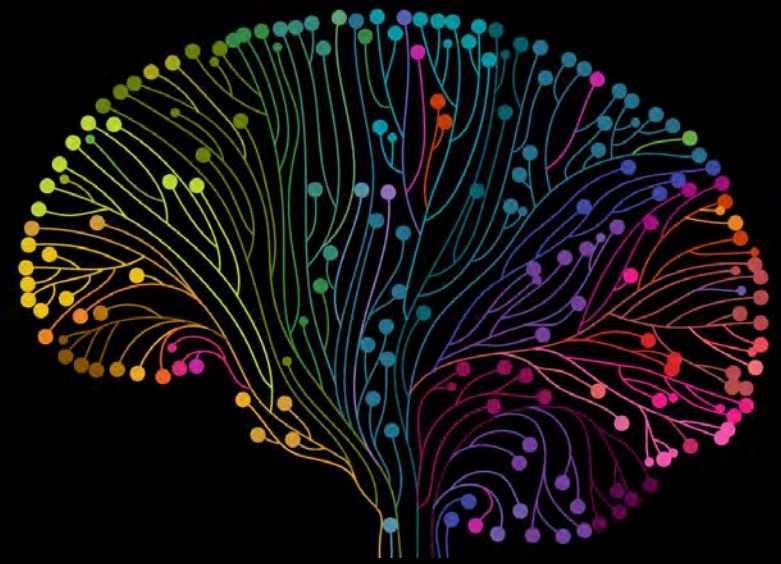
Virtual Reality & Augmented Reality Systems

The Impact on Clinical Care

Walter Greenleaf PhD

Stanford University VIRTUAL HUMAN INTERACTION LAB



Stanford HEALTH CARE

Medical VR/AR Systems – Overall Status and Opportunity

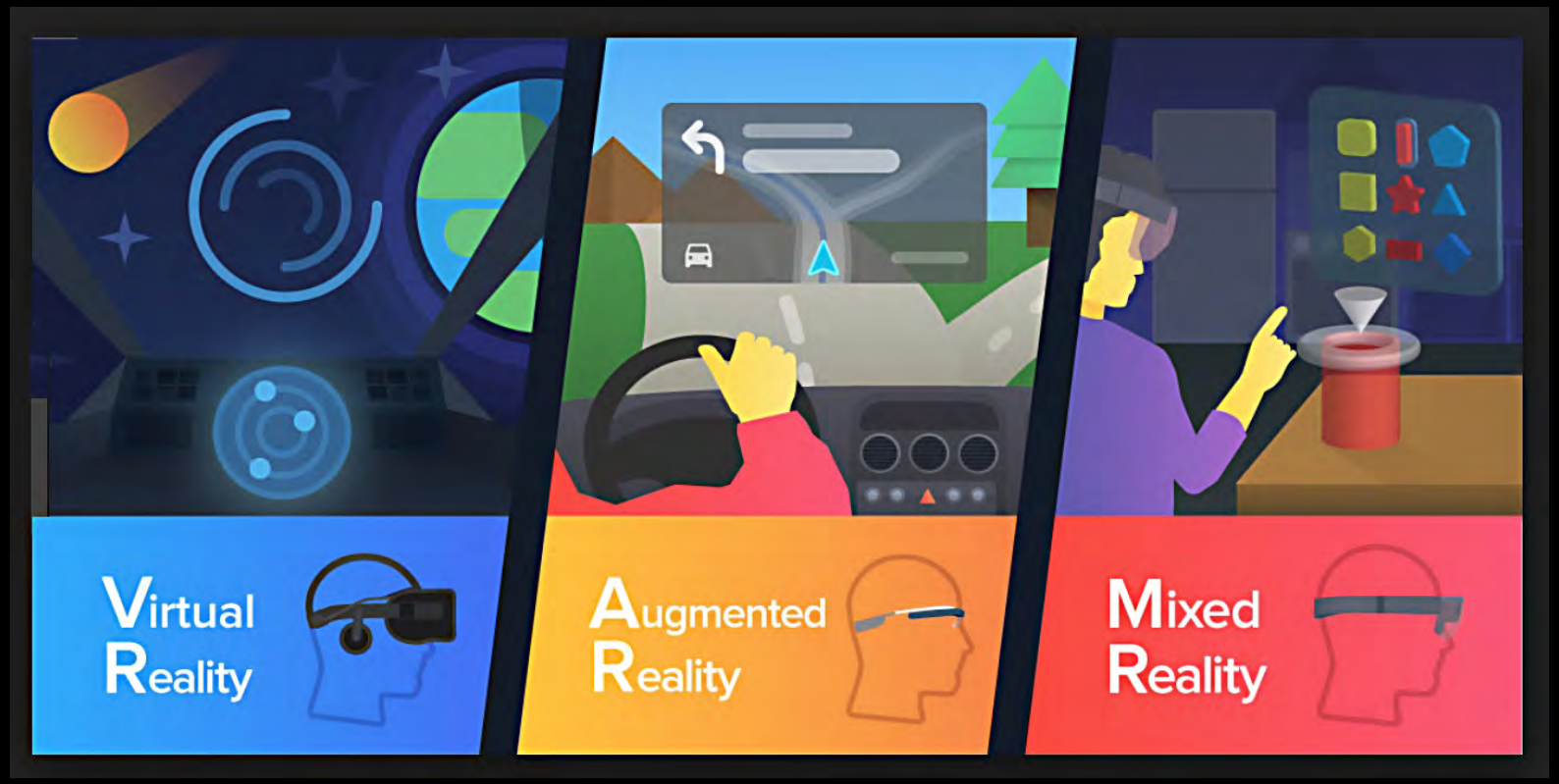
Current technologies and concepts are founded on more than *30 years of research and development*

Recent changes in cost and access make clinical VR systems affordable

After years of study and use by early adopters –
validated systems are moving out into mainstream healthcare

On the horizon - enhanced, ubiquitous, informative and integrated

+ AR + MR = XR



Extended Reality

Immersive Systems

VR/ AR systems are currently used for -

Functional Training

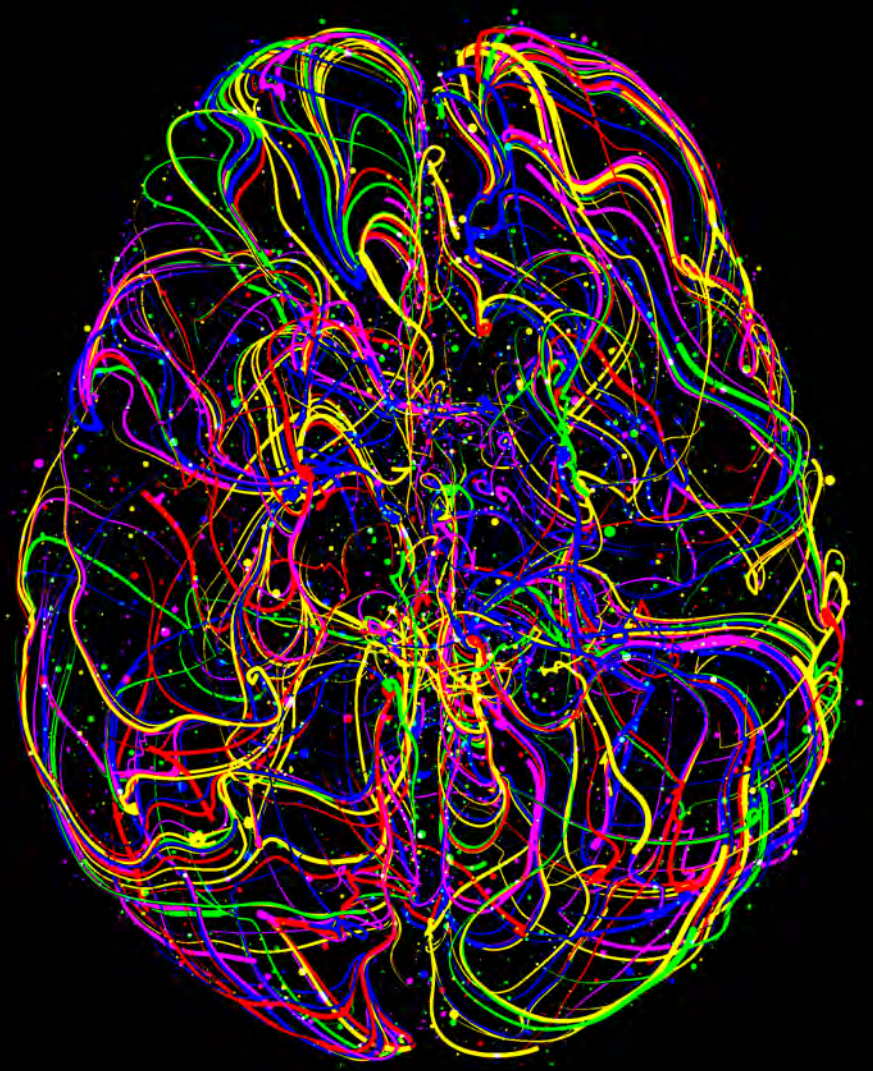
Objective Assessments

Improved Interventions

Facilitated Adherence

Distributed Care Delivery

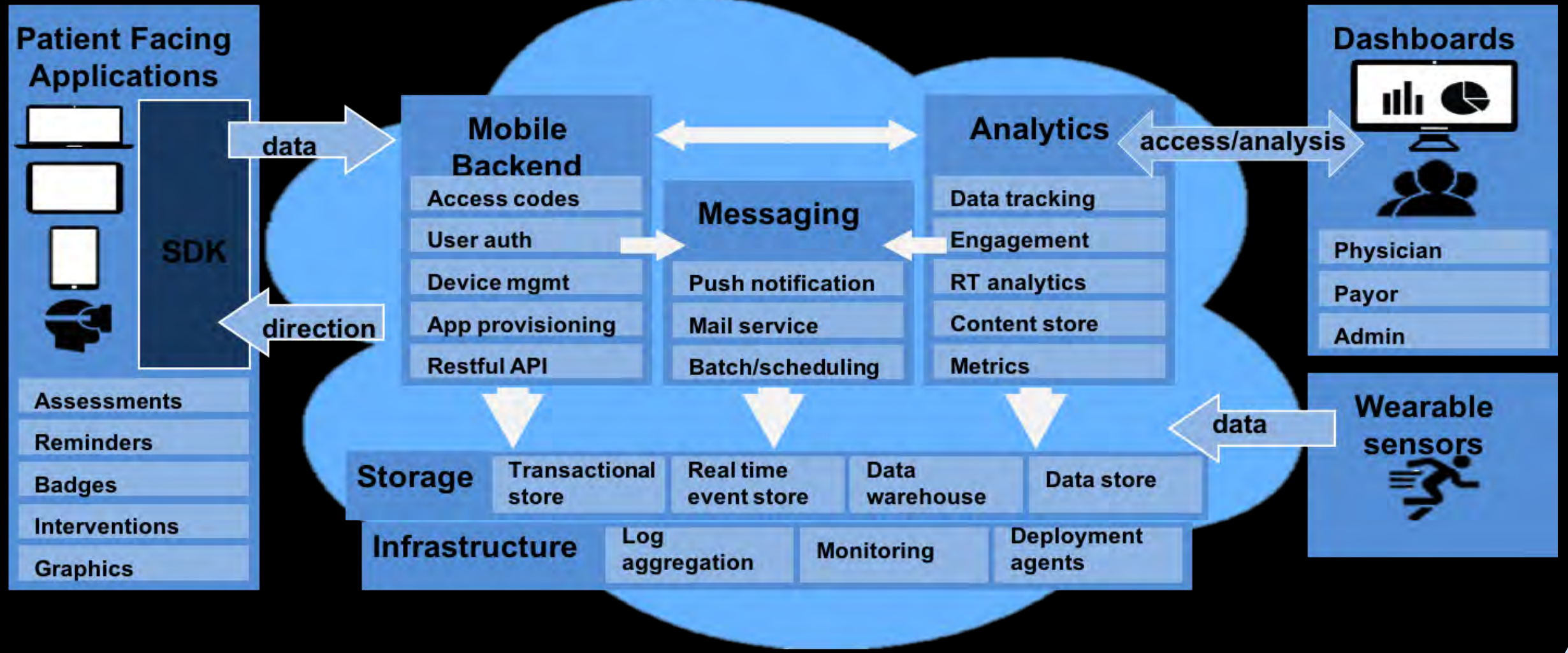
Prevention and Wellness



Digital Health Revolution

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

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



Virtual Reality & Augmented Reality Technology

Immersive Systems

Other Dimensions of Sensory Input - Enhanced Immersion

Scentware

9 scent actuators with interchangeable cartridges
Library of over 250 scents
Custom scent creation

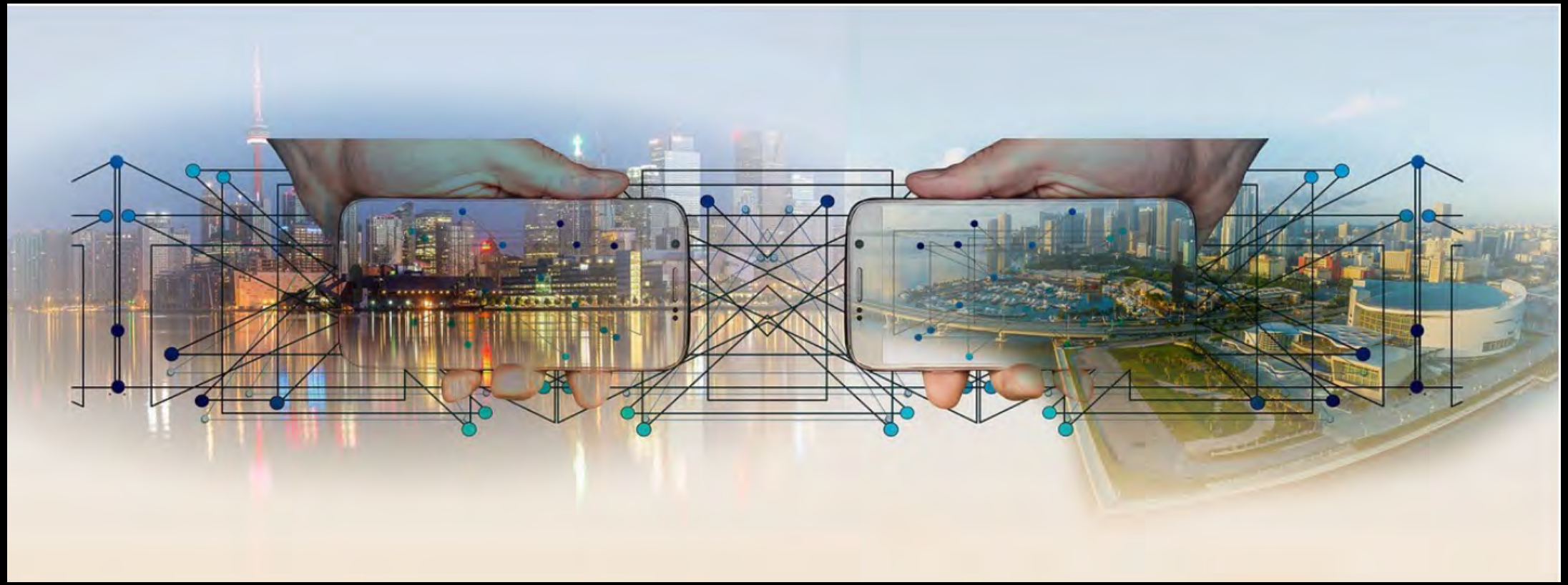
OVR TECHNOLOGY

Aaron Wisniewski

Virtual Humans For Education, Training, Support

"Smart Avatar" with a **virtual voice, image** and **mannerisms via** AI

5G connections will surpass one billion by 2023



Single-digit millisecond latencies with Edge Computing

Cloud-Rendered AR and VR content

Real-time Analytics for Machine Learning, Predictive Modeling

Virtual Worlds – Multiuser Immersive Experiences

space

Cloud-based 3D real time rendering

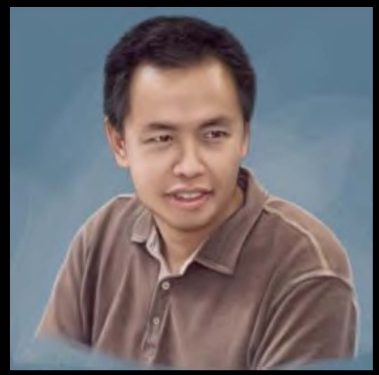
VR Technology Has Evolved

1987

First general purpose and commercially available VR systems.

DO WO

NEXTMED / MMVR
MEDICINE MEETS VIRTUAL REALITY



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

The Difference Between Being and Seeing: The Relative Contribution of Self-Perception and Priming to Behavioral Changes via Digital Self-Representation

Virtual Superheroes: Using Superpowers in Virtual Reality to Encourage Prosocial Behavior

Behaviour Research and Therapy xxx (xxxx) xxx–xxx

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journal homepage: www.elsevier.com/locate/brat

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

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ARTICLE INFO

Keywords:
Self-regulation
Neuroimaging
Virtual reality
Depression
Obesity
Behavior change

ABSTRACT

Precision medicine models for personalizing achieving sustained behavior change are largely outside of current clinical practice. Yet, changing self-regulatory behaviors is fundamental to the self-management of complex lifestyle-related chronic conditions such as depression and obesity - two top contributors to the global burden of disease and disability. To optimize treatments and address these burdens, behavior change and self-regulation must be better understood in relation to their neurobiological underpinnings. Here, we present the conceptual framework and protocol for a novel study, "Engaging self-regulation targets to understand the mechanisms of behavior change and improve mood and weight outcomes (ENGAGE)". The ENGAGE study integrates neuroscience with behavioral science to better understand the self-regulation related mechanisms of behavior change for improving mood and weight outcomes among adults with comorbid depression and obesity. We collect assays of three self-regulation targets (emotion, cognition, and self-reflection) in multiple settings: neuroimaging and behavioral lab-based measures, virtual reality, and passive smartphone sampling. By connecting human neuroscience and behavioral science in this manner within the ENGAGE study, we develop a prototype for elucidating the underlying self-regulation mechanisms of behavior change outcomes and their application in optimizing intervention strategies for multiple chronic diseases.

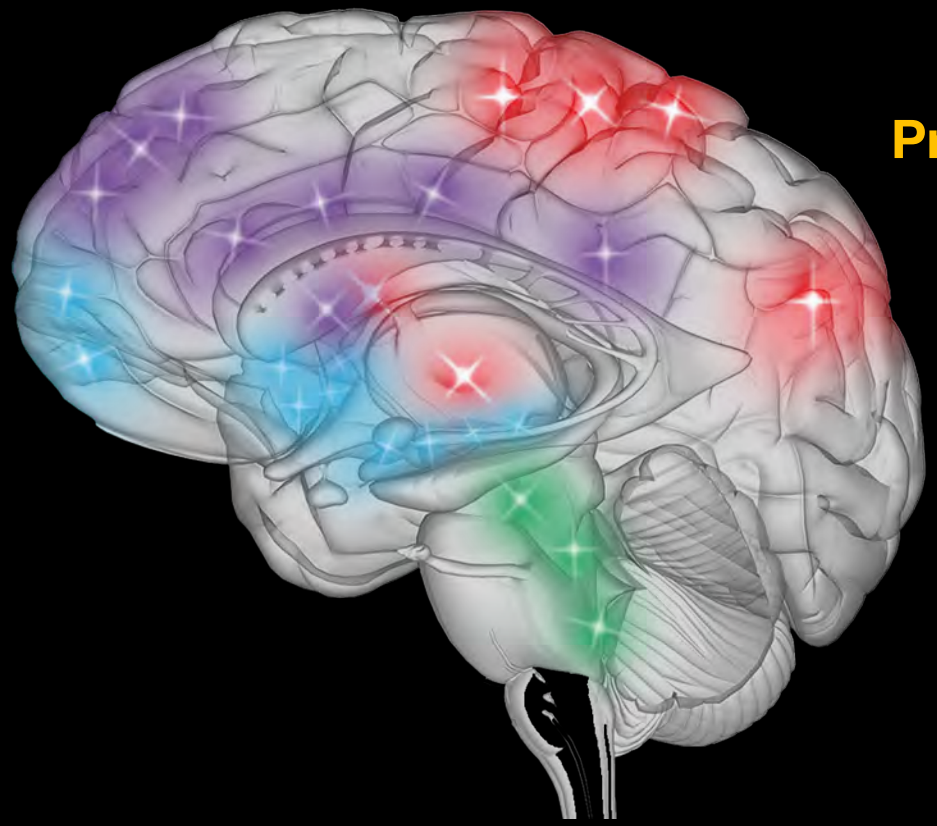
More Than 327 Clinical Application Areas

Targeting Multiple Clinical Sectors and Specific Indications

Acute Pain	Addiction Medicine	ADHD	Anxiety Management	Autism Spectrum Disorder	Chronic Pain
Cognitive Assessments	Depression	Disability Solutions	Emergency Medicine	Medical Education &Training	Ophthalmology
Orthopedics	Palliative Care	Patient Education	Phobias PTSD	Physical Medicine and Rehabilitation	Preventive Medicine
Respiratory Medicine	Senior Care	Stroke & TBI	Surgical Procedure Planning	Surgical Skill Training	Uncomfortable Procedure Distraction

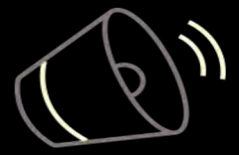
Clinical VR/AR Systems Have Impact

Learning & Retention



Presence & Context

Muscle Memory



Motivation/Engagement

Increased Cognitive Engagement

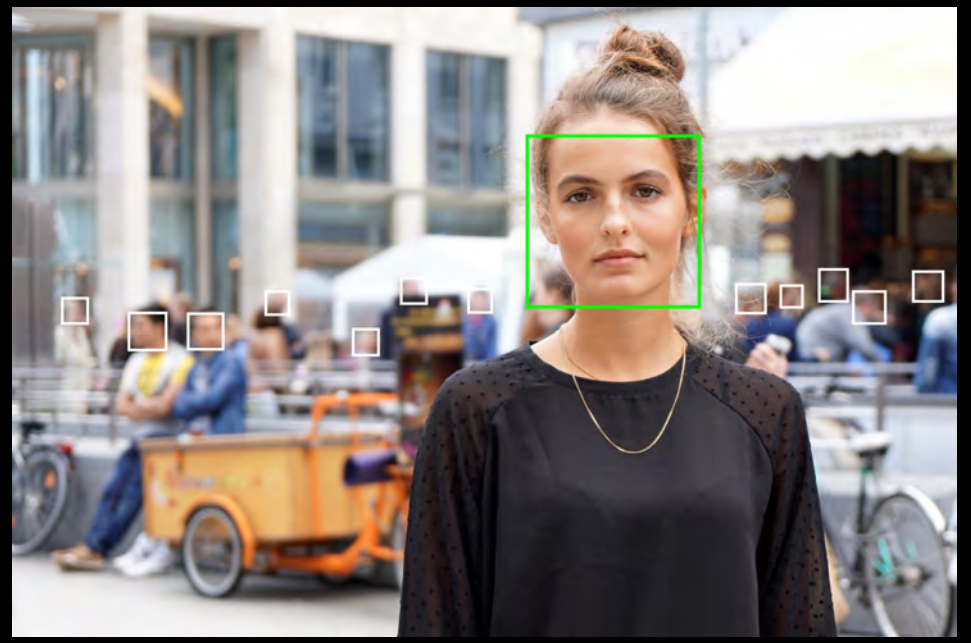
Improved Clinical Adherence

High Dropout Rates for Mental Health Apps

More than 1/2 of the participants in mental health app studies drop out in week #1

Lack of engagement is the primary reason

High dropout rates present a threat to the validity of RCTs of Mental Health Apps



Dropout rates in clinical trials of smartphone apps for depressive symptoms: A systematic review and meta analysis
December 2019
Journal of Affective Disorders 263

Current Examples of XR Systems Applied to Clinical Care

Functional Training

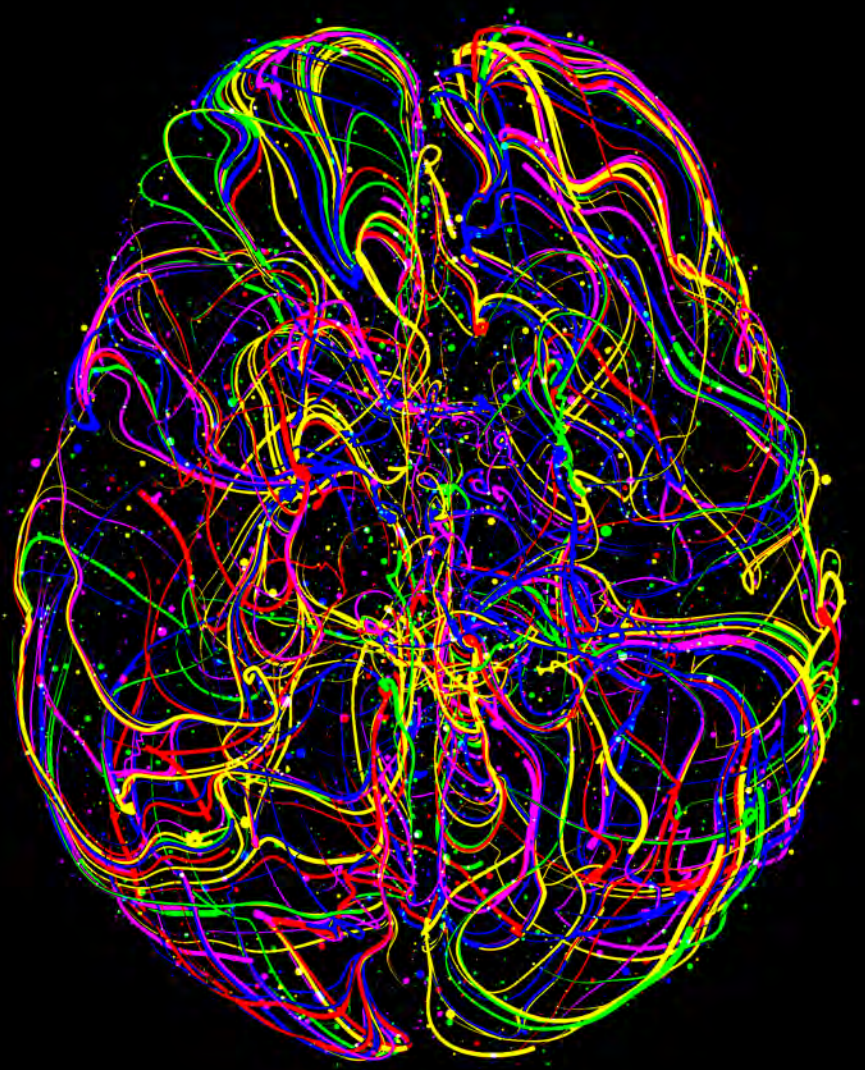
Objective Assessments

Improved Interventions

Facilitated Adherence

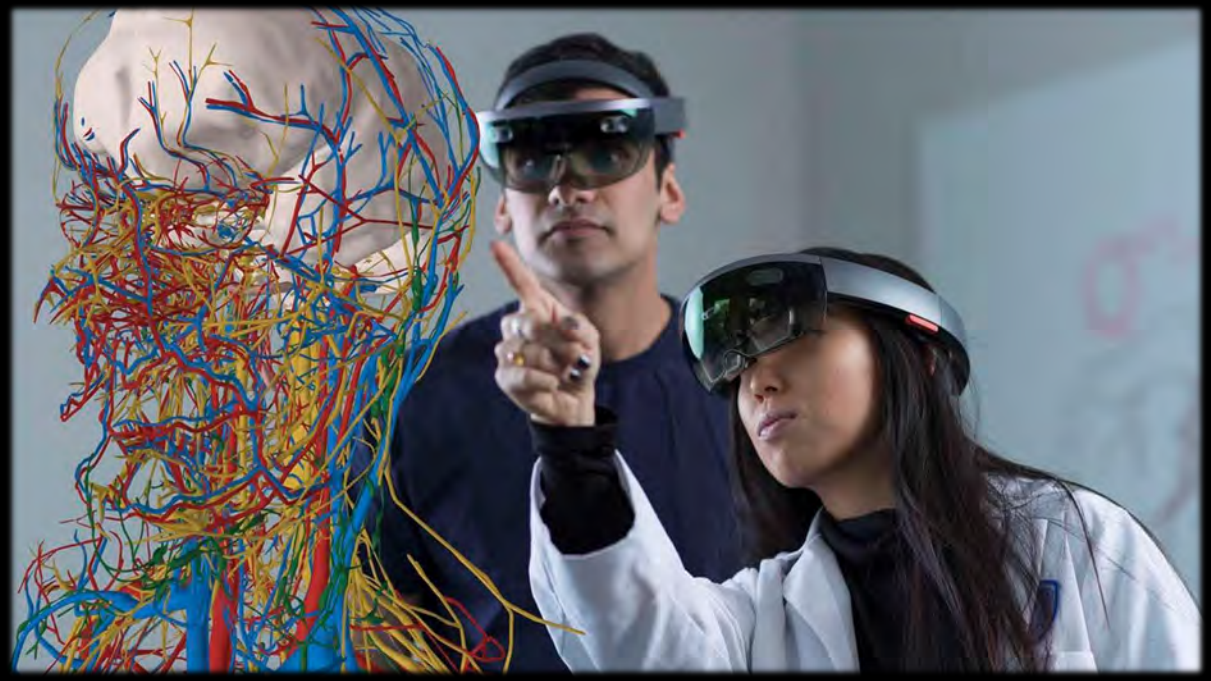
Distributed Care Delivery

Prevention and Wellness



Medical Education and Training

- Clinical Skill Training
- Surgical Skill Training
- Interpersonal Skill Training
- Use of Equipment and Tools
- Team Training:
  - Emergency Department
  - Surgical Team
- Hospital-Wide Emergency Response Training and Rehearsal



VR simulation to train medical students and staff to respond in high-stakes, low-frequency pediatric emergencies.

Pediatric Resuscitation

Children's Hospital LOS ANGELES

USC University of Southern California

Virtual Standardized Patient Simulators

Standardized patient simulators offer medical educators a powerful way to enhance both technical and interpersonal skills.

- Increasing the effectiveness of therapy skills of psychologists
- Enabling prospective nurses to master giving an effective patient history and coaching interview
- Allowing pediatric healthcare providers to train in scenarios involving a parent and an elementary-age child
- Enhancing the debriefing skills of a surgical team

Preparation and Training for Difficult Situations

Improving the communication skills of a doctor delivering a negative diagnosis

VR/AR Technology Provides for Objective Assessments

Functional Training

Objective Assessments

Improved Interventions

Facilitated Adherence

Distributed Care Delivery

Prevention and Wellness

Improved Assessments

Activities of Daily Living Assessments

Physical Medicine – OT / PT

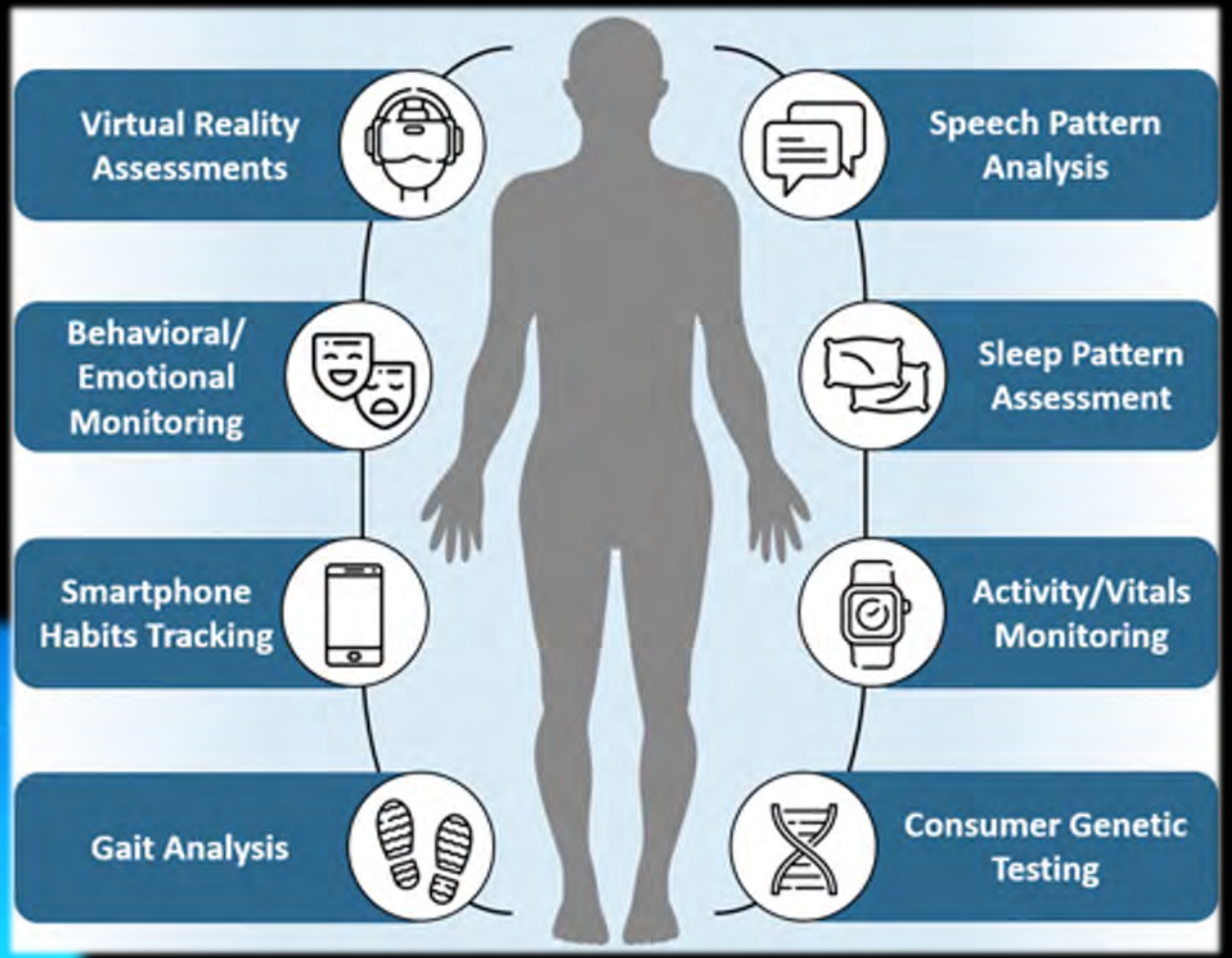
OBJECTIVE ASSESSMENTS

Cognitive Function

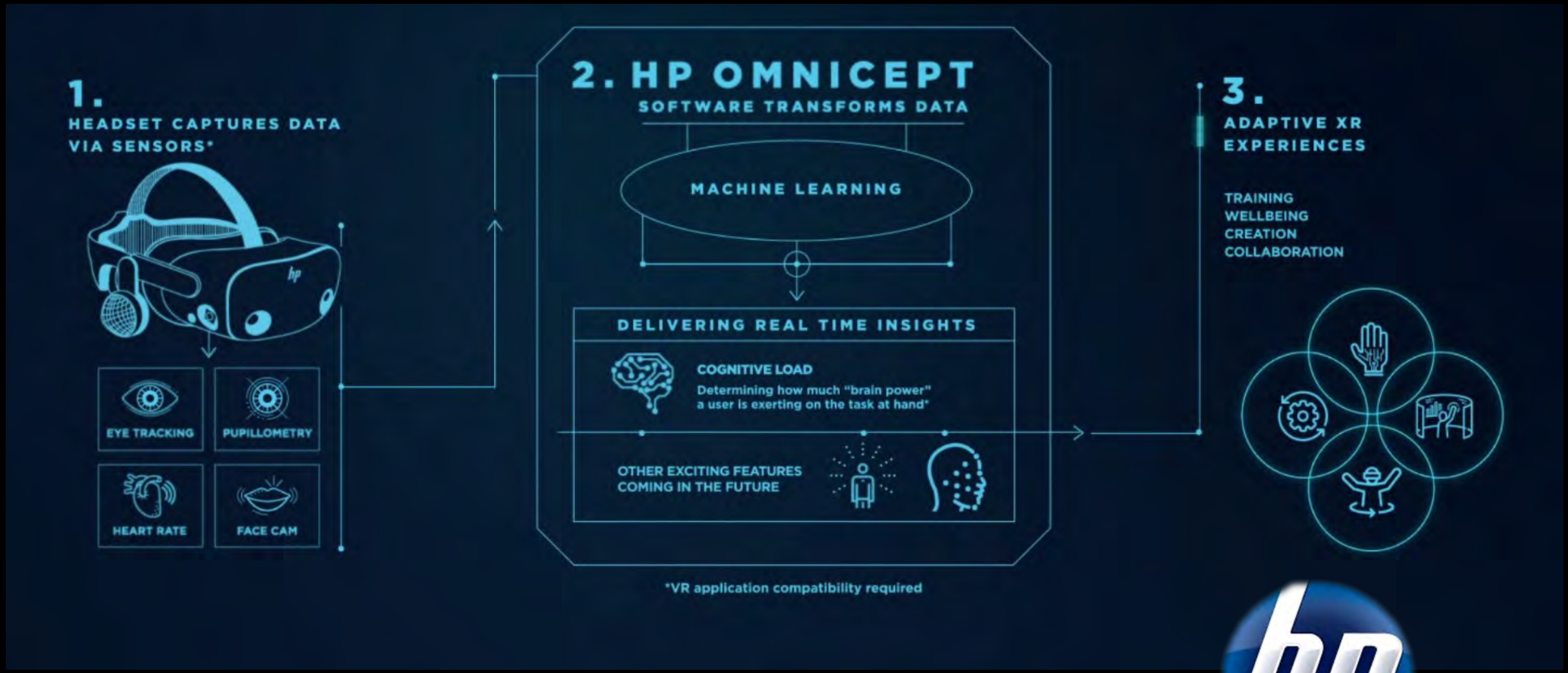
Neuropsychological Assessments

Behavioral Medicine

Psychology, Psychiatry



Uncovering the signals that index cognitive load



XR Technology Provides for Improved Clinical Interventions

Functional Training

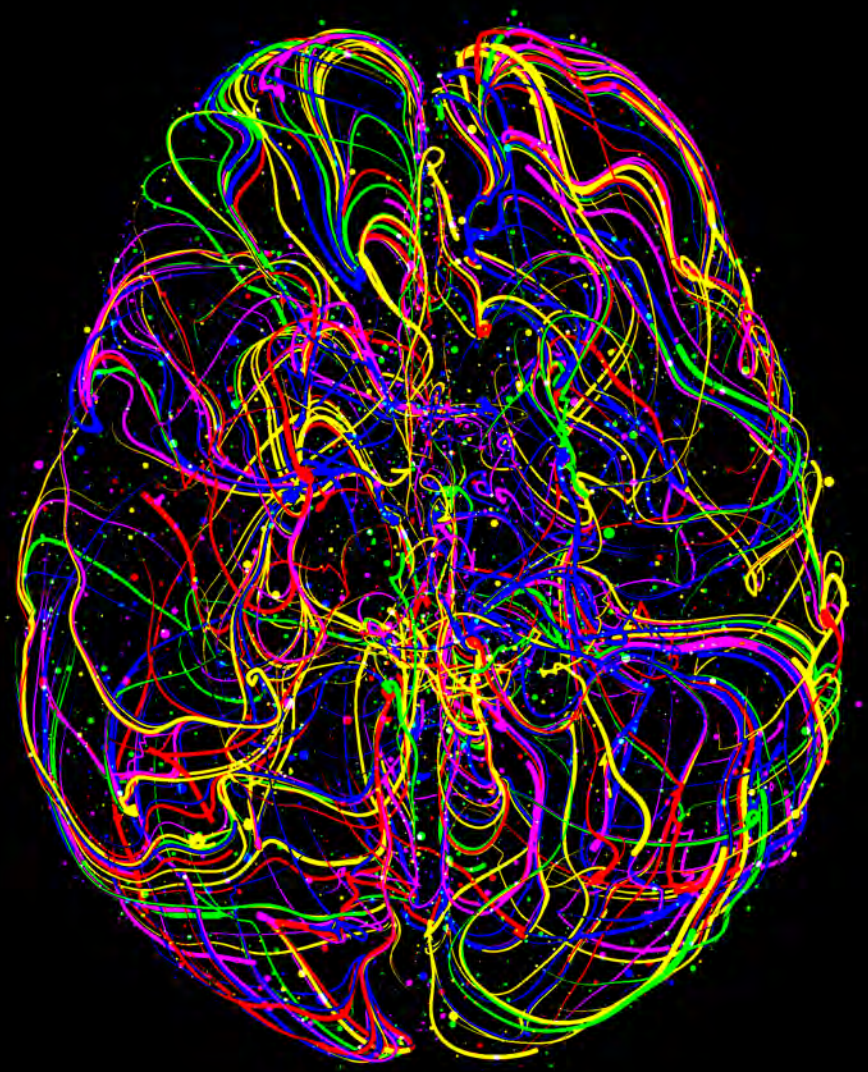
Objective Assessments

Improved Interventions

Facilitated Adherence

Distributed Care Delivery

Prevention and Wellness



Preoperative Planning & Image Guided Surgery

New Approaches to Physical Medicine & Rehabilitation

Stroke and Traumatic Brain Injury

Physical / Occupational Therapy

Neuro Cognitive Rehabilitation

Penumbra

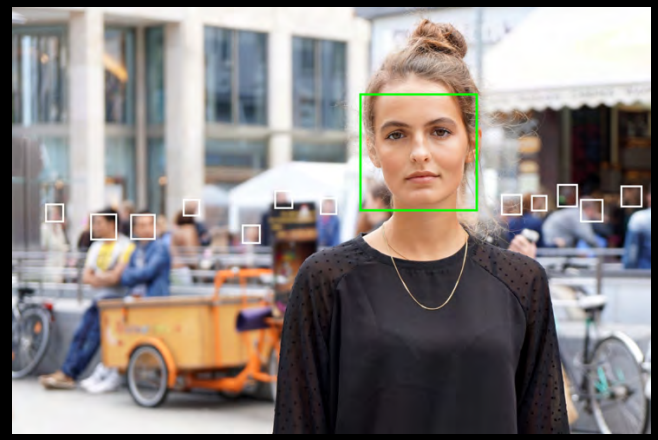
REAL™

NEURO REHAB VR

Virtuleap

MIERON
VIRTUAL REALITY NEUROTHERAPY

Urgent Need for New Approaches to Mental Healthcare



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

Generalized Anxiety Disorder

Phobias

Addictions

Social Anxiety Disorder

Depression

Chronic Pain

Autism Spectrum Disorder

ADHD

Obsessive Compulsive Disorder

Anger Management

Schizophrenia

VR/AR 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

PTSD, Phobias, 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

XR Systems to Support Therapy For Addictions

Refusal skill training

Risk avoidance training

Situational confidence training

HEALTH AND WELLNESS

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

In Summary

Medical VR/AR Systems – Overall Status and Opportunity

Current technologies and concepts are founded on more than *30 years of research and development*

Recent changes in cost and access make dynamic assessment and intervention systems affordable

After years of study and use by early adopters –
validated systems are poised to move to the mainstream

On the horizon - enhanced, ubiquitous, informative and integrated

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