



# **SNS COLLEGE OF TECHNOLOGY**

## **(AN AUTONOMOUS INSTITUTION)**

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Accredited by NBA & Accredited by NAAC with 'A++' Grade,  
Recognized by UGC saravanampatti (post), Coimbatore-641035.



## **Department of Biomedical Engineering**

**Course Name: 19BMT401 – Virtual Reality in Medicine**

**IV Year : VII Semester**

**Unit V –APPLICATIONS**



19BMT401/Virtual Reality in Medicine/Dr  
Karthika A/AP/BME

# Digital Health Revolution

- Mobile Health / eHealth
- Wearable Sensors
- Patient Centered
- Leverages Internet:  
social, quantitative, collaborative



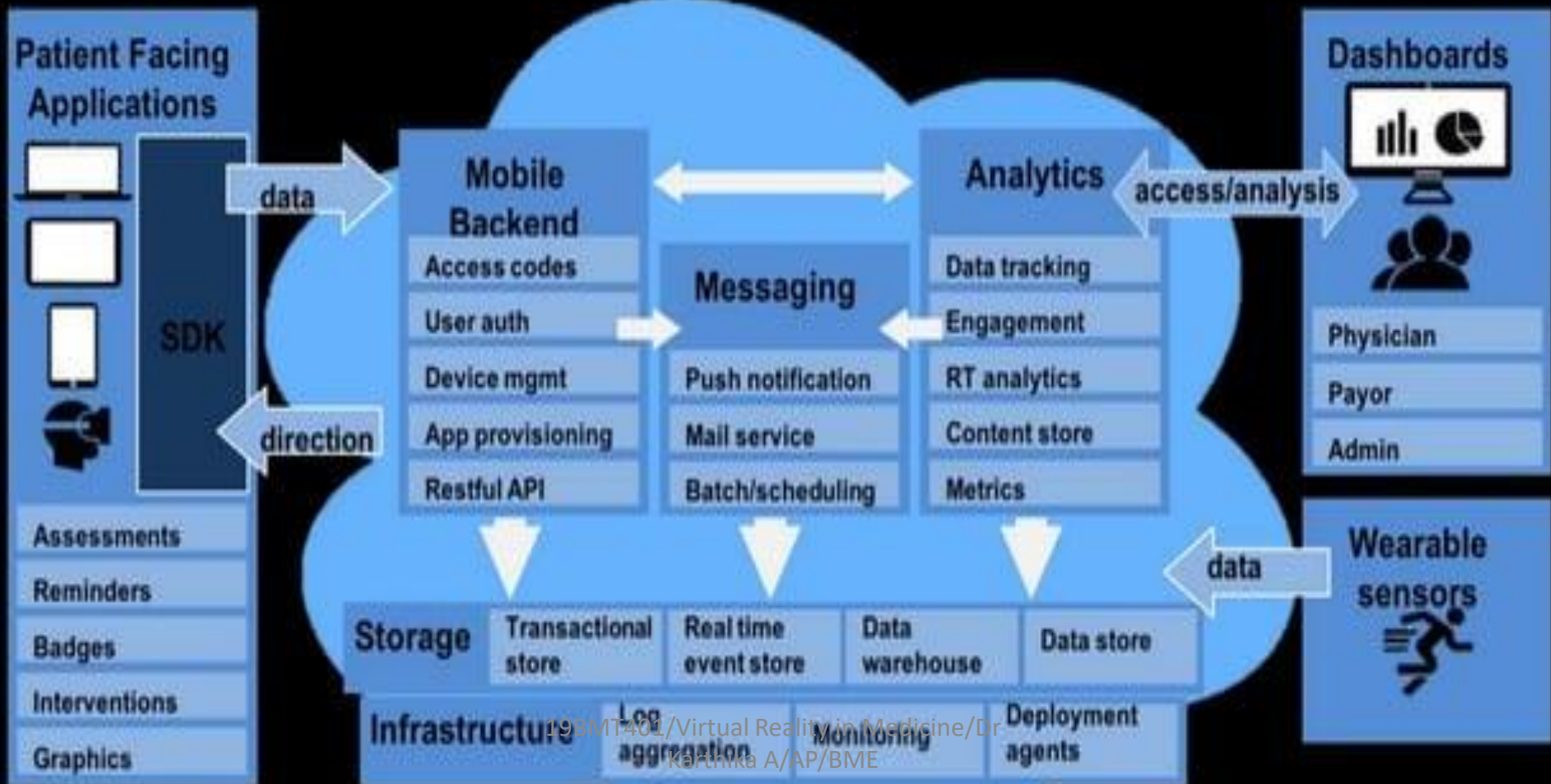
# Every Medical Device Reinvented



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Karthika A/AP/BME



# Digital Health Platforms deliver interventions to patients, and parse data for enhanced analysis



# Digital Health Revolution

## Medical Applications of Virtual Reality & Augmented Reality Technology

# Medical Applications of Virtual Reality Technology

Although entertainment, social connection and gaming will drive the initial adoption of VR technology, the deepest and most significant market for VR will be in clinical care and in improving health and wellness.





# Now is the time for VR & AR

VR technology is now affordable,  
scalable and accessible



Samsung - GearVR



Sony – PlayStation VR



Facebook - Oculus



Microsoft - HoloLens



HTC

Vive



Google - DayDream





# AR MR XR Technology

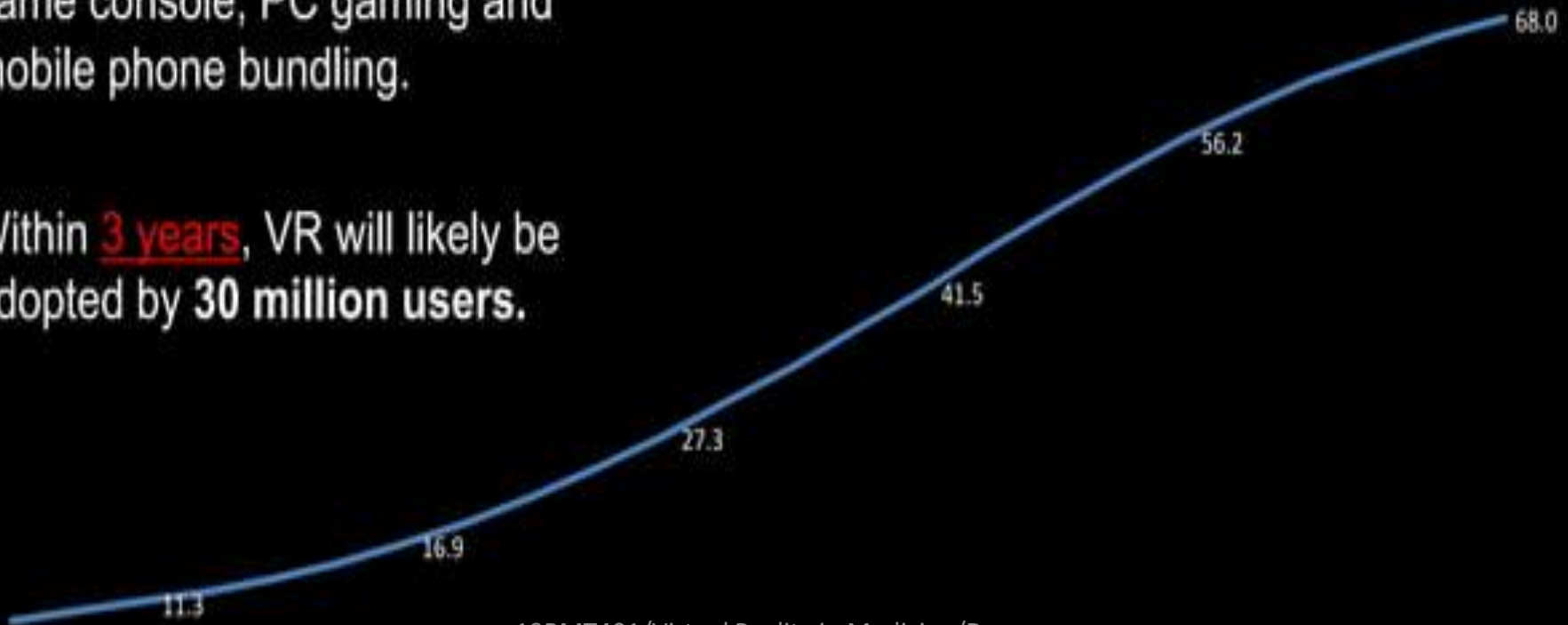




Within 6 years, VR will likely be adopted by **70 million users**

Initial adoption will be driven through game console, PC gaming and mobile phone bundling.

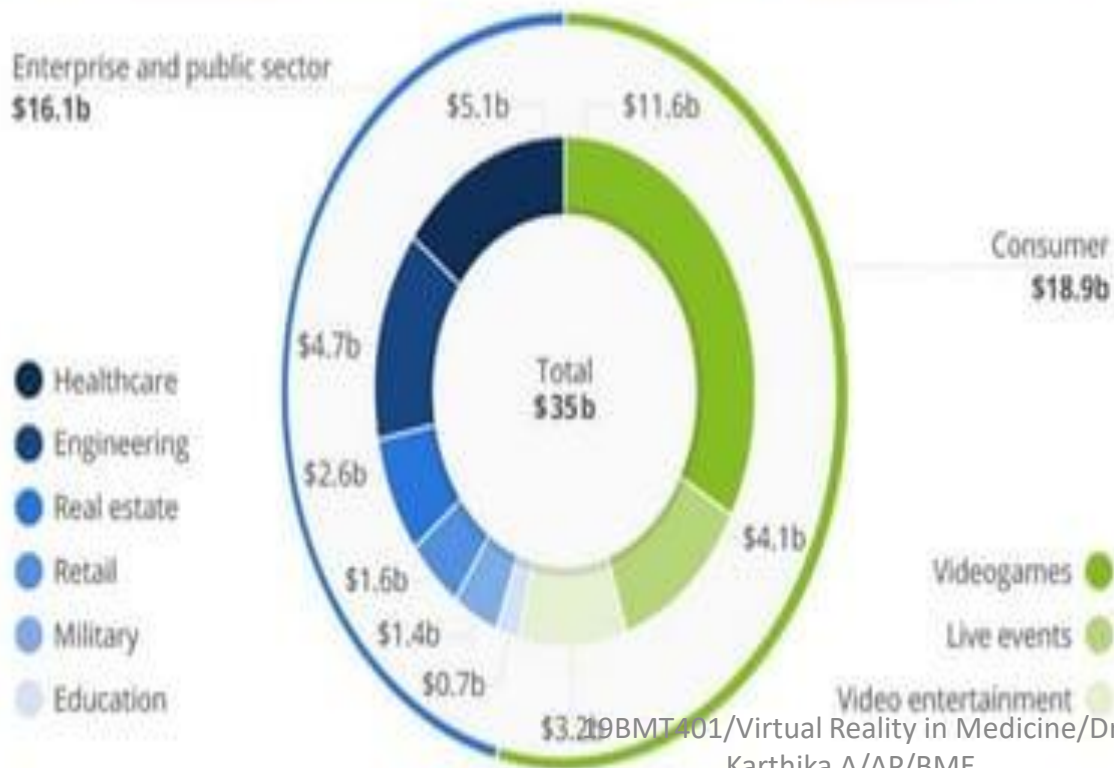
Within 3 years, VR will likely be adopted by **30 million users**.



Within 6 years, VR will likely be \$35B Market

## The Diverse Potential of VR & AR Applications

Predicted market size of VR/AR software for different use cases in 2025\*



The Medical  
VR / AR  
Market  
Segment is  
projected to be  
\$5.1 B in 2025



## My Journey....



# Treating Post Traumatic Stress With Virtual Reality



2008 Sichuan  
Earthquake



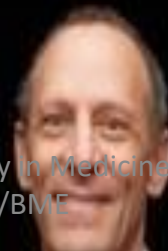
# Treating Post Traumatic Stress With Virtual Reality



2017 Mexico City  
Earthquake







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Academic research has indicated that Virtual Reality can effectively treat a wide variety of clinical problems – ranging from addictions, to stroke, to PTSD



# 270 Medical VR/AR Companies

## 20 Clinical Sectors

Phobias / PTSD

Stress Management /  
Relaxation

Surgical Training /  
Planning

Physical  
Rehabilitation

Pain & Difficult  
Procedure  
Management

Exercise

Cognitive  
Rehabilitation

Optical  
Rehabilitation

Addictions

Neuropsychological  
Assessments

Cognitive Training  
Wellness

Sports Medicine

Disability Solutions

Speech Therapy

Autism Spectrum  
Disorder

Mood Disorders

Patient Education

Preventive Health

ADHD

Senior Care

# Investments in VR Health Startups



TRIPP



BehaVR



mindmaze



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appliedVR





## Why Now?

Over 30 years of academic research and over 3000 studies demonstrate that VR can improve behaviors, attitudes, and health

Until now, the technology was expensive, bulky, and difficult to use. Today, we have the advancements to bring VR to scale in healthcare.



# VR and AR technology will significantly impact Medical Care

- Prevention and Wellness
- Objective Assessments
- Functional Training
- Improved Interventions
- Facilitate Adherence
- Distributed Care Delivery



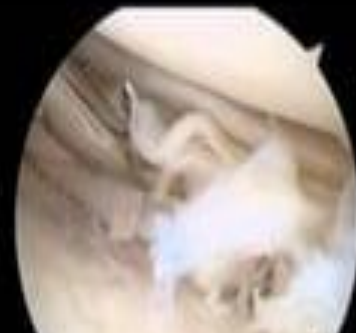
# Medical Training

- Clinical Skill Training
- Surgical Skill Training
- Interpersonal Skill Training
- Use of Equipment and Tools
- Team Training - eg: Emergency Department, Surgical Team
- Emergency Response Training and Rehearsal
- Facilitate Empathy



# Surgical Training

Knee  
arthroscopy  
simulator



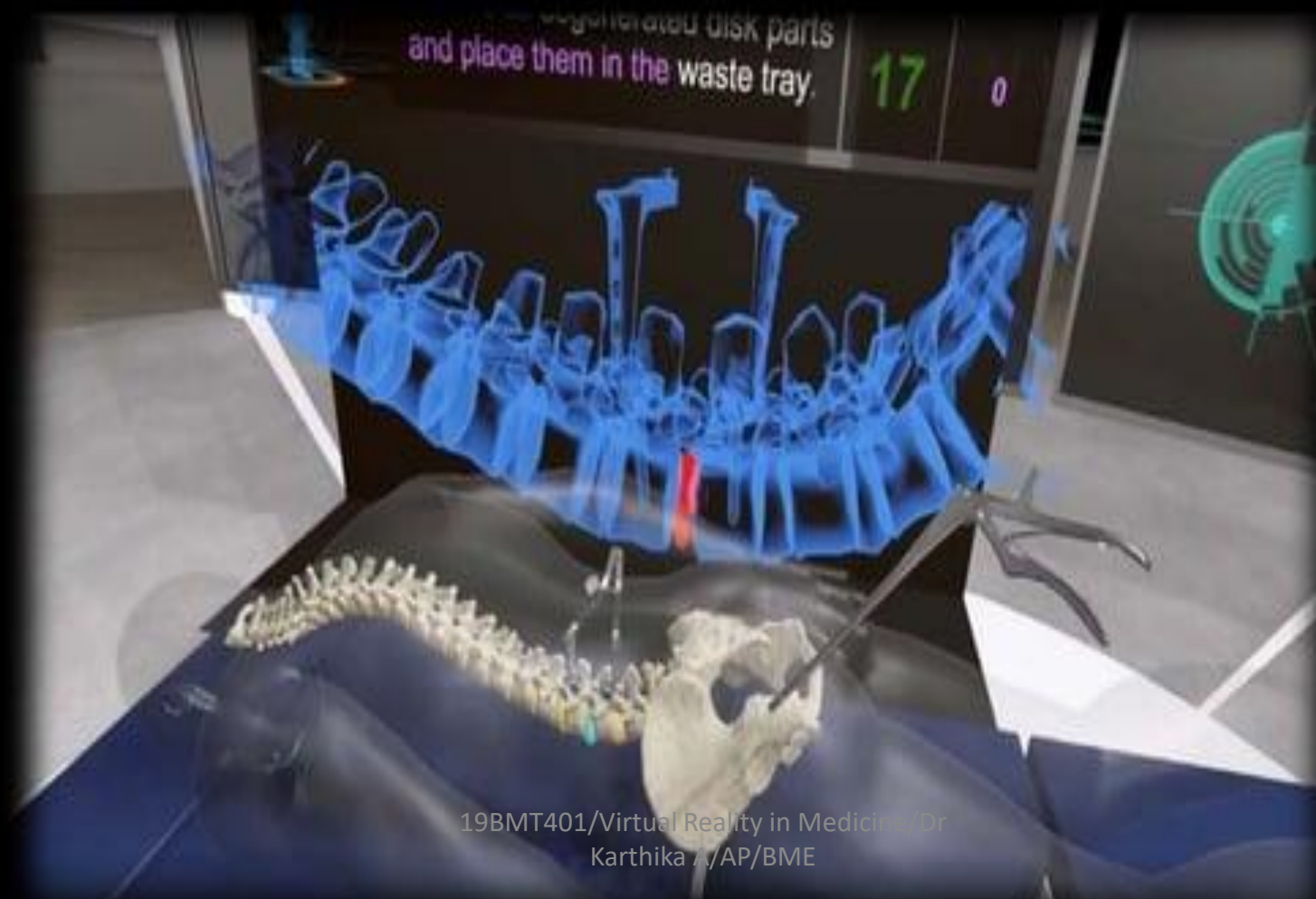


# Surgical Procedure Training





# Medical Device Training

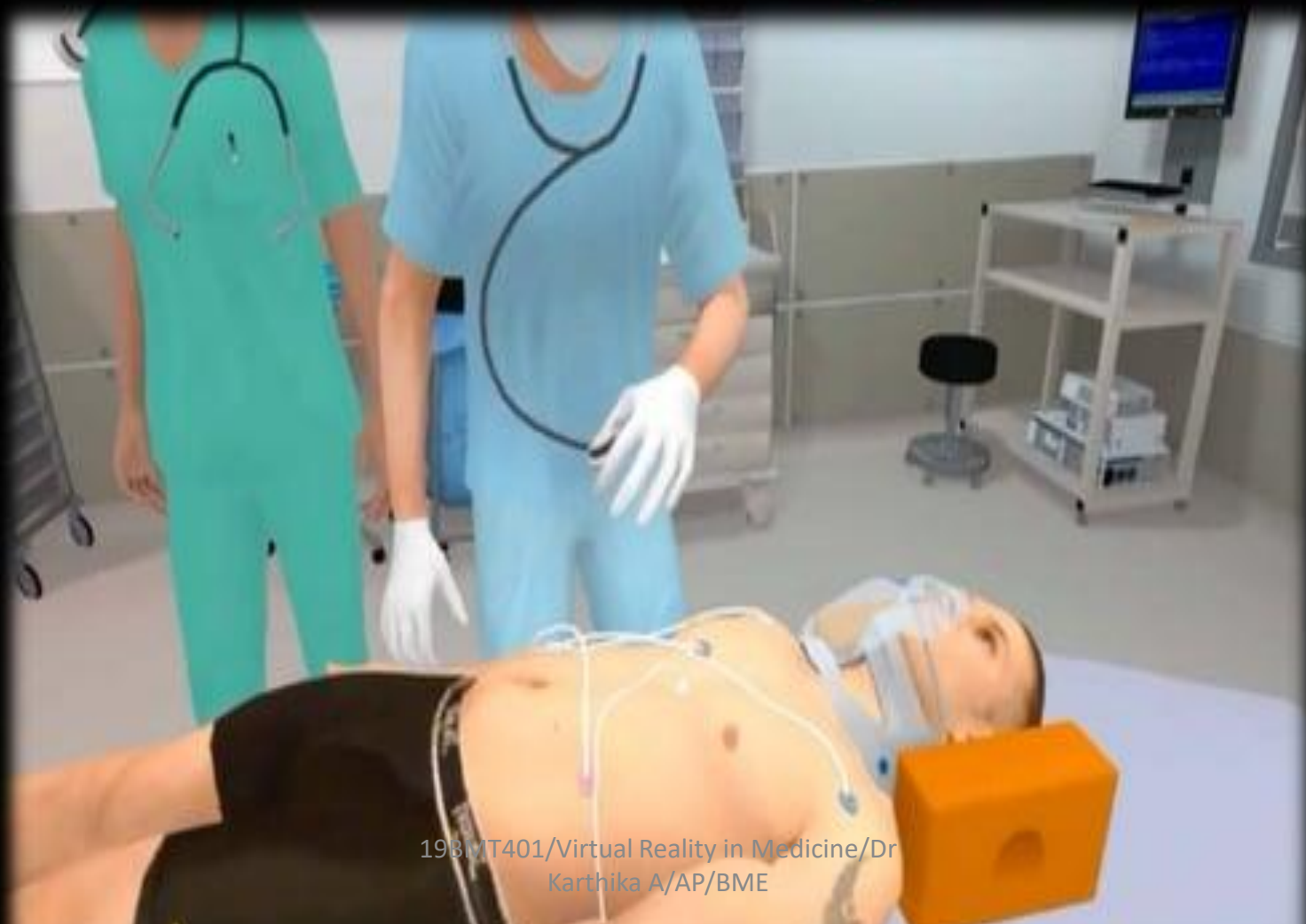


# Virtual Patients for Clinical Skill Training



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# Team Training



# Disaster Preparation

Multi-Department Training and Rehearsal

Situation Awareness

Stress Inoculation

Staff Training – Team Training

Rehearsal for Unusual Situations

AR - Data Fusion, Situation Awareness





# Clinical Training

Empathy for the Patient Experience



## Patient Education & Informed Consent



# Anatomy and Physiology Training

- Response to the acute shortage of human cadavers
- Allows for repetitive training and self-study
- More detailed examination of micro-features of organs, tissue etc.
- Integration of text, video and other media to further enhance learning





## Preoperative Planning & Image Guided Surgery





# DIAGNOSTIC ASSESSMENTS

- Medical Image Review
- Neuropsychological Assessments
- Activities of Daily Living Assessments
- Physical Medicine – OT / PT
- Behavioral Medicine – psychology, psychiatry



# New Approaches for **Cognitive Assessment**

## Standardized Environments for Neurocognitive Evaluation

Migrates traditional paper and subjective evaluations to a more sophisticated level.

Provides robust assessments that can challenge cognitive skills in a more **natural, standardized, objective and reproducible manner.**







# New Approaches for Cognitive Assessment

## Standardized Environments for Neurocognitive Evaluation

frontiers  
in Psychology

ORIGINAL RESEARCH  
published: 05 August 2015  
doi: 10.3389/fpsyg.2015.00117

**A Public Database of Immersive VR Videos with Corresponding Ratings of Arousal, Valence, and Correlations between Head Movements and Self Report Measures**

Bergquist J. J.<sup>1\*</sup>, Jeremy W. Bailenson<sup>1</sup>, Adam Prosser<sup>1</sup>, Walter J. Greenleaf<sup>2</sup> and Lawrence M. Williams<sup>1</sup>

<sup>1</sup>Department of Communication, Southern University, Orange, CA, United States; <sup>2</sup>Department of Psychology and Behavioral Science, School of Medicine, Southern University, Orange, CA, United States

Virtual reality (VR) has been proposed as a methodological tool to study the basic science of psychology and other fields. One key advantage of VR is that sharing of virtual content can lead to more robust replication and representative sampling. A database of standardized content will help fulfill this vision. Thus we have objectives for this study. First, we seek to establish and allow public access to a database of immersive VR video clips that can act as a potential resource for studies on emotion reduction using virtual reality. Second, given the large sample size of participants needed to get reliable valence and arousal ratings for our videos, we were able to explore the possible links between the head movements of the observer and the emotions he or she feels while viewing immersive VR. To accomplish our goals, we recruited for and tested 70 immersive VR clips which participants rated on valence and arousal dimensions using self-assessment manikin. We also tracked participants' relative head movements in the clips using the VR clips, allowing us to correlate head movements and affect. Based on past research we predicted relationships between the standard deviation of head pose and valence and arousal ratings. Results showed that the stimuli varied non-linearly with along the

OPEN ACCESS

Edited by:  
Walter J. Greenleaf,  
School of Medicine,  
Southern University, United States

Reviewed by:  
Gangadhar  
University of Oklahoma, Thailand  
Shreyas Shrivastava,  
Bharat Institute of Learning,  
United Kingdom

\*Correspondence:  
Bergquist J. J.  
jbergquist@suu.edu

TABLE 1 | Overview

ID	Title	Description	Length (s)	Valence	Arousal
01	VR Office	Virtual office environment	1:00	0.00	0.00
02	VR Office with a chair	Virtual office environment with a chair	1:00	0.00	0.00
03	VR Office with a desk	Virtual office environment with a desk	1:00	0.00	0.00
04	VR Office with a chair and desk	Virtual office environment with a chair and desk	1:00	0.00	0.00
05	VR Office with a chair and desk (2)	Virtual office environment with a chair and desk (2)	1:00	0.00	0.00
06	VR Office with a chair and desk (3)	Virtual office environment with a chair and desk (3)	1:00	0.00	0.00
07	VR Office with a chair and desk (4)	Virtual office environment with a chair and desk (4)	1:00	0.00	0.00
08	VR Office with a chair and desk (5)	Virtual office environment with a chair and desk (5)	1:00	0.00	0.00
09	VR Office with a chair and desk (6)	Virtual office environment with a chair and desk (6)	1:00	0.00	0.00
10	VR Office with a chair and desk (7)	Virtual office environment with a chair and desk (7)	1:00	0.00	0.00
11	VR Office with a chair and desk (8)	Virtual office environment with a chair and desk (8)	1:00	0.00	0.00
12	VR Office with a chair and desk (9)	Virtual office environment with a chair and desk (9)	1:00	0.00	0.00
13	VR Office with a chair and desk (10)	Virtual office environment with a chair and desk (10)	1:00	0.00	0.00
14	VR Office with a chair and desk (11)	Virtual office environment with a chair and desk (11)	1:00	0.00	0.00
15	VR Office with a chair and desk (12)	Virtual office environment with a chair and desk (12)	1:00	0.00	0.00
16	VR Office with a chair and desk (13)	Virtual office environment with a chair and desk (13)	1:00	0.00	0.00
17	VR Office with a chair and desk (14)	Virtual office environment with a chair and desk (14)	1:00	0.00	0.00
18	VR Office with a chair and desk (15)	Virtual office environment with a chair and desk (15)	1:00	0.00	0.00
19	VR Office with a chair and desk (16)	Virtual office environment with a chair and desk (16)	1:00	0.00	0.00
20	VR Office with a chair and desk (17)	Virtual office environment with a chair and desk (17)	1:00	0.00	0.00
21	VR Office with a chair and desk (18)	Virtual office environment with a chair and desk (18)	1:00	0.00	0.00
22	VR Office with a chair and desk (19)	Virtual office environment with a chair and desk (19)	1:00	0.00	0.00
23	VR Office with a chair and desk (20)	Virtual office environment with a chair and desk (20)	1:00	0.00	0.00
24	VR Office with a chair and desk (21)	Virtual office environment with a chair and desk (21)	1:00	0.00	0.00
25	VR Office with a chair and desk (22)	Virtual office environment with a chair and desk (22)	1:00	0.00	0.00
26	VR Office with a chair and desk (23)	Virtual office environment with a chair and desk (23)	1:00	0.00	0.00
27	VR Office with a chair and desk (24)	Virtual office environment with a chair and desk (24)	1:00	0.00	0.00
28	VR Office with a chair and desk (25)	Virtual office environment with a chair and desk (25)	1:00	0.00	0.00
29	VR Office with a chair and desk (26)	Virtual office environment with a chair and desk (26)	1:00	0.00	0.00
30	VR Office with a chair and desk (27)	Virtual office environment with a chair and desk (27)	1:00	0.00	0.00
31	VR Office with a chair and desk (28)	Virtual office environment with a chair and desk (28)	1:00	0.00	0.00
32	VR Office with a chair and desk (29)	Virtual office environment with a chair and desk (29)	1:00	0.00	0.00
33	VR Office with a chair and desk (30)	Virtual office environment with a chair and desk (30)	1:00	0.00	0.00
34	VR Office with a chair and desk (31)	Virtual office environment with a chair and desk (31)	1:00	0.00	0.00
35	VR Office with a chair and desk (32)	Virtual office environment with a chair and desk (32)	1:00	0.00	0.00
36	VR Office with a chair and desk (33)	Virtual office environment with a chair and desk (33)	1:00	0.00	0.00
37	VR Office with a chair and desk (34)	Virtual office environment with a chair and desk (34)	1:00	0.00	0.00
38	VR Office with a chair and desk (35)	Virtual office environment with a chair and desk (35)	1:00	0.00	0.00
39	VR Office with a chair and desk (36)	Virtual office environment with a chair and desk (36)	1:00	0.00	0.00
40	VR Office with a chair and desk (37)	Virtual office environment with a chair and desk (37)	1:00	0.00	0.00
41	VR Office with a chair and desk (38)	Virtual office environment with a chair and desk (38)	1:00	0.00	0.00
42	VR Office with a chair and desk (39)	Virtual office environment with a chair and desk (39)	1:00	0.00	0.00
43	VR Office with a chair and desk (40)	Virtual office environment with a chair and desk (40)	1:00	0.00	0.00
44	VR Office with a chair and desk (41)	Virtual office environment with a chair and desk (41)	1:00	0.00	0.00
45	VR Office with a chair and desk (42)	Virtual office environment with a chair and desk (42)	1:00	0.00	0.00
46	VR Office with a chair and desk (43)	Virtual office environment with a chair and desk (43)	1:00	0.00	0.00
47	VR Office with a chair and desk (44)	Virtual office environment with a chair and desk (44)	1:00	0.00	0.00
48	VR Office with a chair and desk (45)	Virtual office environment with a chair and desk (45)	1:00	0.00	0.00
49	VR Office with a chair and desk (46)	Virtual office environment with a chair and desk (46)	1:00	0.00	0.00
50	VR Office with a chair and desk (47)	Virtual office environment with a chair and desk (47)	1:00	0.00	0.00
51	VR Office with a chair and desk (48)	Virtual office environment with a chair and desk (48)	1:00	0.00	0.00
52	VR Office with a chair and desk (49)	Virtual office environment with a chair and desk (49)	1:00	0.00	0.00
53	VR Office with a chair and desk (50)	Virtual office environment with a chair and desk (50)	1:00	0.00	0.00





# New Approaches for Cognitive Assessment

## Standardized Environments for Neurocognitive Evaluation

Behaviour Research and Therapy

The ENGAGE study: Integrating neuroimaging, virtual reality and smartphone sensing to understand self-regulation for managing depression and obesity in a precision medicine model

Leanne M. Williams<sup>1,2\*</sup>, Adam Finner<sup>3</sup>, Andrea N. Galambos-Pokorski<sup>4,5</sup>, Lisa G. Rosen<sup>6</sup>, Monika Kullar<sup>7</sup>, Matthew D. Sacher<sup>8</sup>, Olivier Gruber<sup>9</sup>, Jeremy Bullock<sup>10</sup>, Philip W. Lacob<sup>11</sup>, Paul Dagan<sup>12</sup>, Brian Wandell<sup>13</sup>, Carlos Gomez<sup>14</sup>, Walter Grossman<sup>15</sup>, Trisha Suppes<sup>16</sup>, I. Michael Perry<sup>17</sup>, Joshua M. Smyth<sup>18</sup>, Megan A. Lewis<sup>19</sup>, Elizabeth M. Verditt<sup>20</sup>, Mark Scerif<sup>21</sup>, James M. Stewart<sup>22</sup>, Jon Ma<sup>23</sup>

**ARTICLE INFO**

**ABSTRACT**

1. Department of Psychology and Behavioral Science, Institute for Genome Sciences and Policy, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

2. Center for Genome and Systems Sciences, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

3. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

4. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

5. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

6. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

7. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

8. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

9. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

10. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

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12. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

13. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

14. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

15. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

16. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

17. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

18. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

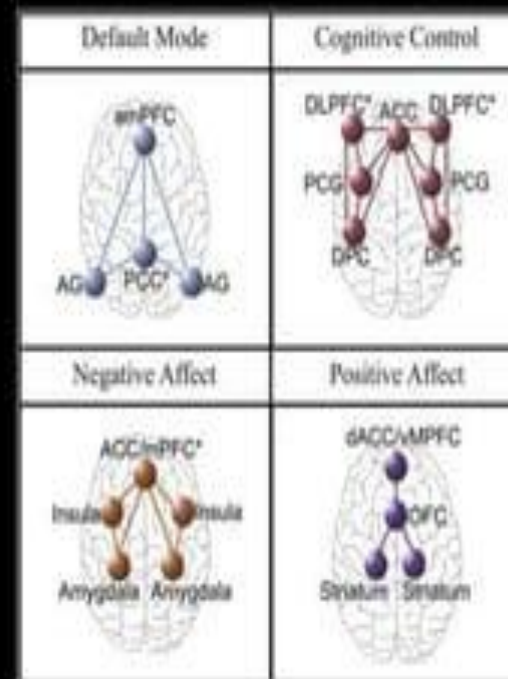
19. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

20. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

21. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

22. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

23. Department of Psychology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA



# BioMarkers - Cognitive and Emotional State

Collecting and analyzing emotional and physical responses in VR



# Improved cognitive function assessment at the primary care level – using AR and smartphone sensors

10 minute test

Diagnostic accuracy of 94%

FDA Class II Medical Device





# Virtual environments are **currently used** clinically

Here are a few examples -

- Stroke and Traumatic Brain Injury
- Physical / Occupational Therapy
- Acute and Chronic Pain Mitigation



Virtual environments are used clinically to treat several important **mental and behavioral health problems**

- Post-Traumatic Stress Disorder
- Generalized Anxiety Disorder
- Social Anxiety Disorder
- Depression
- Mild Cognitive Impairment
- Autism Spectrum Disorder
- ADHD



Virtual environments are used clinically to treat several important **mental and behavioral health problems**

- Generalized Anxiety Disorder
- Phobias
- Obsessive Compulsive Disorder
- Anger Management
- Eating Disorders
- Schizophrenia



# New Approaches to Mental Health





# HEALTH AND WELLNESS

- Improve Cognitive Function
- Promote Exercise & Weight Management
- Stress Management
- Mood and Resilience
- Disability Solutions
- Addressing Isolation
- Grief Counseling



# Portable Telemedicine Platform



# Virtual Humans For Training, Confidential Interaction, and Telemedicine Support

## MultiSense



## SimSensei



# Virtual Humans For Training, Confidential Interaction, and Telemedicine Support



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“Smart Avatar” with a virtual voice,



# Preparation and Training for Difficult Situations



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# Some Examples



# PTSD, Phobias, and Anxiety Disorders

- Exposure-based treatments can be conducted in the safety and comfort of an office setting
- Effective tools for treating a variety of clinical problems, in particular anxiety and addictive disorders
- Fully immersive environments, which include the use of a head mounted display, 3D sound, tactile stimulation via shaking platform, and olfactory stimulus are used for PTSD therapy





# Palliative and Hospice Care





# Cognitive Assessments for ADHD

- Enhanced Continuous Performance Test (CPT) in a real-world classroom environment
- Can introduce visual and auditory distractions during CPT administration
- More familiar for children than traditional PC-Based CPT
- Performance and response times more closely approximate true classroom
- Can become a skill building platform



# RISK AVOIDANCE TRAINING

Refusal skill training, Situational Confidence



# Virtual Hospital Tours Used To Relieve Pre-procedure Anxiety





# VR for Pain Distraction

## Clinical Research and Validation

Interactive virtual environments significantly reduce pain from as much as 44% during the most painful procedures (ex: burn wound treatment)

Diverts patient attention away from perceiving and feeling pain; (selective attention theory)

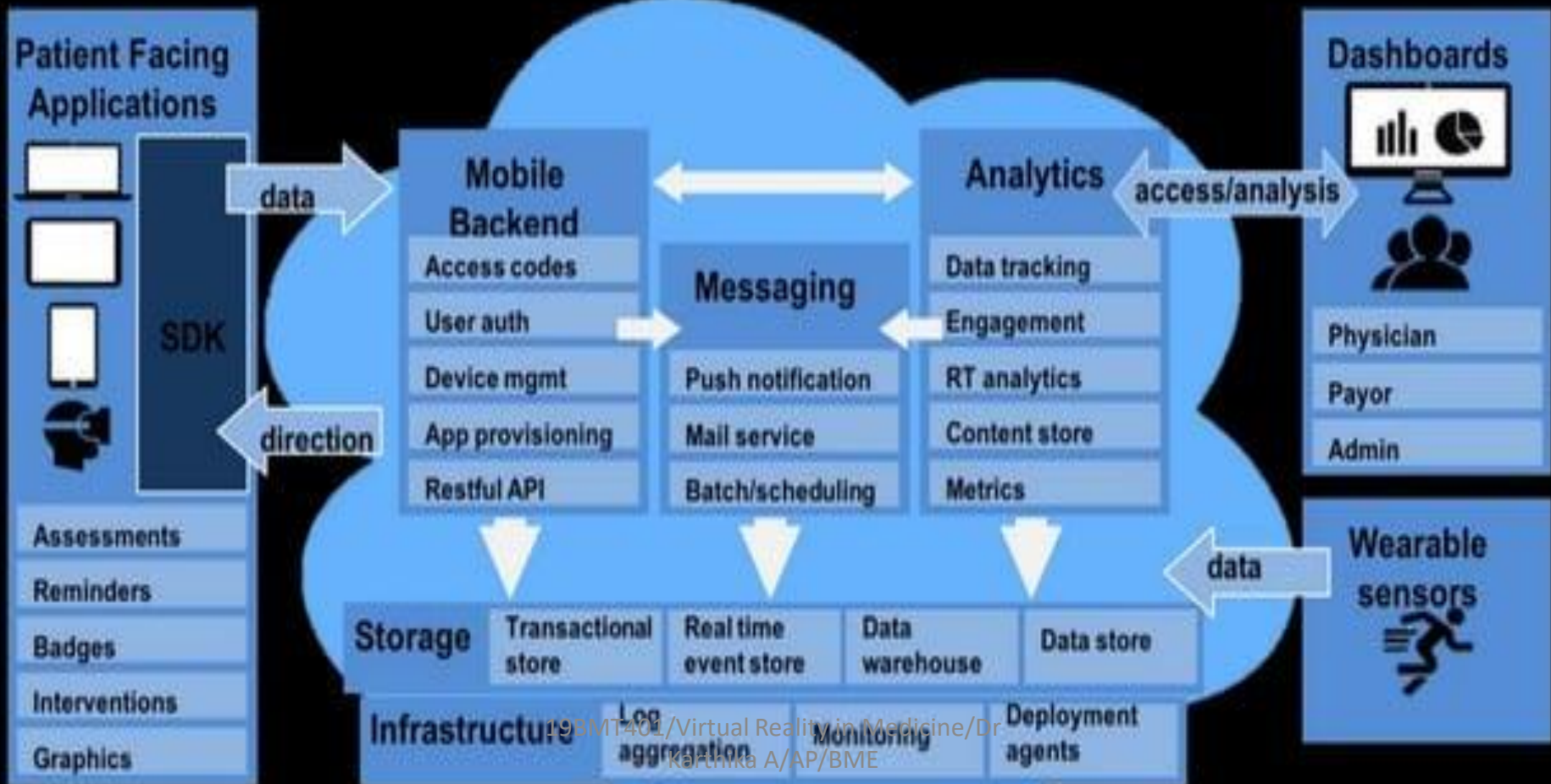
Decreases pain-related brain-activity

Reduces need for anesthesia, opioid medication

No pharmacological side effects



# Digital Health Platforms deliver interventions to patients, and parse data for enhanced analysis



# VR & AR - A Key Part of a **Combination Therapy** Digital Health Platform



Medication with  
clinical benefit

Patient-facing software  
designed to enhance

*eFormulation-*  
pharmaceutical



# A Fully Integrated, Closed Loop Solution for Mental Health and Wellness - Enabled on a Mobile, Digital Health Platform

Miniaturized, programmable,  
low power electronic  
architecture w/extensive therapy  
delivery options



## Wearable Stimulator

- Wireless
- Personalized
- Treatment Anytime
- Discrete



## Digital Health Platform

- Health Monitoring
- Voice Monitoring
- Emotional Monitoring
- Patient



## Digital Therapies

- VR
- Music
- Mindfulness
- Telemedicine
- Virtual Therapist



# The Neuroscience of How VR Promotes Behavior Change



# The Neuroscience of How VR Promotes Behavior Change

VR can promote behavior change by taking advantage of the way our brain's learning and reward systems function

VR systems can:

Activate neuroplastic change via reward systems

Shorten the reward feedback loop – show progress

Leverage mirror neuron systems



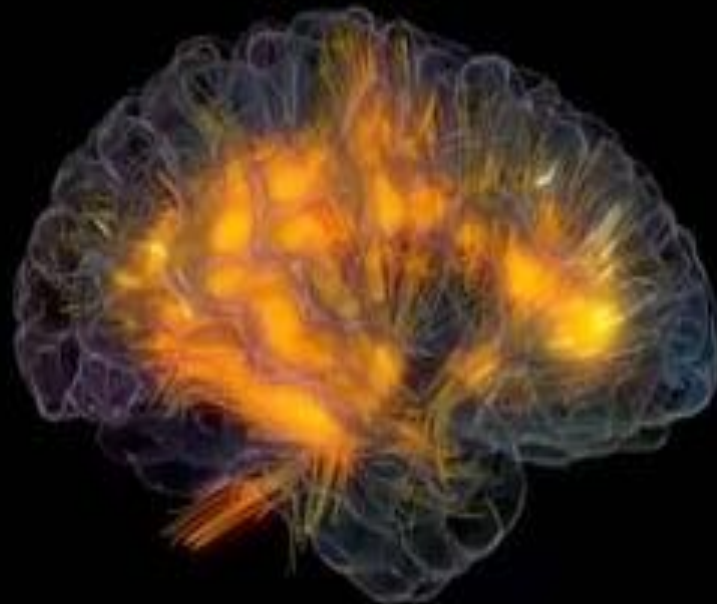


# Neuroscience Rationale

It is necessary to activate the associated brain system to enable neuroplasticity

Repetition is required

It is critical to engage the brain's reward systems



# Leveraging Mirror Neurons



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Ability to change attitudes and behavior after "being" one's future self.

# Your Future Self



Students interacted with 3-D avatars of future self.

Participants who interacted with future self put more than twice as much money into retirement account.



# Why Use Interactive / Immersive Systems for Health?

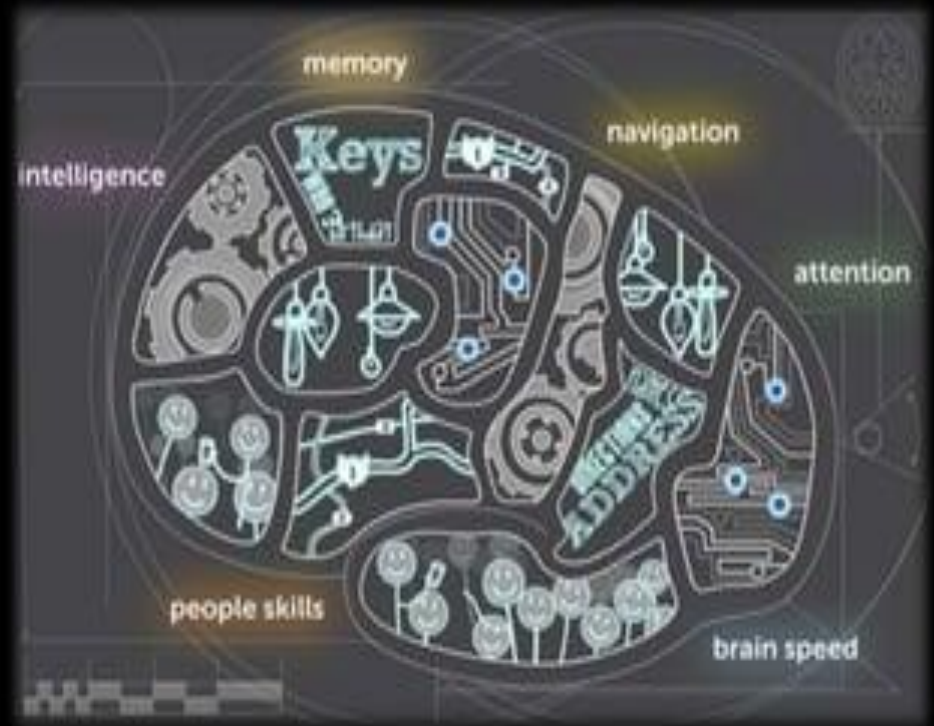
- **Active Involvement:** AR/VR systems provide patients with immersive experiences that make them feel more involved in their care.
- **Feedback:** behavior is reinforced by direct, immediate and relevant feedback that reinforces positive behavior.
- **Engaging and Motivating:** gives patients something to control and can provide immediate rewards. (Contingency Management)
- **Social Connections:** provide and enhance social resilience. (Social Physics)
- **Cost Effective:** Systems extend the effect of therapy while reducing the cost of face-to-face



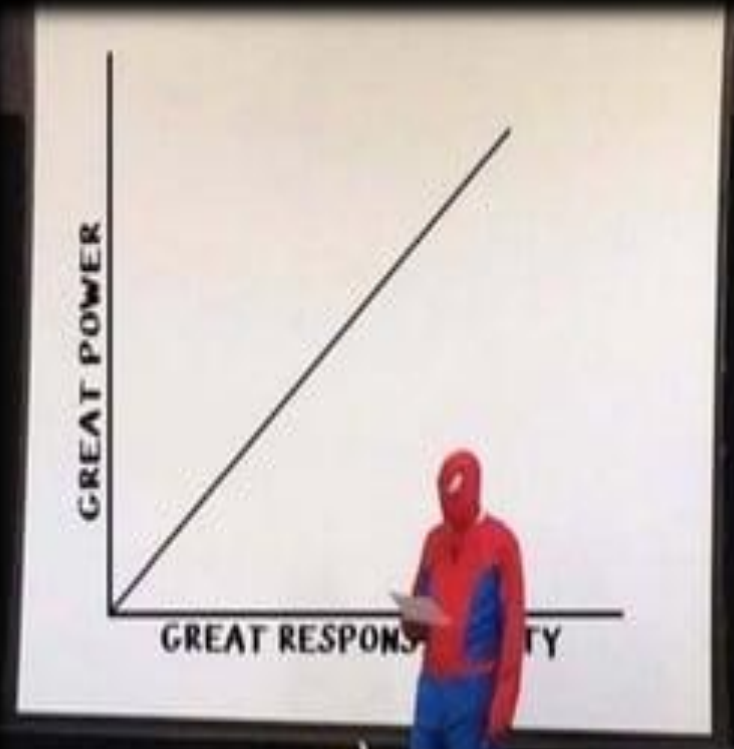
# Wired for Narrative Stories

Research shows that STORY:

- Provides superior retention (memory and recall)
- Provides improved understanding
- Creates context and relevance
- Creates empathy
- Makes readers/listeners pay attention
- Enhances the creation of meaning



What Are The Constraints?  
What are the gating-steps to  
adoption?





# No Clear Technology Path – Too Many Options

Rapid evolution = fears of obsolescence

Mobile / PC-Based vs. All-in-One

Which platform will prevail?

Graphics-based vs. 360 video

Concerns over infrastr

Lack of IT support



# Research Gaps

Body of literature is expanding with encouraging results,  
But remains insufficient

Available research varies by condition treated

Lack of randomized controlled trials

Population-specific studies

Obsolete platforms and equipment

Small sample sizes



# Perception of VR as a Gaming Platform





# Products need to be aligned with healthcare system needs

Full practices – no need to attract new patients

Evidence-based treatments are already available



What is the financial and time benefit?

Does it interfere with the clinic workflow?

# Virtual Environments and Senior Care

Improved Assessments and Diagnostics

Addressing Isolation and Loneliness

Acute and Chronic Pain

Depression and Anxiety Disorders

Physical and NeuroRehabilitation

Design for Disabilities

Post-Discharge Follow-up

Staff Training: not just procedures, but  
empathy



# Digital Health Technology For Medicine



- Current technologies and concepts are founded on more than 30 years of research and development
- Recent changes in cost and access make digital health technology affordable
- Digital health technology is currently used for prevention, evaluation, treatment and chronic disease management

- After years of validation and use by early adopters, validated systems are poised to move to the mainstream





# Thank You