Haptic guidance improve the visuo-manual tracking of ellipses drawing in adults

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Haptic Guidance

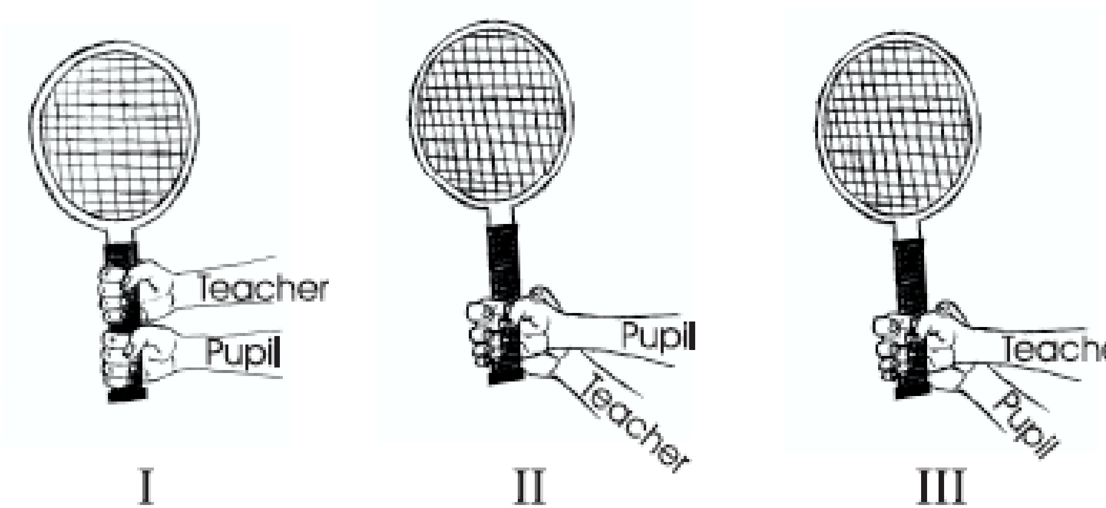
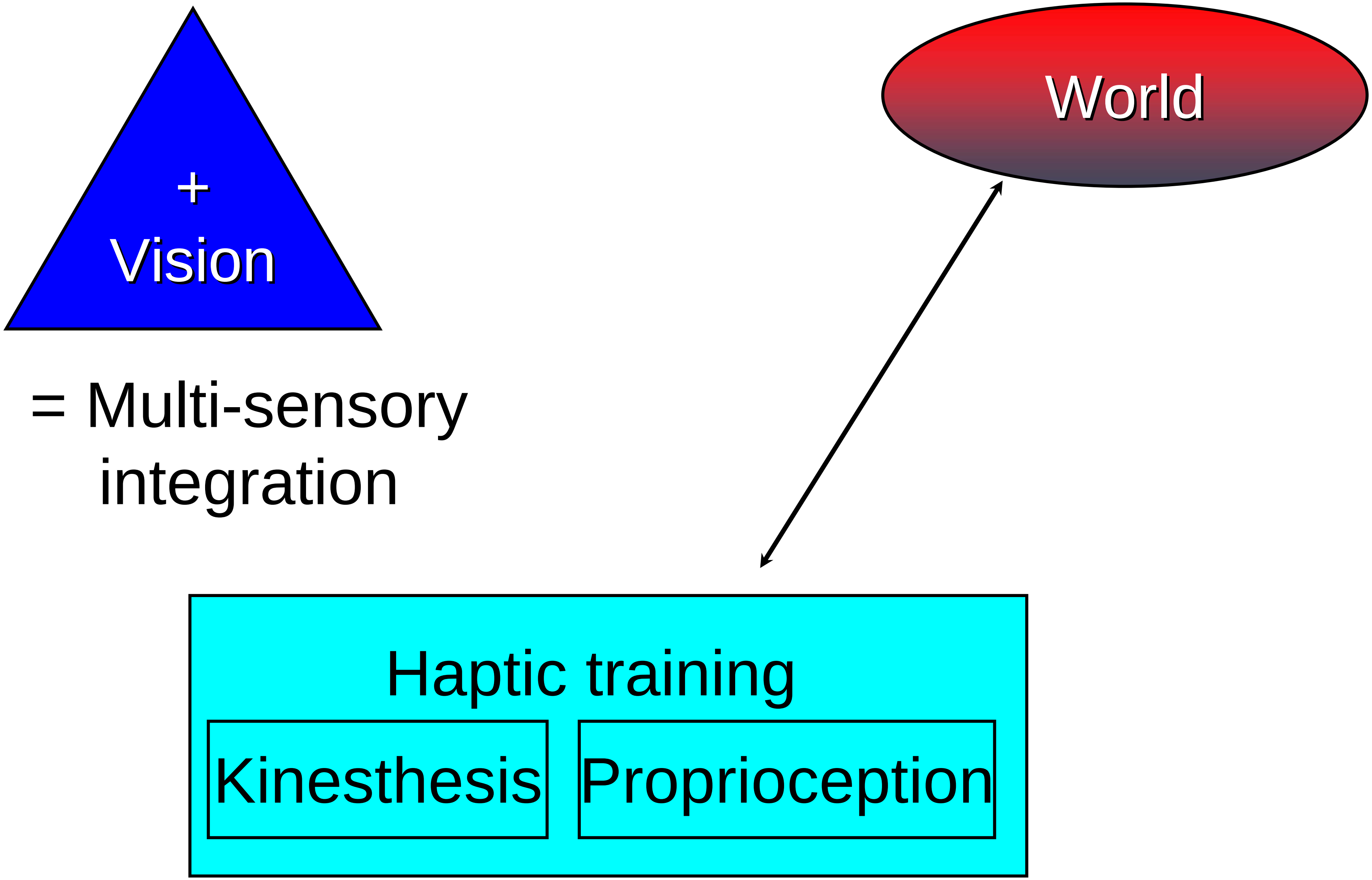


Figure 1: *Three teaching paradigms, distinguished by the arrangement of mechanical contact between teacher's hand, pupil's hand, and implement handle. I) Indirect Contact Paradigm. II) Double Contact Paradigm. III) Single Contact Paradigm.*

=> Virtual Teacher

[Gillepsie 1998]



Kinesthetic memory [Clark and Horch,1986]

Positive effects of haptic addition while learning 3D trajectories

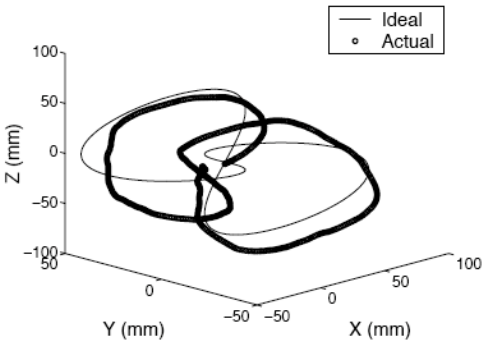


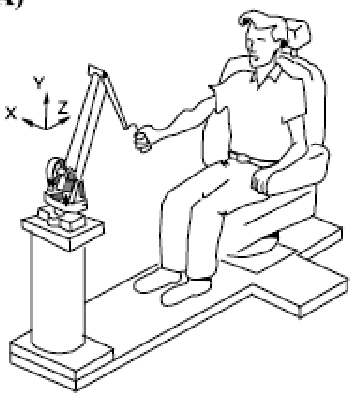
Figure 1: Experiment in progress. Visual (left), haptic (center), and haptic + visual conditions.

36 subjects
H< V < V+H

[Feygin 2002]

H < V < V+H

(A)

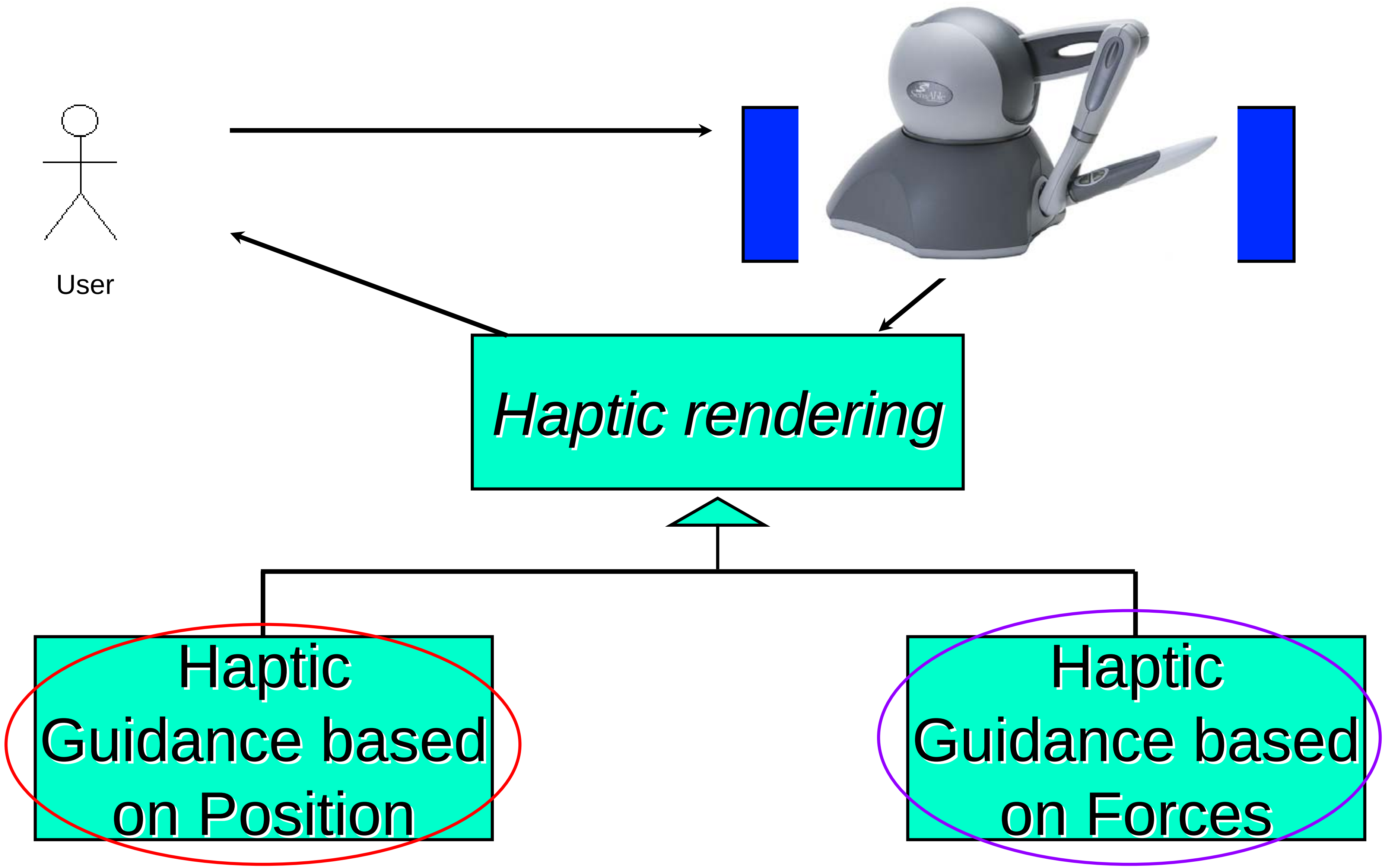


Similar results during rehabilitation

20 subjects
V < V+H

[liu 2006]

Haptic Guidances : two types of haptic guidances



Simple and oftently used

Less used

Haptic Guidances : two types of haptic guidances

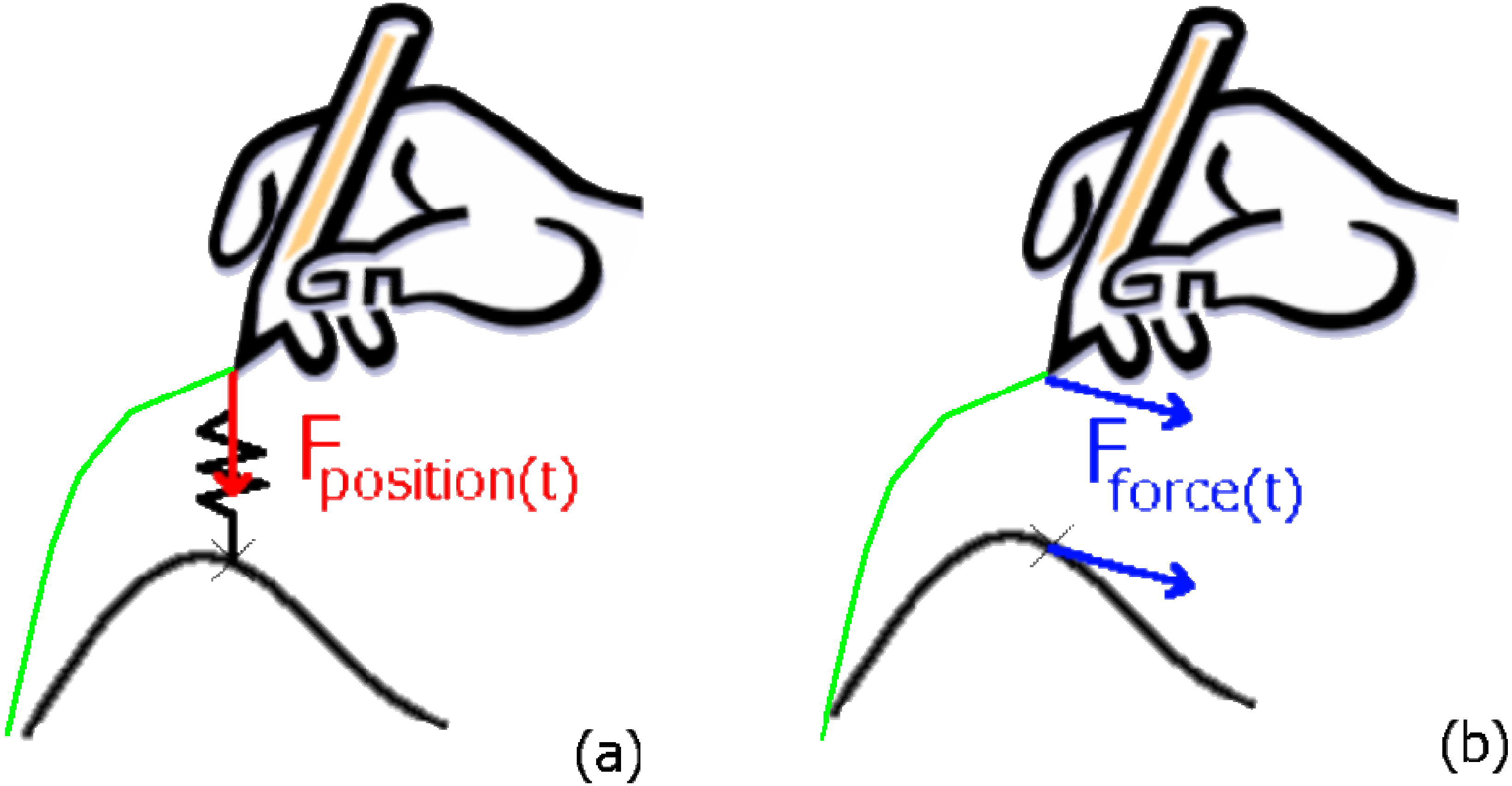


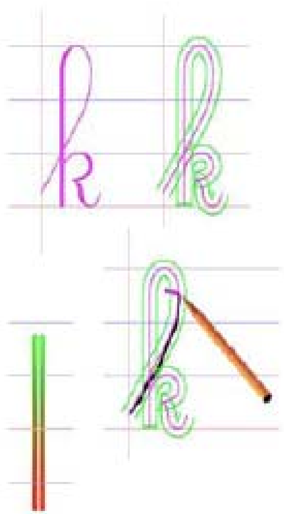
Figure 1 – Schematic view of haptic guidances: (a) Haptic guidance in position (HGP); the force felt by the user at time *t* is proportional to displacement between the current user position and the theoretical position on the model trajectory; (b) Haptic guidance in force (HGF); the force felt by the user at time *t* is the same as the force existing for the theoretical trajectory at the same time.

Haptic Guidance based on Position

Cursive handwriting learning in children

twenty-two 6 years old children

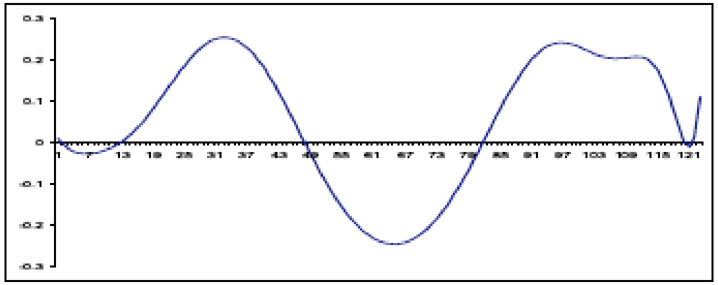
=> increase of fluidity during handwriting



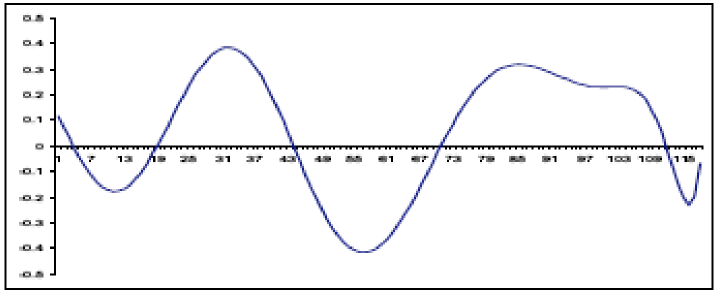
A letter used in the circuit game exercise

[Palluel-Germain 2007]

Haptic Guidance based on Forces



Day 1



Day 7

[Srimathveeravalli 2005]

Haptic profile for one given trajectory are stable in time.

=> this information is relevant as input for haptic device control

Haptic Profile Learning

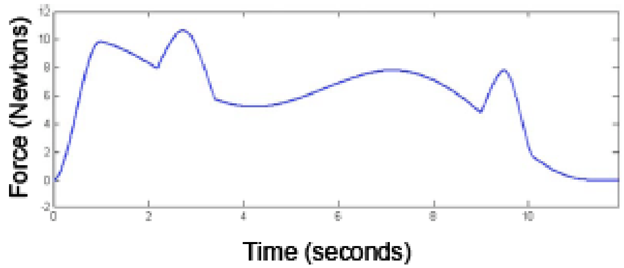


Figure 2. A typical experimental force pattern.

[Morris 2007]

*"We find that recall following **visuohaptic training** is significantly **more accurate** than recall following visual or haptic training alone, although haptic training alone is inferior to visual training alone.This suggests that **in conjunction with visual feedback**, haptic training may be an **effective tool for teaching** sensorimotor skills that have a **forcesensitive component to them**, such as surgery."*

=> Learning sequence of forces is possible

Haptic Guidance based on Forces

Figure 1 - A subject undergoing training on the interface

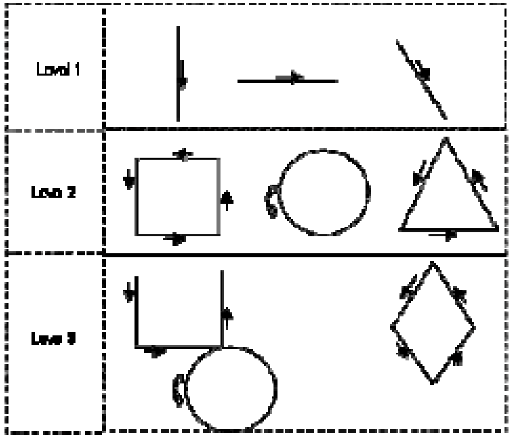


Figure 2 - The sample training trajectories taken from the VMI test book

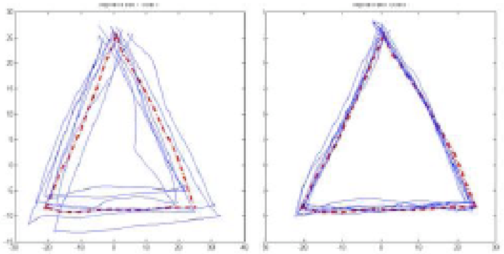


Figure 3 - Sample trajectories for training and recall for one of the subjects. Dashed - reference, solid - training (right)/recall (left)

6 subjects

=> Positive effect on shape with haptic guidance based on force

=> Record-and-Replay strategy

[Srimathveeravalli 2007]

Experiment - Hypotheses

Objectives

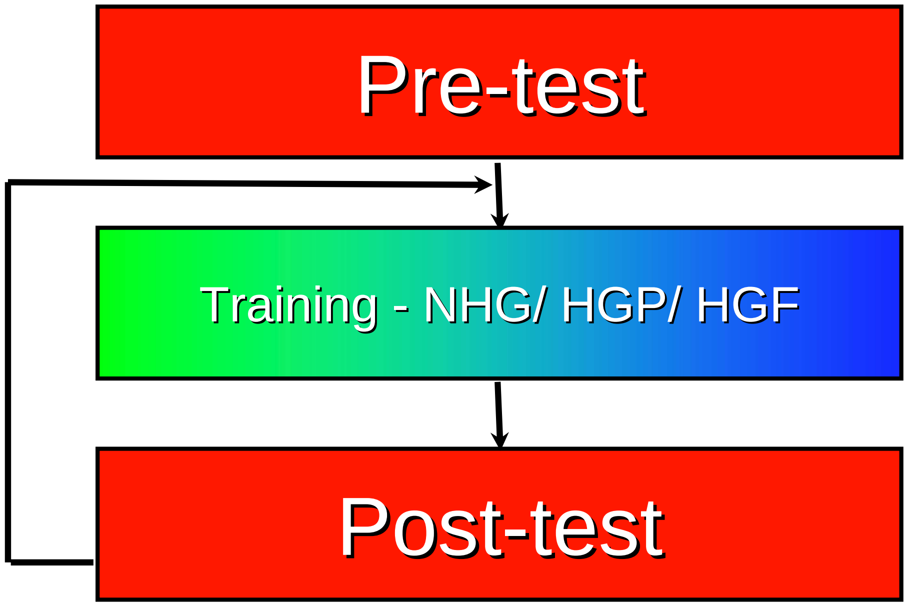
- Compare the two types of haptic guidance on haptic-specific criterions (dynamics, fluidity, force profile)
- Not teacher-dependant or shape-dependant inputs to better understand the brings of haptic guidance based on forces

Hypotheses

- Haptic guidance based on force would perform better then haptic guidance in position due to better adequation to isochrony and homothety principle of writing (Viviani , 1983)
- Both methods would have benefits on haptic-specific criterions
- Previous improvement on shape should be found

Participants

- 24 right-handed adults subjects, with no significant language, motor or neurological dysfunction aged from 18 to 28 years.
- 3 Training conditions : haptic guidance in position (HGP), haptic guidance in force (HGF), No haptic guidance (control group).
- Randomized intra-subject experimental design: each participant go through all conditions to avoid baseline level variability

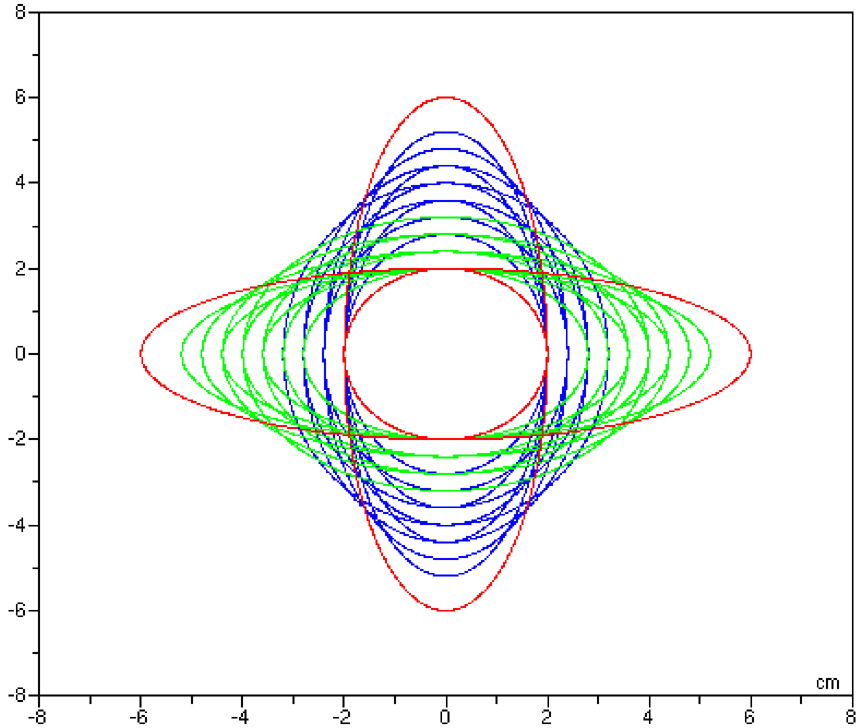


(video)

Elliptical Trajectories

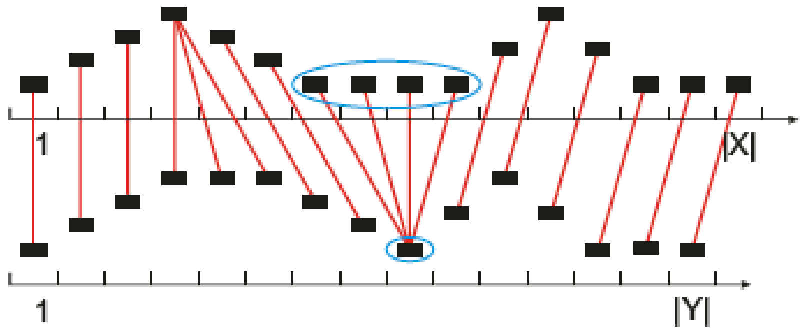
- Each parameter is controller : size, velocity profile, number of points
- Composed of 1000 points (X,Y).
- Biological trajectories : their velocity profiles followed the two-third power law (i.e., velocity V is proportional to the radius of curvature R of the trajectory: $V = k * R^{-1/3}$; equivalent to angular velocity A is proportional to the curvature c of the trajectory: $A = k * c^{2/3}$ - cf. Viviani).

- Several training trajectories (green and blue) to introduce motor variability of required movements (red)



Measured criterions :

- Shape Matching to reference trajectories - DTW : Dynamic Time Wrapping on X and Y axis.



[Niels 2004]

-Mean Velocity
-Number of velocity peaks.

Results

	No Haptic Guidance	Haptic Guidance in Position	Haptic Guidance in Force
Number of Velocity peaks	NS	Significant reduction from 14.48±2.37 to 10.19±1.58	Significant reduction from 14.19±1.91 to 9.20±1.38
Mean Velocity	NS	NS	Significant increase from 4.62±0.48 cm/s to 6.23±0.48 cm/s
Shape matching score (DTW)	NS	NS	NS

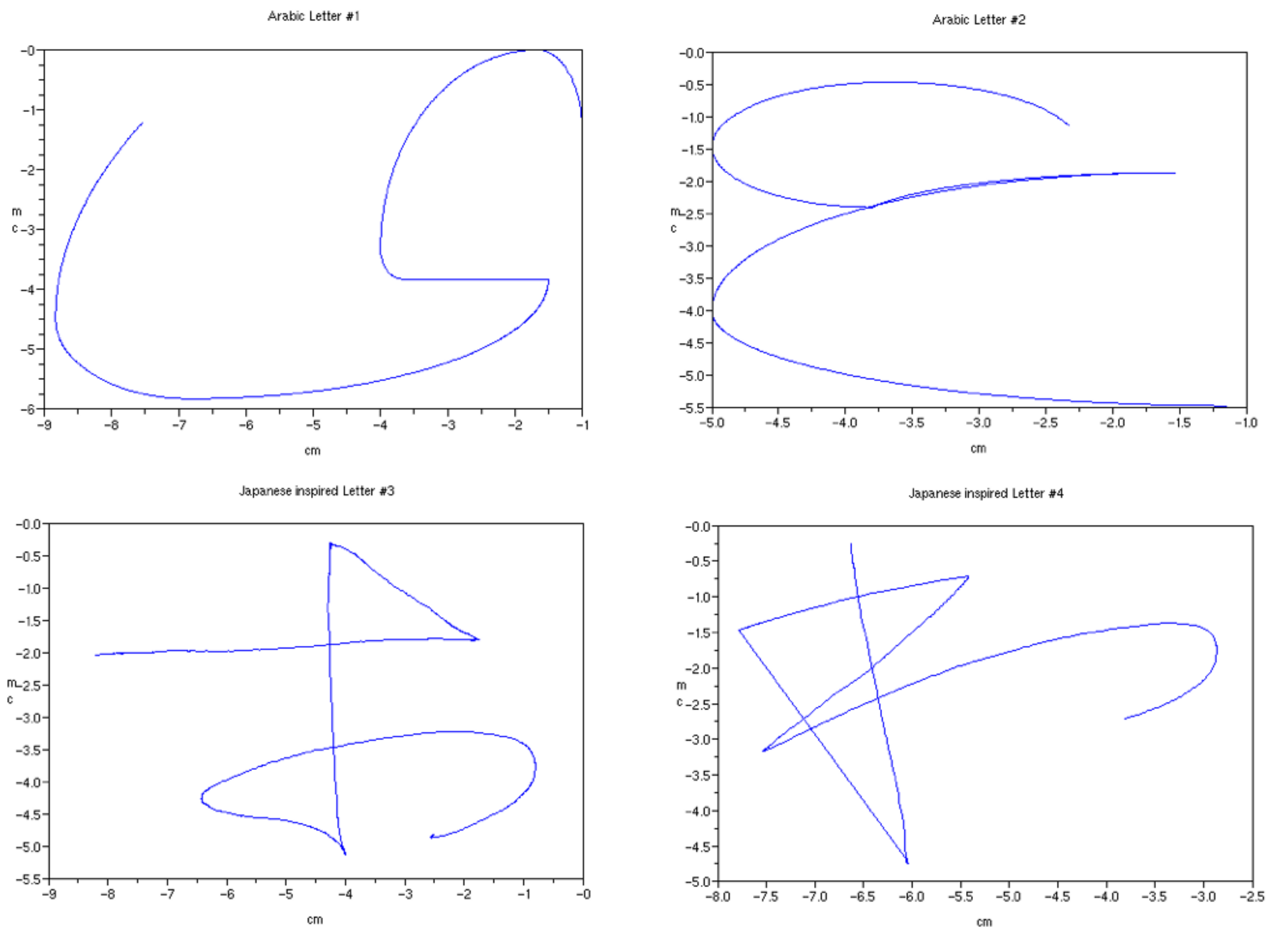
Discussion & Conclusion

- Positive effect of haptic guidance on haptic-specific criterions (fluidity) for both type of haptic guidance.

- However, haptic guidance in force perform better on mean velocity criterion.

- No significant deterioration or improvement were found on shape only. (result in contradiction with previous studies)

- Similar results were observed with four unknown foreign letters



Discussion & perspectives

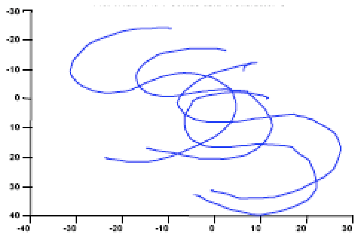
	Our results	Palluel-germain's results
Population	Adults	Children
Haptic guidance which improve the fluidity criterions	HGF	HGP

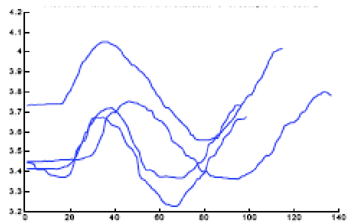
Discussion & perspectives

Why ? two hypotheses

1. Conflicts or perturbations for adults between what they feel and what they are expected to produce with HGP ? Lack of control from the subject ?

2. Encoding of kinematics information change with age : From an Euclidian coordinates encoding in children to an haptic force profile encoding in adults ?





Or / And / Then ?

Thanks to...

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References:
Bluteau J, Coquillart S, Payan Y, Gentaz E (2008) **Haptic Guidance improves the visuo-manual tracking of trajectories.** PLoS ONE. (www.plosone.org).