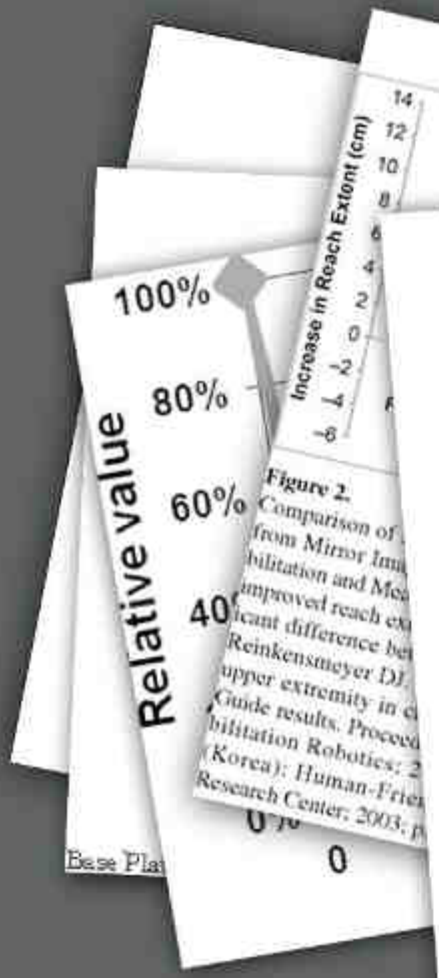

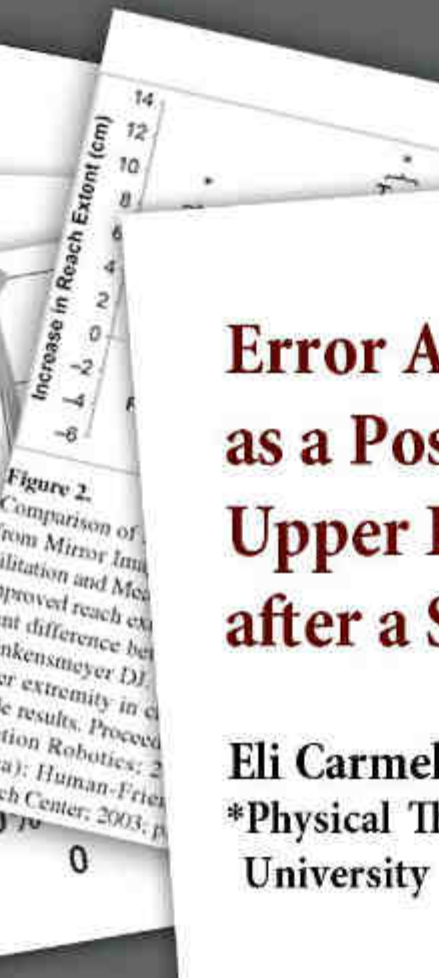

Error Augmentation as a Possible Technique for Improving Upper Extremity Motor Performance after a Stroke - a pilot study

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Background

- **In the United Kingdom, strokes affect 150,000 people each year.**
- **Only 33% to 70% of patients recover useful arm function (Huang & Krakauer 2009).**

- **Conventional neuro-rehabilitation seems to have little impact on the impairment beyond the spontaneous biological recovery.**
- **Neuro-rehabilitation is mainly improve motor control of proximal segment and lower limb, with some improvement of the proximal segment of upper limb (Kordelaar J et al 2013).**

Background

Kinematic impairments of *reaching movements* are related to abnormal reaching performance in post-stroke subjects.

increased in movement duration

decreased velocity

increased variability in path trajectory

leading to restricted use or even non-use of the affected hand.

New treatment approach

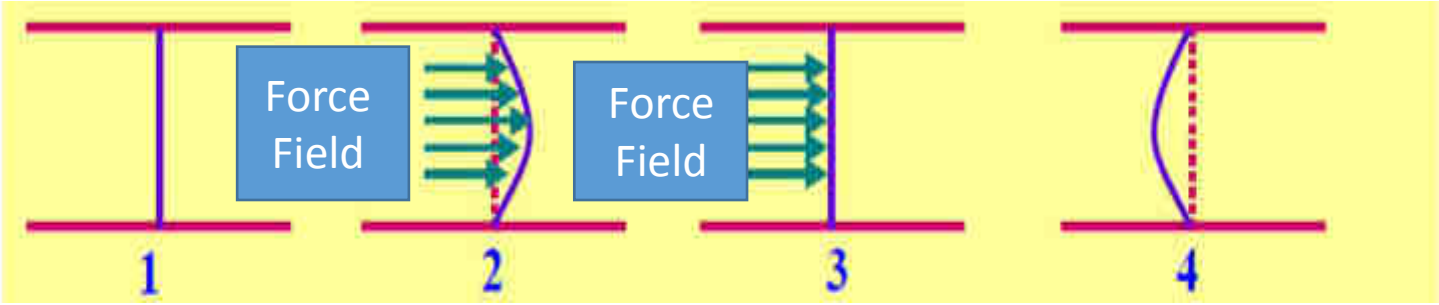
- Error Augmentation, instead of neuro facilitation, is proposed as a possible Technique for Improving Upper Extremity Motor Performance.
- This system uses the error enhancement method, in which movement errors are temporarily magnified to encourage learning.

Background

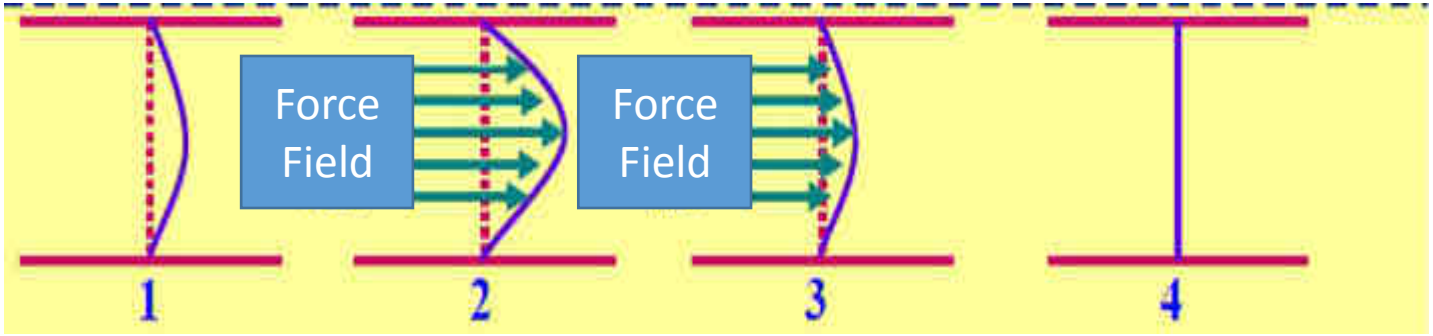
- **Error augmentation (EA) utilizes erroneous sensory feedback (e.g., tactile/vision) to enhance motor recovery after neurological damage.**
- **The computer singles out the patient's hand movement, every moment, from a specific desired trajectory, thus it provides a proportional sensory feedback (i.e., incorrect, mistaken, amplified, and exaggerated) to magnify the errors in proportional manner.**
- **The presence of this error in the haptic systems, forces patients to strengthen their control as they counteract the error-driven disturbance to the movements.**

Why adaptation leads to learning?

A. Effect of error augmentation on **correct** movement trajectory- adaptation



B. Effect of error augmentation on **erroneous** movement trajectory



Rational

- **Motor learning is based on "making movement errors during practice".**
- **Therefore, manipulation of error signals during practice is believed to be central to movement adaptation.**
- **Intrinsic feedback mechanisms are often impaired, providing augmented feedback by making errors are more noticeable to the senses.**
- **Larger errors increase motivation to learn.**
- **Machine-assisted training is precise; sustained for long time; measure progress automatically; and produce a wide, monitored range of forces and motions.**

Principles during 'error augmentation' therapy

1. Many repetitions.
2. High intensities.
3. Variability of practice
4. Advanced practice

Bowden et. al. 2013, krakauer 2005

Research question

Can error enhancement of the velocity component improve motor performance and functional abilities?

Research/Pilot study aims

Primary

to measure the effect of error augmented therapy.

Secondary

to compare outcomes between sEMG results and Fugel Myere score.

to evaluate association between writing skill and arm reach.

Participants

Stroke (n =5), males

Control (n =5) age-and-gender matched

Inclusion criteria: basic understanding, partial UE active movement,

ability to open/close fingers 5 times.

Exclusion criteria: apraxia, agnosia, spasticity, shoulder subluxation /pain of UE.

Outcome measure (1)

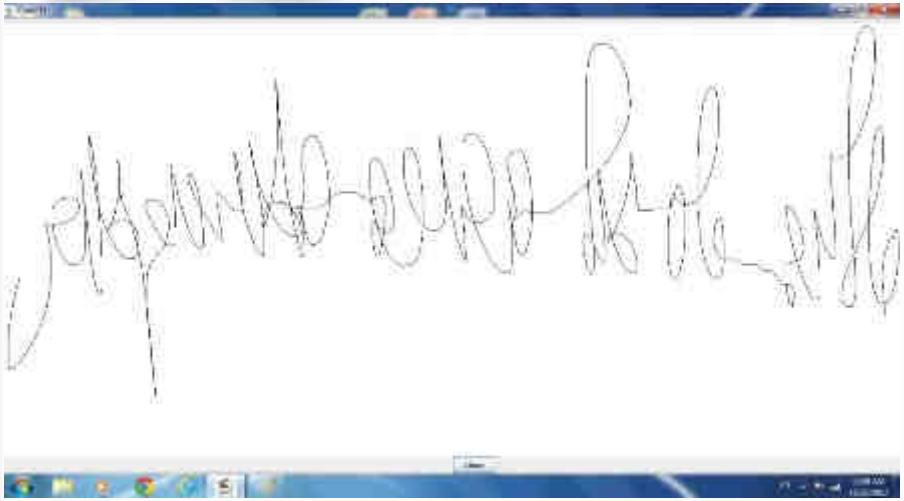
Digital plate + software

1. **Writing speed**
2. **Pressure**
3. **Off-time**
4. **On-time to- off-time time ratio**

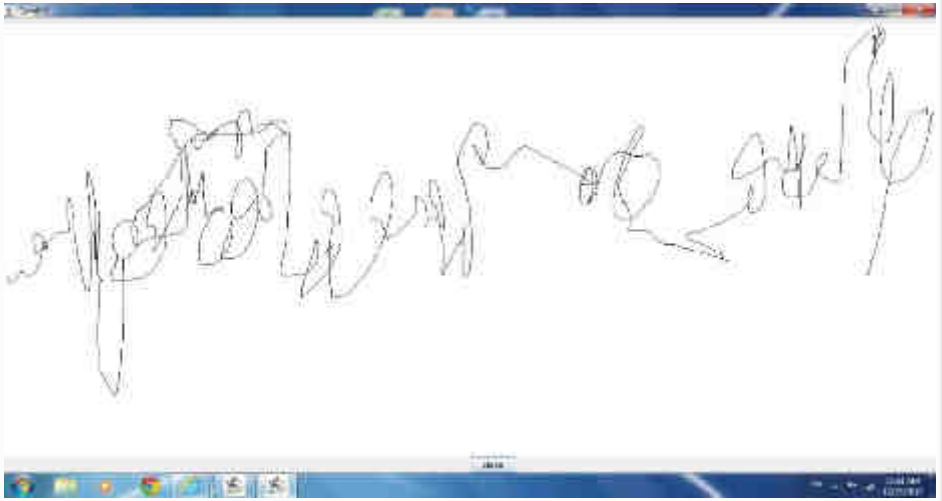
(Rosenblum S et al., 2013)

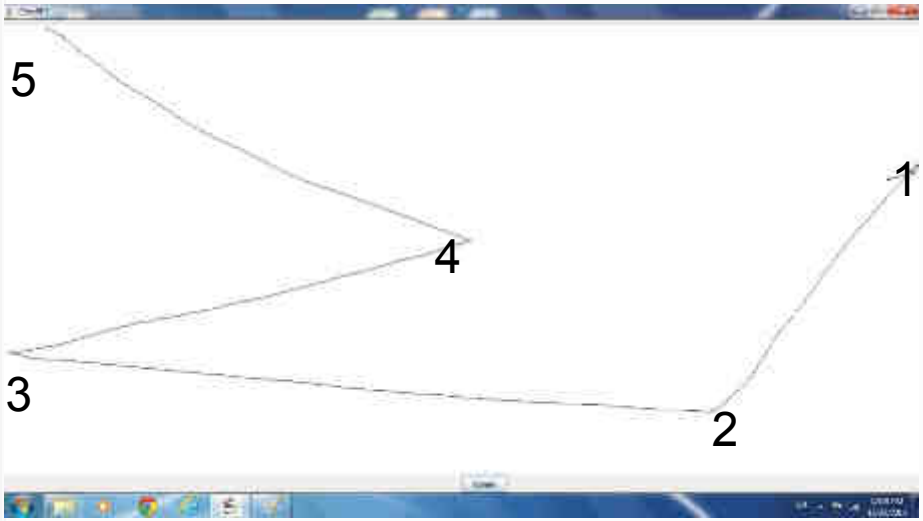
Decoding writing and connecting dots in healthy individuals compared to stroke patients using ComPET

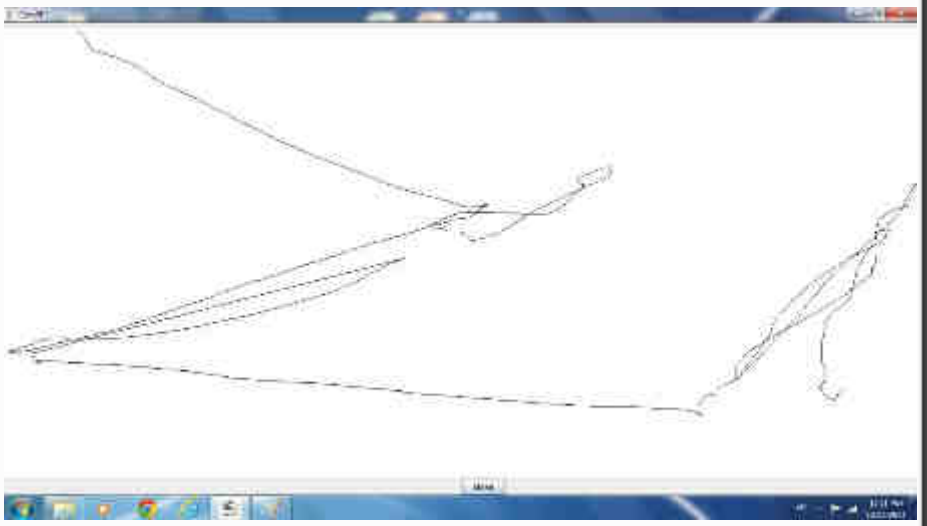
Healthy control



Stroke

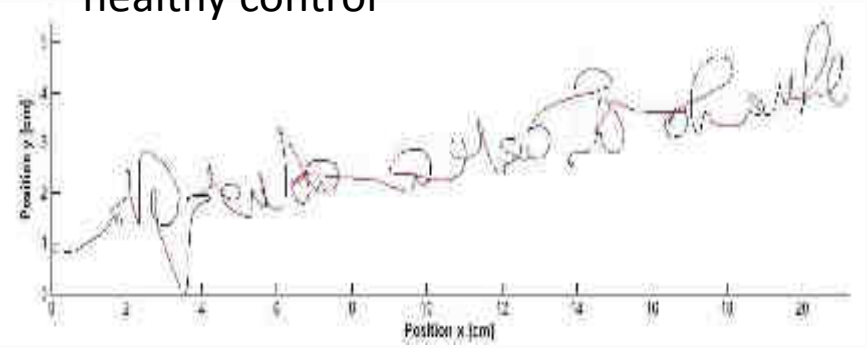






Decoding writing and connecting dots

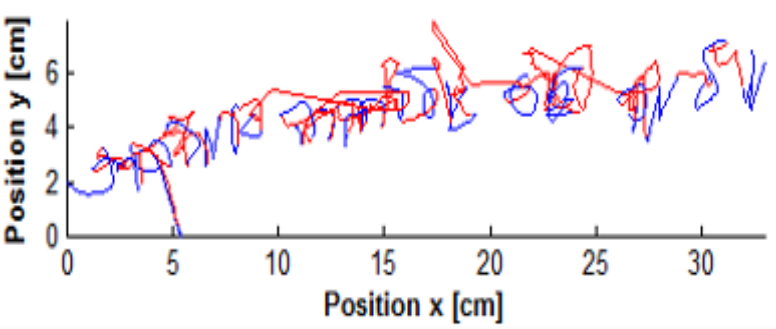
A: “characteristics **on/off-time**” - healthy control



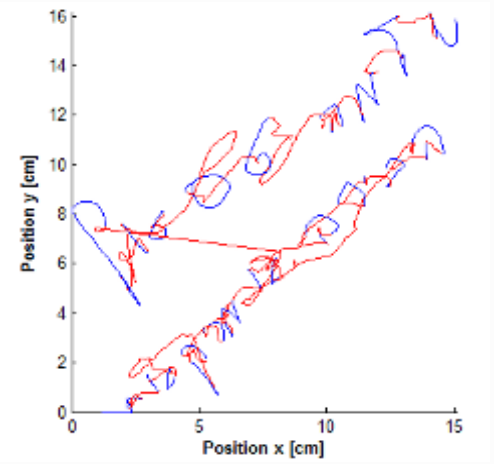
The red lines represent the course of pen movements during their stay in the air (off-time).

A1. Stroke patient has vague movements, jerky rather than smooth in compare to **A2**

B1. Pre treatment: “characteristics on-off-time” - Stroke



B2. Post-treatment: “characteristics on-off-time” - Stroke



Fugl Meyer (2)

Motor assessment of the upper extremity

Consists of 33 items.

A 3-point scale:

0 - inability to complete the test item

1 - partial ability

2 - full completion

Assessing DTR

Movement synergy

Movement isolation

Grasping

Fugl Meyer A, Jasko L, Leyman I, Olsson S, Steglind S. Scand J Rehabil Med 1975;7(1):13-31.

FM- Validity & Reliability

Construct validity (spearman`s rho):

Vs. Box and Blocks test 0.921

Vs. Action Research Arm Test 0.925

ICC inter-rater 0.99

ICC intra-rater 0.95

Standard Error Measurement (SEM) 3.6 points

Smallest Real Difference (SRD) 5.2 points

Minimal Clinically Important Difference 10 points

Outcome measure (3)

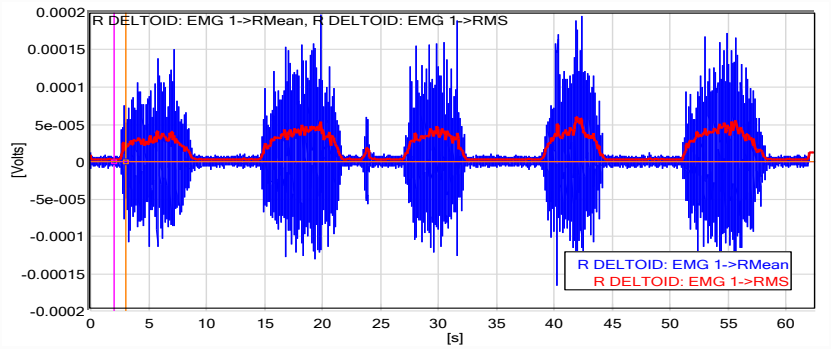
- **sEMG, wireless system, Trigno Lab, Delsys, USA**

1. Muscle amplitude analysis (%MIVC*)
2. Muscle onset
3. Co-activation Index

*MIVC – **M**aximum **I**sometric **V**oluntary **C**ontraction

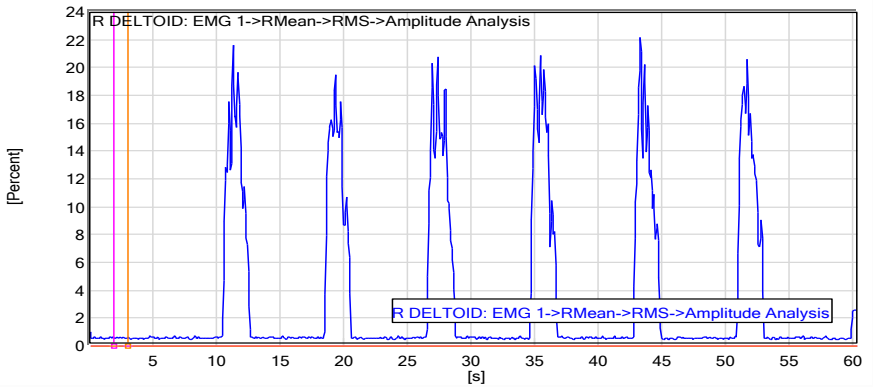
Data analysis - sEMG

A



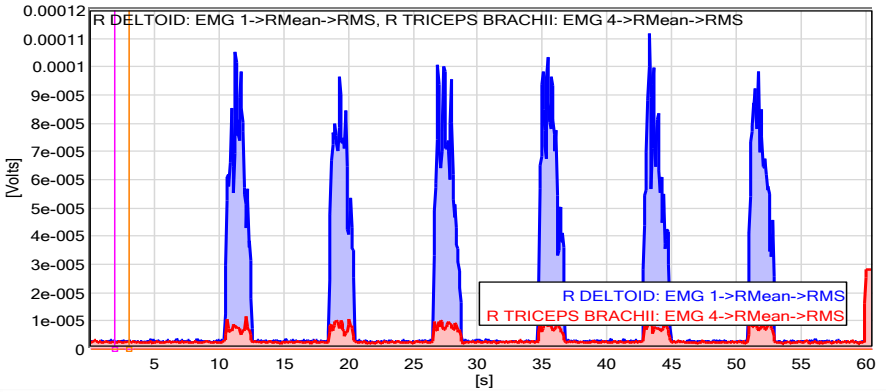
A. Blue: Raw EMG signal with positive and negative values Red: EMG signal after processing of Root Mean Square (RMS). Combining Rectification processing (transfer of all negative values to positive values) and signal smoothing by Filtration Unites are in Voltage as a result of an 'action potential'.

B



B. How much (in %) of the maximum isometric contraction the patient Deltoid uses during the forward reach.

C



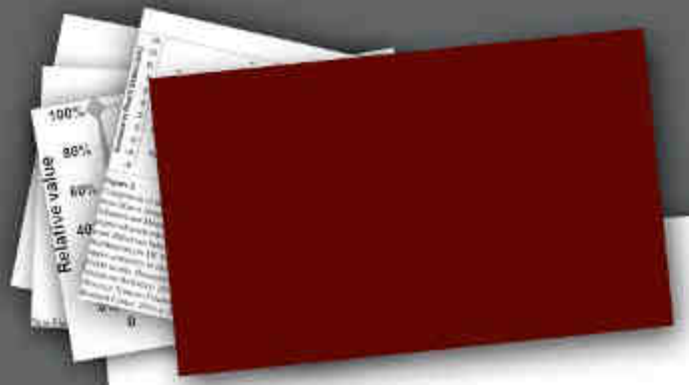
C. **Root Mean Square (RMS):**
Deltoid (blue) vs. Triceps (red).
Deltoid is the ***prime mover*** during forward reach.

Index Co-activation measure through data on the subjects muscles activity relative to Deltoid activity.

Outcome measure (4) and Intervention - 4 weeks/3Wk

Robotic system, ROBOTEACHER-2, Bioxtreme, ISRAEL

Average error (in cm).
Total score (points).



A preliminary investigation of error enhancement of the velocity component in stroke patients' reaching movements

Ronit Givon-Mayo, Esther Simons, Avi Ohry, Hana Karpin, Sharon Israely, Eli Carmeli

International Journal of Therapy and Rehabilitation, April 2014, Vol 21, No 4

Results

	Study Group	Control Group
Gender (Male)	5	5
Age (Years)	57.2 ±8.2	54.8 ±7.8

Pilot study – preliminary results

	Study group (N =5)		Control (N =5)	
	Pre	Post	Pre	Post
Fugel-Meyer (points)	36.4	44.2*	51.8	55.7*
Total "accuracy" score (points)	2328	2802*	2960	3574*
Average error (cm)	6.2	3.7*	2.3	0.6*

Data robotic system - the degree of improvement (in points)

*(P>0.05) Independent sample t-test

Velocity profile of 2 representative patients after stroke

Stroke
With error augmentation

Stroke ("Control")
Without error augmentation

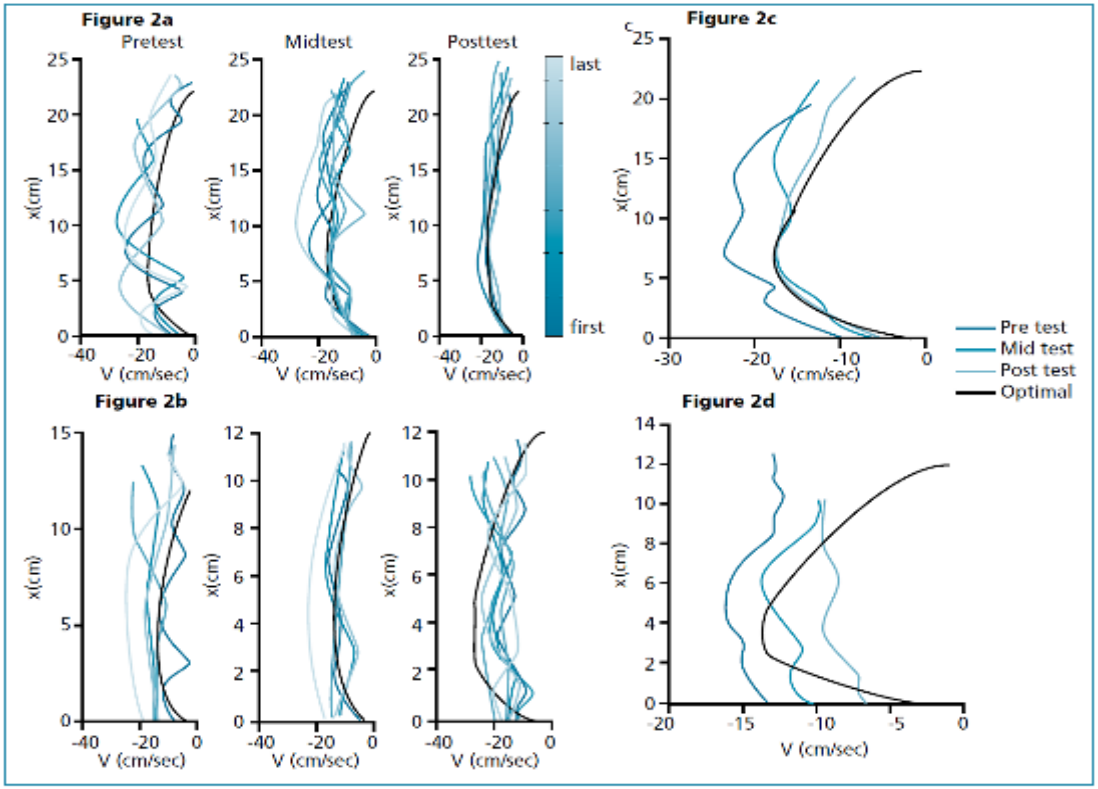
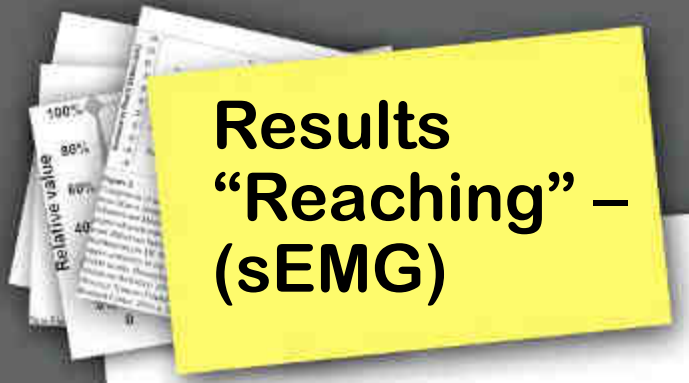


Figure 2. Movement velocity profiles for a representative experimental subject: (a) and a representative control subject; (b) at three time points (pre, mid and post test), compared with the optimal velocity profile (black line). The successive profiles are represented by graduated colors ranging from cyan (first profiles) to magenta (last profiles); (c) The average velocity profile for the experimental subject; and (d) the control subject, compared with the optimal velocity profile (black line).

Givon-Mayo et. al. (2014)



Results "Reaching" – (sEMG)

1. Stroke patients use higher MIVC% than control in Deltoid and Trapezius ms ($p<0.05$).

2. Stroke patients use all UE muscles relatively late than control ($p<0.05$).

Write indices **correlation** between sEMG indices during reaching

1. **Muscular activation delay in reaching is correlated to slow pace of writing ($0.568<r<0.911$, $p<0.05$).**

2. **Efficient use of Deltoid muscle (i.e., MIVC% is low) during reaching is highly correlated in applying high writing pressure ($0.636<r<0.8$).**

Discussion and Conclusions

Writing - Stroke patients are slower writers, put less pressure on the writing plate and spend more time in the air ('OFF') during the writing compared to healthy subjects.

'Reaching' in patients with stroke is characterized by inefficient activation of muscles (i.e., high MIVC%) , and a delay in activating muscles (delayed onset).

Treatment error augmentation is preferable than treating without error augmentation.

Thank you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as a Possible Technique for Improving
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Relative value
100%
80%
60%
Increase in Reach Extent (cm)
Figure 2.