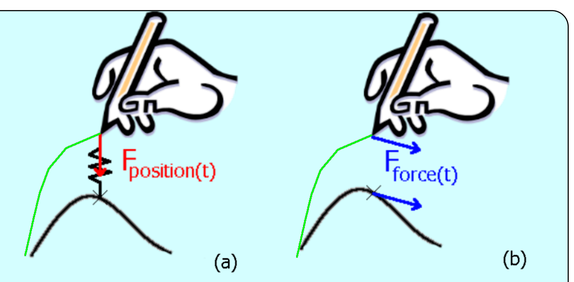
Haptic guidance improves the visuo-manual tracking of Japanese and Arabic Letters

Jérémy Bluteau[123], Sabine Coquillart[1], Yohan Payan[2] and Edouard Gentaz[3]

1. i3D, INRIA Grenoble-Rhône-Alpes, Laboratoire d'Informatique de Grenoble, France
2. TIMC-IMAG, UMR CNRS-University Joseph Fourier, Grenoble, France
3. CNRS and University of Grenoble 2, France

Context

Learning to perform new movements is usually achieved by following visual demonstrations. Haptic guidance by a force feedback device is a technology which provides additional kinesthetic and proprioceptive cues during visuo-motor learning tasks. However, the effects of two types of haptic guidances - control in position (HGP) or in force (HGF) – on visuo-manual tracking ("following") of trajectories are still under debate [1-3].
We focused our research [4] on the impact of each type of haptic guidance, regarding shape and dynamics criterions.

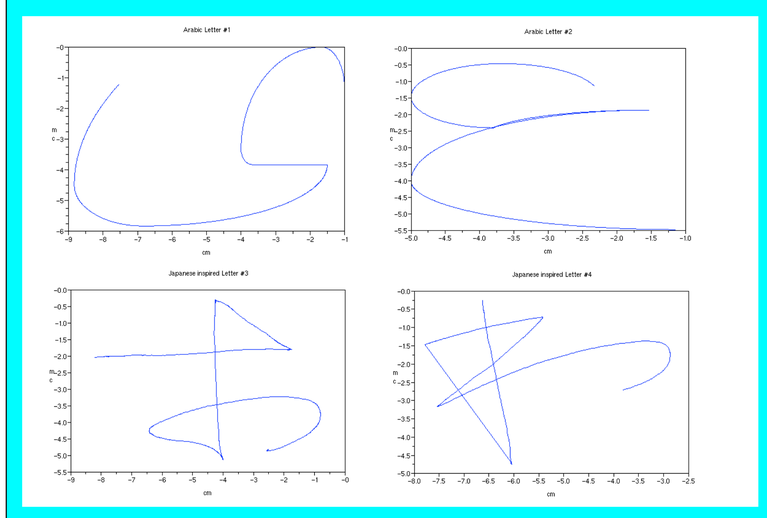


Schematic view of haptic guidances
(a) Haptic guidance in position (HGP); the force felt by the user at time *t* is proportional to displacement between the current user position and the theoretical position on the model trajectory;
(b) Haptic guidance in force (HGF); the force felt by the user at time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

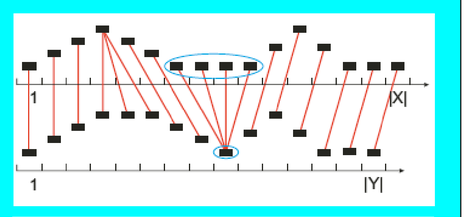
Experiment

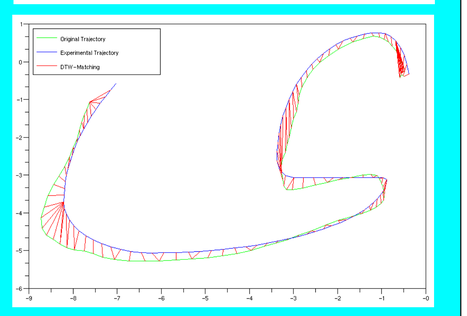
Task

Three training techniques of haptic guidance (HGP, HGF or control condition, NHG, without haptic guidance) were evaluated. Movements produced by adults were assessed in terms of shapes (dynamic time warping) and kinematics criteria (number of velocity peaks and mean velocity) **before** and **after** the training sessions.
Trajectories consisted of two Arabic and two Japanese-inspired letters.



Trajectoires used in Experiment
Left: Letters proposed in experiment 1: Letters 1 and 2 are Arabic and letters 3 and 4 are "Japanese-like" letters.





Dynamic Time Warping
Top : Schematic View of Algorithm [Mytkowicz, 06]
Bottom : Application of DTW Algorithm for Letters as Shape Matching Criterion

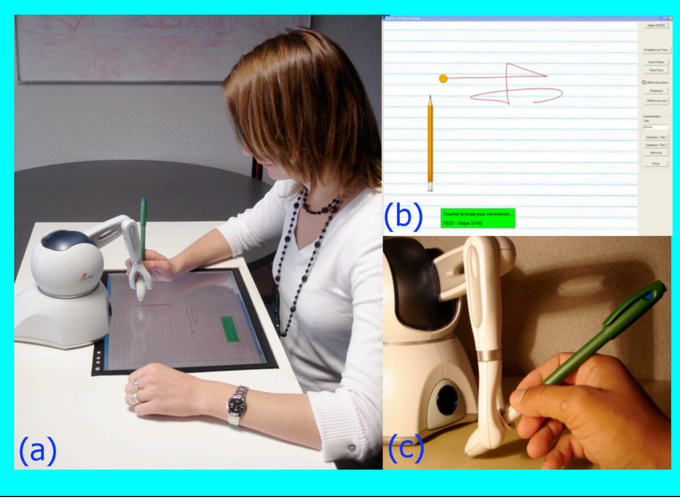
Participants

23 right-handed Caucasian adults, with no significant language, motor or neurological dysfunction and no Japanese or Arabic knowledges were asked to learn to track visuo-manually trajectories with the stylus as accurately and as promptly as possible.

Experimental Setup

Trajectories were presented on a user-friendly interface, designed to be as close as possible to the usual handwriting task. A modified force feedback device's pen was used provide haptic information to the subject.

System Overview
(a) Subject undergoing the experiment on the "What You See Is What You Feel" interface. The force feedback device's stylus served as a pen over a simple flat screen, which served as a paper;
(b)The graphic User Interface displayed to the subject;
(c) The modified stylus pen.



Results

- We observed that the use of HGF globally improves the fluency of the visuo-manual tracking of trajectories while no shape damage was observed.
- No significant improvement was found for HGP or NHG.

	No Haptic Guidance	Haptic Guidance in Position	Haptic Guidance in Force
Number of velocity peaks	NS	NS	Significant reduction from 10.82±1.16 to 8.58±1.16
Mean velocity	NS	NS	Significant increase from 4.97±0.4 cm/s to 6.34±0.52 cm/s
Shape matching score (DTW)	NS	NS	NS

Conclusion

- Haptic Guidances (HGF and HGP) do not influence the shape quality, mainly guided by visual feedbacks.
- HGF better improved the fluidity of movements than HGP for these trajectories.
- The global superiority of HGF over HGP suggested that learned information for this specific motor activity could be stored as internal inverse model, encoded in force coordinates.

References

1. Feygin D, Keehner M, Tendick R - Haptic guidance: Experimental evaluation of a haptic training method for a perceptual motor skill. Proceedings of 10th Haptic Interfaces for Virtual Environment and Teleoperator Systems 2002; 40–47.
2. Palluel-Germain R, Bara F, Hillairet de Boisferon A, Hennion B, Gouagout P, Gentaz E - A Visuo-haptic device - Telemaque - increases kindergarten children's handwriting acquisition. Proceedings of IEEE World Haptics 2007; 72–77.
3. Srimathveeravalli G, Thenkurussi K - Motor skill training assistance using haptic attributes. Proceedings of Haptic Interfaces for Virtual Environment and Teleoperator Systems 2005 ; 452–457.
4. Bluteau J, Coquillart S, Payan Y and Gentaz E - Haptic guidance improves the visuo-manual tracking of trajectories. PLoS ONE 2008 ; 3: e1775, doi: 10.1371/journal.pone.0001775

INRIA

Laboratoire de Psychologie et NeuroCognition

TIMC