ATACCC (Tampa FL) -- August 2009

Virtual Reality Analgesia: *Separating Fact from Fiction in the Pain Laboratory*

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Overview

- Virtual Reality (VR) distraction analgesia

- What is it?
- In what clinical settings might it be used?
- How do experimental pain studies contribute?

Essentials of VR Analgesia

- Non-pharmacologic technique that directs conscious attention away from nociception, thereby modulating the pain experience

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Essentials of VR Analgesia

- **Non-pharmacologic technique that directs conscious attention away from nociception, thereby modulating the pain experience**
- **Ideal for brief, painful procedures in awake, cooperative patients**
- **Generally used as adjunct to pharmacologic analgesics for moderate procedural pain *(reduces subjective pain by 15-40%)***

Components of VR Distraction

Human-computer interface
- high-speed CPU
- custom software

User 'immersed' in the virtual environment
- 3-dimensional, wide FOV, high-resolution, head-mounted visual display
- stereophonic, 3-D sound *(sights/sounds of immediate environment are excluded)*

User interacts with the virtual environment
- head- and limb-tracking
- navigation by joystick or data gloves, & peripherals
- tactile feedback devices

Clinical Applications of VR Analgesia

- **Ideally suited for brief, painful procedures . . .**

- **Dental pain (adults)**

  Hoffman HG: Cyberpsych Behav 4:527, 2001

- **Prostate thermal ablation (adults)**

  Wright JL: Urology 66:1320, 2005

- **Postoperative physical therapy (kids)**

  Steele E: Cyberpsych Behav 6:633, 2003

- **IV starts / blood draws (kids)**

  Gold JL: Cyberpsychol Behav 9:207, 2006

Clinical Applications of VR Analgesia

- **Cancer-related procedures -- chemo/IV (kids/adults)**

Windich-Biermeier A: J Ped Oncol Nurs 24:8, 2007
Schneider SM: Oncol Nurs Forum 34:39, 2007
Gershon J: J Am Acad C/A Psych 43:1243, 2004
Schneider SM: Oncol Nurs Forum 31:81, 2004
Gershon J: Cyberpsych Behav 6:657, 2003
Schneider SM: Cyberpsych Behav 6:301, 2003
Sander Wint S: Oncol Nurs Forum 29:E8, 2002
Schneider SM: Pediatr Nurs 26:593, 2000

Clinical Applications of VR Analgesia

- **Burn wound care & burn/trauma physical therapy (kids/adults)**

Markus LH: Burns Epub 2009
Hoffman HG: Cyberpsych Behav 12:47, 2009
Manni C: J Cyberther Rehab 1:193, 2008
Hoffman HG: Clin J Pain 24:299, 2008
Sharar SR: Arch Phys Med Rehab 88:S43,2007
Wiechman-Askay SA: Rehab Psych 52:247, 2007
Chan EA: J Clin Nurs 16:786, 2007
van Twillert B: J Burn Care Res 28:694, 2007
Patterson DR: Int J Clin Hypnos 54:130, 2006
Haik J: J Burn Care Res 27:195, 2006
Das DA: BMC Pediatrics 5:1, 2005
Patterson DR: Int J Clin Exp Hypn 52:27, 2004
Hoffman HG: J Clin Psychol 60:189, 2004
Hoffman HG: Clin J Pain 17:229, 2001
Hoffman HG: Clin J Pain 16:244, 2000
Hoffman HG: Pain 85:305, 2000

Clinical Applications of VR Analgesia

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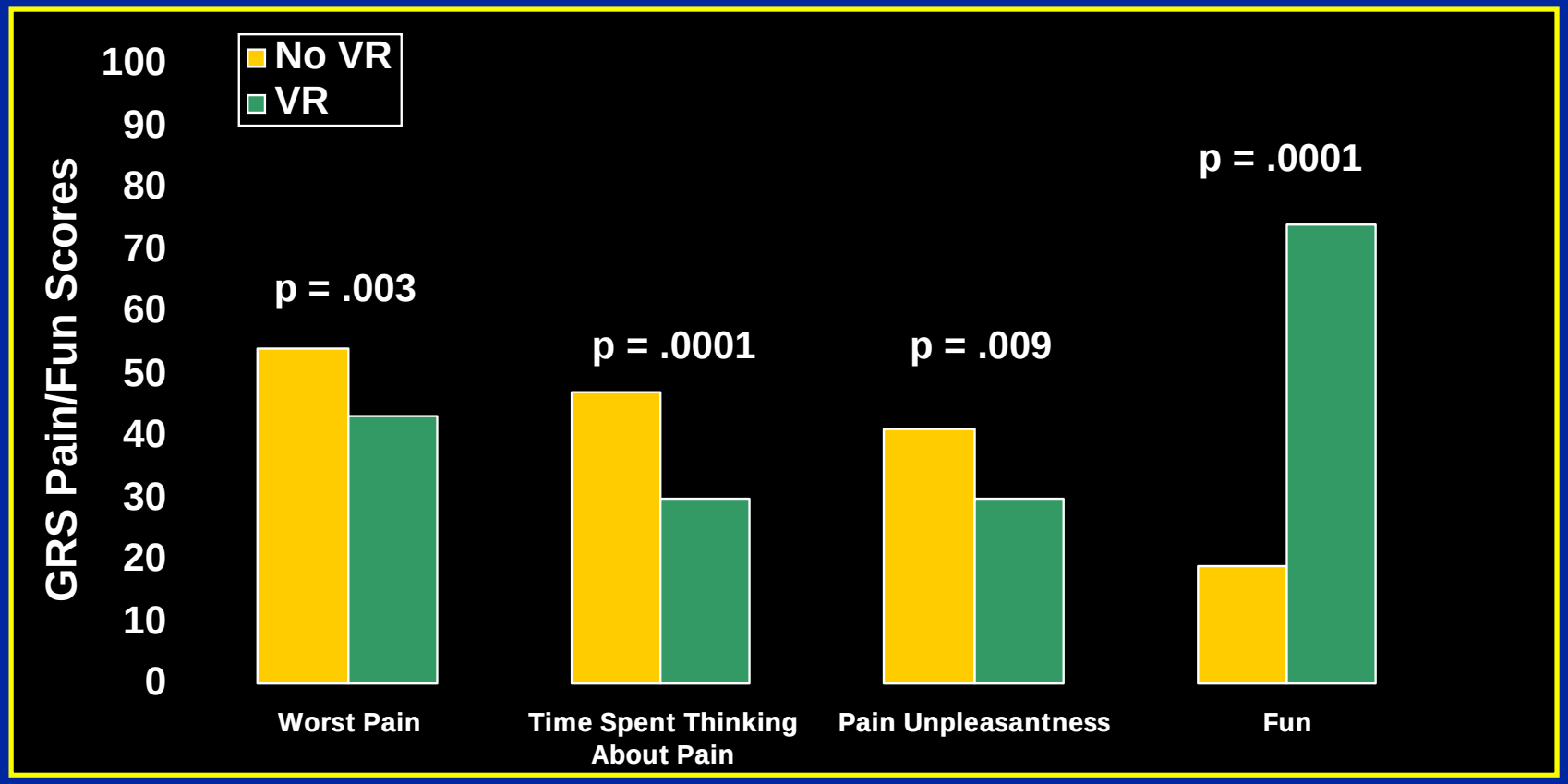
PAIN CONTROL DURING WOUND CARE FOR COMBAT-RELATED BURN INJURIES USING CUSTOM ARTICULATED ARM MOUNTED VIRTUAL REALITY GOGGLES

Christopher Maani, MD[1], Hunter G. Hoffman, Ph.D[2], Peter A. DeSocio, DO[1], Michelle Morrow[1], Chaya Galin[1], Jeff Magula[2], Alan Maiers[1], and Kathryn Gaylord[1]

VR Distraction -- Physical Therapy Pain

- 88 burn rehab. inpatients (146 comparisons)
- Age range 6-65 years; TBSA range 3-80%



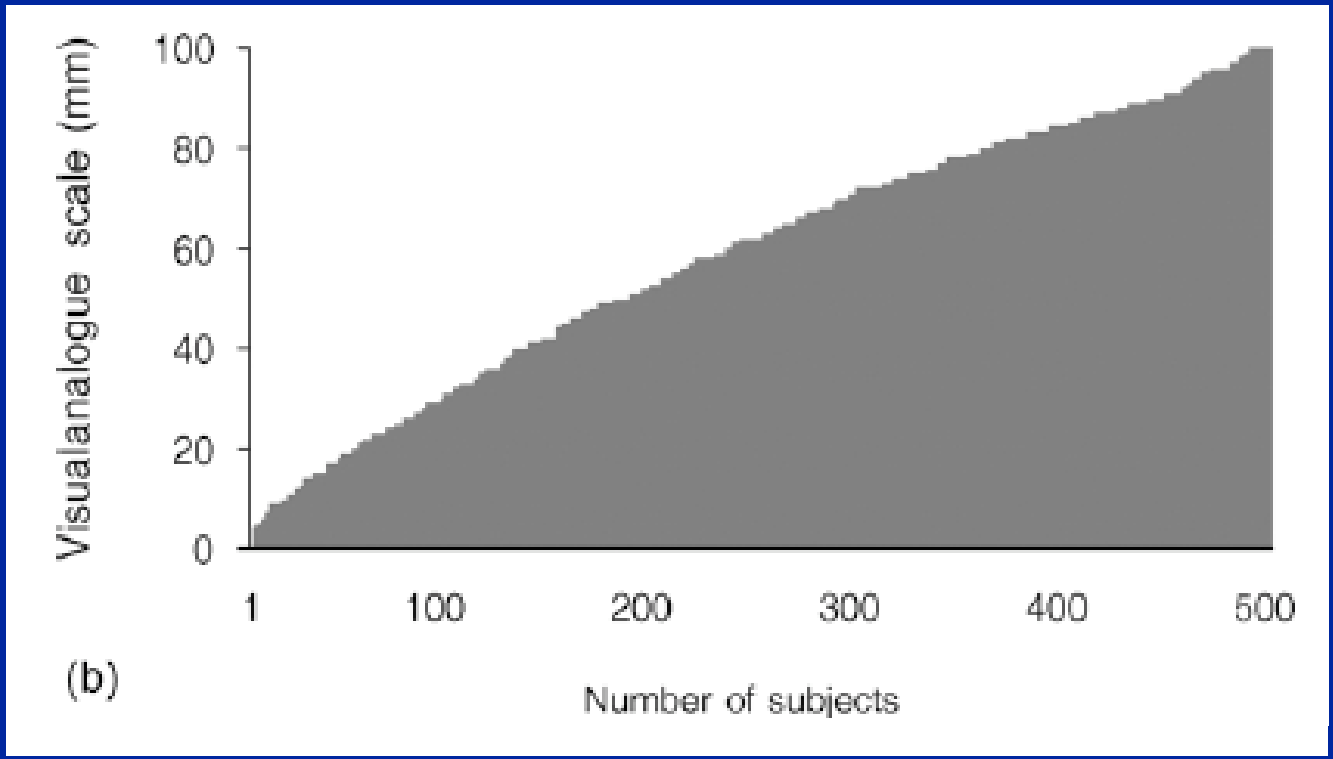
Sharar SR: Arch Phys Med Rehab 88:S43, 2007

Experimental Pain Advantages

- More homogenous & consistent nociception
- Pain experience less affected by pre-morbid & concurrent medical or psychological factors
- Wider array of pain assessment techniques
- Easier application of ‘control’ conditions

Experimental Pain Not Perfect

- **Subjective pain in response to 30s of 49ºC still highly variable!**



Kim H: Pain 109:488, 2004

Experimental Evidence for VR Analgesia

- **Volunteers experiencing laboratory pain . . .**

- **Ischemic pain**

  Magora F: Isr Med Assoc J 8:261, 2006
  Hoffman HG: Int J Human-Comp Interact 15:469, 2003

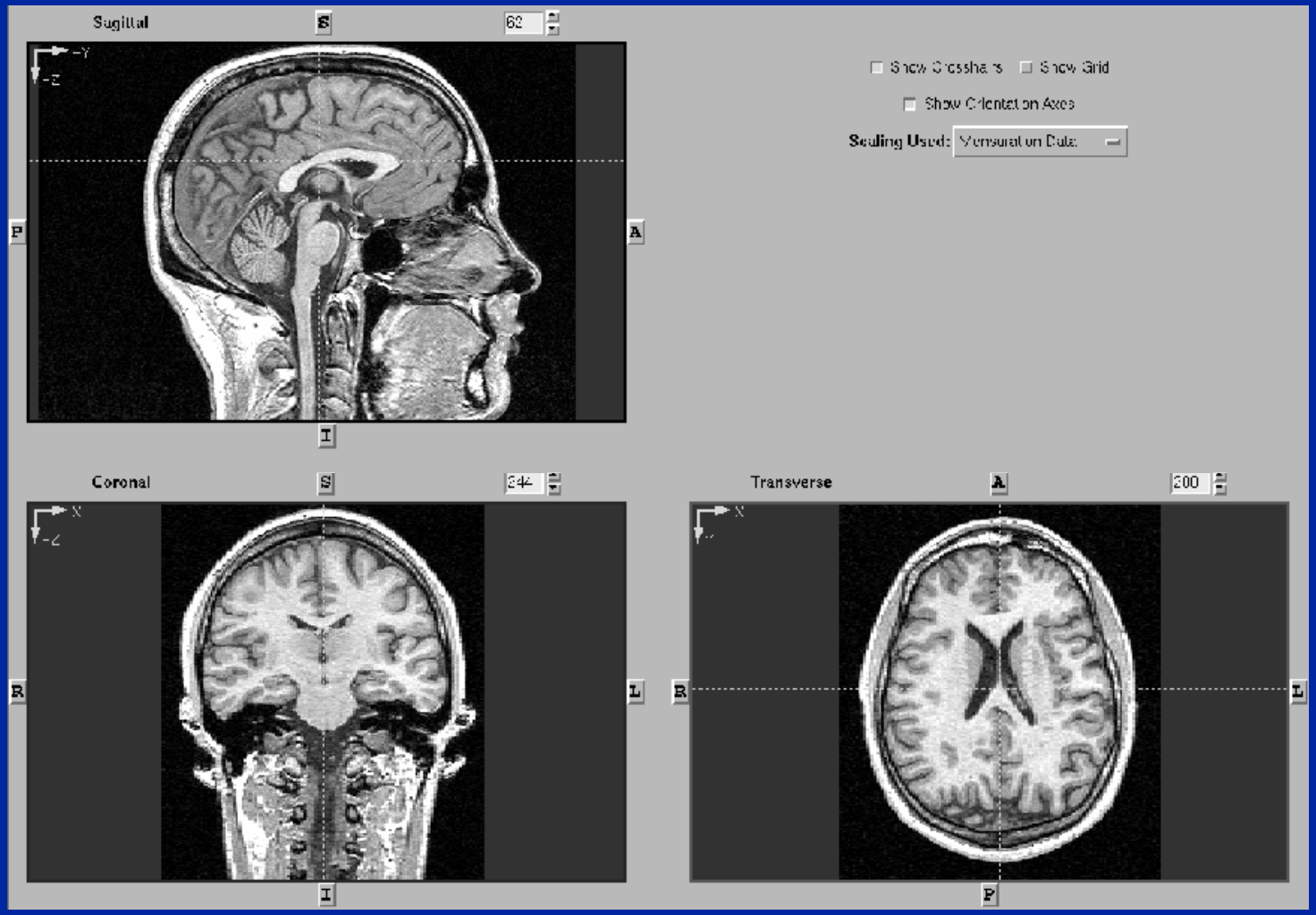
- **Thermal heat pain**

  Wender R: J Cyberther Rehab 2:27, 2009
  Hoffman HG: Anesth Analg 105:1776, 2007
  Patterson DR: J Abnormal Psych 115:834, 2006
  Hoffman HG: J Pain 7:843, 2006
  Hoffman HG: NeuroReport 15:1245, 2004
  Hoffman HG: Pain 111:162, 2004

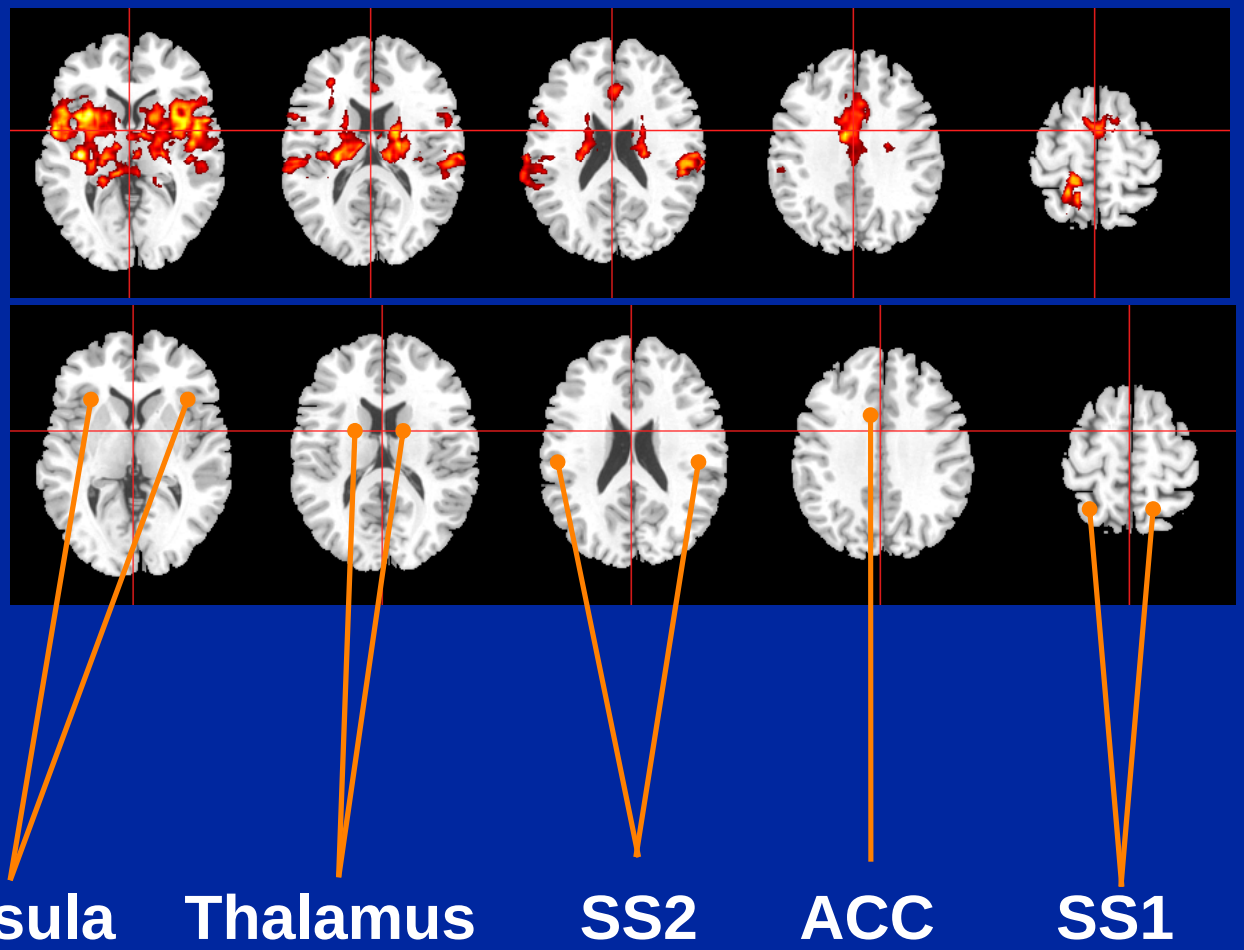
- **Cold pressor pain**

  Dahlquist LM: Health Psychol 26:794, 2007

Evidence for VR Analgesia Effect?

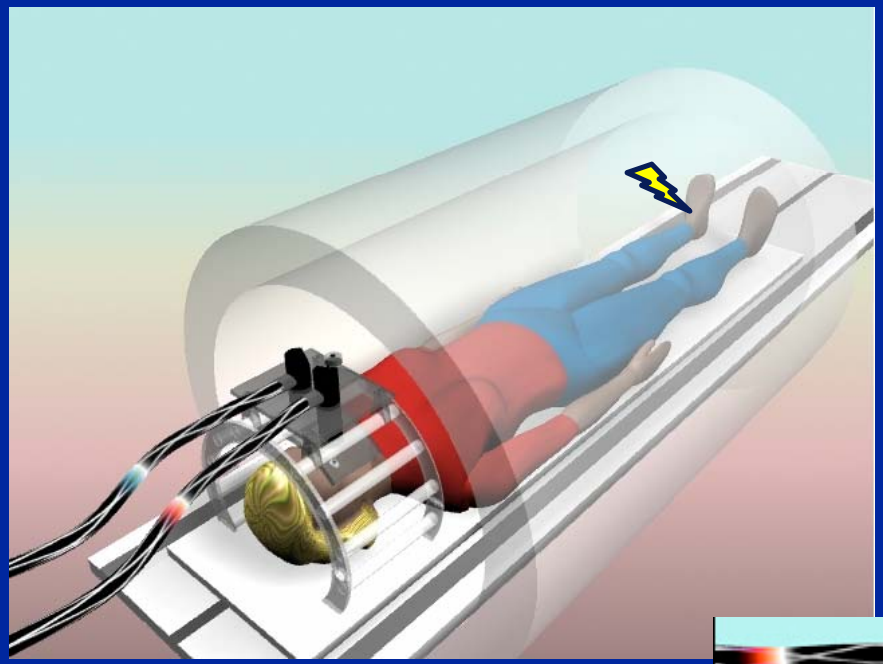


Brain Activation with Thermal Pain

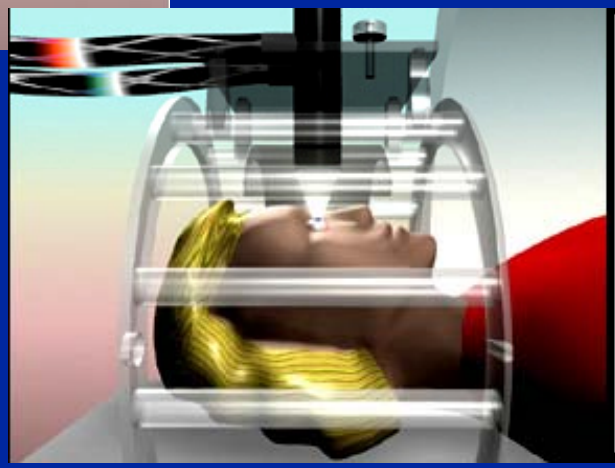


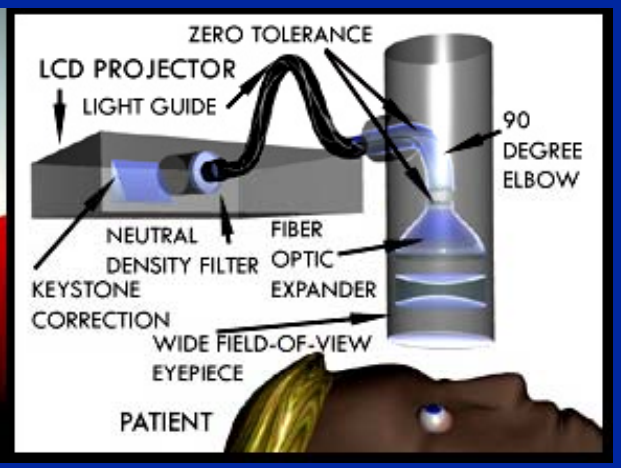
‘Pain Matrix’

Combine VR, Pain, and fMRI



- Non-ferromagnetic VR projection system
- Thermal pain stimulation (foot)





Two Study Questions

- Is there objective evidence to support subjective analgesic reports with VR?
- How do subjective/objective findings with VR compare with those of opioids?

Comparing VR & Opioid Analgesia

Control → GRS ?

VR → GRS ?

Opioid → GRS ?

VR + Opioid → GRS ?

Hoffman HG: Anesth Analg 105:1776, 2007

Comparing VR & Opioid Analgesia

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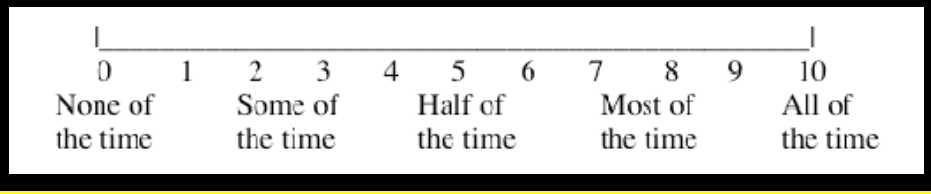
Subjective, self-report pain scores assessed by Graphic Rating Scales (GRS) [~ Visual Analog Scales (VAS)]



Hoffman HG: Anesth Analg 105:1776, 2007

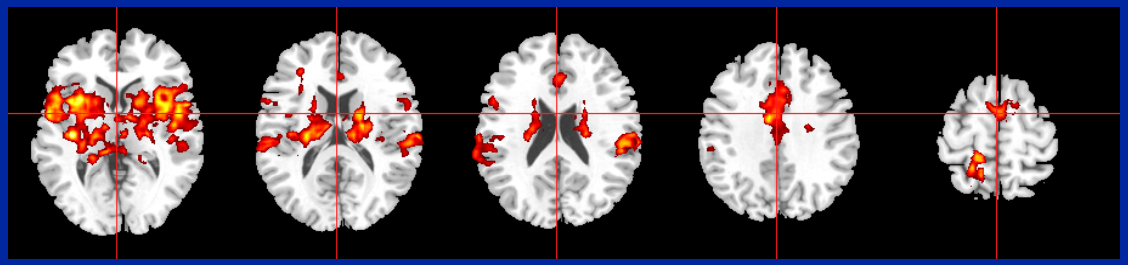
Comparing VR & Opioid Analgesia

Control	→	GRS ~8.5
VR	→	GRS ~5.5
Opioid	→	GRS ~7.0
VR + Opioid	→	GRS ~4.0

Hoffman HG: Anesth Analg 105:1776, 2007

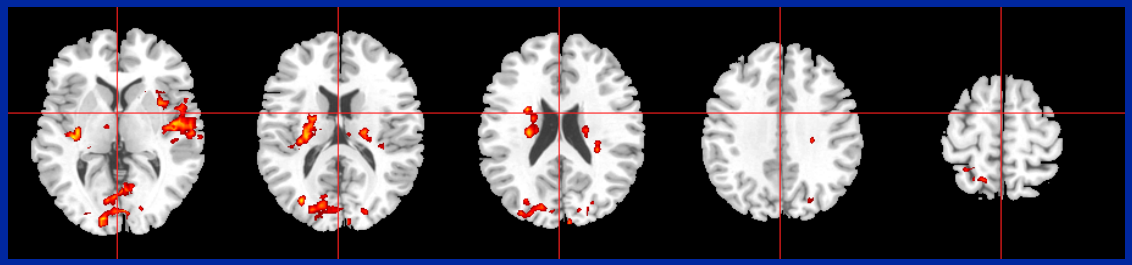
Comparing VR & Opioid Analgesia

Control



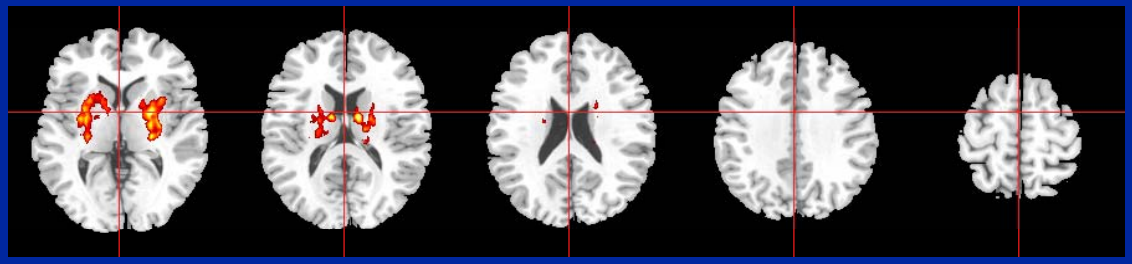
GRS ~8.5

VR



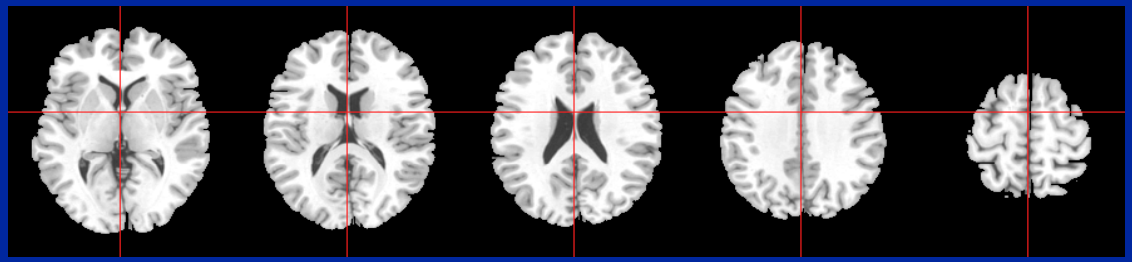
GRS ~5.5

Opioid



GRS ~7.0

VR + Opioid



GRS ~4.0

Hoffman HG: Anesth Analg 105:1776, 2007

Study Answers

- **Changes in pain-related brain activation with VR are similar in magnitude/direction to subjective VR analgesia reports**
- **Subjective & objective analgesia with VR is of similar magnitude to clinical opioids**
- **Combining VR and opioids produces additive analgesia *(+/- same mechanism?)***

Next Study Question

- **Does user 'presence' in the virtual world alter analgesic effect? (*i.e.*, is the users' pain experience improved as one captivates more of their attention?)**

Study Design

- Alter VR ‘immersiveness’ with simultaneous changes in VR system hardware & software

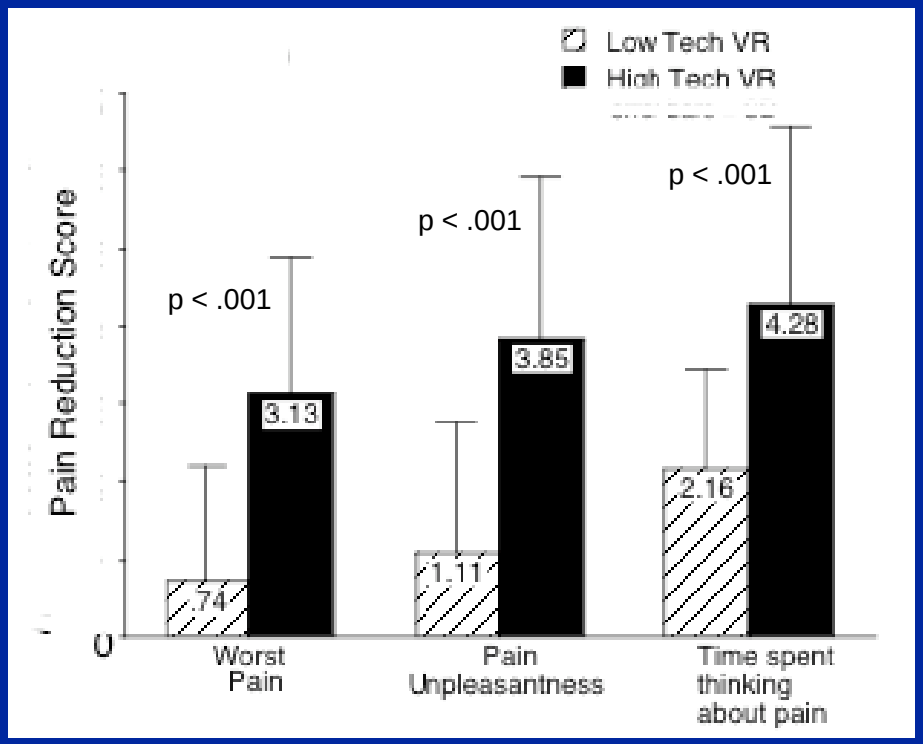
  -- different head-mounted displays (field-of-view, resolution, exclusion of immediate environment)
  -- with / without sound effects
  -- with / without head-tracking
  -- with / without user interaction (gaming)

- Assess subjective ‘presence’ in virtual world

- Assess subjective pain to thermal nociception

Study Results

- Changes in software, visual input, and sound together increase presence – and analgesia



Correlation – presence / analgesia

Outcome	r-value	p-value
Worst Pain	0.48	< .005
Unpleasantness	0.47	< .005
Time Thinking	0.51	< .001

Hoffman HG et al: Pain 111:162, 2004

Study Answers

- Changes in VR system immersiveness (hardware/software) affect user presence
- User presence in virtual world determines subjective VR analgesic effect
- VR system design impacts analgesic effect

Study Question

- What is effect on analgesia of VR ‘helmet’ alone?

Virtual Vision
(Group 1)

480 x 640 pixels
monocular
no sound
no exclusion
$.5-1K

CyVisor
(Group 2)

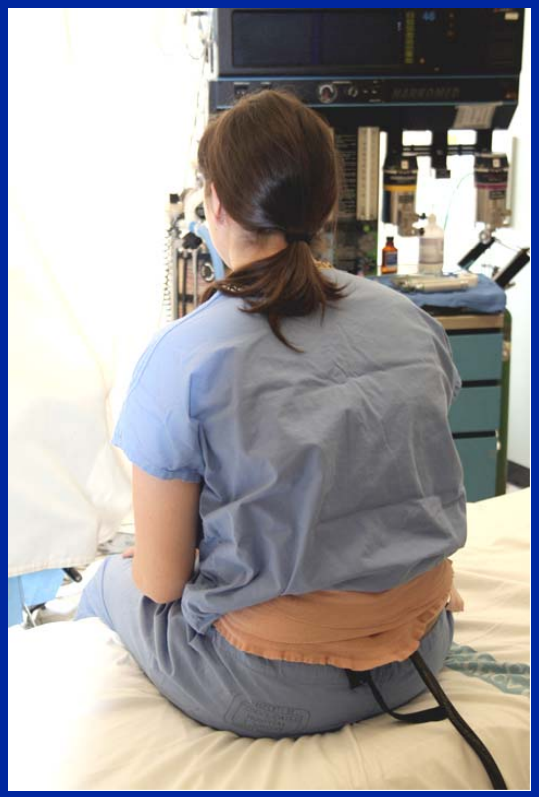
600 x 800 pixels
binocular/3-D 30° FOV
stereo sound
some exclusion
$2-3K

Kaiser SR80
(Groups 3 + 4)

1024 x 1280 pixels
binocular/3-D 80° FOV
stereo sound
much exclusion
$27K

Experimental Pain Setting

- ‘Simulated’ LP in healthy volunteers using 30 sec thermal pain stimulus to lower back

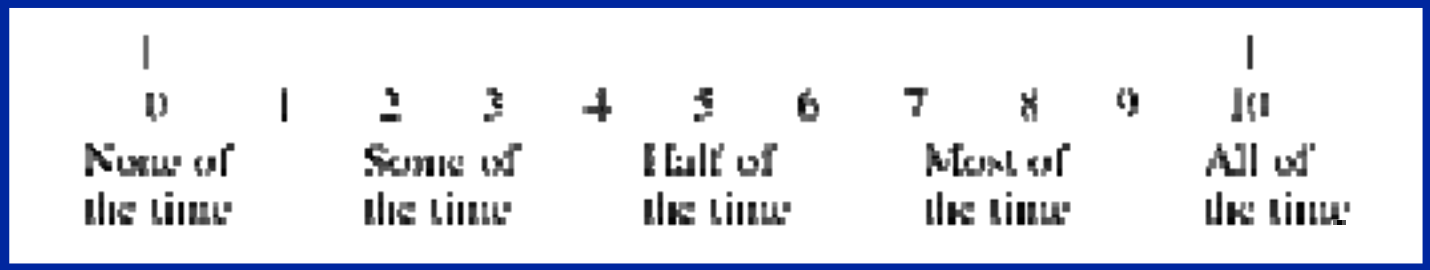


VR Distraction for Lumbar Puncture

- Between-subjects comparison of VR ‘helmets’
- Outcomes -- subjects’ self-reports of pain

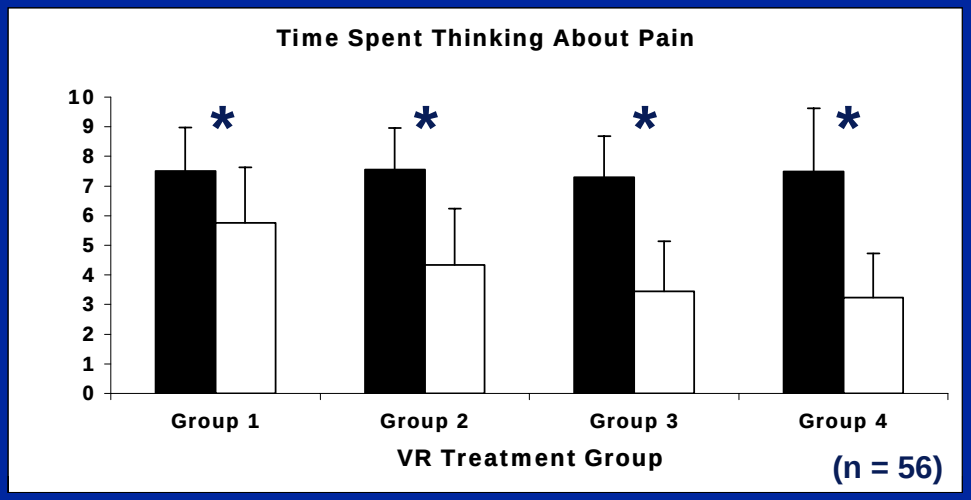
<u>Graphic Rating Scales</u> for various components of the pain experience:

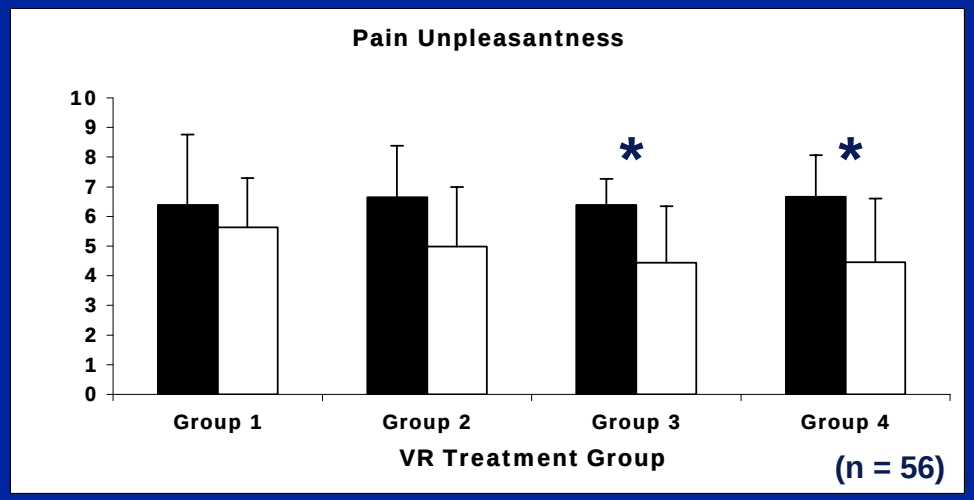
-- ‘worst pain’ (sensory pain)
-- ‘pain unpleasantness’ (affective pain)
-- ‘time thinking about pain’ (cognitive pain)

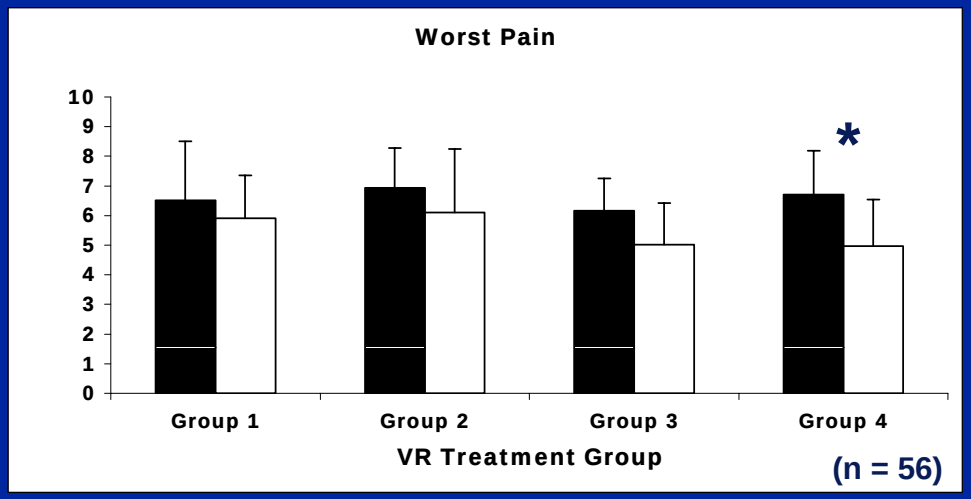


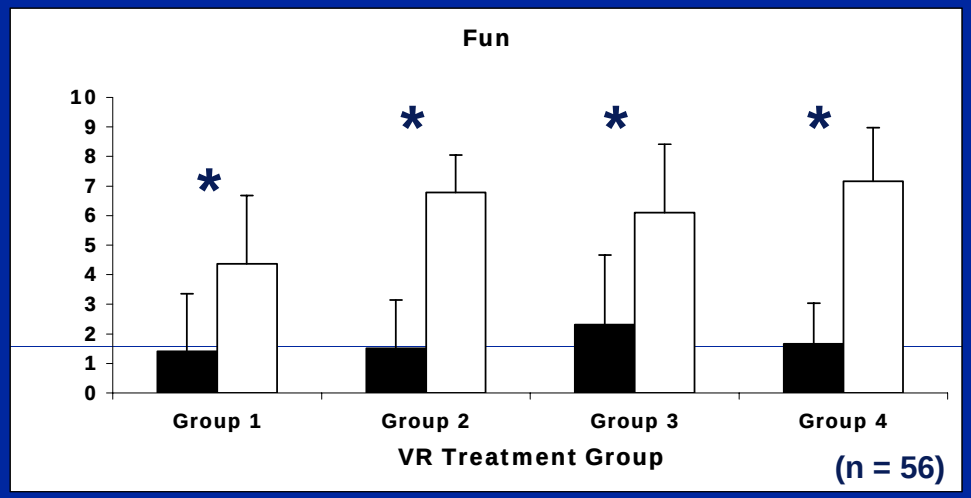
Subjective Pain Scores

No VR VR



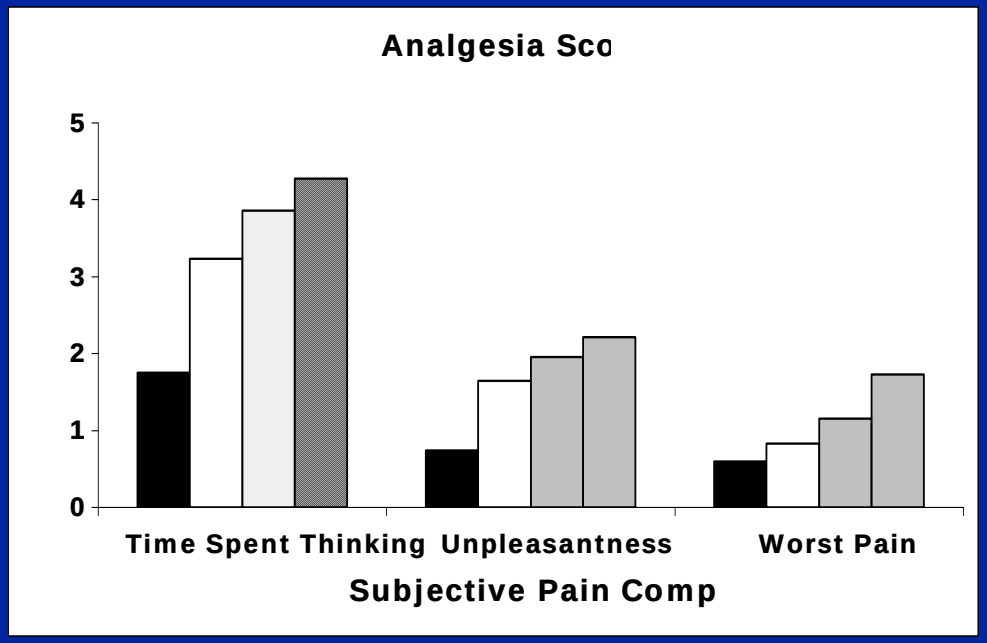






Study Results

- VR helmet characteristics determined analgesic effect



Group 1
Virtual Vision-lateral

Group 2
CyVisor-lateral

Group 3
SR80-lateral

Group 4
SR80-sitting

Study Answer

- The higher the quality of VR helmet, the better the analgesic effect
- VR helmets are the major cost component in any immersive VR system
- Cost-benefit analysis is essential

Summary - Experimental Pain for VR

- Confirm concurrent subjective & objective evidence for analgesic effect
- Explore VR system issues and potential VR-drug combinations that inform safe and effective clinical use
- Investigate neurophysiologic mechanisms of VR analgesia

Experimental Pain – Next Steps

- **Assess mechanisms of VR distraction analgesia:**
  - -- does opioid receptor blockade affect analgesia?
  - -- functional neuroimaging (connectivity analysis, diffusion tensor imaging) to identify pain pathway
- **Determine ideal combination of analgesic drug(s) and VR to maximize VR effect and minimize side effects:**
  - -- opioids, NMDA antogonists, α2 agonists

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