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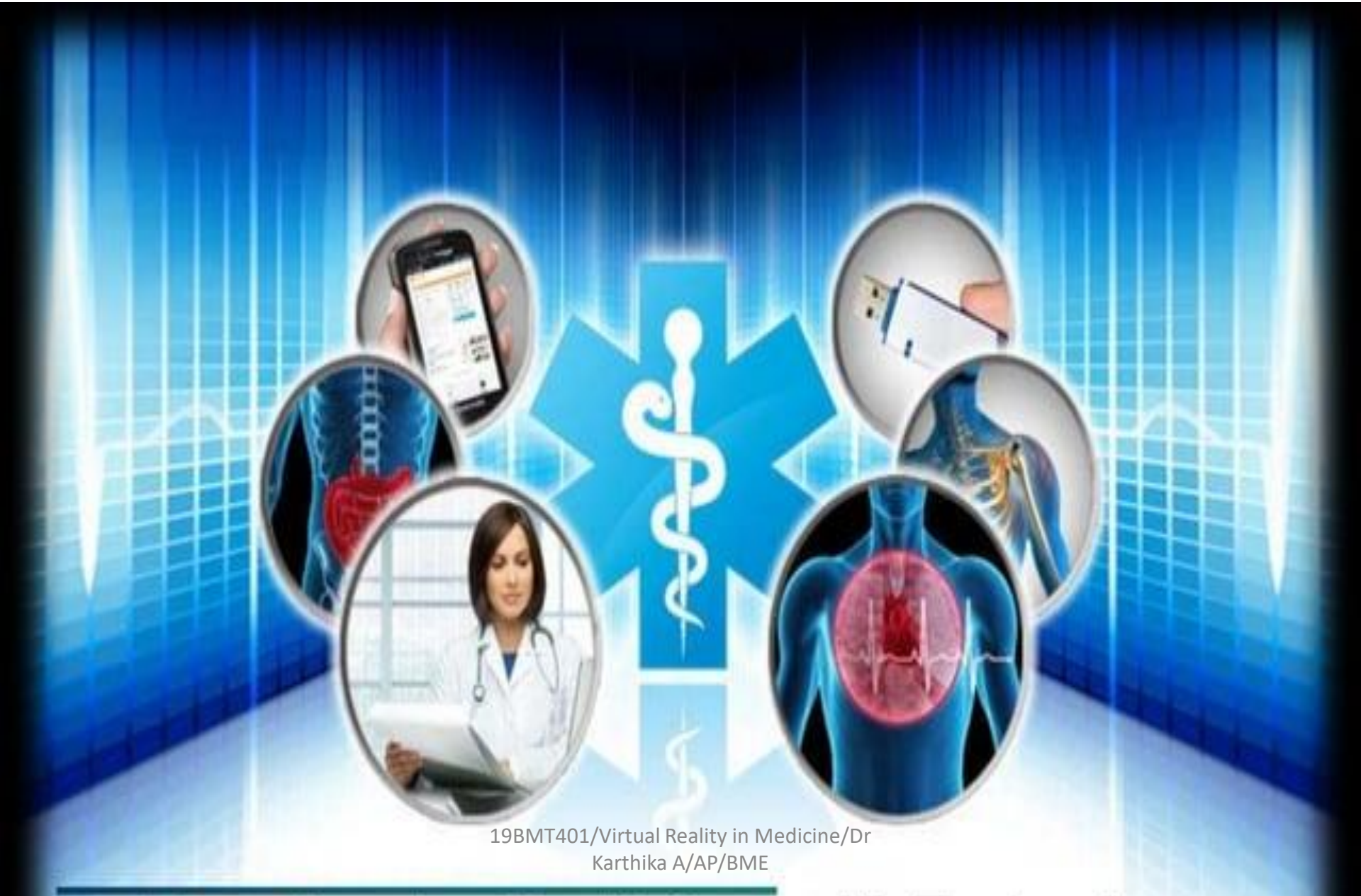
Department of Biomedical Engineering

Course Name: 19BMT401 – Virtual Reality in Medicine

IV Year : VII Semester

Unit V –APPLICATIONS

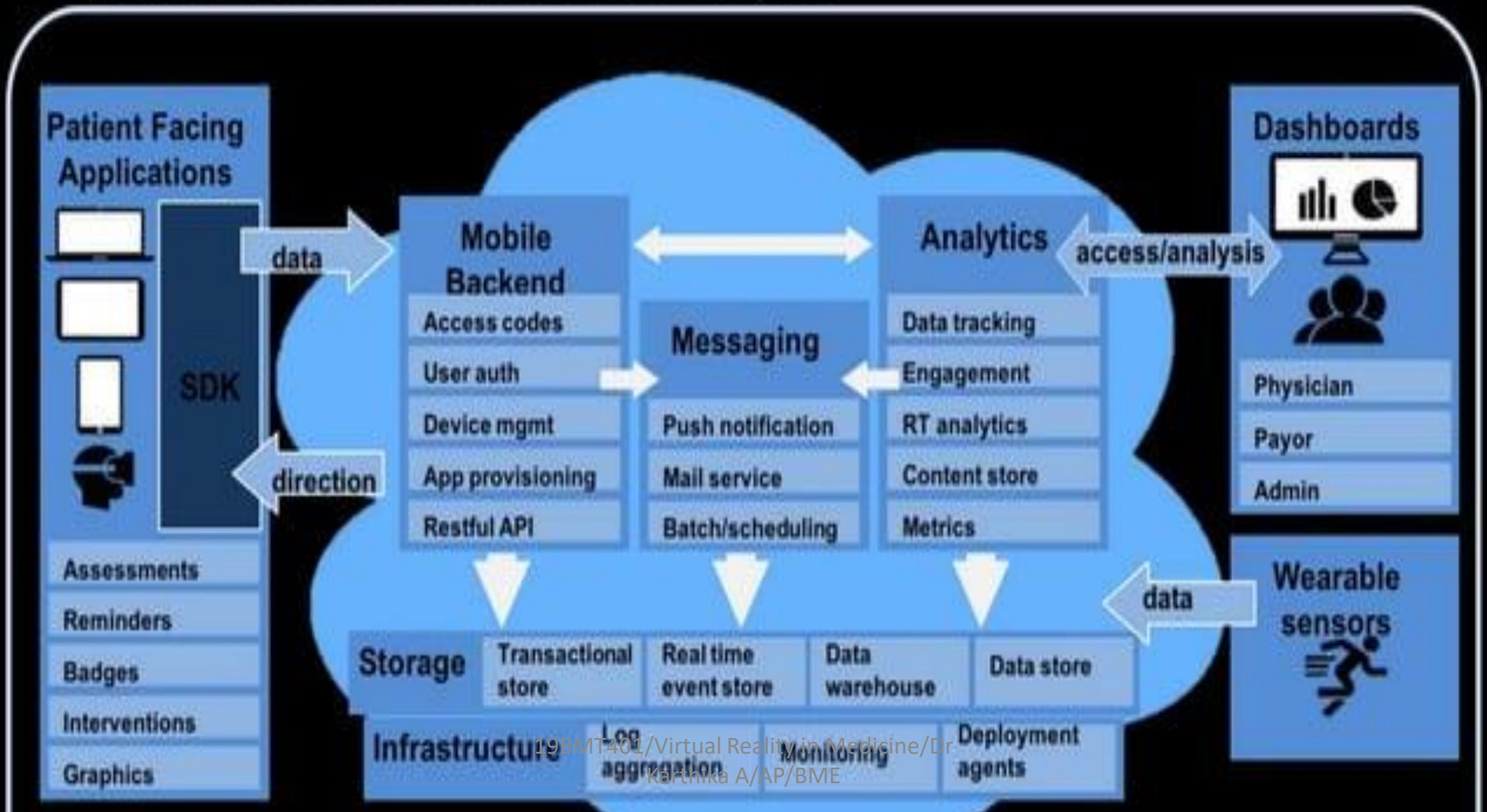


Digital Health Revolution

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

Every Medical Device Reinvented
118

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

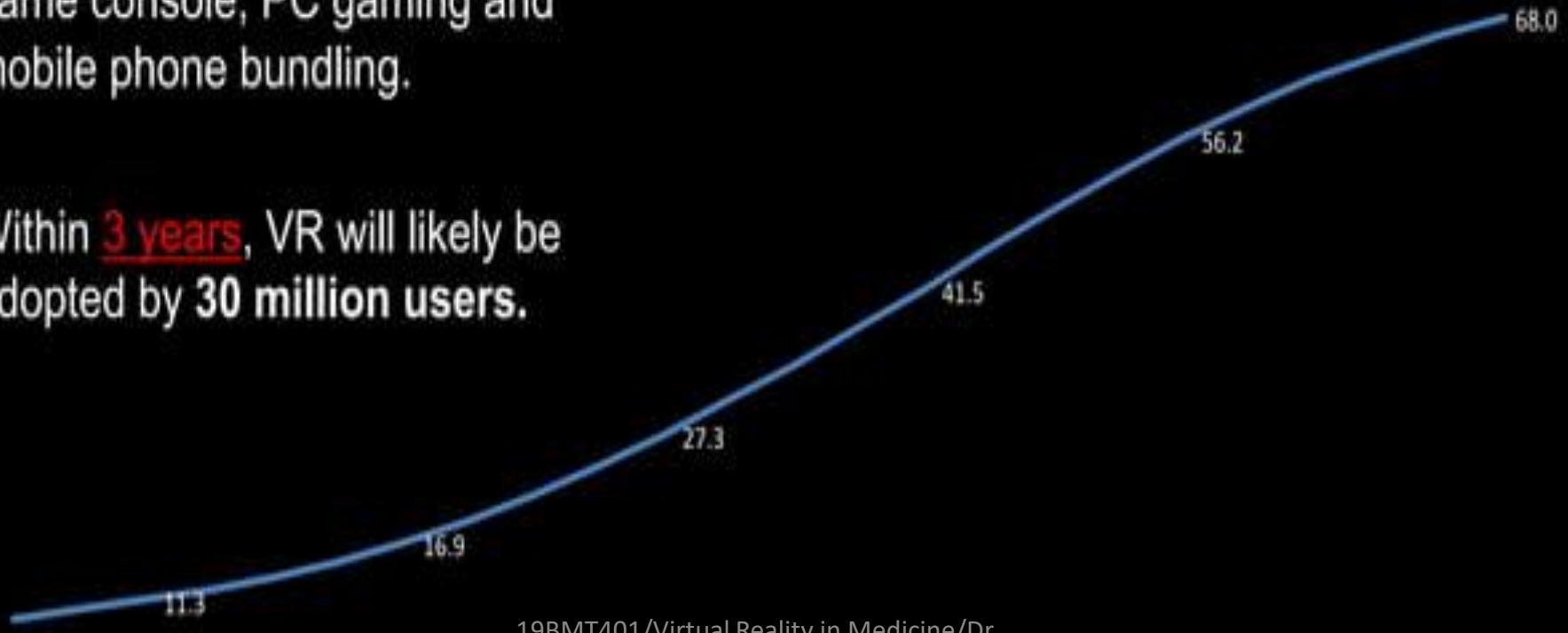
Google - DayDream

AR MR XR Technology

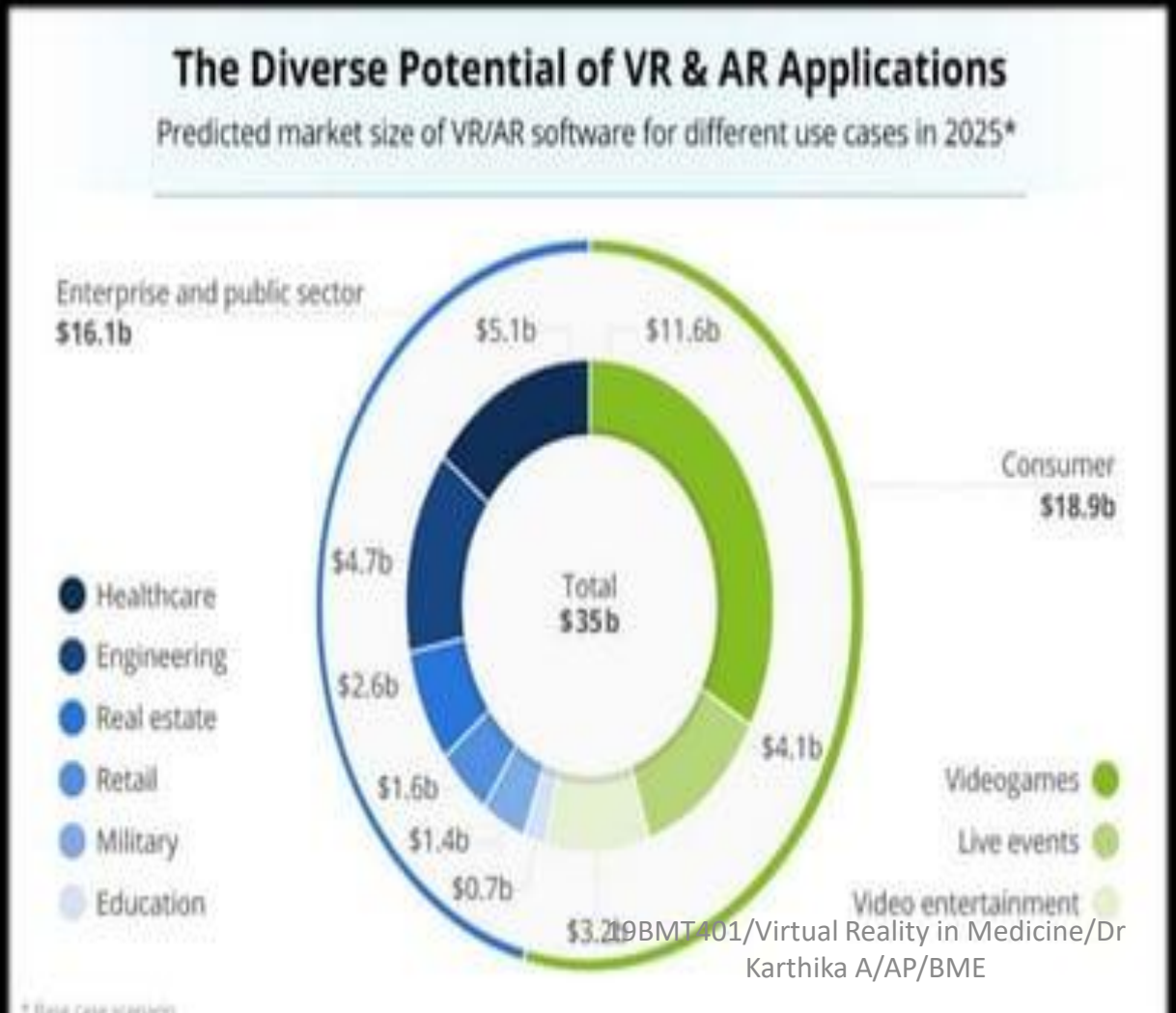
Within 6 years, VR will likely be adopted by 70 million users

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 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

NEXTMED / MMVR

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

Investments in VR Health Startups
TRIPP
BehaVR
ALTOIDA
COGNITIVE LEAP
mindmaze
Penumbra
Limbix

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

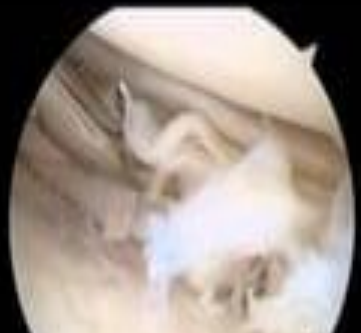
- Prevention and Wellness
- Objective Assessments
- Functional Training
- Improved Interventions
- Facilitate Adherence
- Distributed Care Delivery

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

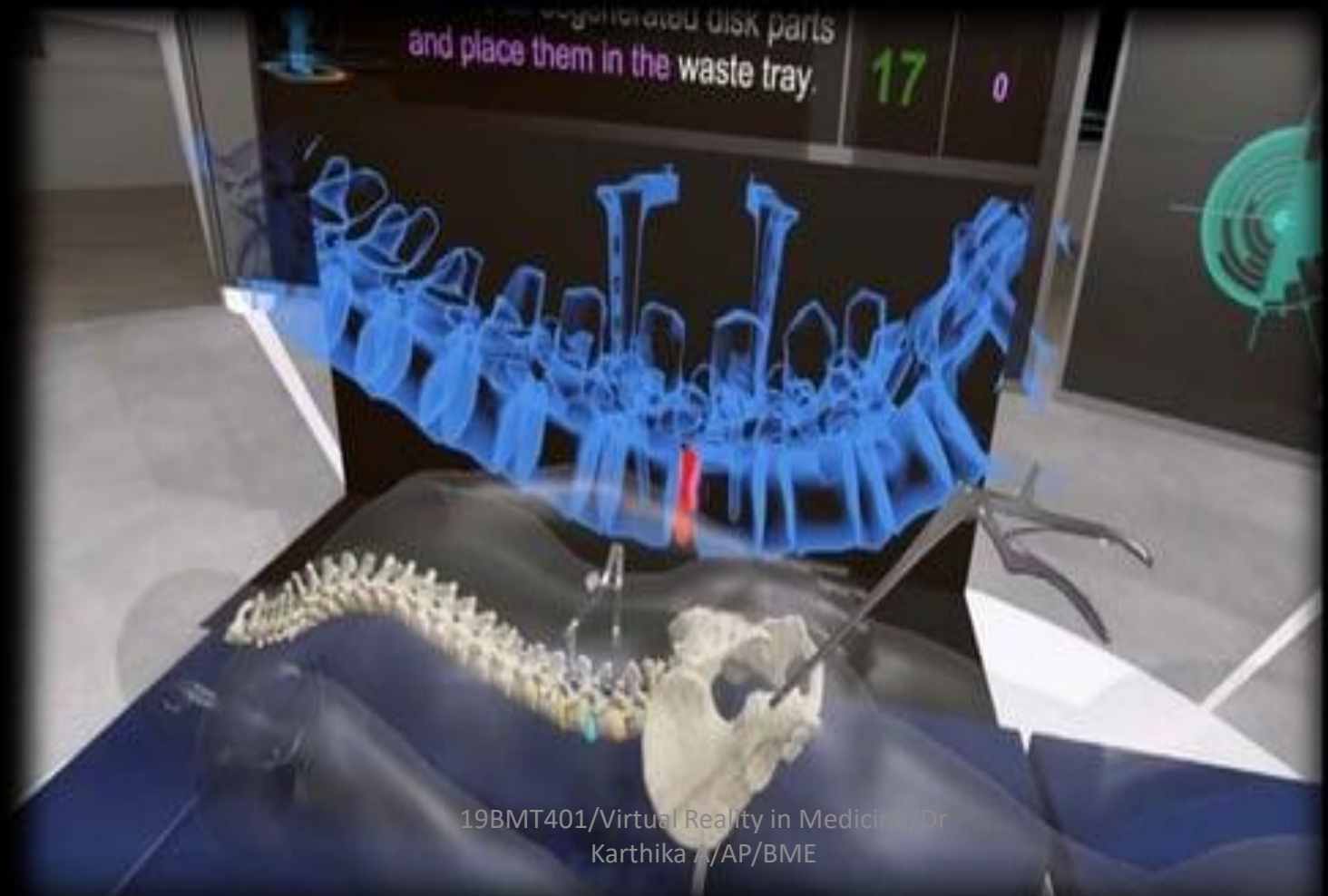
Surgical Training

Knee arthroscopy simulator



Surgical Procedure Training

Medical Device Training



Virtual Patients for Clinical Skill Training

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

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

New Approaches for Cognitive Assessment

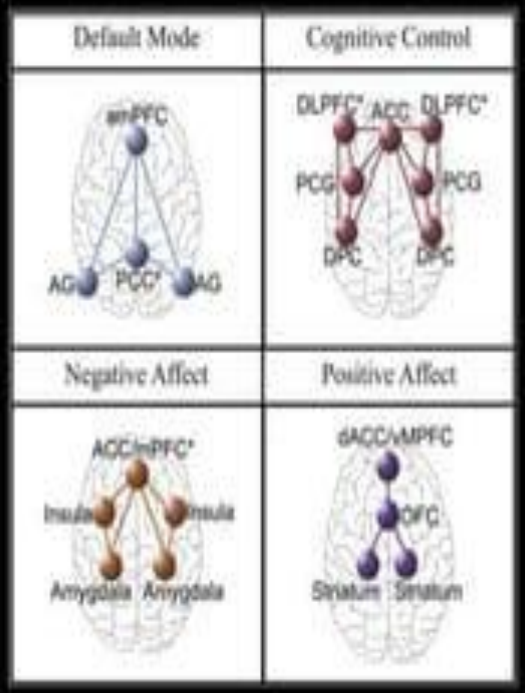
Standardized Environments for Neurocognitive Evaluation

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

ARTICLE INFO

ABSTRACT



VIRTUAL HUMAN

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

ALTOIDA

Continuous data of everyday functions

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

"Smart Avatar" with a virtual voice,

Preparation and Training for Difficult Situations

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, with 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

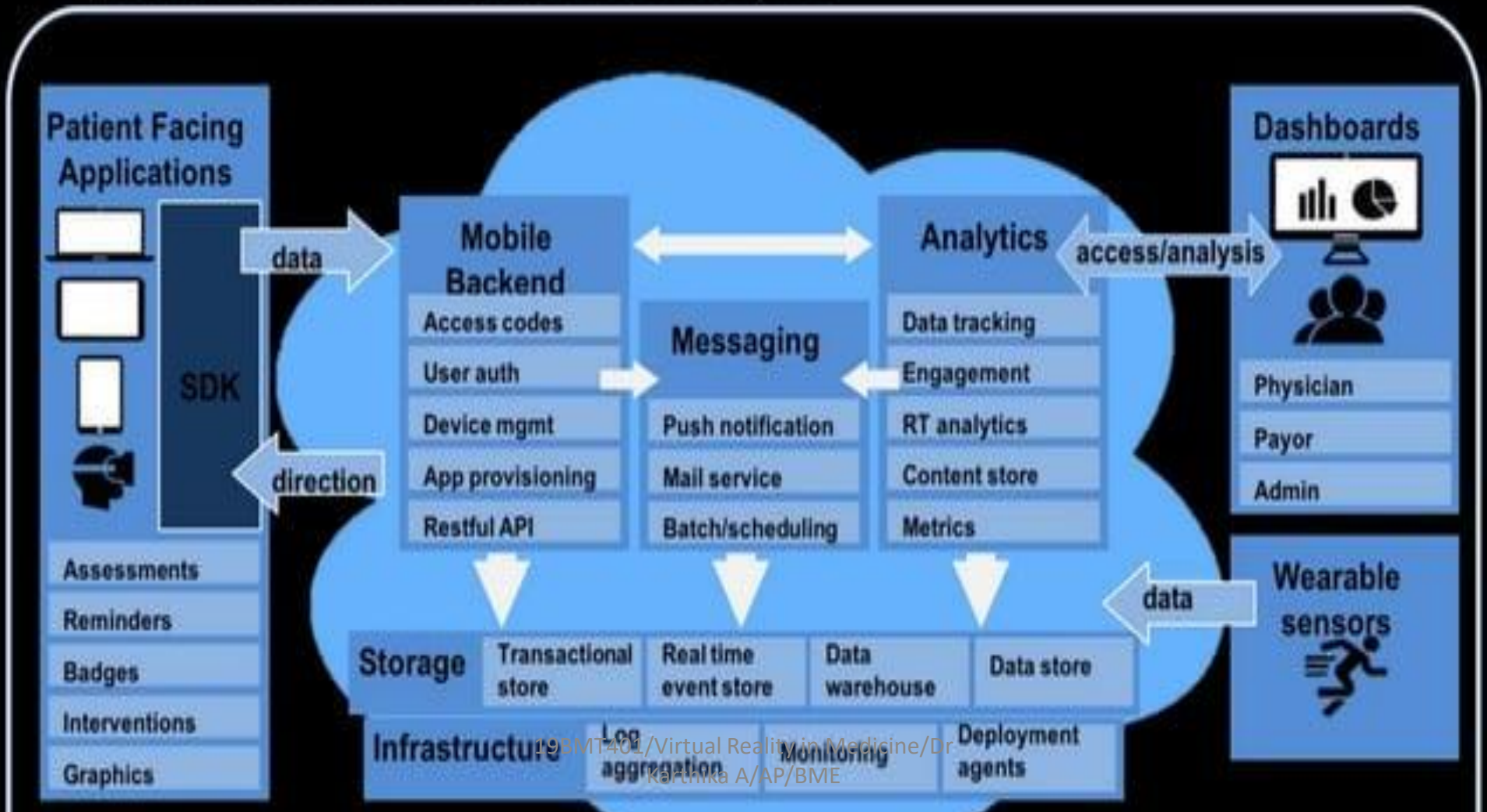
Interactive virtual environments significantly reduce pain from as much as 44% during the most painful procedures
(ex: burn wound treatment)

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

Decreases pain-related brain-activity

Reduces need for anesthesia, opioid medication

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

PEAR
THERAPEUTICS

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

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

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

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

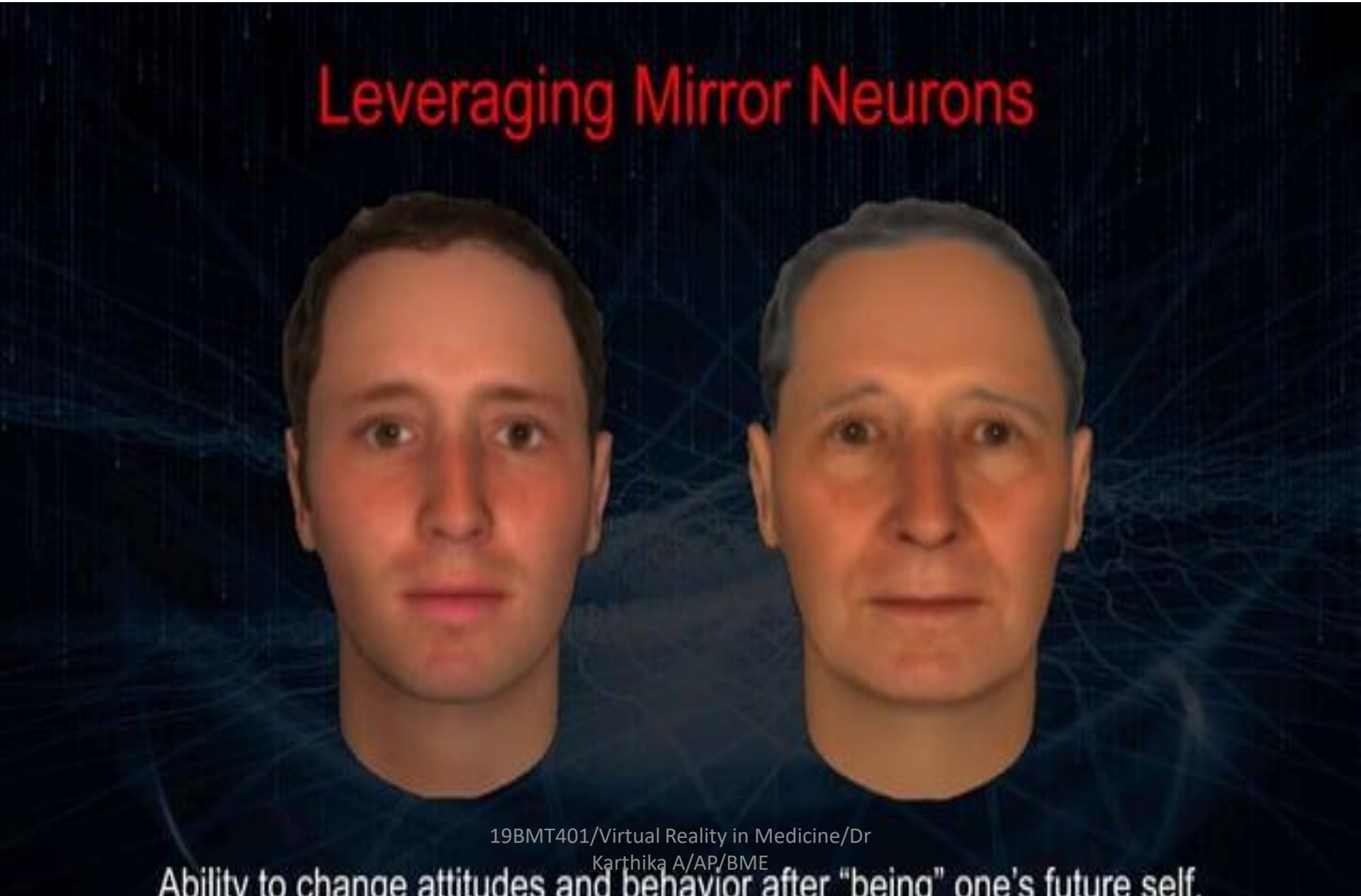
Leverage mirror neuron systems

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
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.

Stanford University VIRTUAL HUMAN INTERACTION LAB

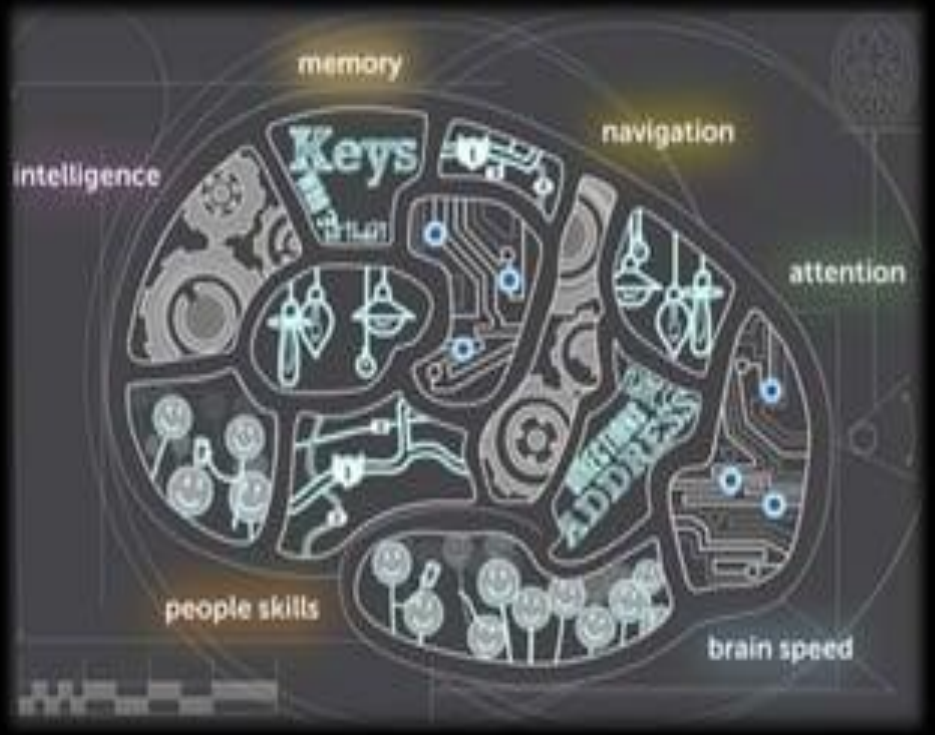
Why Use Interactive / Immersive Systems for Health?

- **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 infrast

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