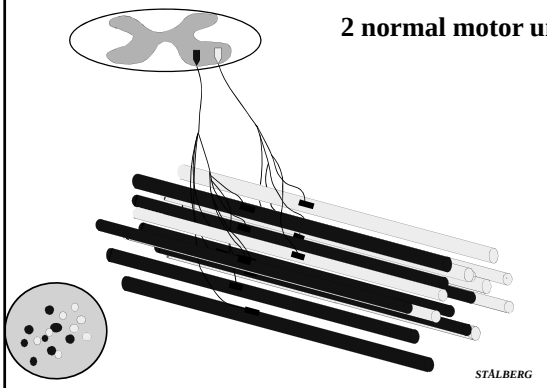
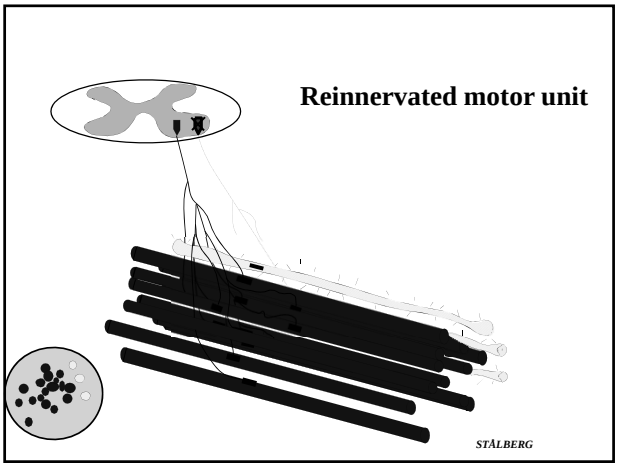
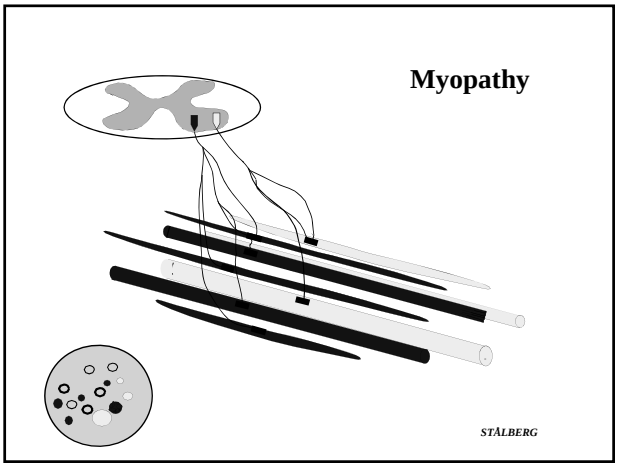
Analysis of the motor unit potential

Erik Stålberg







What do we want to express?

- Muscle membrane function - spontaneous
- Muscle fibre characteristics; diameter
- MU organisation
  - number of fibres
  - grouping
- N-M transmission
- # motor units
  - total
  - activation; pattern, fullness

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Parameters to quantify

- shape of individual MUPs
- jiggle
- fullness
- recruitment (early, reduced)
- dynamic changes with time (fatigue)

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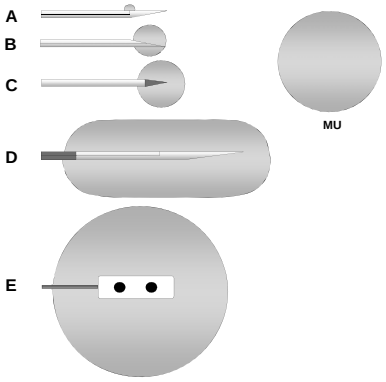
Electrodes



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Spontaneous activity

Spontaneous activity in normal

- insertional activity
- end-plate noise
- ”nerve spikes”
- positive wave at end-plate zone

Visual scoring

Spontaneous activity
from the ***muscle***

FINDING
- fibrillation potentials, psw
- myotonic discharges
- CRD
- myokymic discharges
- myogenic extra discharges

MEASURE AS
- **#/ 10 recording sites**
- **or +, ++, +++, ++++**
  - **few**
  - **moderate**
  - **abundant**
- **or**
  - **spontaneous or**
  - **after provocation**

Visual scoring

Spontaneous activity
from the ***nerve***

FINDING
- neuromyotonic discharges
- myokymic discharges
- muscle cramps
- fasciculations
- neurogenic extra discharges

MEASURE AS
- **#/ 10 recording sites**
- **or +, ++, +++, ++++**
  - **few (per time unit)**
  - **moderate**
  - **abundant**
- **indicate**
  - **spontaneous or**
  - **after provocation**

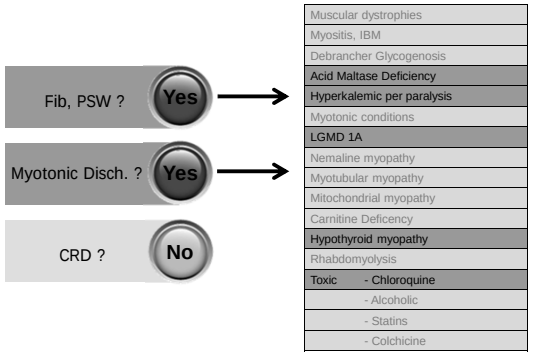
Spontaneous activity in myopathy

Fib, PSW ?	Yes →
Myotonic Disch. ?	No
CRD ?	No

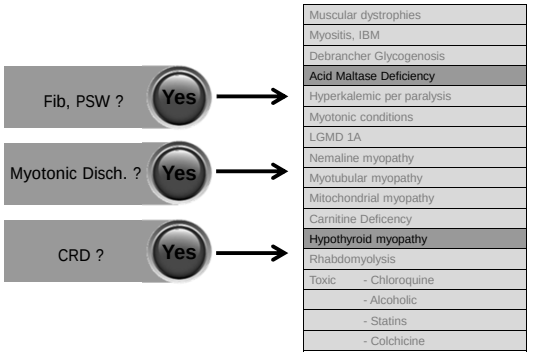
Muscular dystrophies
Myositis, IBM
Debrancher Glycogenosis
Acid Maltase Deficiency
Hyperkalemic per paralysis
Myotonic conditions
LGMD 1A
Nemaline myopathy
Myotubular myopathy
Mitochondrial myopathy
Carnitine Deficency
Hypothyroid myopathy
Rhabdomyolysis
Toxic - Chloroquine
- Alcoholic
- Statins
- Colchicine

Courtesy R.Liguori, modified

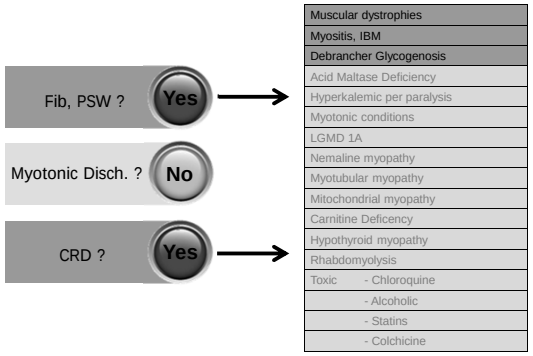
Spontaneous activity in myopathy



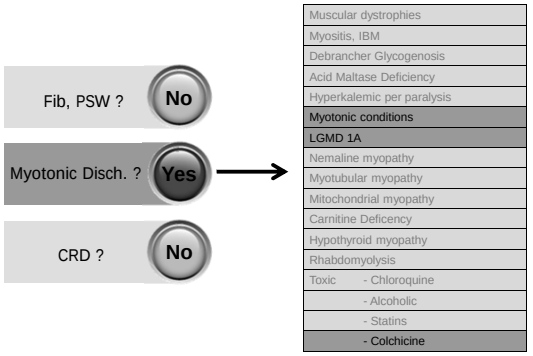
Spontaneous activity in myopathy



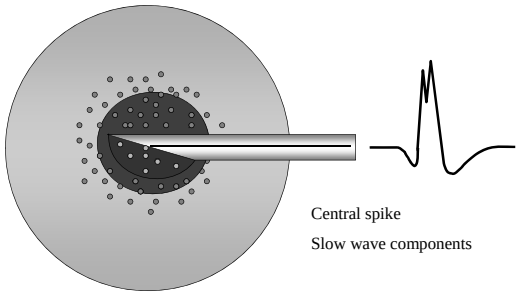
Spontaneous activity in myopathy



Spontaneous activity in myopathy



CNEMG
signals from 2 - 15 muscle fibres



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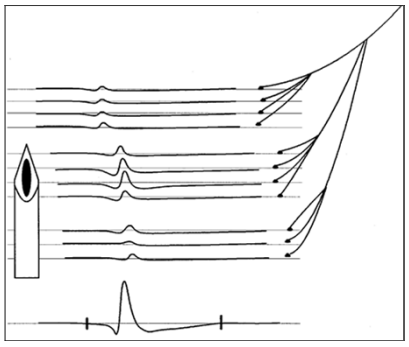
Schematic presentation of the concentric EMG MUP



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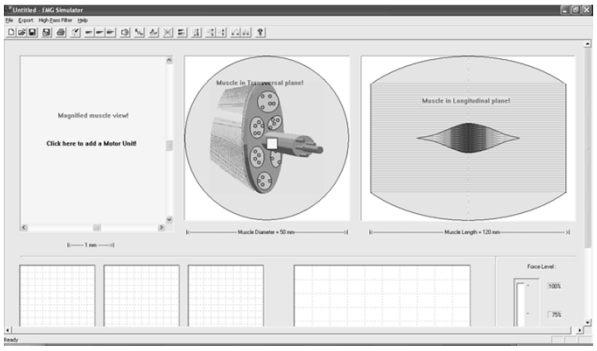
The simulator



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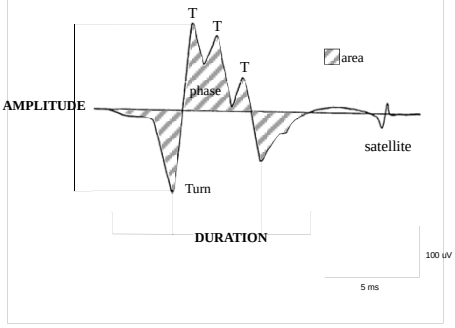
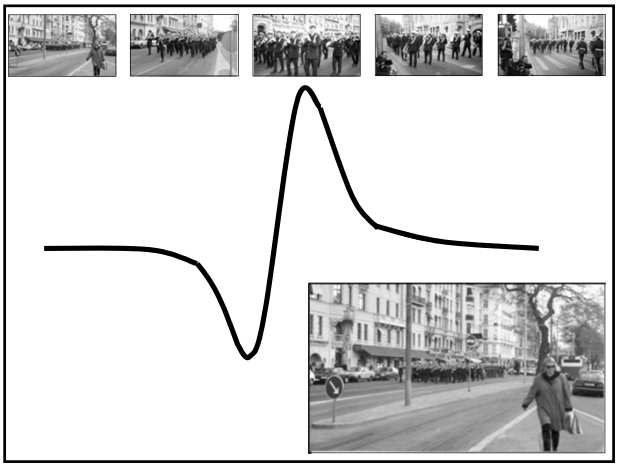
Parameters of a MUP





Parameters used in MUP analysis

parameter	significance	measurement
• amplitude	# fibres/0.5mm	peak-peak
• area	# fibres/2 mm	
• duration	# fibres in 2.5 mm	slope criteria
• phases	temp dispersion	0-cross + 1
• turns	"	change in dir
• rise time	closeness to fibre	neg-pos peak
• satellites	extreme delay	late spike
• jiggle	n-m transm	shape stability

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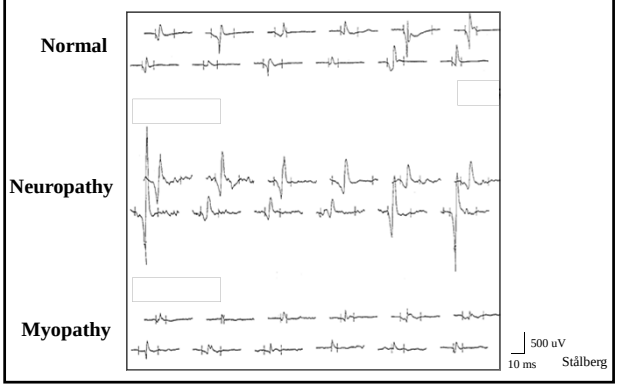
MUPs in different conditions



How to describe the MUP

Visual assessment

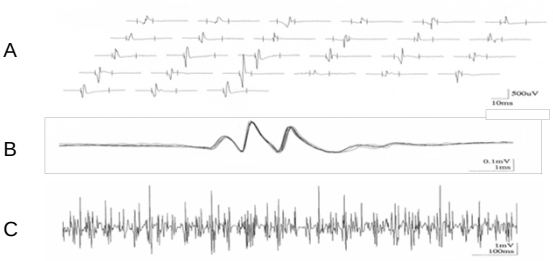
free run; ampl, dur, phases

trigger; jiggle, extra discharges, ….

Automatic analysis

Visual analysis

Normal EMG



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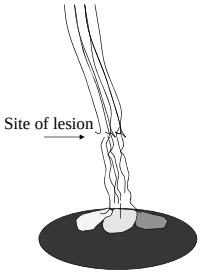
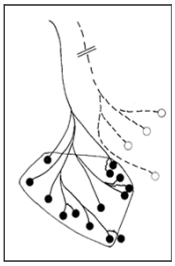
Neuropathy

Two types of reinnervation





After complete denervation

After partial denervation

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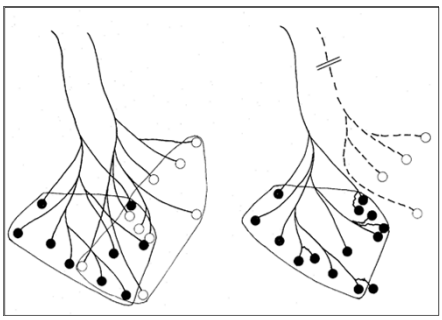
Schematic fig of reinnervation



2 normal motor units

grouping but no extension outside borders

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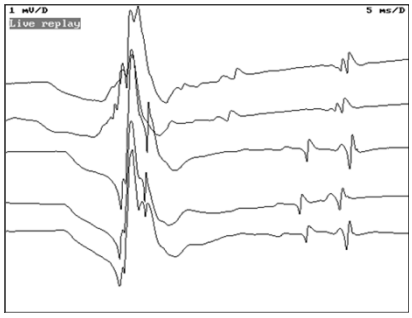
Satellites



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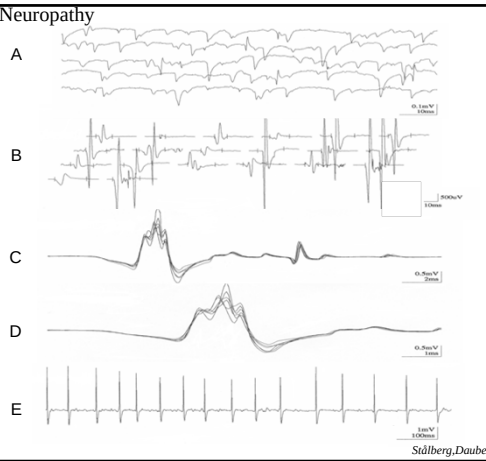
EMG in Neuropathy



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Subacute neurogenic

- **spont (m)** **fib/psw** **CRD**
- **spont (n)** **neuromyot myokymia**
- **MUP** **↑ ampl** **↑ dur**
- **shape** **poly**
- **jiggle** **↑**
- **recruitment** **late**
- **TA/FFT** **neurog.**
- **fullness** **↓**
- **FD** **↑**
- **jitter** **↑**

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Inactive neurogenic

- **spont (m)**
- **spont (n)**
- **MUP** **↑ ampl** **↑ dur**
- **shape**
- **jiggle**
- **recruitment** **late**
- **TA/FFT** **neurog.**
- **fullness** **↓**
- **FD** **↑**
- **jitter**

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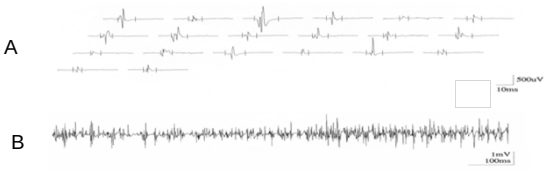
Myopathy

EMG in Myopathy



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Myopathy

- **spont (m)** **fib/psw** **myotonic** **CRD**
- **spont (n)**
- **MUP** **↓ ampl** **↓ dur**
- **shape** **poly**
- **jiggle**
- **recruitment** **early**
- **TA/FFT** **myopathic**
- **fullness** **normal**
- **FD** **↑**
- **jitter** **normal**

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Central weakness

- spont (m)
- spont (n)
- MUP normal
- shape normal
- jiggle normal
- recruitment irregular
- TA/FFT
- fullness ↓
- FD normal
- jitter

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Parameters that can be assessed visually/manually

parameter	significance	measurement
Amplitude	# fibers/0.5mm	peak-peak
area	# fibers/2 mm	within dur
Duration	# fibers in 2.5 mm	slope criteria
Thickness	# close fibre	area/ampl
Size index	MU size	normalized thickness
Phases	temp dispersion	0-cross + 1
Turns	"	change in dir
Irregularity	"	length/ampl
Rise time	closeness to fibre	neg-pos peak
Satellites	extreme delay	late spike
Jiggle	n-m transm	shape stability

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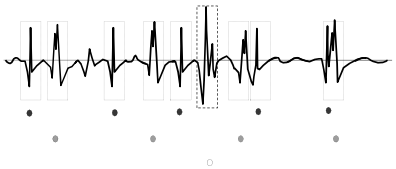
Automatic analysis

Decomposition;

techniques to decompose a mixed signal into its constituents

This example: Multi MUP analysis



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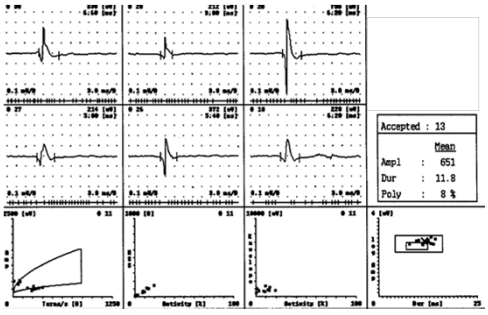
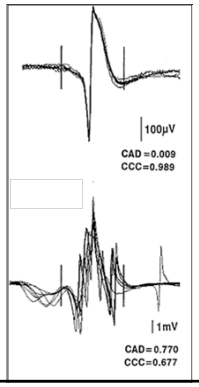
Multi-MUP, result



Jiggle in normal and abnormal

Normal

ALS



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So, shall I use all these parameters??

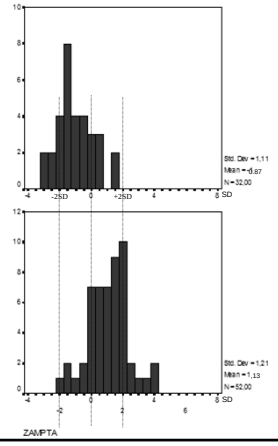
Which one is best?

Let us look at the diagnostic power of a few parameters

Amplitude (Tib.ant.)

polymyositis

ALS

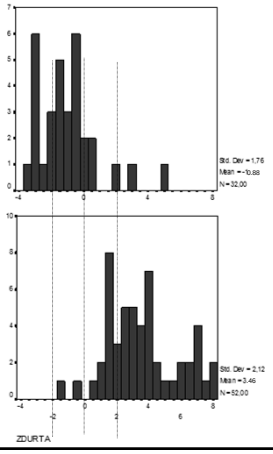


Stålberg,Erdem unpublished

Duration

polymyositis

ALS

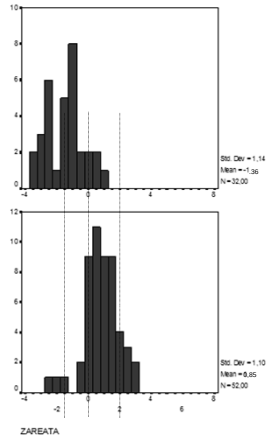


Stålberg,Erdem unpublished

Area

polymyositis

ALS

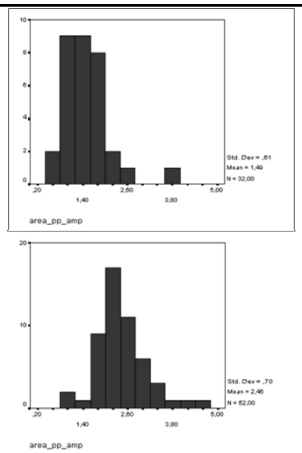


Stålberg,Erdem unpublished

Thickness

polymyositis

ALS



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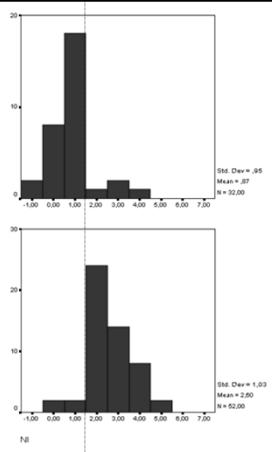
Size index

polymyositis

ALS



Stålberg,Erdem unpublished

Reference values

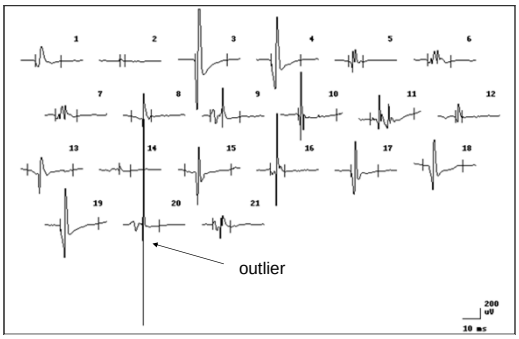
necessary to separate abnormal from normal

This is a crucial point in quantitative EMG analysis

- mean, SD (# of SDs = Z-score)
- median, percentiles
- outliers
- combine different data (multivariate analysis, index)

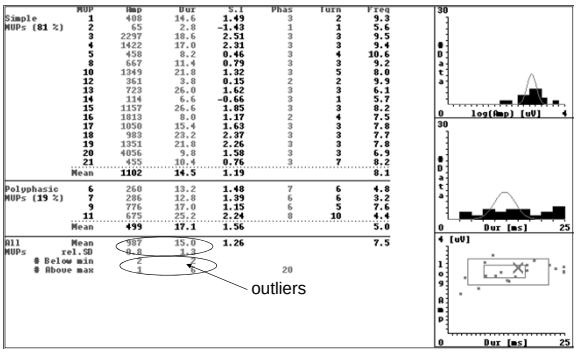
A few examples →

Combination of abnormally small and large MUPs
(Hereditary distal myopathy)



Lat vastus m

Combination of abnormally small and large MUPs
(Hereditary distal myopathy)



Lat vastus m

Reasons for performing QEMG

- standardized way of measuring
- improved sensitivity
- results can be transferred
  - from one time to the other - follow up
  - from one physician to the other
  - from on lab to the other
- reliable results also from less experienced EMGers
- good during training