Proficiency-Based Progression Feedback Improves Training in Epidural Analgesia Simulation

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Ben-Gurion University of the Negev

Biomedical Robotics Lab

SOROKA Medical Center feeling secure

Getting Started

- Training is very difficult – a resident will reach a success rate of barely 80% after 90 attempts (Konrad et al. 1998).
- Possible risks and complications (Vaughan et al. 2013).
- Current training paradigm jeopardizes patient safety (Houben et al. 2011).

Dr. Yair Binyamin

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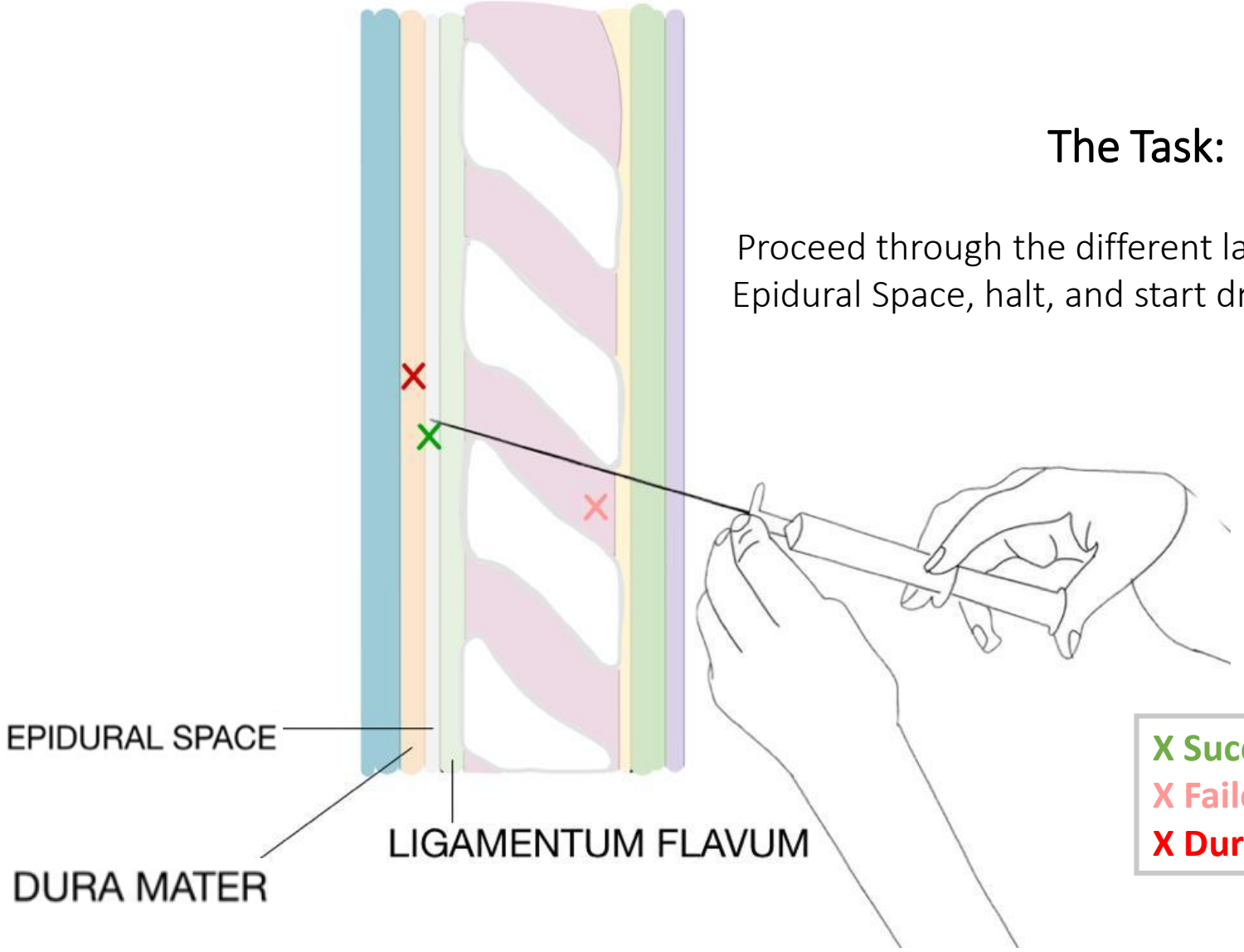
Dr. Yair Binyamin

Medical Simulation

- A possible solution for the trade-off between high-quality skill acquisition and unharmed patient care (Rodriguez-Paz et al. 2009).
- We can record kinematic information to evaluate users' performance and strategy.

The Epidural Region



The Task:

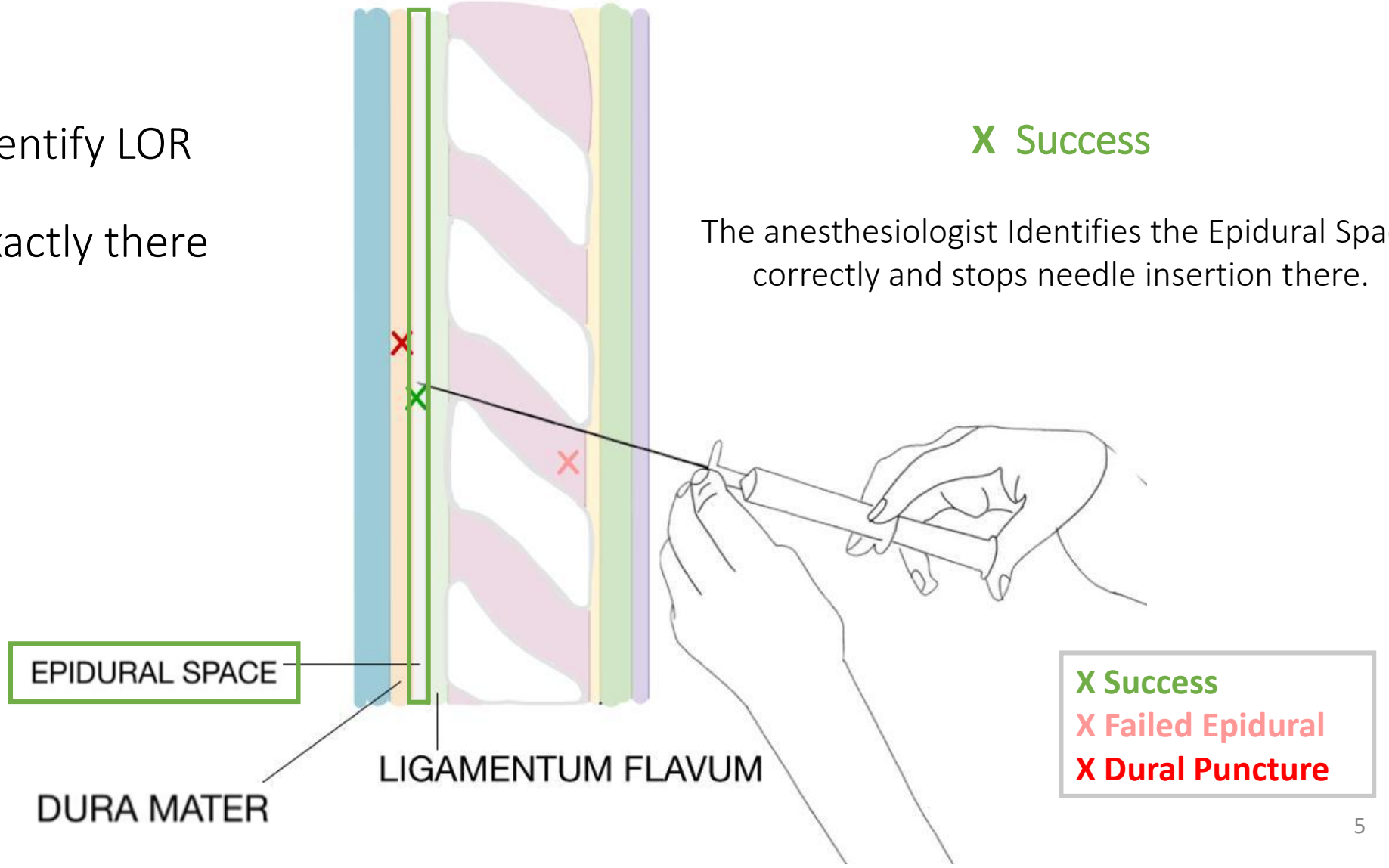
Proceed through the different layers, arrive at the Epidural Space, halt, and start drug administration.

X Success
X Failed Epidural
X Dural Puncture

The Epidural Region

Perception: identify LOR

Action: stop exactly there



X Success

The anesthesiologist Identifies the Epidural Space correctly and stops needle insertion there.

X Success
X Failed Epidural
X Dural Puncture

The Epidural Region

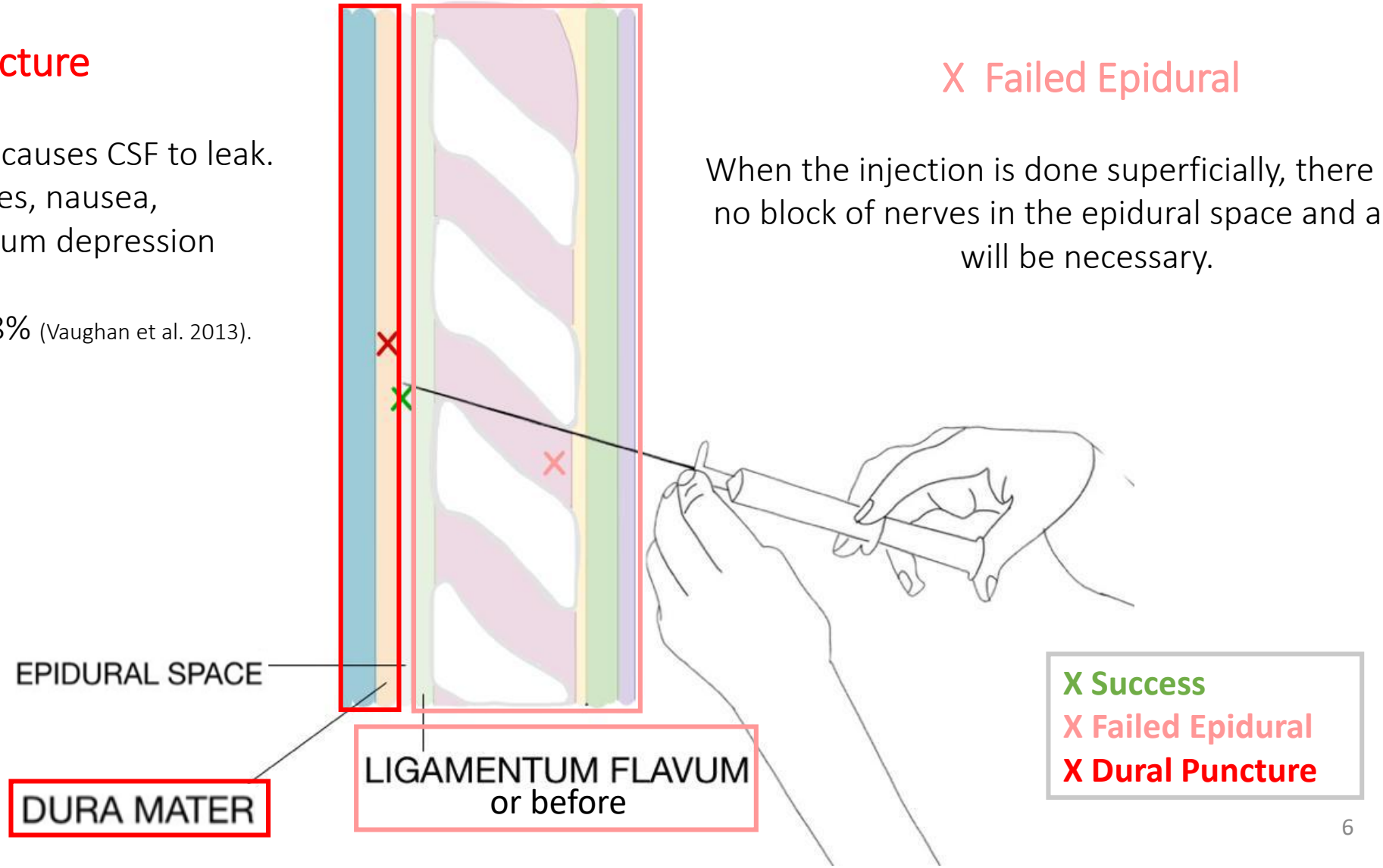
X Dural Puncture

Puncturing the Dura Mater causes CSF to leak.
Can cause headaches, nausea,
chronic aches, postpartum depression

Occurrence rate of 1%-2.8% (Vaughan et al. 2013).

X Failed Epidural

When the injection is done superficially, there will be no block of nerves in the epidural space and a re-do will be necessary.



Task Instruments

Tuohy Needle

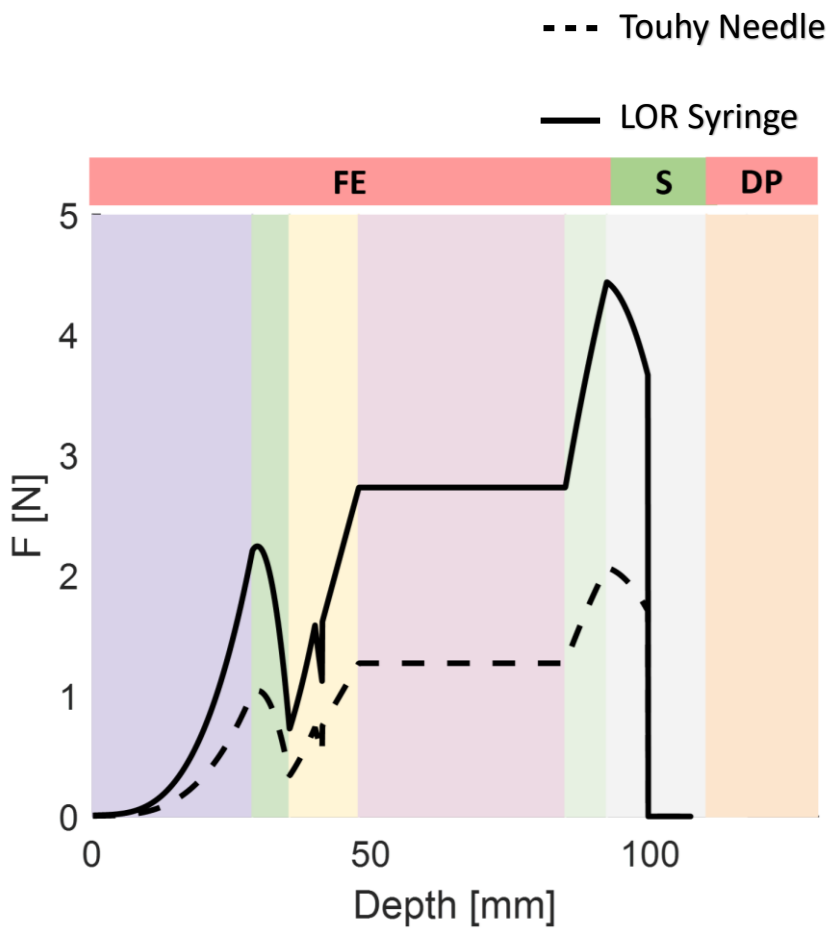
Used to proceed through the tissues in the Epidural region

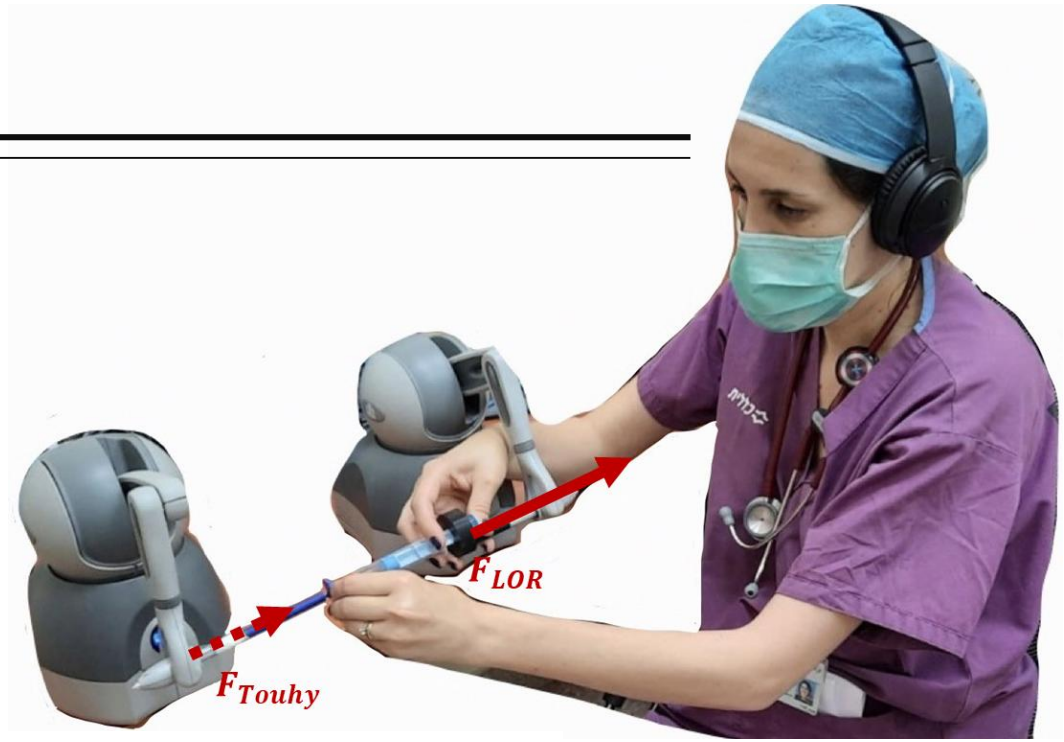
Loss of Resistance (LOR) Syringe

Used to sense environment stiffness and identify loss of resistance

Simulator Design

Haptic Feedback

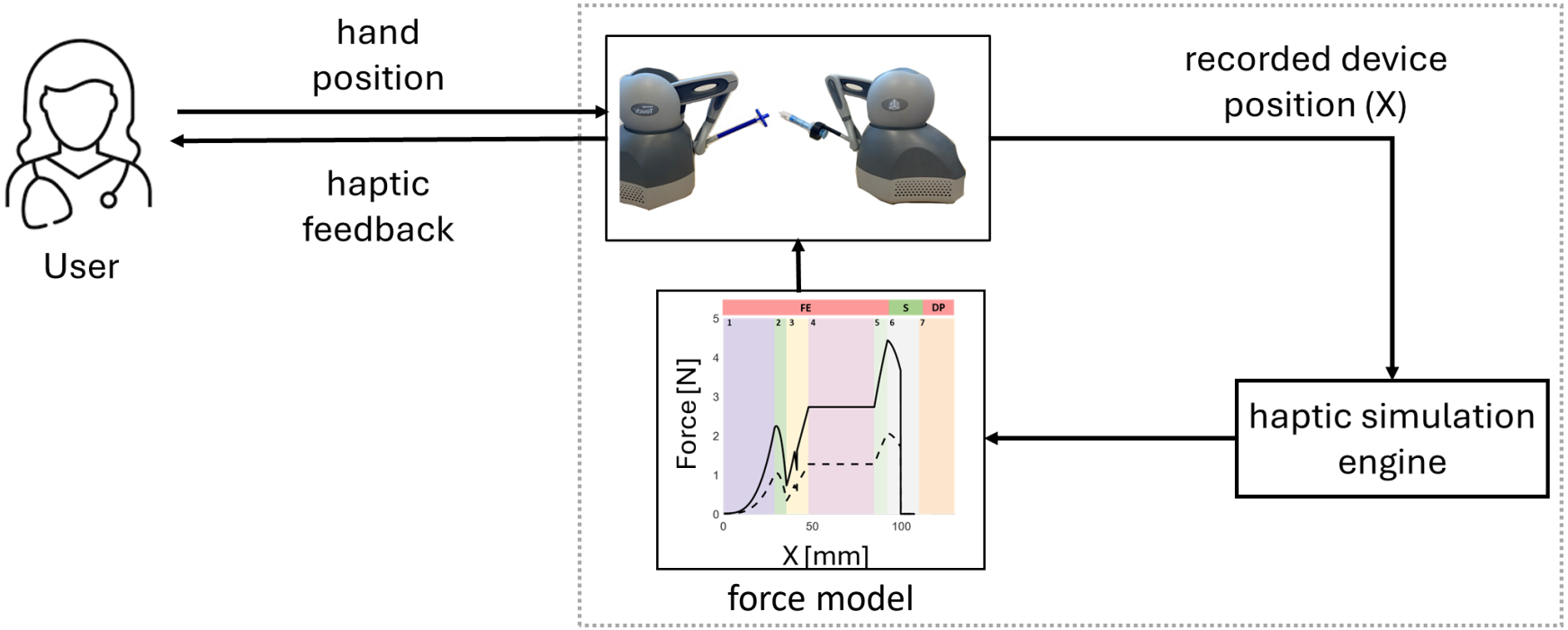




Skin
Subcutaneous Fat
Supraspinous Ligament
Interspinous Ligament
Ligamentum Flavum
Epidural Space
Dura Mater

Force models are based on Brazil et al. 2018, “Haptic Forces and Gamification on Epidural Anesthesia Skill Gain”

Haptic Feedback

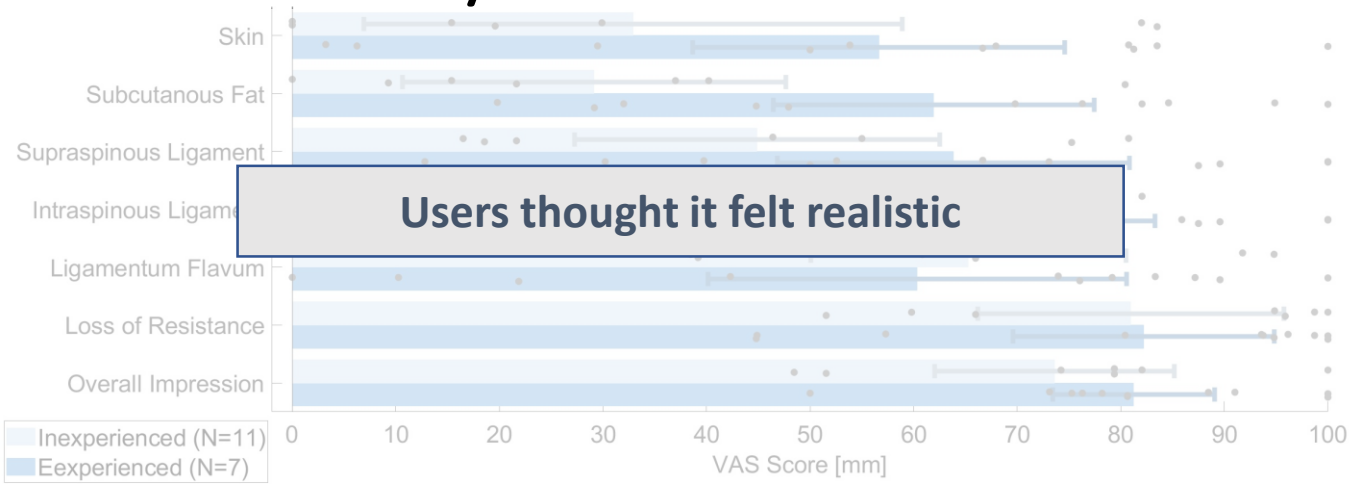


Force models are based on Brazil et al. 2018, “Haptic Forces and Gamification on Epidural Anesthesia Skill Gain”

Simulator Validation

Participants: N=22 anesthesiologists

Face Validity

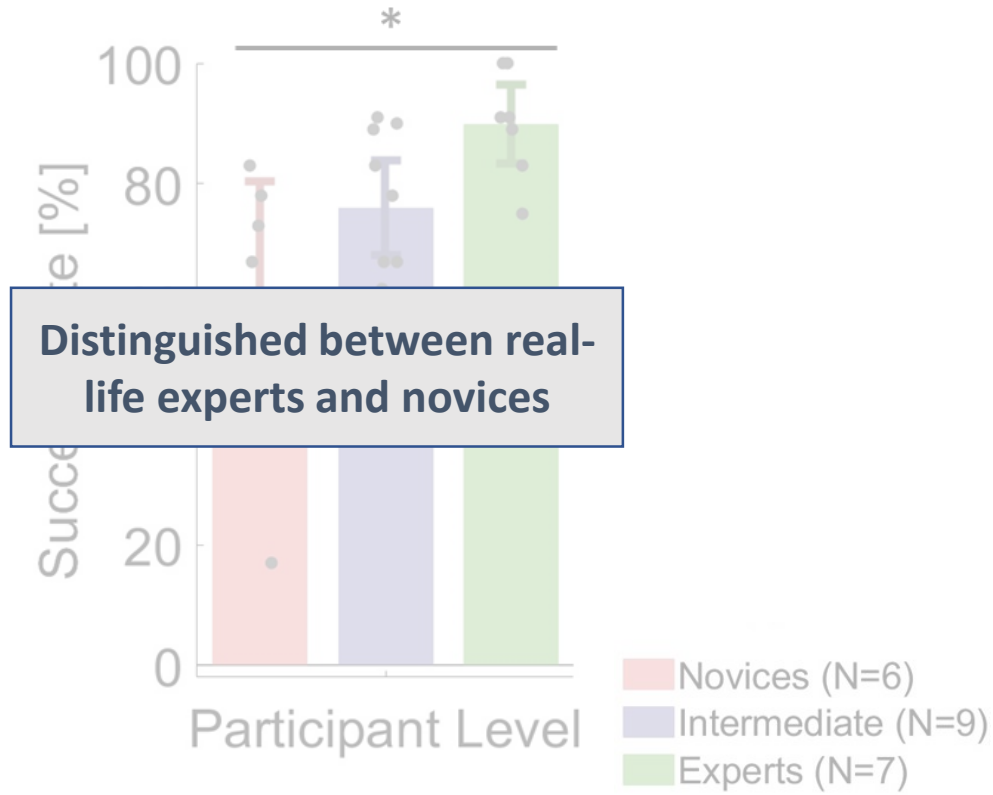


Users thought it felt realistic

Content Validity

Fulfilled purpose as a training tool

Construct Validity



Distinguished between real-life experts and novices

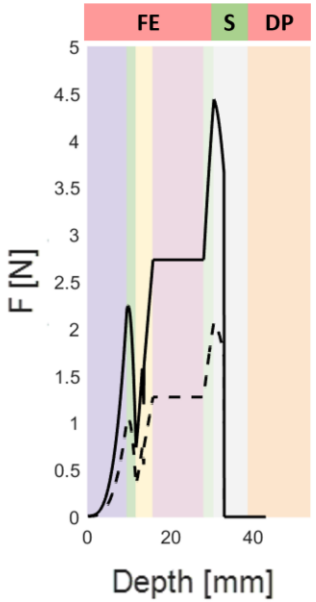
What Next?

Variability or Consistency?

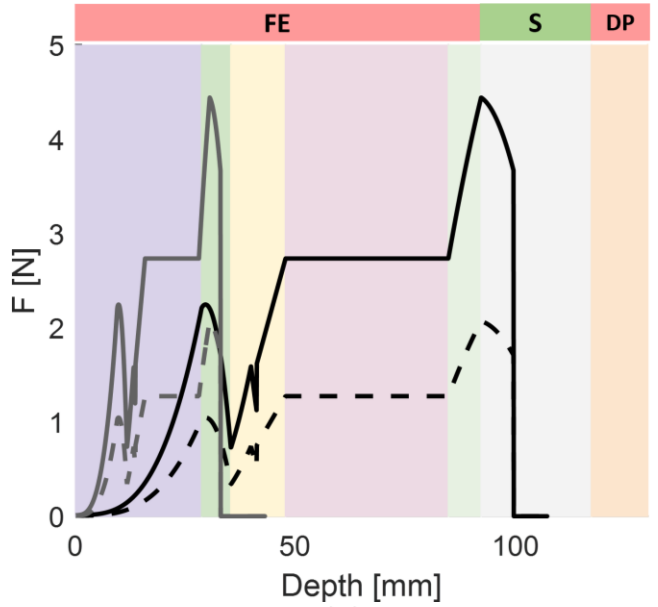
Motor Variability ↑

Herzfeld et al. 2014, Wu et al. 2014, Fernandez-Ruiz et al. 2011

55, 70, 85, 100, 115, 130 kg



55 kg



55 kg **115 kg**

What Next?

Repeated or Deliberate Practice?

Verbal Instructions 

Masters, 1992 Hodges and Franks, 2001

Proficiency-based progression (PBP)

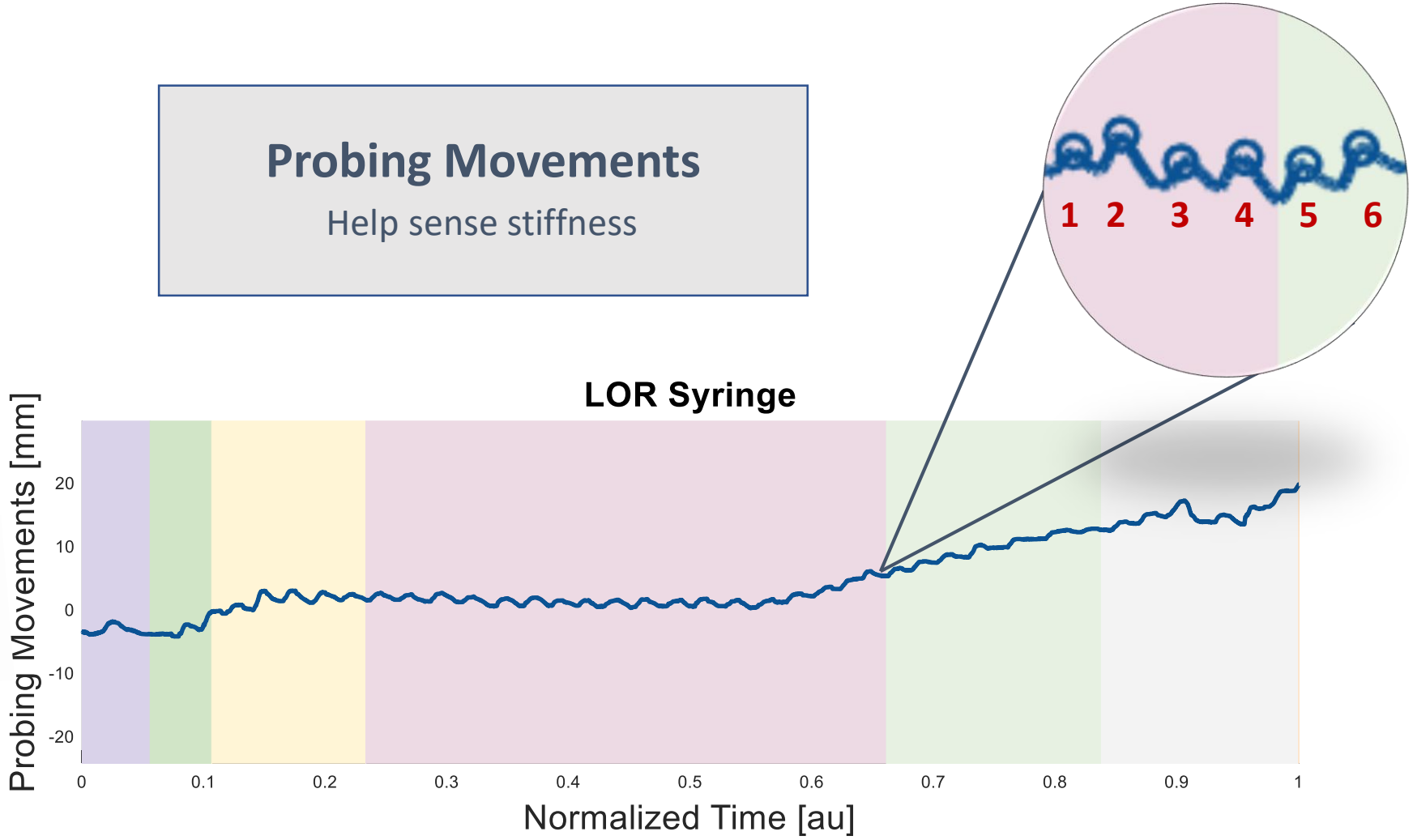
Performance Metrics → **Feedback and Instructions**

Gallagher, 2018

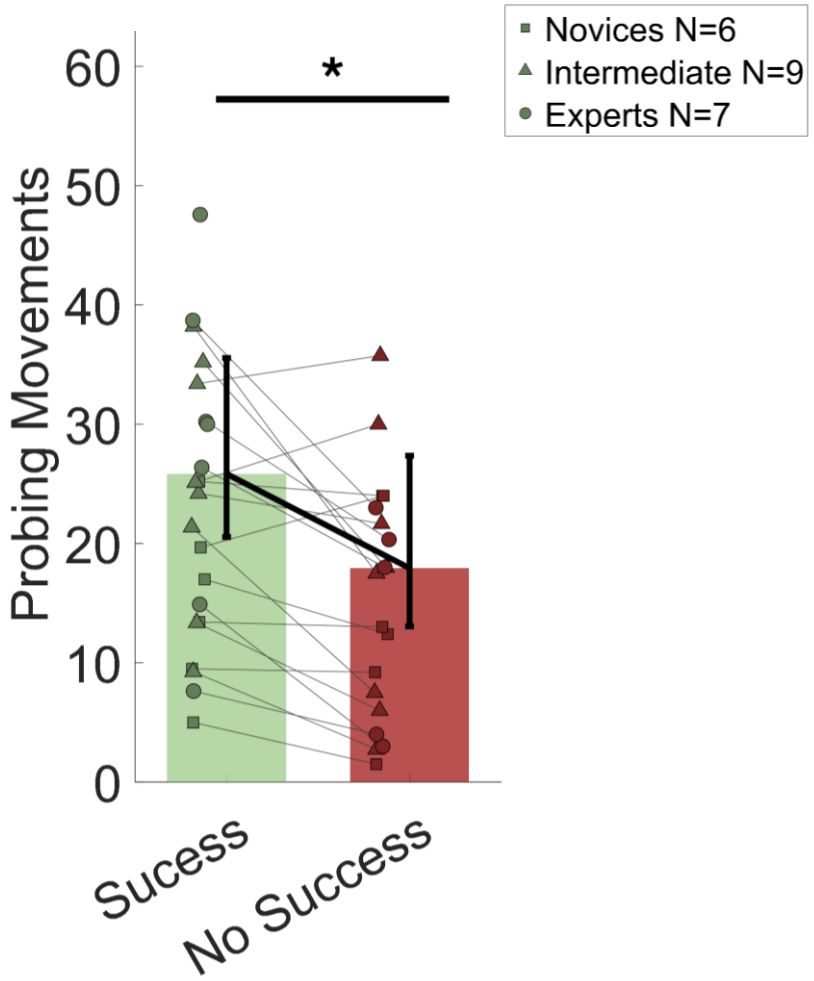
Defining Performance Metrics for PBP

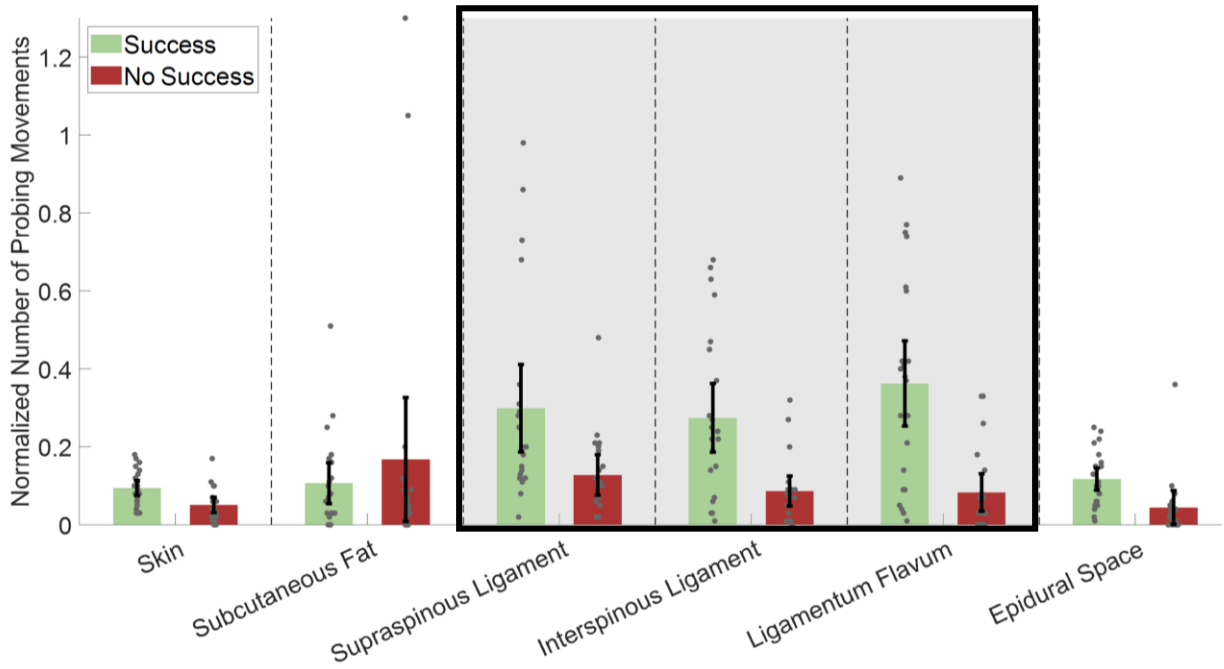
Probing Movements

Help sense stiffness



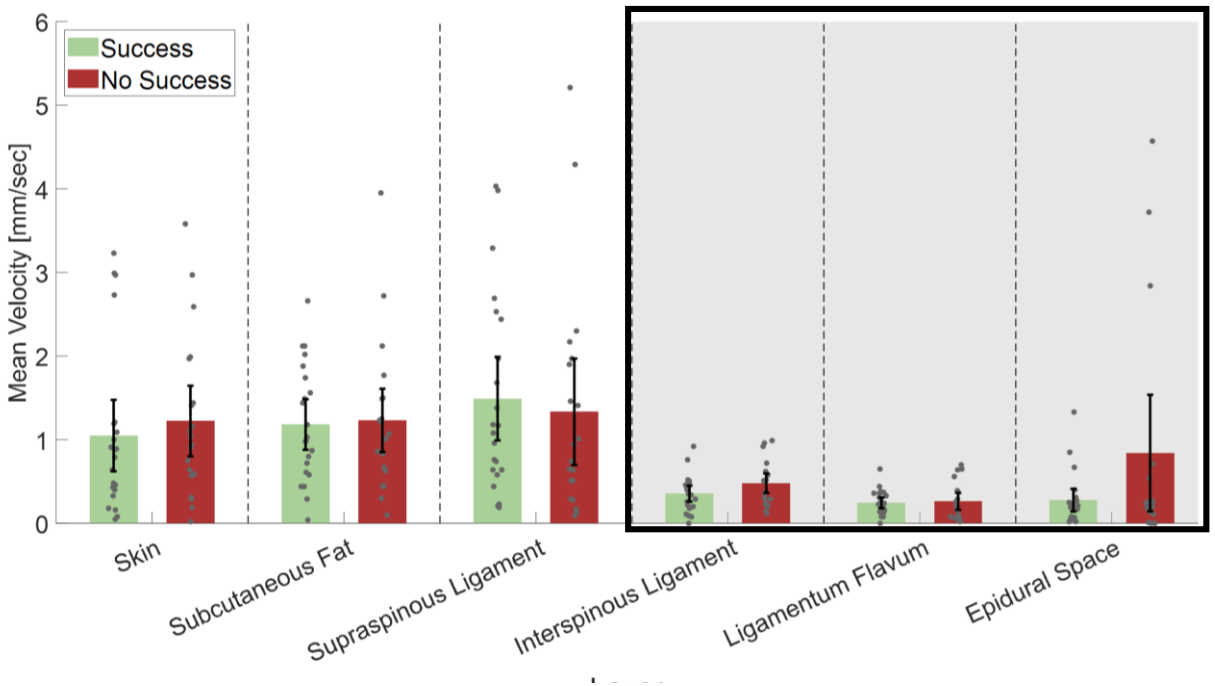
Defining Performance Metrics for PBP

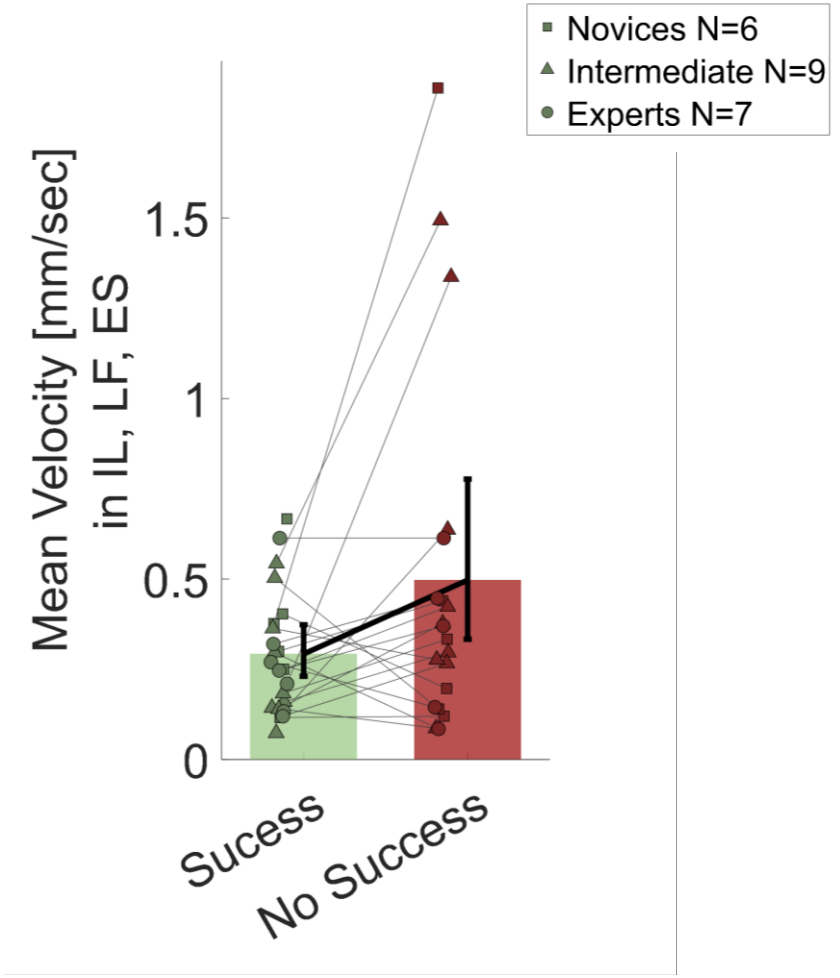




Under Revision: Davidor et al., 2025, “Proficiency-Based Progression Feedback Improves Training in Epidural Analgesia Simulation”

Defining Performance Metrics for PBP





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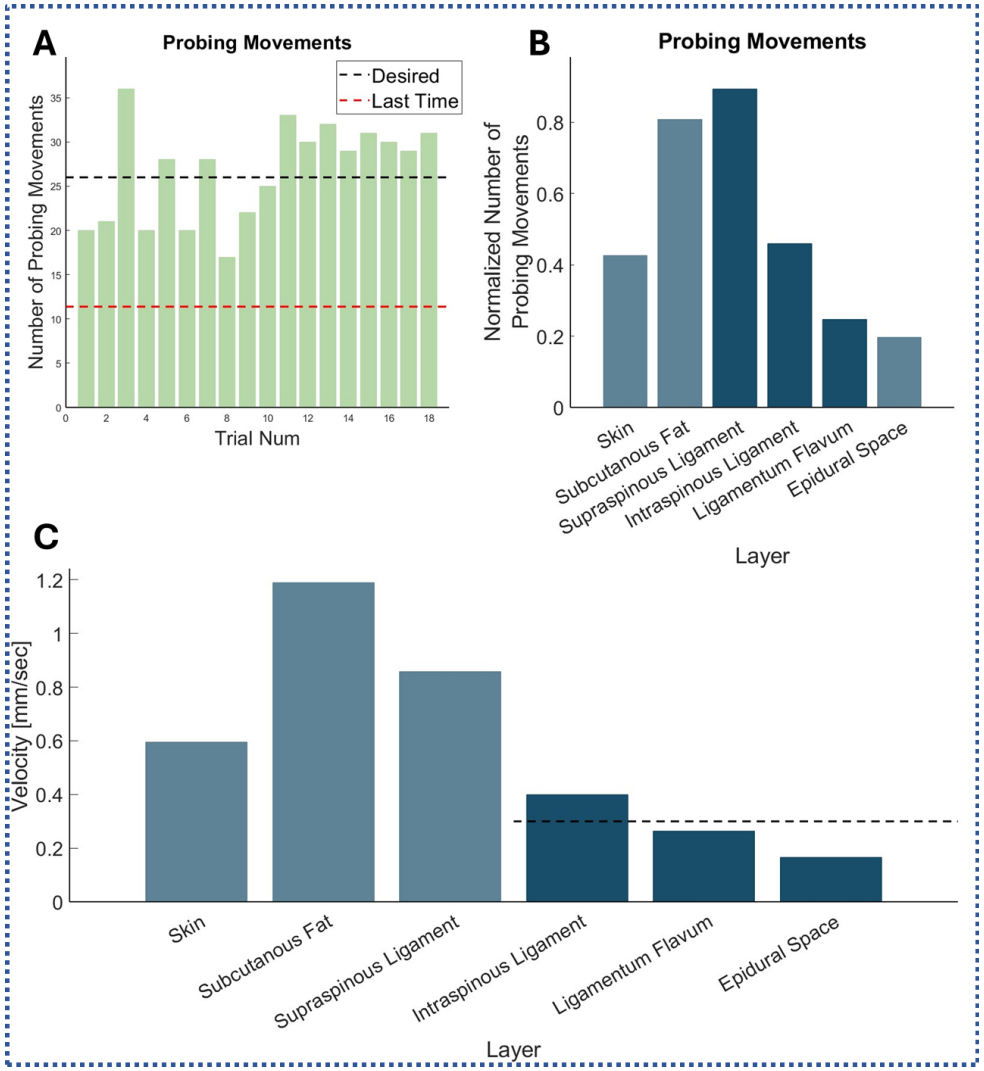
Designing a PBP Approach



Goal: teach participants to

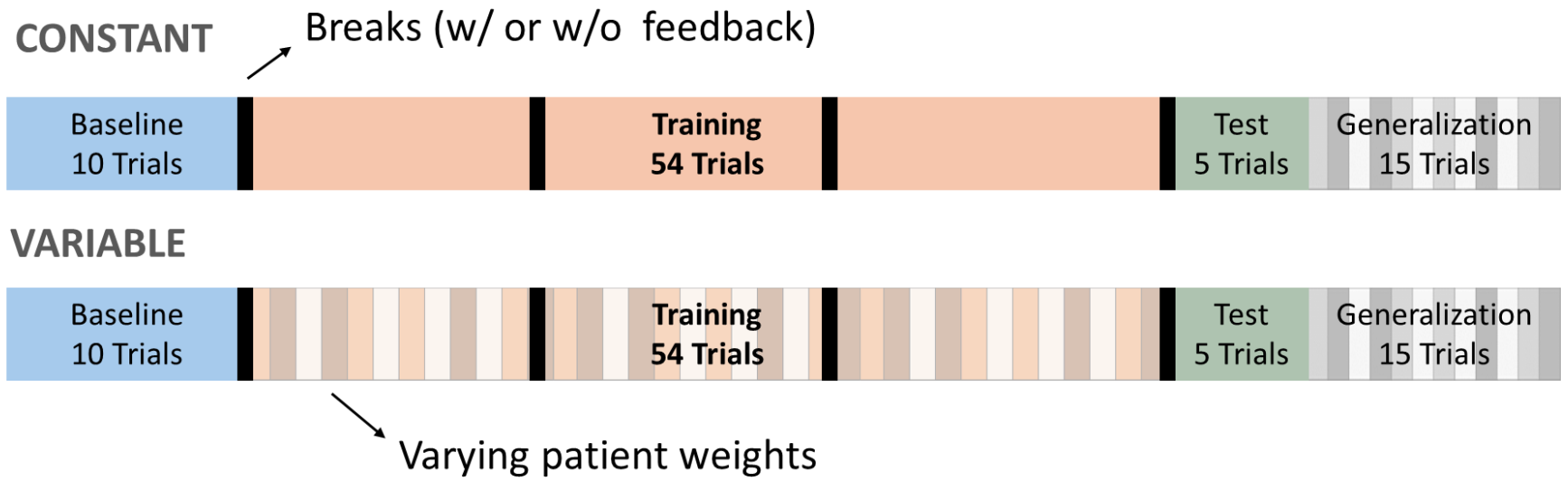
- Probe more
- Slow down near epidural space

Under Revision: Davidor et al., 2025, “Proficiency-Based Progression Feedback Improves Training in Epidural Analgesia Simulation”

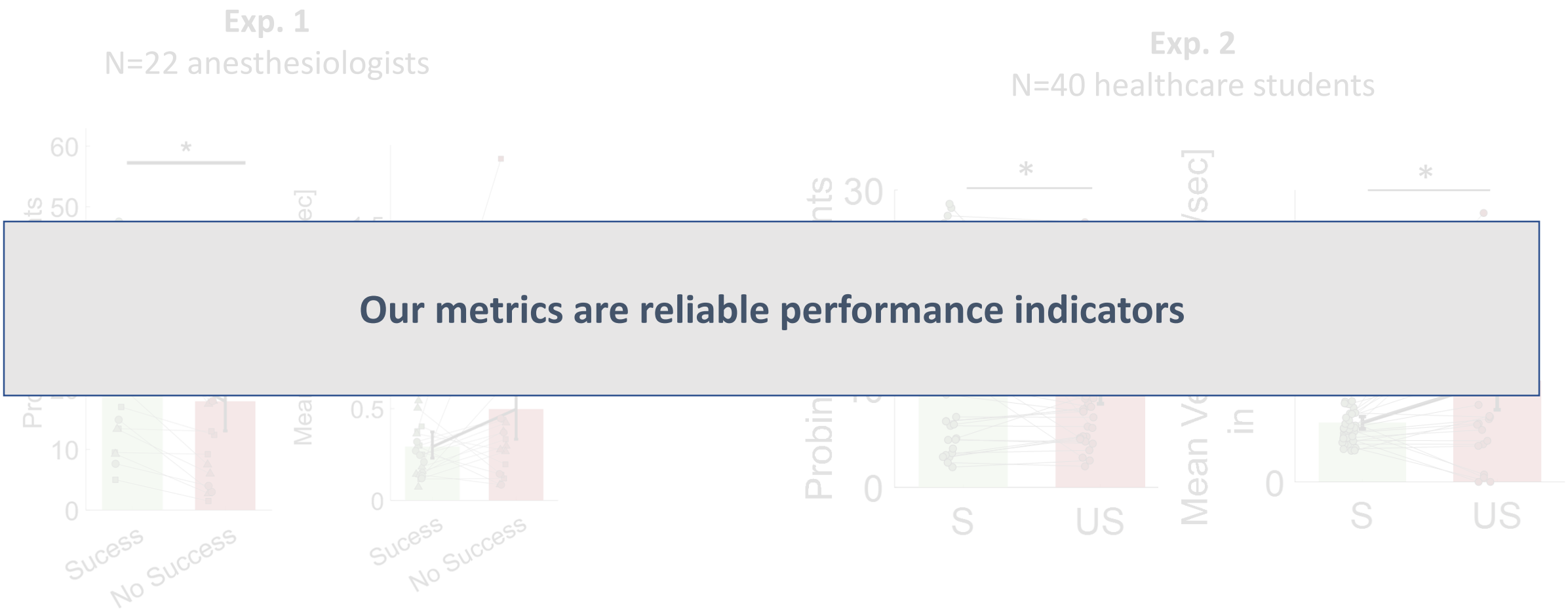
Determining a Preferred Training Protocol

Participants: 40 healthcare students, N=10 per group

Constant, no PBP feedback	Constant, w. PBP feedback
Variable, no PBP feedback	Variable, w. PBP feedback



Performance Metrics



Our metrics are reliable performance indicators

Determining a Preferred Training Protocol

Targeted PBP feedback successfully taught participants to probe more

Determining a Preferred Training Protocol

With constant weight, PBP feedback successfully taught participants to slow down near the epidural space

Determining a Preferred Training Protocol

Constant, no PBP feedback	**Constant, w. PBP feedback**
Variable, no PBP feedback	Variable, w. PBP feedback

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Adding Visual Information

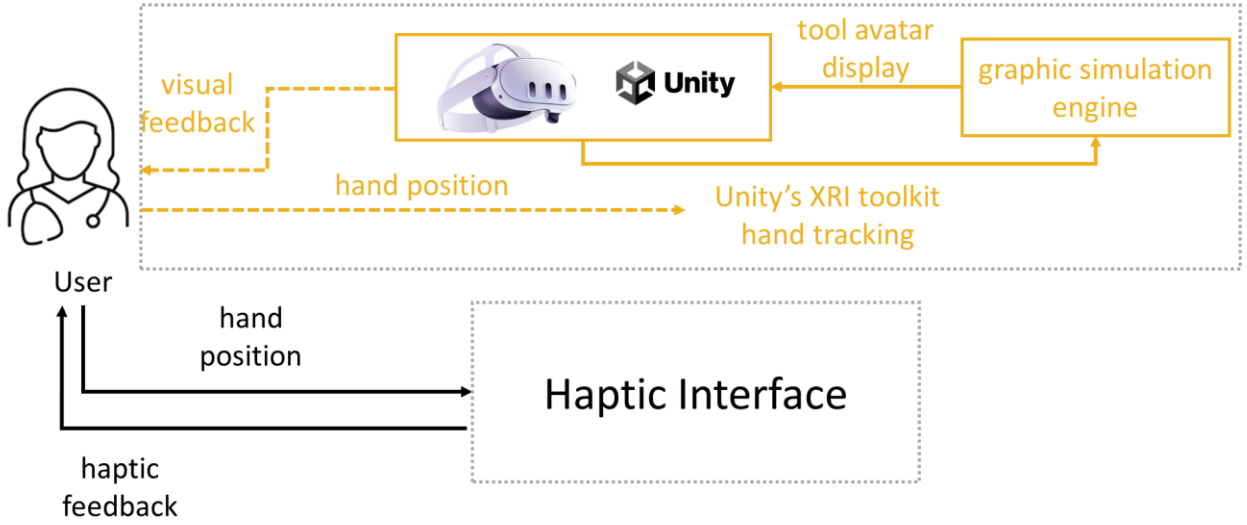
Adding Visual Information

Realistic graphics increase **motivation** and VR **appeal**, though the effect is largely surface-level
(Harris et al. 2020).


Shachar Maidenbaum


Yoav Farawi

Unity



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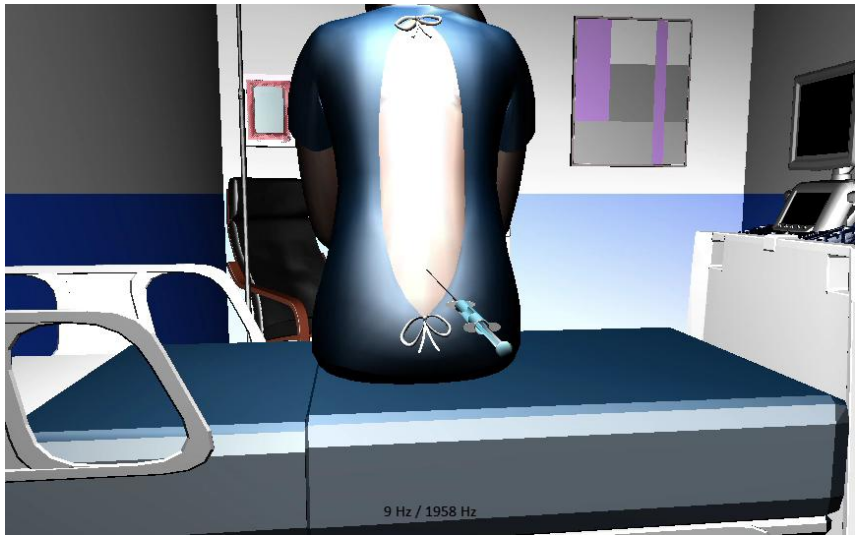
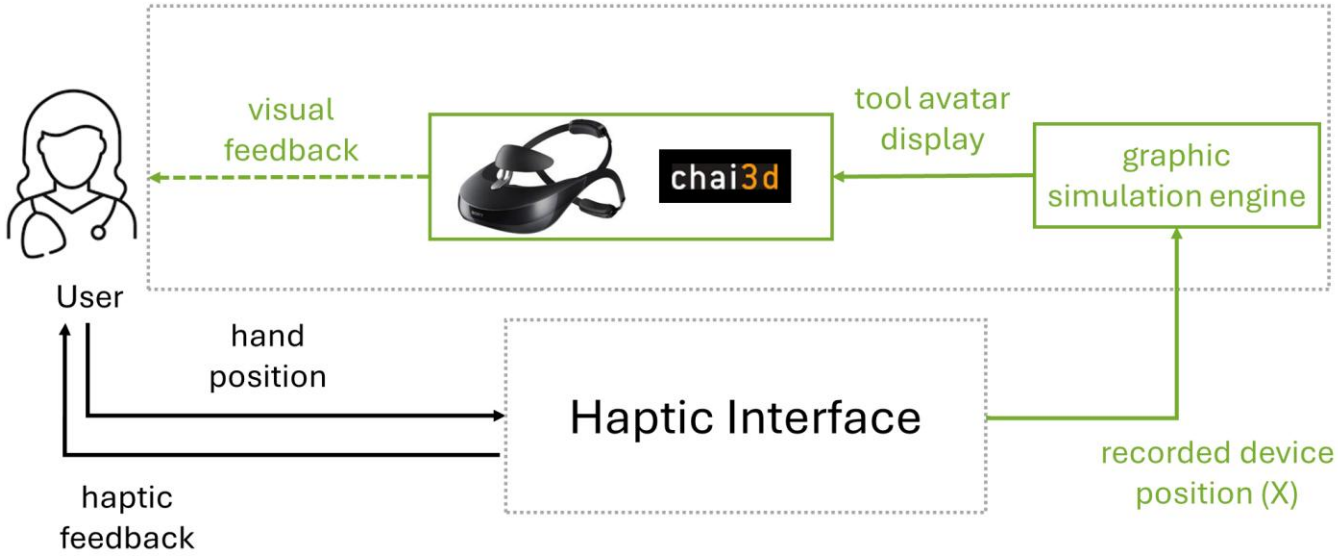
chai3d





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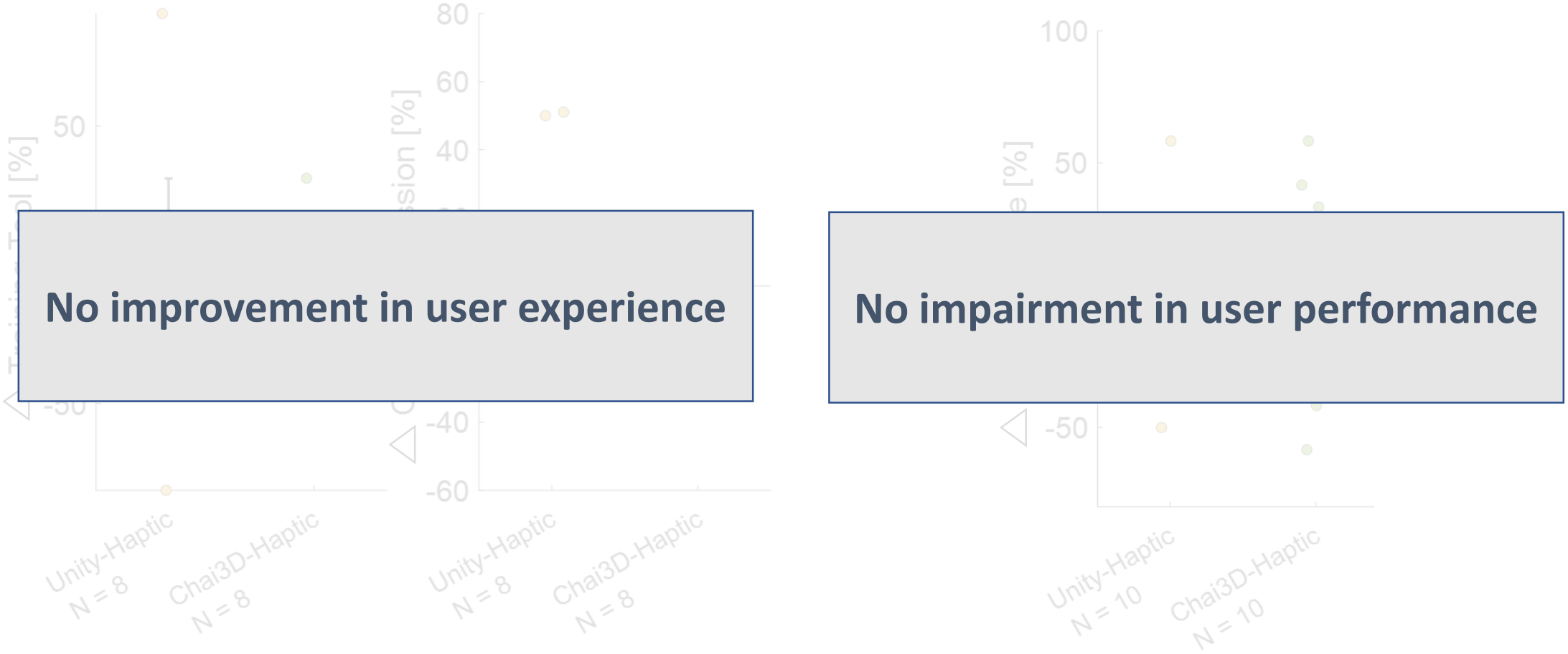
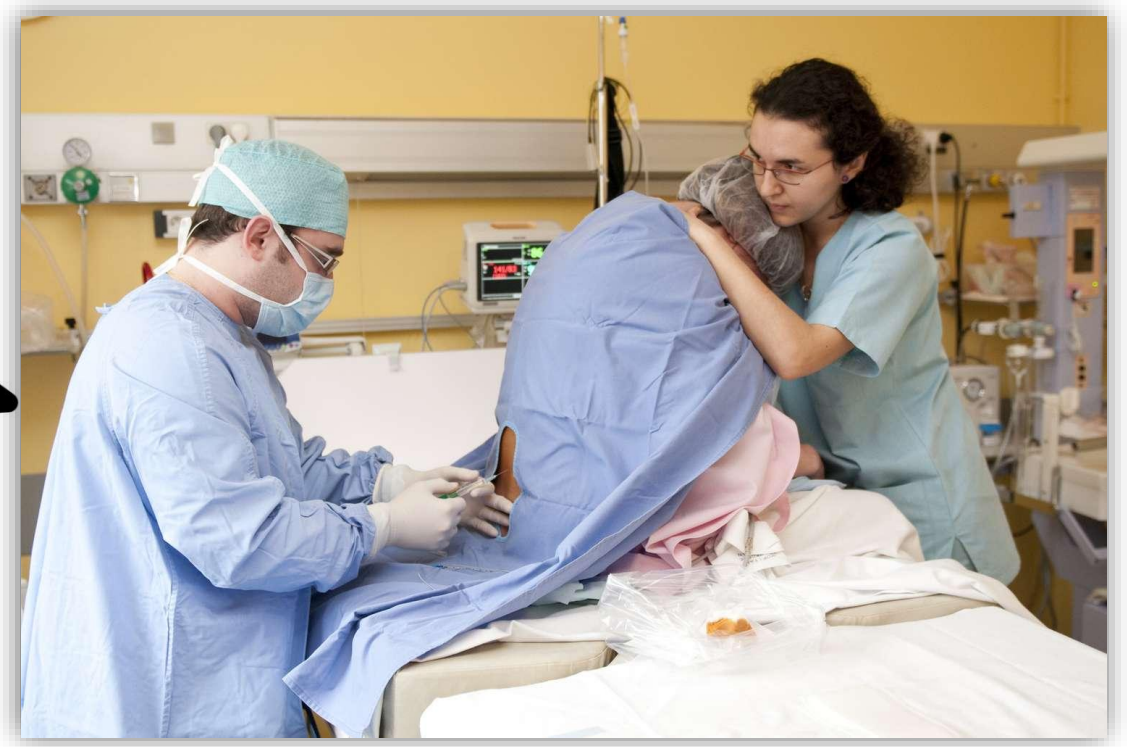


No improvement in user experience

No impairment in user performance

Submitted: Davidor et al., 2025, “Design and Evaluation of a Haptic-Visual Simulators for Skill Acquisition in Epidural Analgesia”

Transfer to Real-life



"When training is hard, the battle will be easy"
—David Dalglish, *Magic, Myth & Majesty*

QUESTIONS?

Prof. Ilana Nisky

Dr. Yair Binyamin

Biomedical Robotics Lab

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SOROKA Medical Center feeling secure