SKILLS

Multimodal Interfaces for Capturing and Transfer of Skill

Effects of Practice and Sensory Modality on Stiffness Perception

Korman M. Weiss K., Cohen A., Gelfeld T., Reiner M., Gopher D.

TECHNION- Israel Institute of Technology

Touch perception

Touch is a proxal modality and is extremely important for finding out properties of objects and providing feedback for manipulation.

– Weight, strength give feedback on how well user is holding object
– Hardness, texture, vibration, interia or weight convey information about the properties of objects

Touch Information

- Tactile (Cutaneous)
– Receptors in the *skin*
- Proprioceptive (Kinesthetic)
– Receptors in the *muscle and joints*

Haptic compliance information

Combination of tactile, Proprioceptive and Visual position information (Freyberger, 2007)

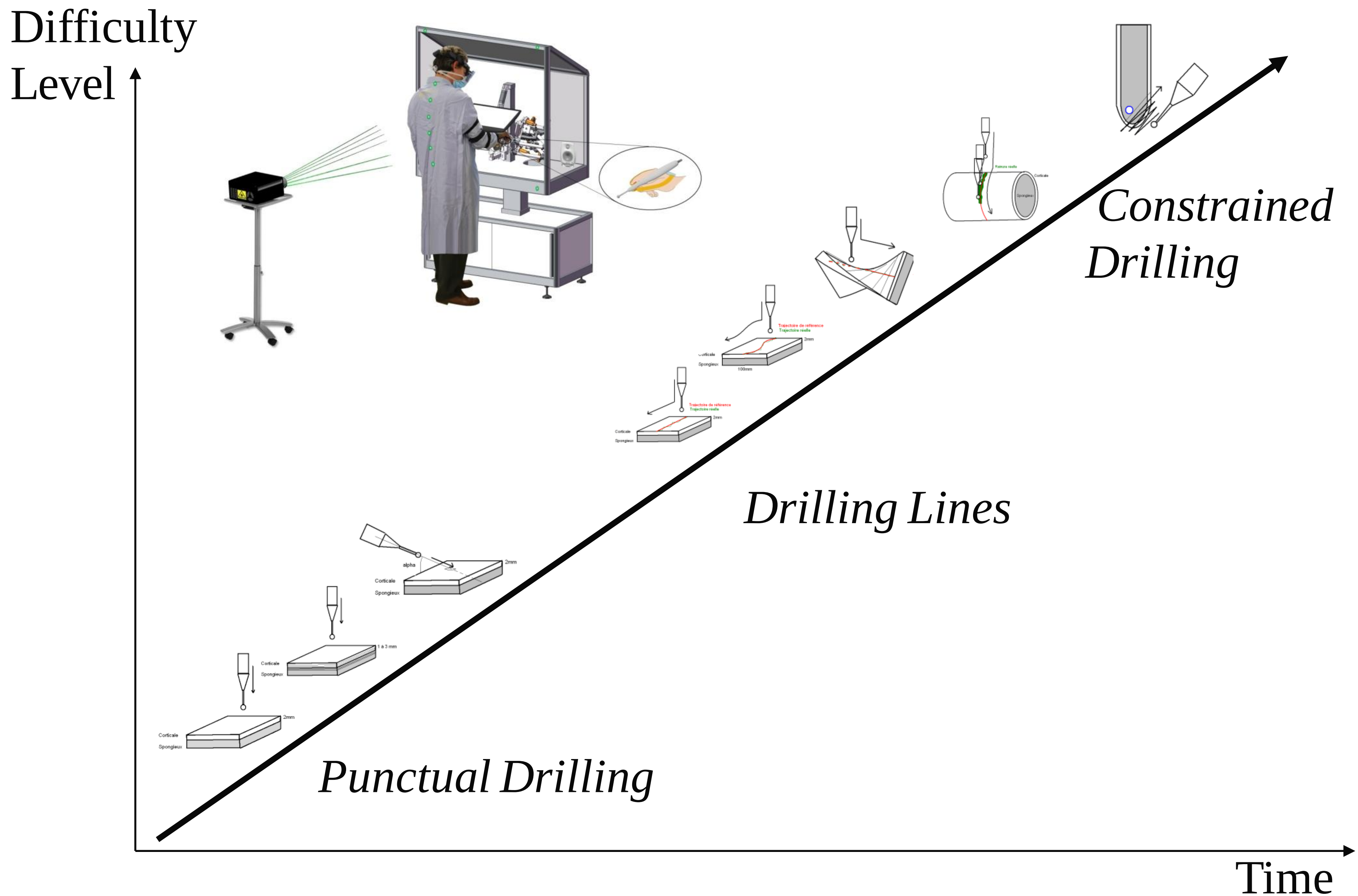
Motivation

Compliance sensitivity is essential for many complex tasks. Training manual skills such as surgery in VE simulators implies that that simulator-based training needs to be carefully structured and that modal feedback is one of the key factors throughout the development of a skill (Tsuda et al., 2009).

Recent theories on sensory integration suggest that acquiring information from multiple sensory modalities can produce better performance than from a single modality and the degree of dominance is determined by the statistical reliability of the available sensory information. Thus, in situations where visual information is unreliable, haptic training may prove to be more beneficial than vision. (Feygin et al., 2002, Ernst&Banks, 2001)

Multimodal Interfaces for Capturing and Transfer of Skill

Training program in VE



Objectives

We explored humans' ability to detect differences in stiffness, based either on purely haptic feedback or together with congruent/incongruent visual cues, in VR setup.

1. **Effects of uni- vs. multi- modal feedback on stiffness discrimination ability**
2. **Effects of order on performance with different types of feedback**

We used static haptic model manipulating the stiffness parameter of a virtual spring beneath the solid target square, providing both force and visual feedback, seen as a change in the size of the target proportional to the force applied. We considered the static model as a simplified model of object compliance and express the parameters of stiffness in corresponding compliance values (mm/N).

Task

2AFC discrimination task:

"Which target is softer?"

In each trial, subjects were asked to discriminate between two stiffness values, presented by two squares, and determine which of the two presented targets is softer.

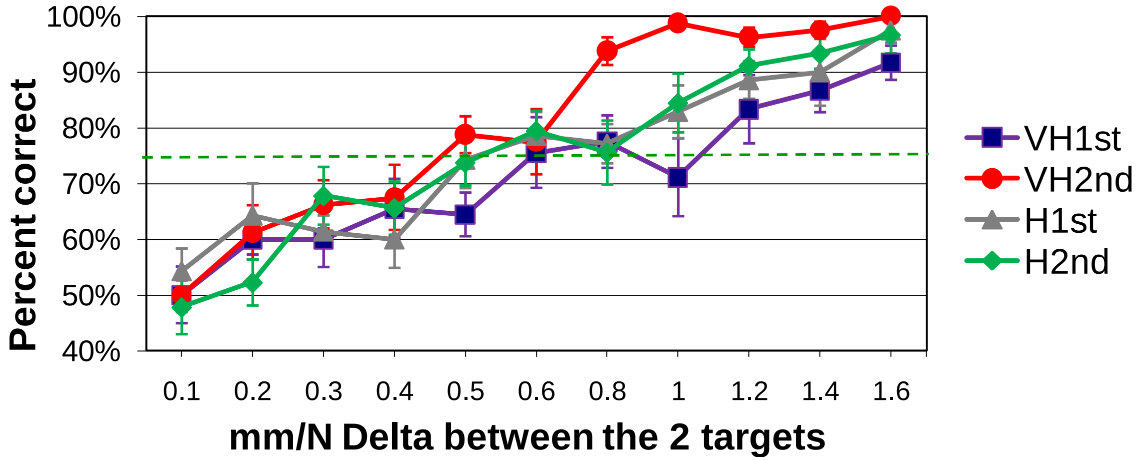
We used compliance values (4 to 2.4 mm/N) translated to simple stiffness static models

Task

- Each comparison pair was comprised of one standard value (held constant, 4 mm/N) and one comparison value out of 11 (at the range of 3.9-2.4).
- Each block consisted of the same 11 comparisons, each pair was repeated 10 times in a block. The within block order of comparison values, and its localization (left/right) were randomized. The order of the blocks was counter-balanced across subjects.

Group I (n=20)	Group II (n=16)
Haptic-only block	**Haptic-only** block
Visual-haptic block	**Visual-only** block

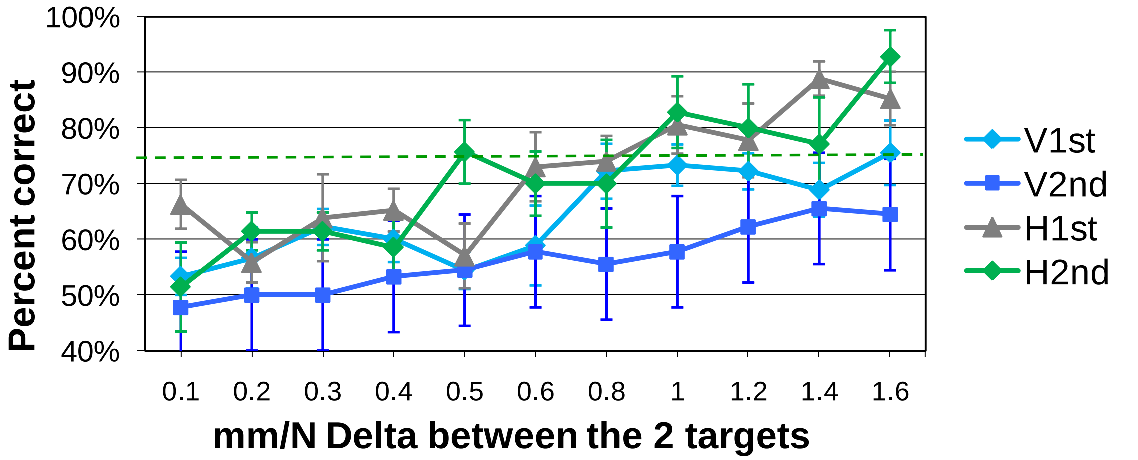
Results – order effects



Group I

Visual-haptic vs. Haptic only

Improved performance in VH2nd

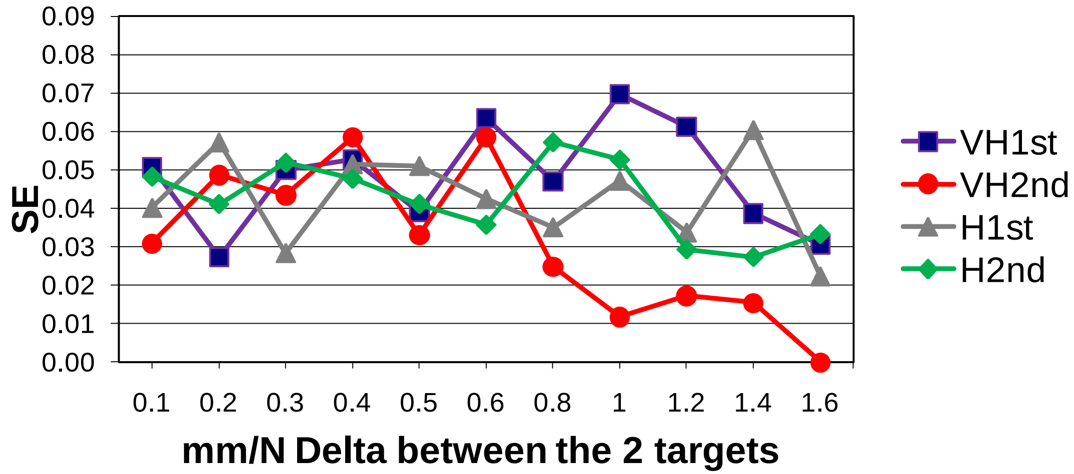


Group II

Visual only vs. Haptic only

Degraded performance in V2nd

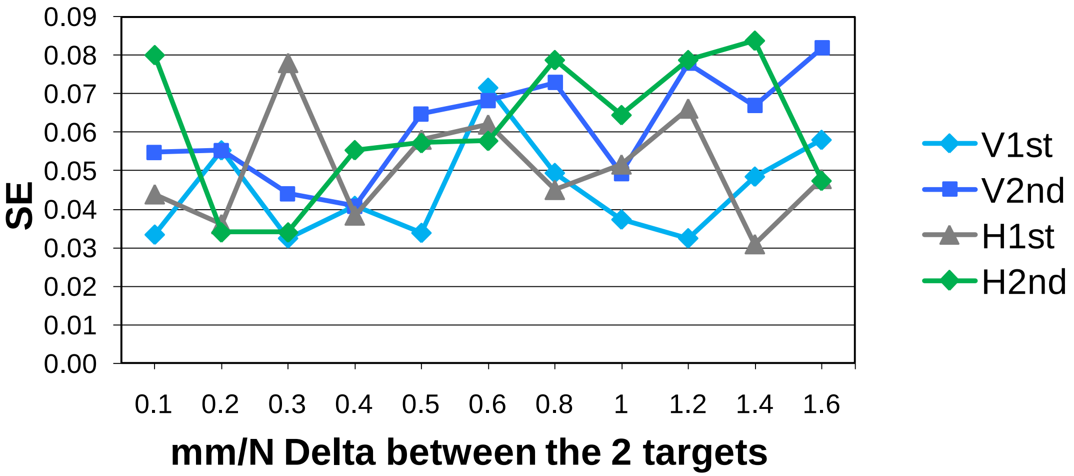
Results - variance



Group I

Visual-haptic vs. Haptic only

Decreased variance in VH2nd

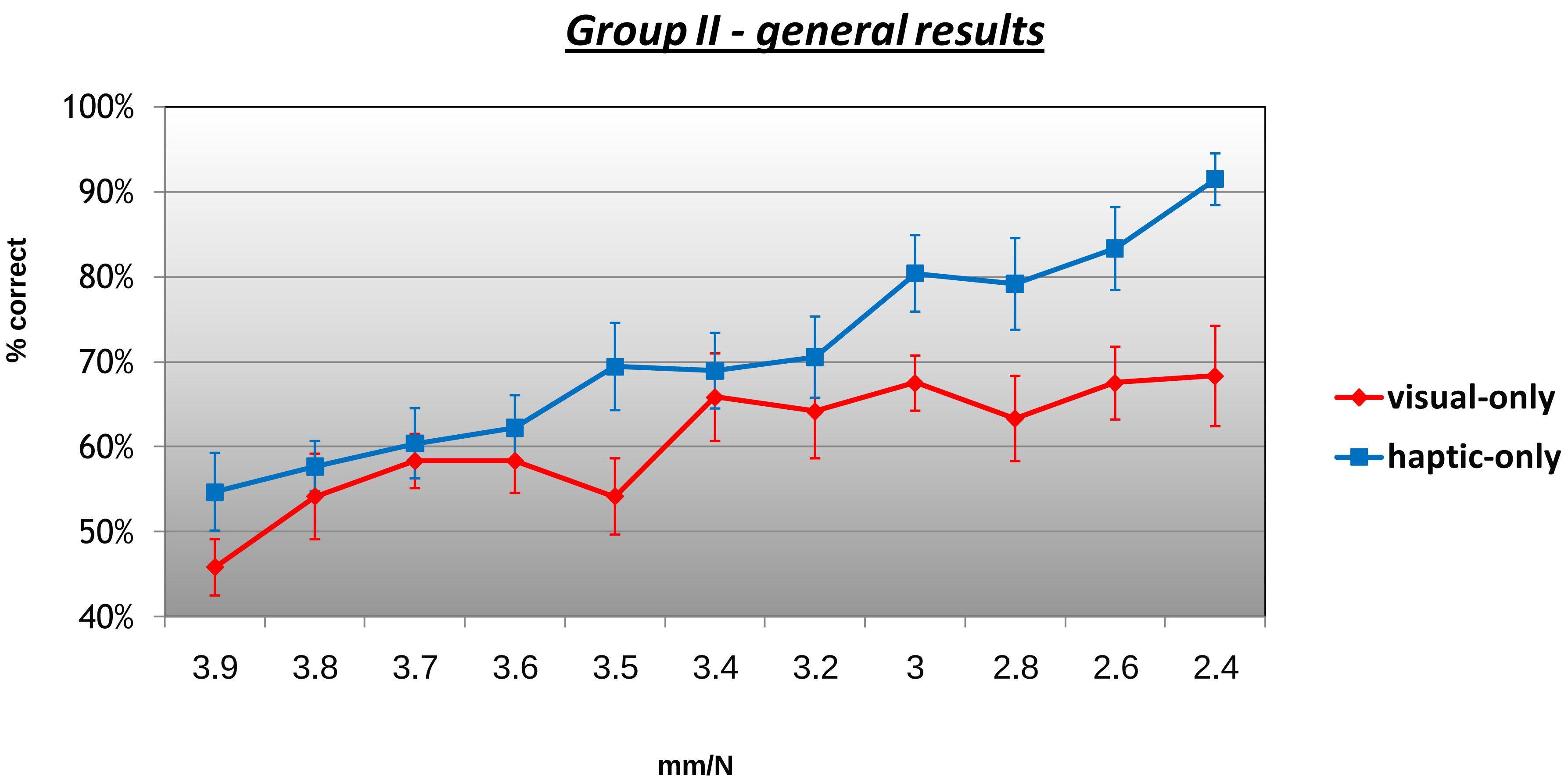


Group II

Visual only vs. Haptic only

No difference in variance among conditions

Results – disregarding order



Disregarding order effects the results would show:

No significant difference between the H and VH conditions

Significant differences between the H and V conditions

Conclusions

- The window of significant differences between uni-modal and multi-modal performance is within the range of supra-threshold comparisons.
- Both accelerating and inhibiting effects were found to be order dependent, such that presence of previous haptic experience is critical for effective bi-modal interaction.
- Congruent multimodal cue significantly and positively affected discrimination ability, if was preceded by haptic experience.
- Incongruent multimodal cue significantly decgraded discrimination ability, especially if was preceded by haptic experience.

Practically, in the light of developing training facilitators for manual skills, we therefore suggest that training should include extensive practice with only the haptic component prior to more advanced multi-modal training conditions.

Current and future

- Study1, in progress: Training stiffness discrimination: effects of immediate feedback +/- difficulty matched visual cues.
- Study2, in progress: Effects of practice and multisensory integration on vibration detection (vibration + sound / vibration + sound + stiffness)
- Study 3, in preparation: Learning and Memory for touch information – training a sequence of movements using implicit compliance-based rules
- In progress: Evaluation of basic science results in real complex task training using the MFS simulator – assessment of skill enhancement and transfer.

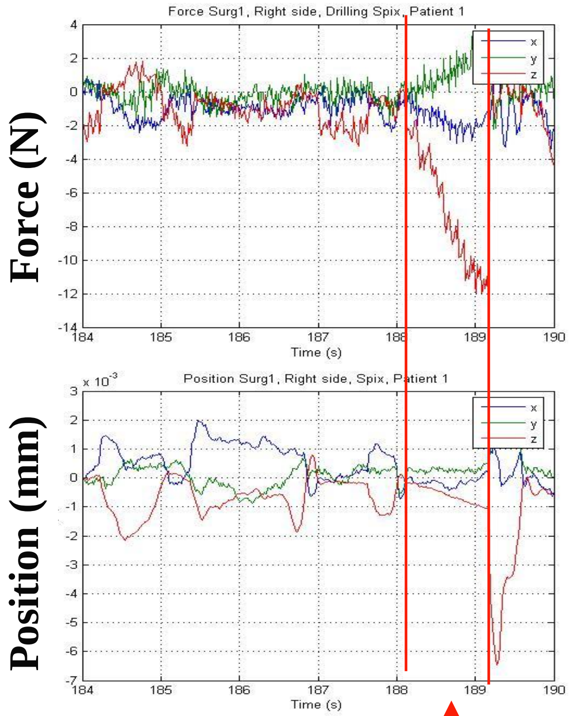
A set of Matlab function for force/motion analysis has been developed:

Data processing

Data calibration/synchronisation

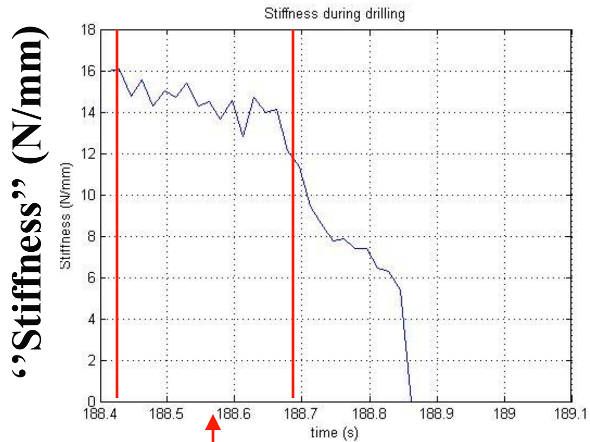
Re-sampling

Advance data analysis (correlation) → Analysis of skills and the identification of expertise



Drilling sequence

Correlation analysis

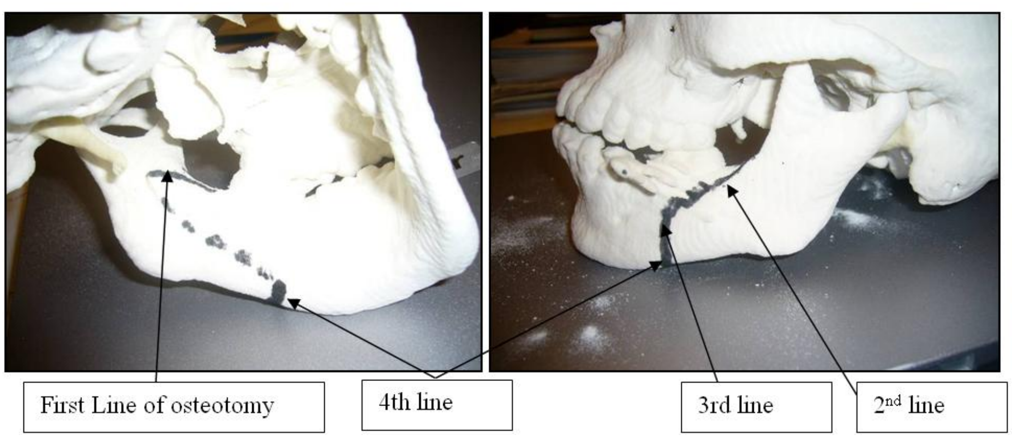


Drilling sequence

Results on compliance management by the surgeon

Maxillo Facial Surgery

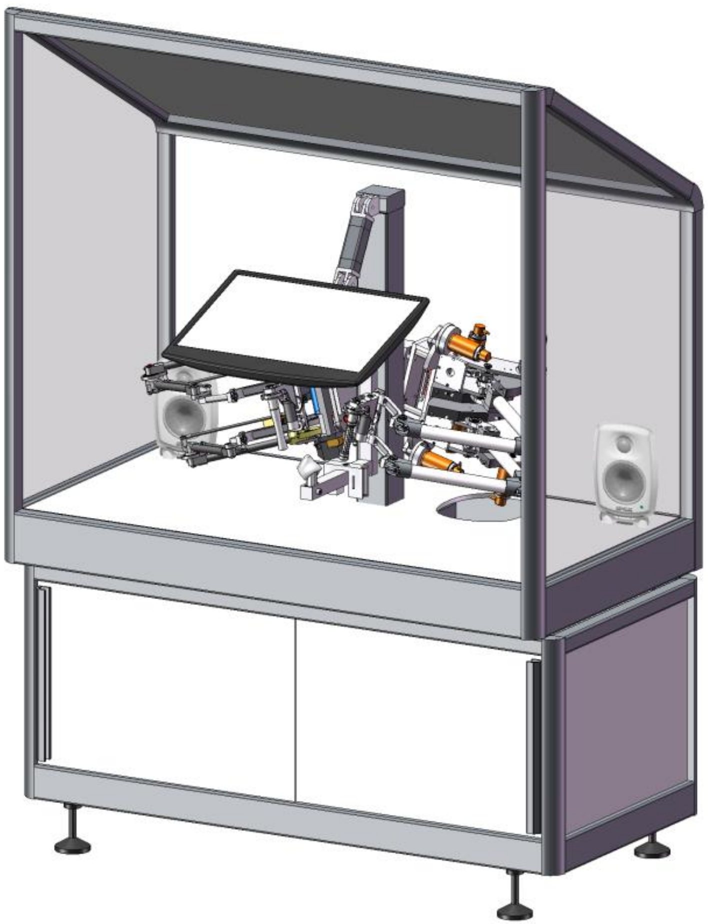
We explored the possibilities of enhancing human perception of stiffness/compliance of objects with regard to haptic skill acquisition. We evaluated humans' ability to detect differences in compliances with visual cues in order to explore the effects of practice and multimodal integration. Results are intended to feed the development of training protocols that facilitate the acquisition and enhancement of relevant haptic skills in surgery simulator



The aim of the Maxillo-Facial Surgery Simulator is to provide a pedagogical training system allowing to ease the transfer of skills from senior operators to novices for some of the basic skills that underlie a very delicate operation in the field of facial surgery called the Epker osteotomy

MFS Simulator

Objectives : Development and integration of a demonstrator covering all aspects of skills management in the field of Maxillo Facial Surgery (MFS).



Key points:

- Multimodal (Force feedback, sound, vision, vibration)
- Immersive
- Bi-manual
- A trainer, not only a simulator (definition of specific exercises/accelerators)

SKILLS

Multimodal Interfaces for Capturing and Transfer of Skill

Thank you for listening