The Impact of 3D Stereopsis and Hand-Tool Alignment on Effectiveness of a VR-based Simulator for Dental Training

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Introduction

• Proliferation of VR-based dental simulators
  • High-fidelity, reusable, configurable
  • Record and analyze data on performance and outcome

• Wide variety of VR configurations used

• Display
  • 2D monitors
  • 3D monitors
  • Half-mirrored displays
  • HMDs

• Instrument manipulation
  • With and without haptic feedback
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  • 2D monitors
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  • Half-mirrored displays
    • Stereoscopic depth perception
  • HMDs

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• Each new simulator typically has an associated evaluation study
• Only few comparative studies to determine benefits of VR technologies
• None that examine impact on transferability

• In this work seek to determine the impact on teaching effectiveness of
  • 3D stereoscopic rendering
  • Hand-tool alignment
VR-based Simulator

- Two haptic devices: drill, mirror
- HTC Vive HMD
- Unreal Engine
- Patient modeled with Metahuman
- Haptic feedback, drill sound
VR-based Simulator

- Two haptic devices: drill, mirror
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- Tooth model - internal anatomy, 3 layers
User Study: 40 fifth year dental students

Access for eligibility

Exclude
- Experience with haptic VR simulation
- Unwilling to give written informed consent

Pre-test (plastic tooth)

Group 1: Stereoscopic 3D & hand-tool alignment
Group 2: Monoscopic 3D & hand-tool alignment
Group 3: Stereoscopic 3D & hand-tool misalignment
Group 4: Monoscopic 3D & hand-tool misalignment

Day 1: Training with simulator (3 trials)
Day 2: Training with simulator (3 trials)

Post-test (plastic tooth)
Scoring

- Two experts (kappa 0.87)
- Standard scoring scheme
Results

• Hand-tool alignment
  • Students with misaligned tools did not improve
  • Students with aligned tools showed significant improvement (2.71 to 2.21; -0.5)

• Stereo rendering
  • Contrary to our hypothesis
  • Students with monoscopic rendering learned better (2.56 to 2.08; -0.47)
  • Compared to students with stereoscopic rendering (2.97 to 2.95; -0.03)
Conclusion & Future Work

• Hand-tool alignment important for training effectiveness
• Stereoscopic rendering can have negative effect
  • Monoscopic group on average looked more closely at the tooth
  • Stereoscopic group unable to look closely due to high inter-ocular disparity

• Further investigate stereoscopic effect
  • Higher HMD resolution could alleviate the problem
  • VR zoom feature similar to real surgical loupes