysis in possible FT

- Rest tremor
- Postural tremor with and withoud loading
- Postural tremor in wing beating position
- Kinetic tremor
- Recordings include EMG of hand flexors and extensors (bilateral)
- Accelerometry of fingers (bilateral)

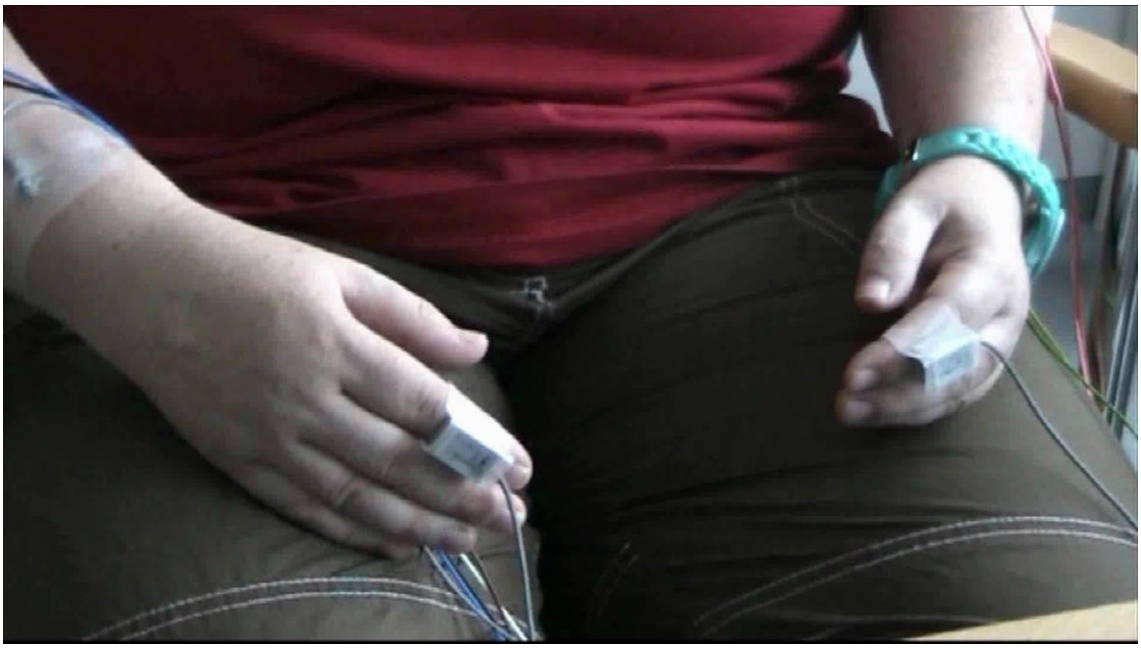
- **Additional recordings in presumed functional tremor:**
- Tapping to requested frequencies with less affected hand (1, 3, 5 Hz)
- „Ballistic movement task“

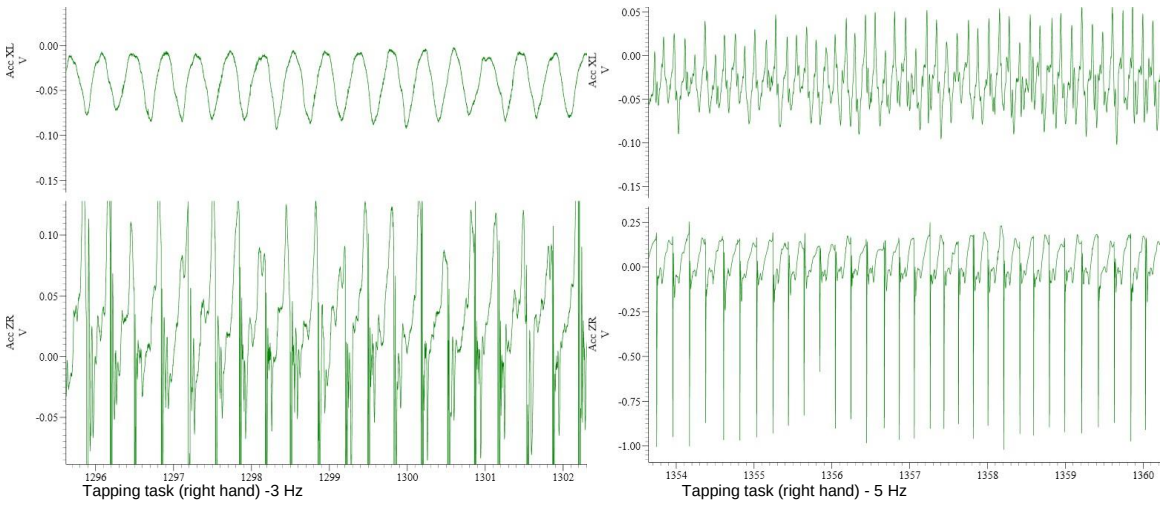
Functional tremor

- Cut-Off FT 3/10 P. (Sensitivity&Specificity 100%)
- Validation Study: 38 FT, 73 OT, Sensitivity 89.5%, Specificity 95.9%

SUM SCORE	Max. 10 points
Incorrect tapping performance at 1/3/5Hz	max. 3 points
Entrainment, suppression or pathological frequency shift at 1/3/5Hz	max. 3 points
Pause in amplitude with ballistic movements	1 point
Tonic coactivation before tremor onset	1 point
Coherence of bilateral tremors	1 point
Increase of amplitude with loading	1 point

Schwingenschuh et al, Mov Disord 2011&2016





Schwingenschuh et al, Movement Disorders 2011&2016

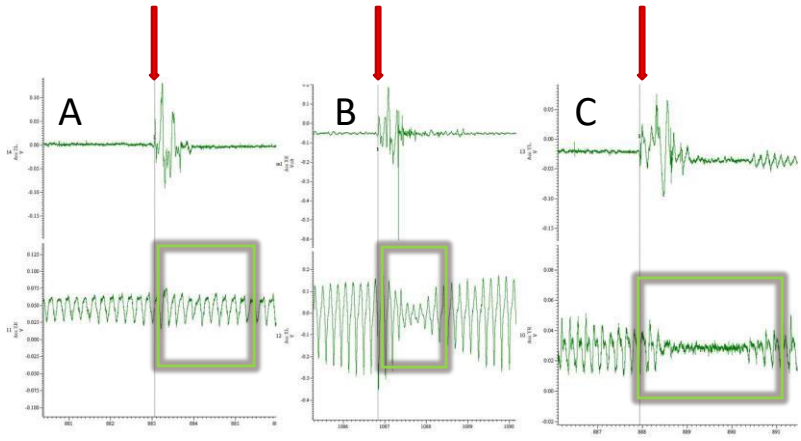


Fig. 1: Representative examples of the effects of ballistic movement (upper traces of each pair) in (A) a patient with OrgT (PD) and no effect on tremor, (B) a patient with OrgT (PD) and >50% reduction of tremor amplitude, and (C) a patient with PsyT and a pause of tremor.

Tonic coactivation according to the original description by Deuschl et al MovDis 1998:

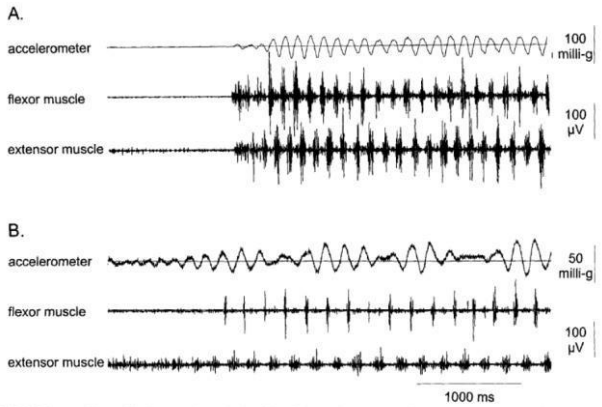
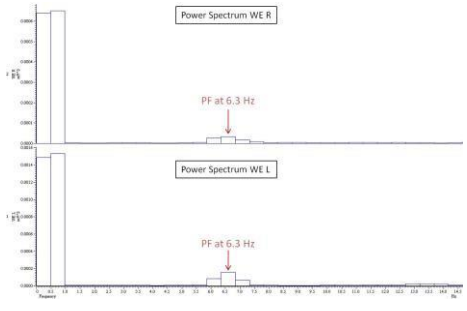
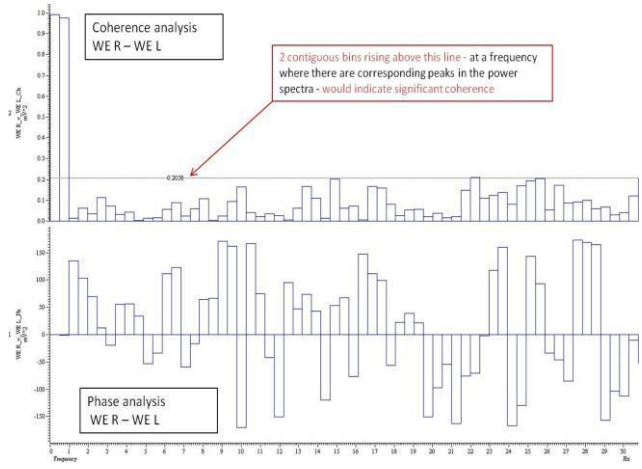


FIG. 2. Polymyographic recording demonstrating coactivation of finger flexors and extensors preceding tremor in a patient with psychogenic tremor (A). The muscle activation starts with tonic contraction for approximately 300 ms in the wrist flexor and extensor muscles before reciprocal alternating tremor bursts develop. Such a preparation of the trembling can be demonstrated in many of the patients with psychogenic tremor. In comparison, a patient with Parkinson's disease shows tremor bursts of reciprocal alternating pattern already at the onset of movement (B).





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Increase of amplitude with loading	1 point

Schwingenschuh et al, Movement Disorders 2011&2016

Thank you for your attention !

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