Machine Learning, Biosensing, Virtual Reality Technology

Converging to Transform Healthcare

Walter Greenleaf PhD

Stanford University VIRTUAL HUMAN INTERACTION LAB

Stanford HEALTH CARE

National Mental Health Innovation Center

UNIVERSITY OF COLORADO **ANSCHUTZ MEDICAL CAMPUS**

VR / AR Technology and Healthcare

The Digital Health Revolution

Emerging and Confluent Technologies

Overall Landscape of XR Technologies

Neuroscience – Why XR Has Impact

History of VR - and Why it Matters

Current Status – Where There is Traction

Future Perspective and Predictions

Academic Affiliations

BRAINSTORM
The Stanford Laboratory for Brain Health Innovation and Entrepreneurship

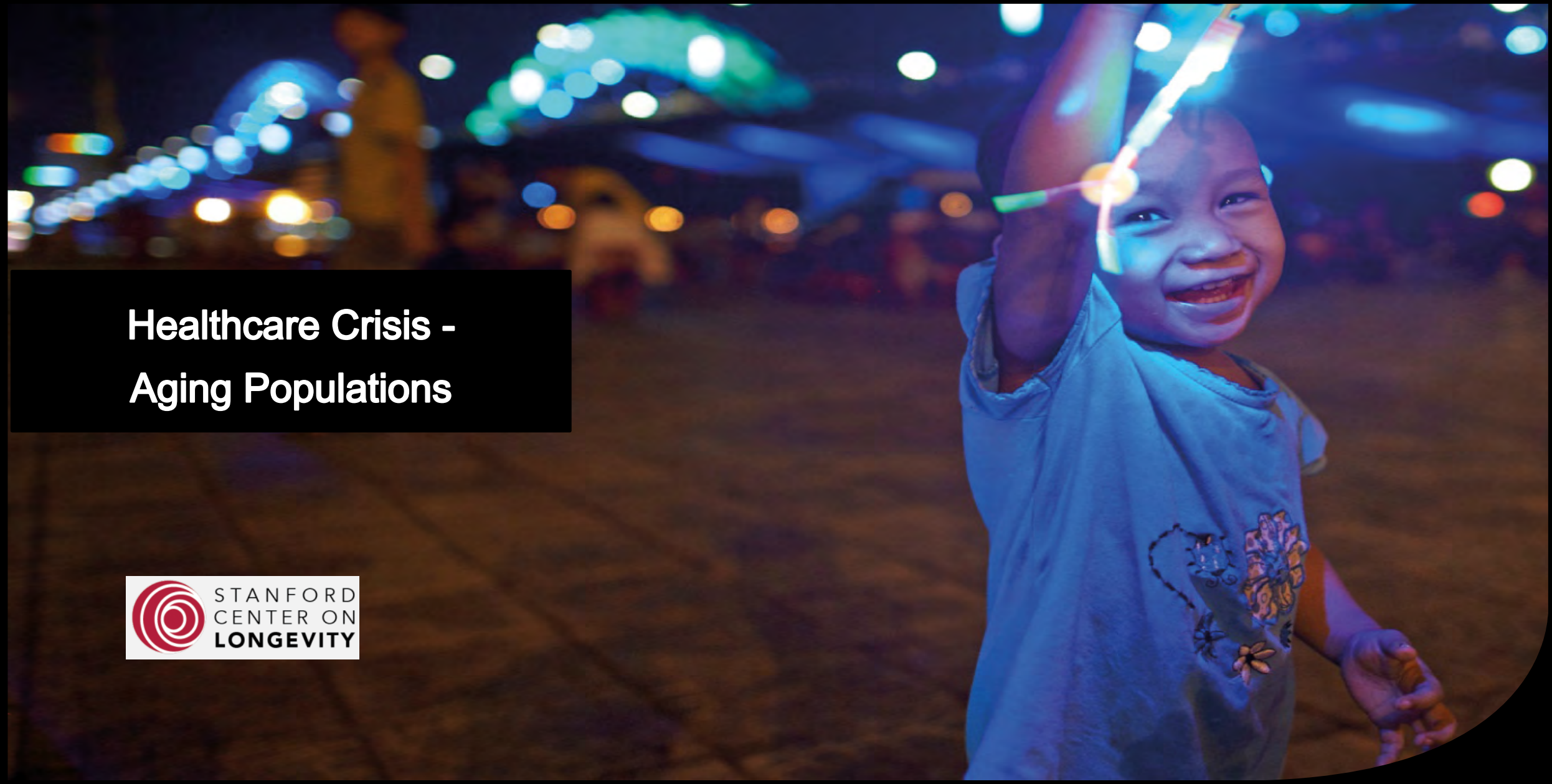
Stanford University
VIRTUAL HUMAN INTERACTION LAB

Stanford HEALTH CARE

media at Stanford University

VR-IT
Stanford Virtual Reality Immersive Technology Clinic

National Mental Health Innovation Center
UNIVERSITY OF COLORADO **ANSCHUTZ MEDICAL CAMPUS**



Healthcare Crisis - Aging Populations

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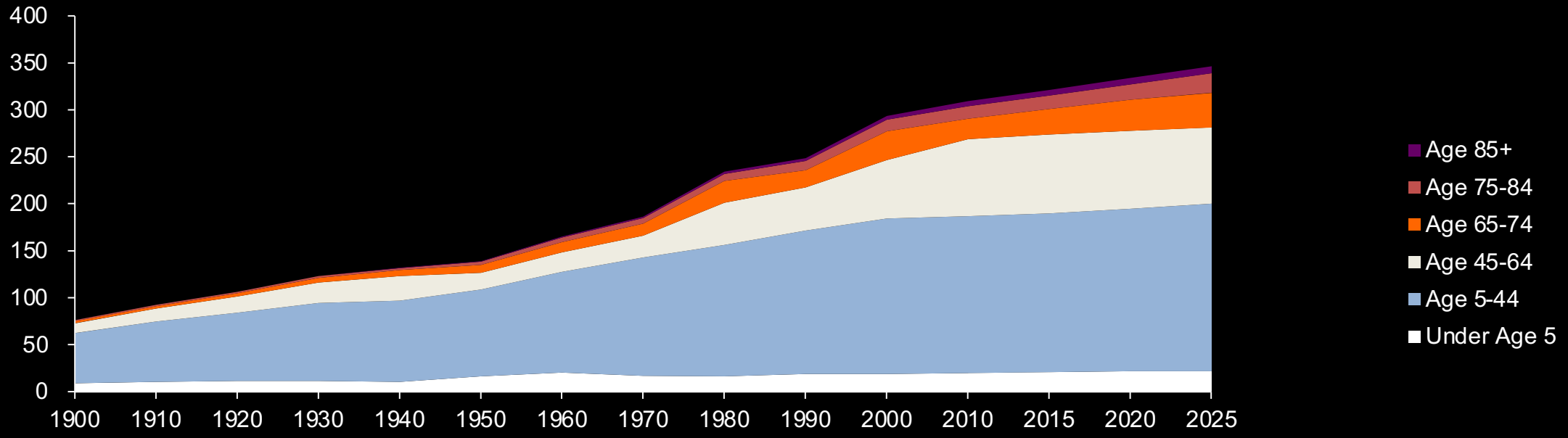
Healthcare Crisis:
Aging Populations



Transforming HealthCare with Technology

Joyance
Partners

Ellipsis Health

TAKE
PAUSE

HEALIUM

VR and AR Technology Impacts All Sectors of HealthCare

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

Recent changes in cost and access make VR/AR technology affordable

VR/AR systems are currently used for - prevention, evaluation, treatment, and chronic disease management

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

Digital Health Revolution

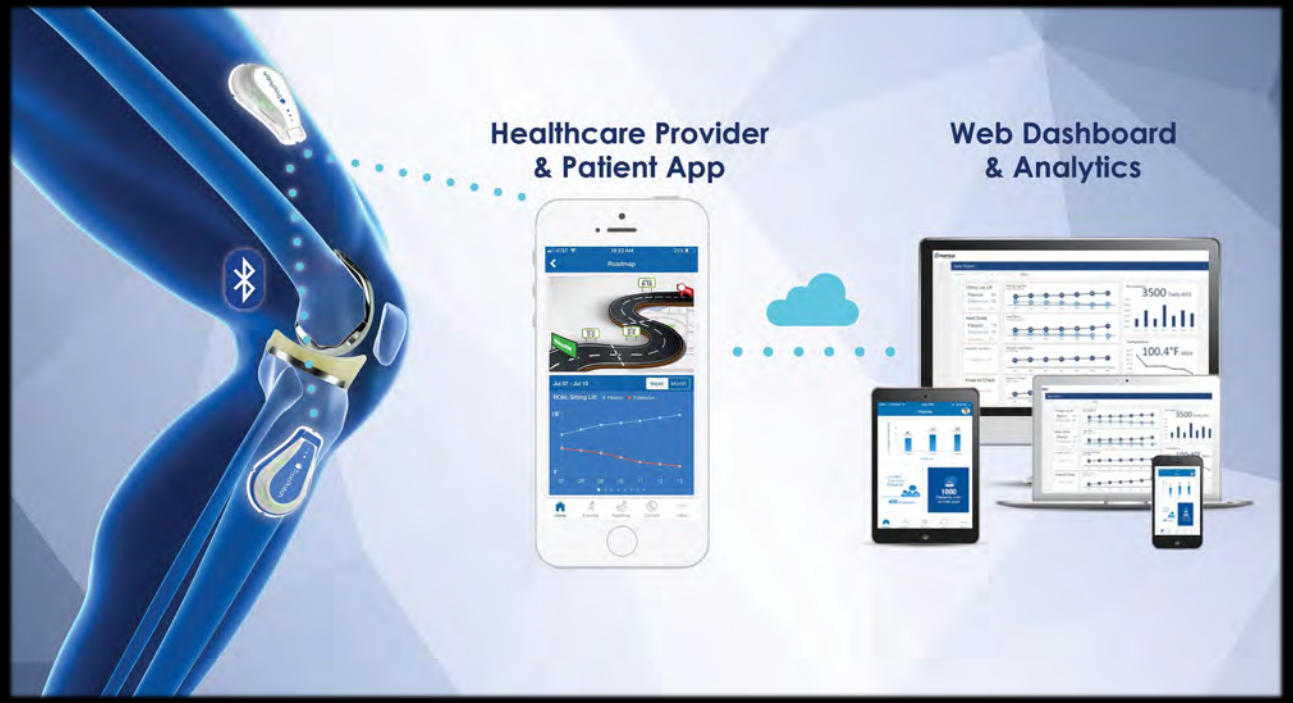
- Mobile Health / eHealth
- Machine Learning
- Wearable Sensors
- Patient Centered
- Leverages Internet:
  social, quantitative, collaborative

Digital Health technology will *significantly* impact Medical Care

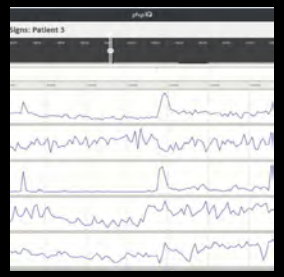
- Prevention and Wellness
- Objective Assessments
- Functional Training
- Improved Interventions
- Facilitate Adherence
- Distributed Care Delivery

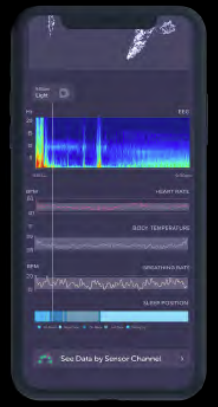
Every Medical Device Reinvented

Entering the Era of Medical Wearables



Wearables, Hearables…





Digital systems are not just measuring the physical parameters of our health.

New methods are being developed that will allow us to collect and analyze biomarkers that reflect our cognitive and emotional status.

Here are four examples…

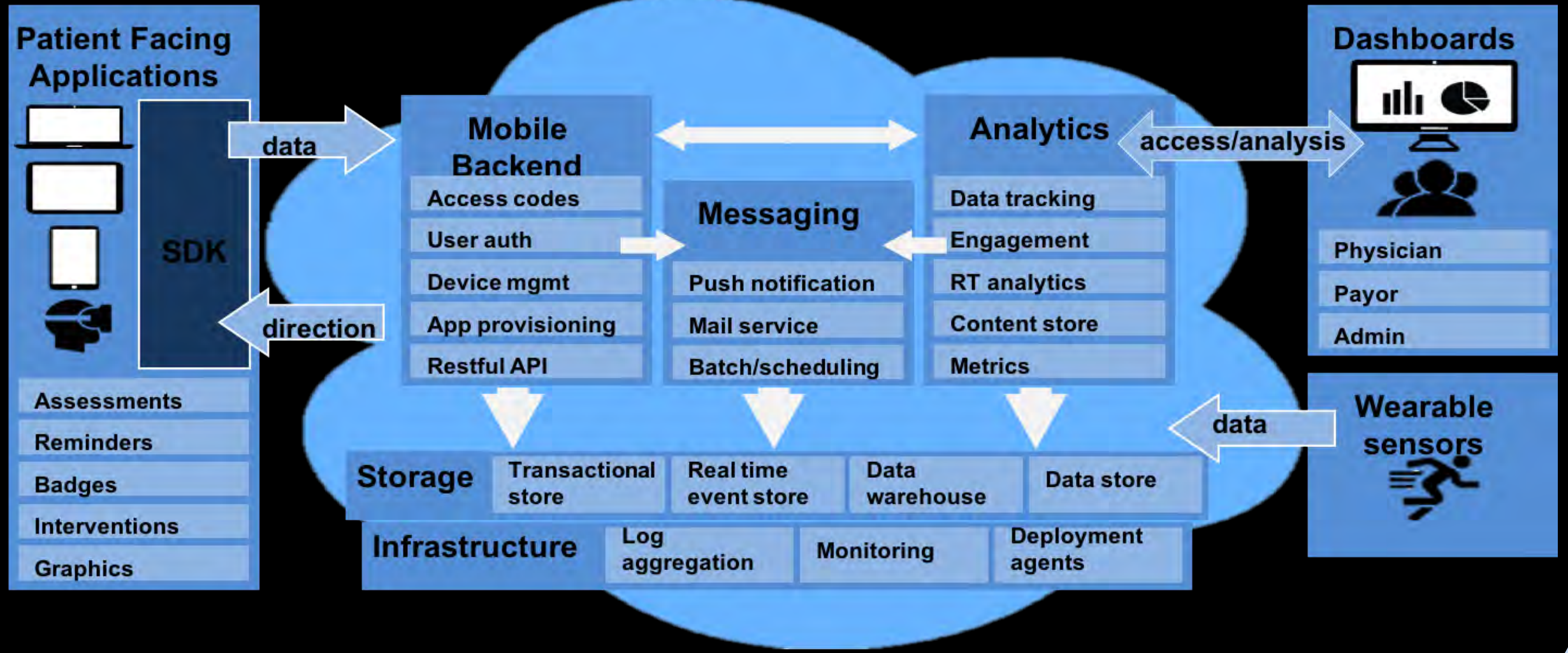
Brain Health BioMarkers - Passive Data from Smart Phones

Voice Analytics as a BioMarker of Depression

Facial expressions and other signals in response to a VR Challenge

Cognitive function assessment using AR and smartphone sensors

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



Prescription Digital Therapeutics

Combination Therapy - Digital Health Platform

Medication with clinical benefit

+

App-based system designed to enhance medication efficacy

=

Prescribed combination product with enhanced efficacy

Prescription Digital Therapeutics

Create Value In Areas Of High Patient Need

Combination Therapy	Software-based therapies have been shown to be effective as stand-alone interventions – there is incremental effectiveness when PTDs are used in combination with standard treatment
Dose Optimization	PDTs can monitor toxicity and personalize treatment Can leverage sensor data.
Address Comorbid Conditions	PDTs can monitor and address comorbid conditions: insomnia, poor nutrition, anxiety, depression, activity levels, use of nicotine and alcohol, etc
Facilitate Adherence	PDTs have several tools to facilitate adherence –provide key information, close the feedback loop, show progress, connect to the care team, leverage games and other motivational tools, provide reminders and sound alerts, etc
Collect Utilization And Efficacy Data	PDTs collect de-identified utilization and efficacy data – combined with sensor data Advancing research, facilitating improved formulations, and allowing for personalized protocols based on large-scale studies.

The “digital layer” creates value – across all parts of the clinical care

- Standardizes data collection for clinical studies
- Tracks the supply chain to a pill-by-pill level via QR codes etc.
- Collects real-world data supporting regulatory submissions
- Enhances clinician touch-points via data-based dashboards
- Enhances therapeutic adherence and efficacy
- Provides real-world data to support reimbursement discussions

Enhanced outcomes - plus value for patients, clinicians, and payors

For patients

- ***More convenient*** care, reducing transportation and wait times
- Offers the ***better outcomes*** for for patients
- Provides ***immediate care*** allowing patients to access therapeutic content when needed

For clinicians

- Enables ***data-driven care*** demonstrating efficacy and engagement
- Leads to greater engagement, ***fewer drop-outs, and reduced no-shows***
- *Extends the reach of the clinician –* ***facilitating improved follow-up and reduced readmissions****.*

For payors

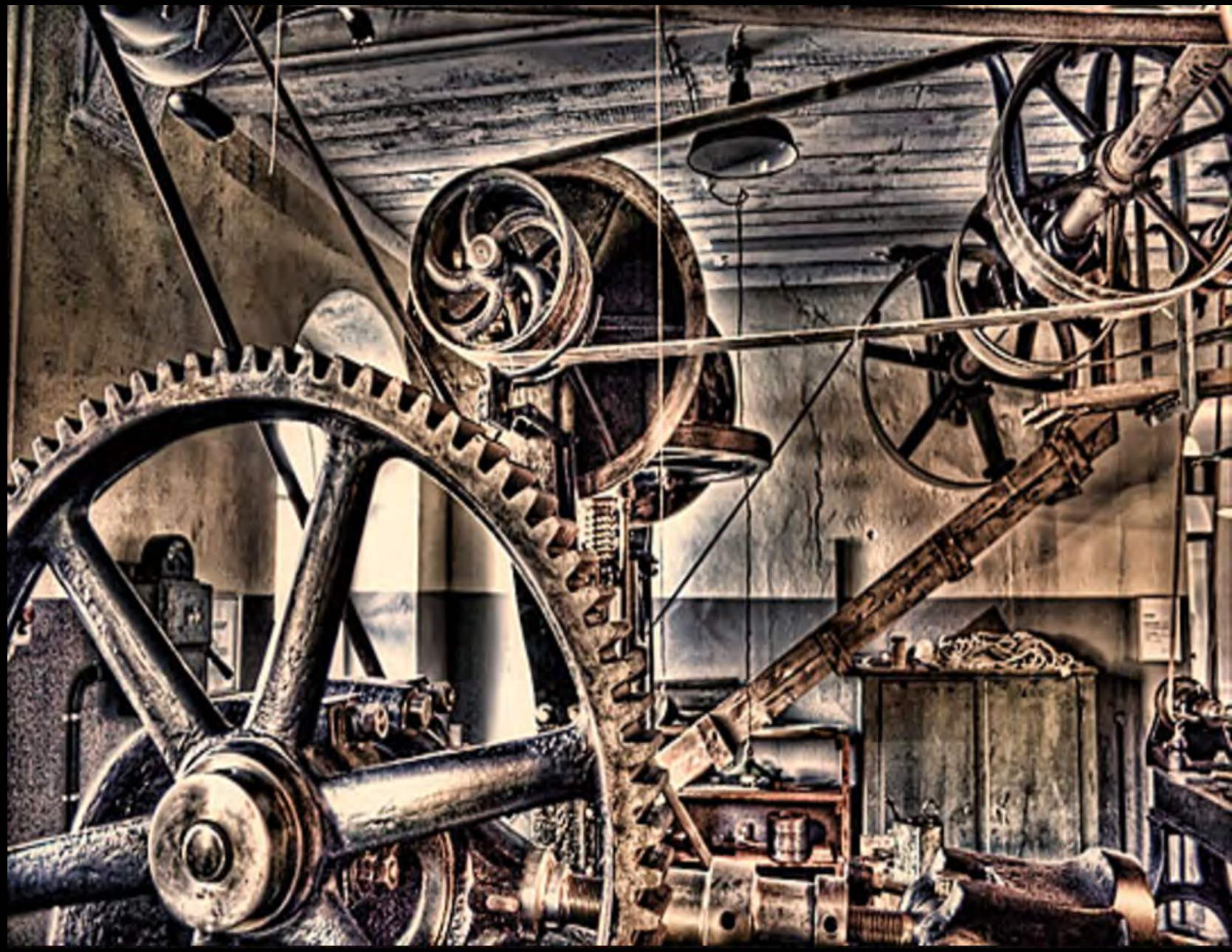
- Collects data to ***measure and validate quality of care***
- Allows evidence-based treatment to be ***widely standardized***
- ***Reduces overall care costs*** for a large and expensive patient population

One Example- Depression: Intervention and Digital Adaption Possibilities

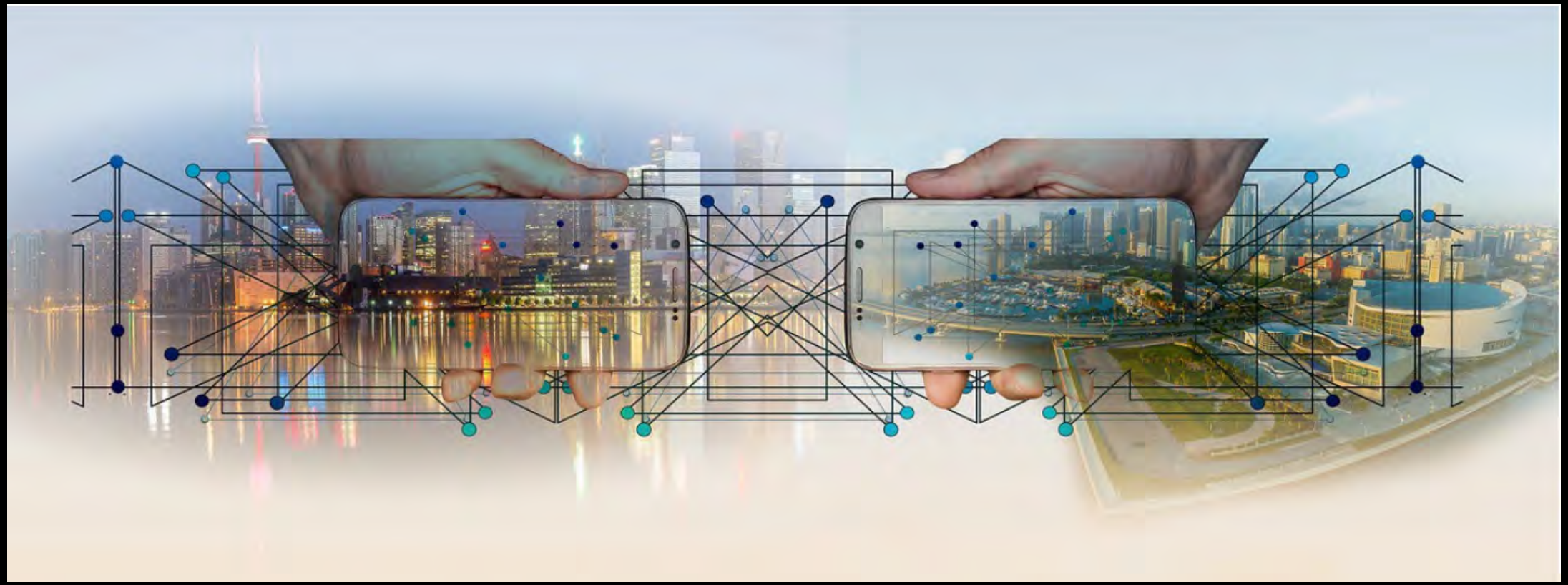
Intervention	Key Components	Example Targets	Digital Adaption Possibilities
Cognitive Behavioral Therapy (CBT)	• Capture thoughts that arise in response to specific situations • Check those thoughts to determine if they are accurate or distorted • Change distorted thoughts by substituting them with more helpful thoughts.	• Target: depressive thoughts • Identify thoughts that arise in response to situations. • Identify distortions in thinking. • Identify accurate, more helpful thoughts.	Gamified exercises: • Catch it – identify automatic thoughts • Check it – evaluate it against list of common distortions • Change it – come up with more accurate interpretation of the event.
Behavioral Activation (BA)	• Identify life values and goals • Identify activities that are aligned with those values • Create a hierarchy of activities • Schedule these activities and track progress over time	• Target: avoidant behavior • Value identification • Activity Scheduling • Tracking mood and activities	Interactive feature with: • Values clarification • Identifying and scheduling activities to support those values • Tracking activities and mood

Mindfulness Meditation	• Progressive muscle relaxation
	• Guided imagery
	• Guided meditation
		• Target:
		  • Relax the body
		  • Relax the mind
		  • Be fully present
			Guided meditation activities
			(e.g Headspace, Calm)
			Full meditation courses

Emerging and Confluent Technologies



5G connections will surpass one billion by 2023

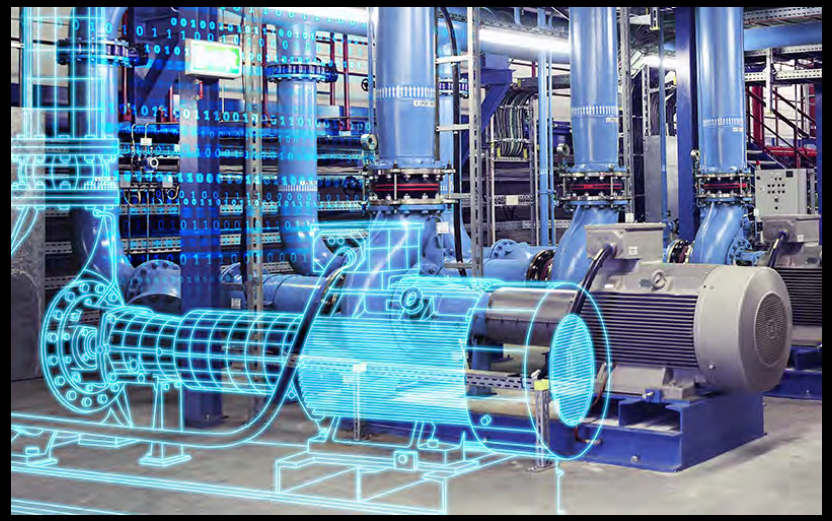


Single-digit millisecond latencies with Edge Computing

Cloud-Rendered AR and VR content

Real-time Analytics for Machine Learning, Predictive Modeling

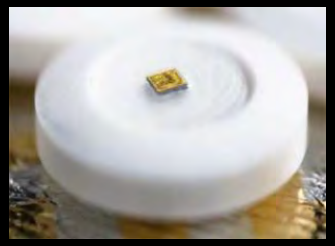
Machine Learning

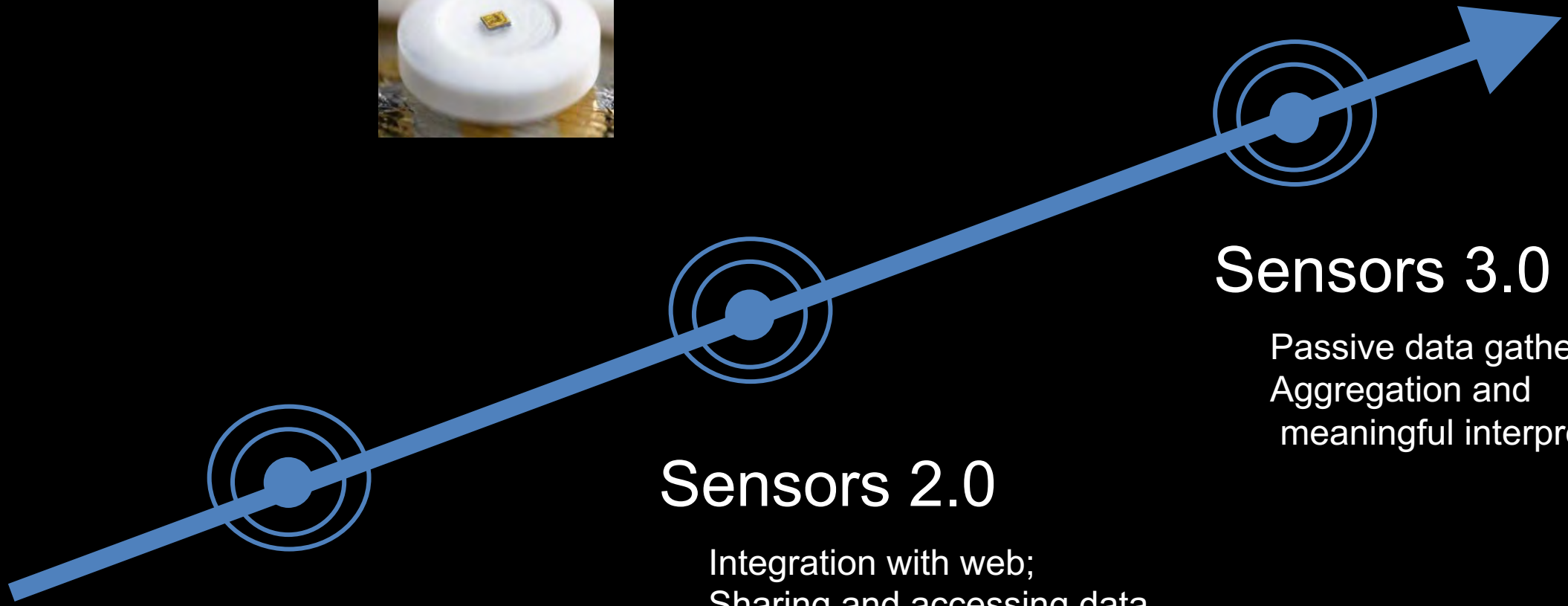


Digital Twin Paradigm

For Precision Healthcare

Sensors Are Evolving, Connecting, Promulgating





Sensors 1.0

Measure and record

Sensors 2.0

Integration with web;
Sharing and accessing data

Sensors 3.0

Passive data gathering;
Aggregation and
meaningful interpretation

Ready or not…

The wearable tech, always on, always online world

On the way - arriving soon.

Other Dimensions of Sensory Input - Enhanced Immersion

Scentware

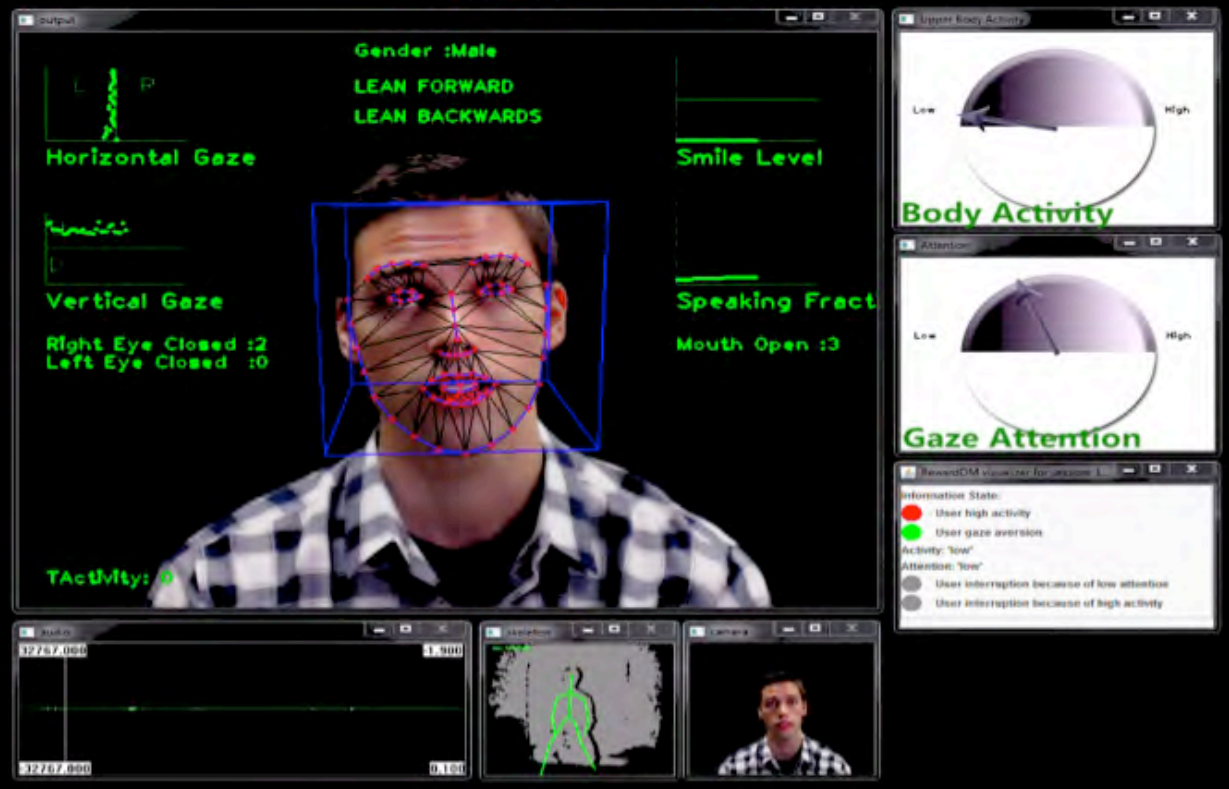
9 scent actuators with interchangeable cartridges
Library of over 250 scents
Custom scent creation

OVR TECHNOLOGY

Aaron Wisniewski

Virtual Humans - Voice Recognition, Emotion Detection- Dynamic Response

MultiSense



SimSensei

Virtual Humans For Education, Training, Support

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

Virtual Worlds – Multiuser Immersive Experiences

Cloud-based 3D real time rendering

BLOCKCHAIN

CLEANBOX

Kills 99.99% of viruses, bacteria and fungi, supported by independent lab testing

- Utilizes medical grade UV-C light in an LED, eliminating the need for heat, moisture or toxins in the decontamination process
- Multi-functionality can include storage, locking, charging and credit card access capabilities
- Can be used for any size hardware or products including HMDs, production/broadcaster headsets, earphones, tablets and cell phones

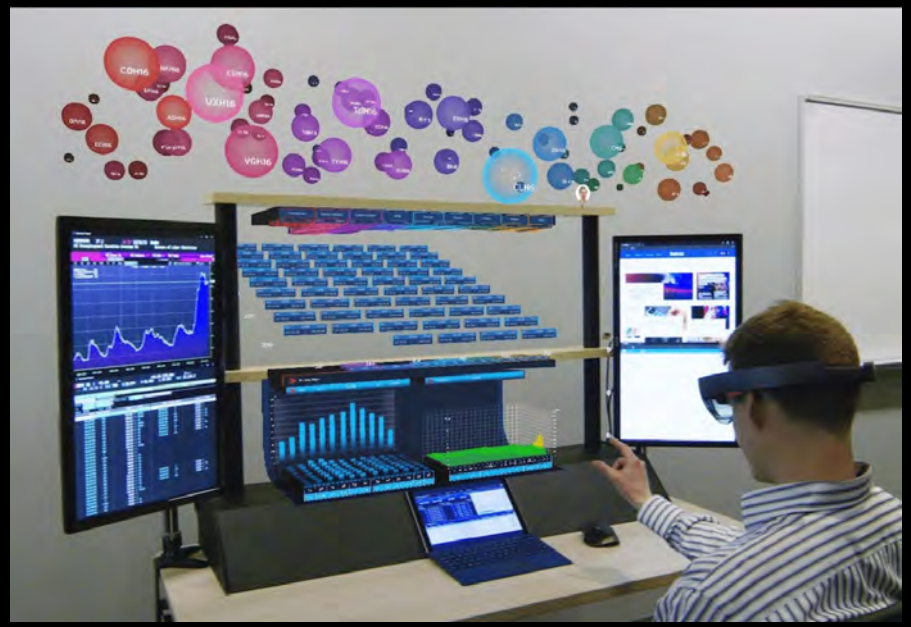
Amy Hedrick

VR + AR + MR = XR

THE LANDSCAPE

GAINING MOMENTUM
EVOLVING RAPIDLY

The Next Computer Platform



Work
Play
Educate
Socialize
Shop
Entertain
Communicate
Etc

Now is the time for VR & AR

XR technology is now affordable, scalable and accessible

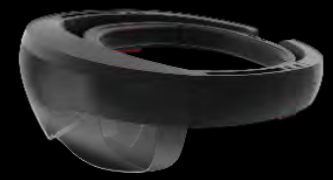
Varjo HMD - 60 PPD for 20/20 vision resolution

HP - Reverb

Sony – PlayStation VR

Facebook - Oculus

Microsoft - HoloLens



HTC - Vive

Apple -

Why use XR?

Uniquely Capable

Extension of existing virtual capabilities

Intuitive “spatial” language

natural interactions streamlines engagement

Highly Functional

Experimenting with systems & concepts to better understand

Applying learned concepts in practice

Can do things are otherwise expensive or impossible

-e.g. due to safety/cost

Deeply Personal

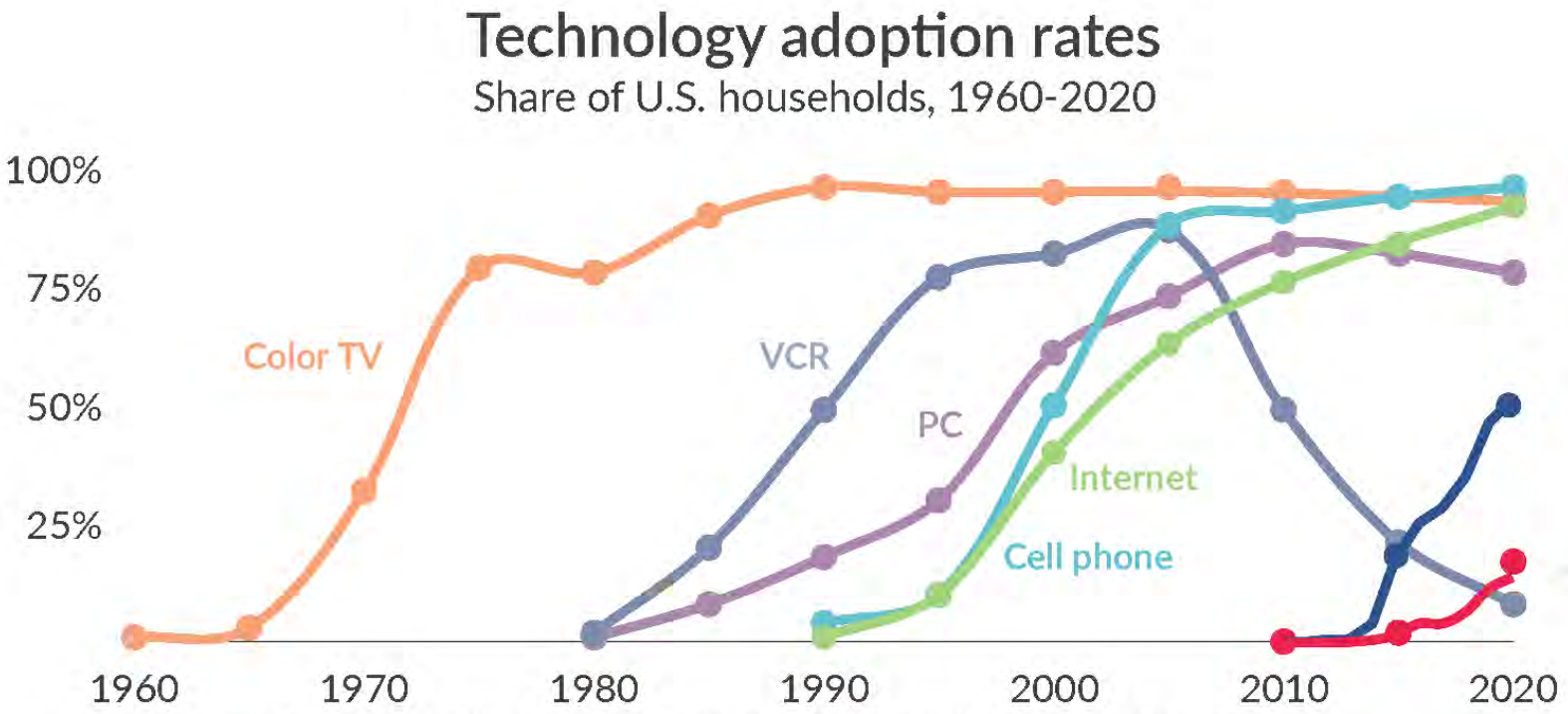
Learning content made meaningful through user’s interaction & feedback

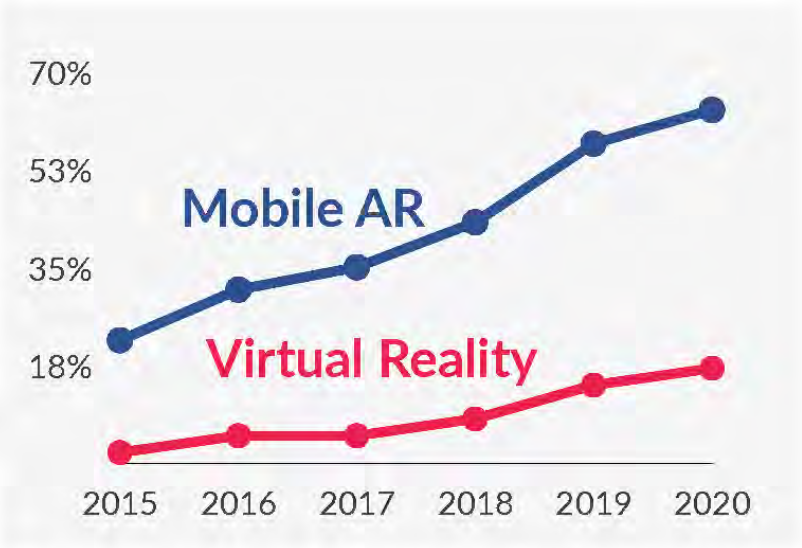
Immersion enhances **engagement**, retention

Making experiences “personal” drives motivation to learn & keep learning

VR Adoption

Technology adoption rates
Share of U.S. households, 1960-2020

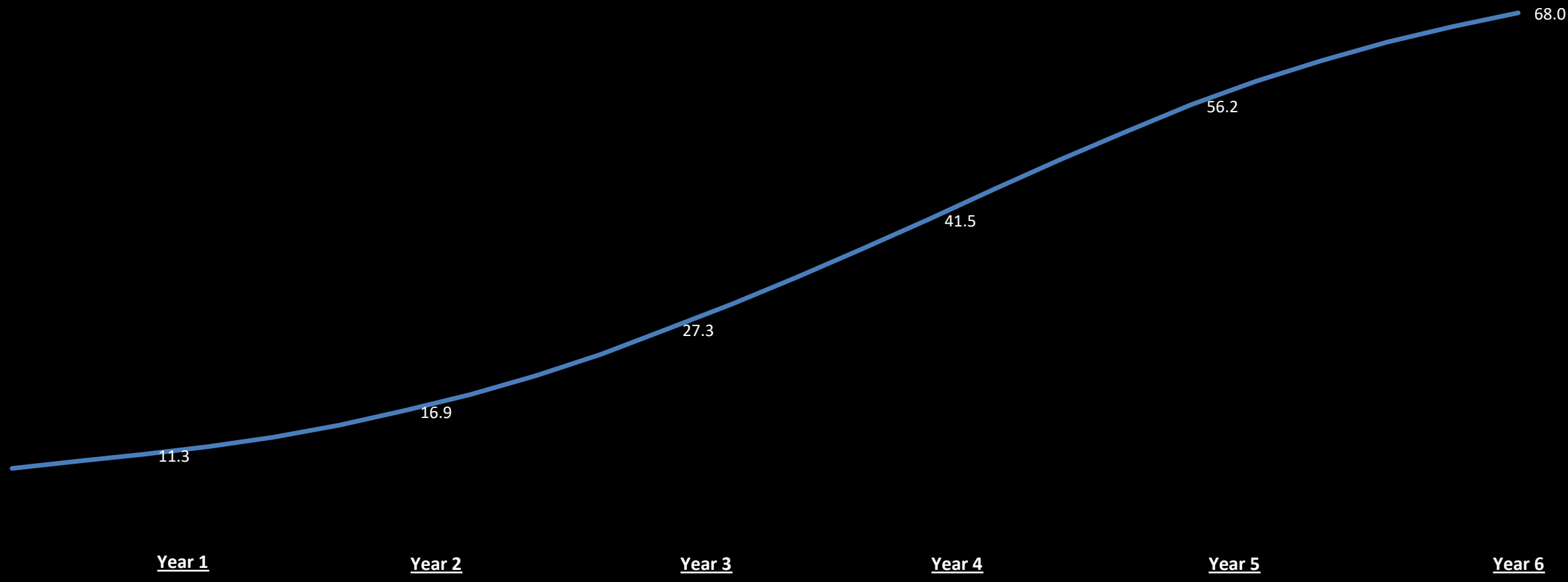




*Includes all mobile phones that have accessed an AR-enabled at least once that year
**Includes Google Cardboard-based devices.

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

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



XR Technologies

Currently Disrupting

- Education & Training
- Manufacturing
- Maintenance
- Product Design
- Process Design
- Healthcare
- Simulation & Modeling

Digital Health Revolution

Medical Applications of Virtual Reality & Augmented Reality (XR) Technology

XR Technology Impacts All Sectors of HealthCare

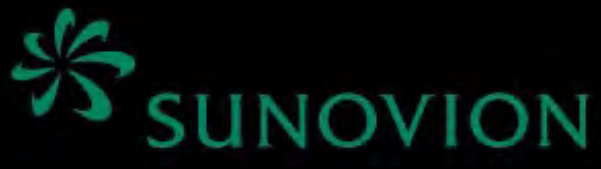
- Prevention and Wellness
- Objective Assessments
- Functional Training
- Improved Interventions
- Facilitate Adherence
- Distributed Care Delivery

More Than 200 Emerging Medical VR/AR Companies 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 Mitigation

Significant Investment in XR for HealthCare

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



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

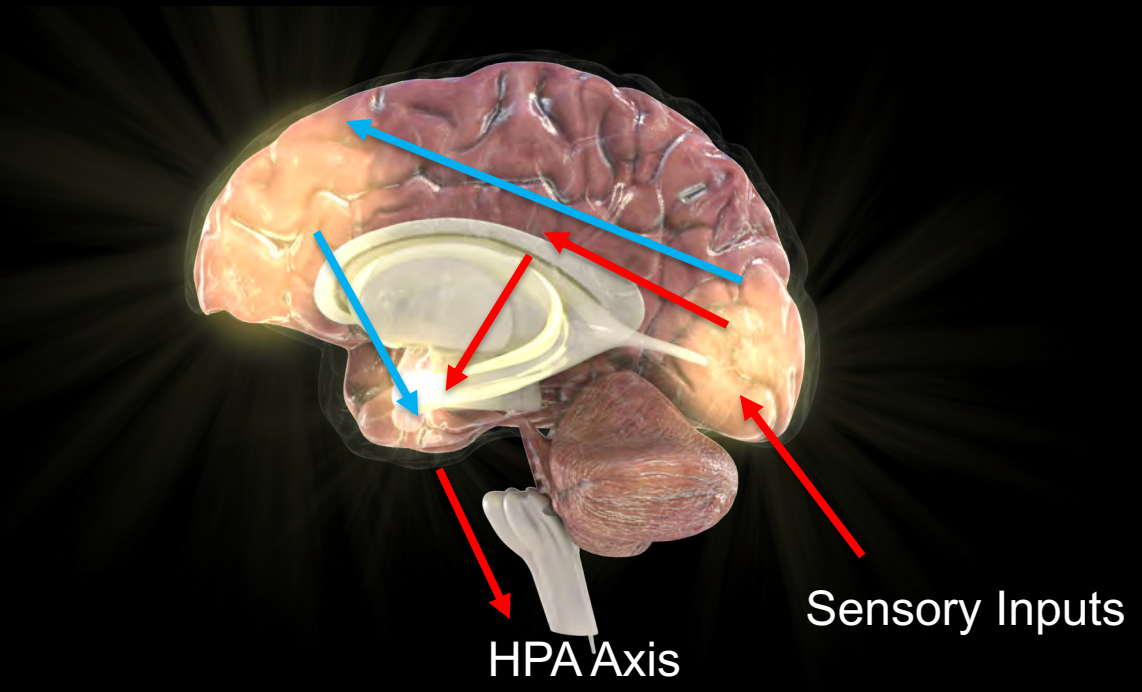
Leverage mirror neuron systems

VR is More Effective than Imaginal or *In Vivo* Exposure Techniques

VR exposure floods the visual thalamus and cortex, activating both subcortical, threat detection and response pathways as well as cortical, conscious pathways

In this manner, VR exposure therapy is more effective than imaginal exposure therapy - it activates both exposure/cognitive processes and threat extinction processes.

In vivo exposure is inconvenient, expensive, time-consuming, difficult to standardize, difficult to monitor, and imposable to provide in a graduated or controlled manner.



Leveraging Mirror Neurons

Ability to change attitudes and behavior after “being” one’s future self.

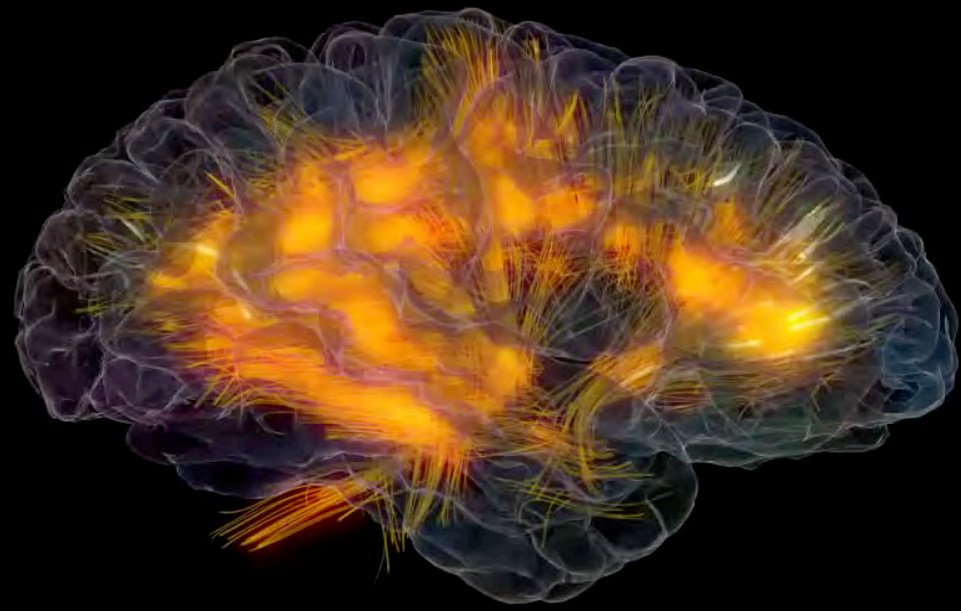
Stanford University
VIRTUAL HUMAN INTERACTION LAB

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



Addition Mechanisms of Impact

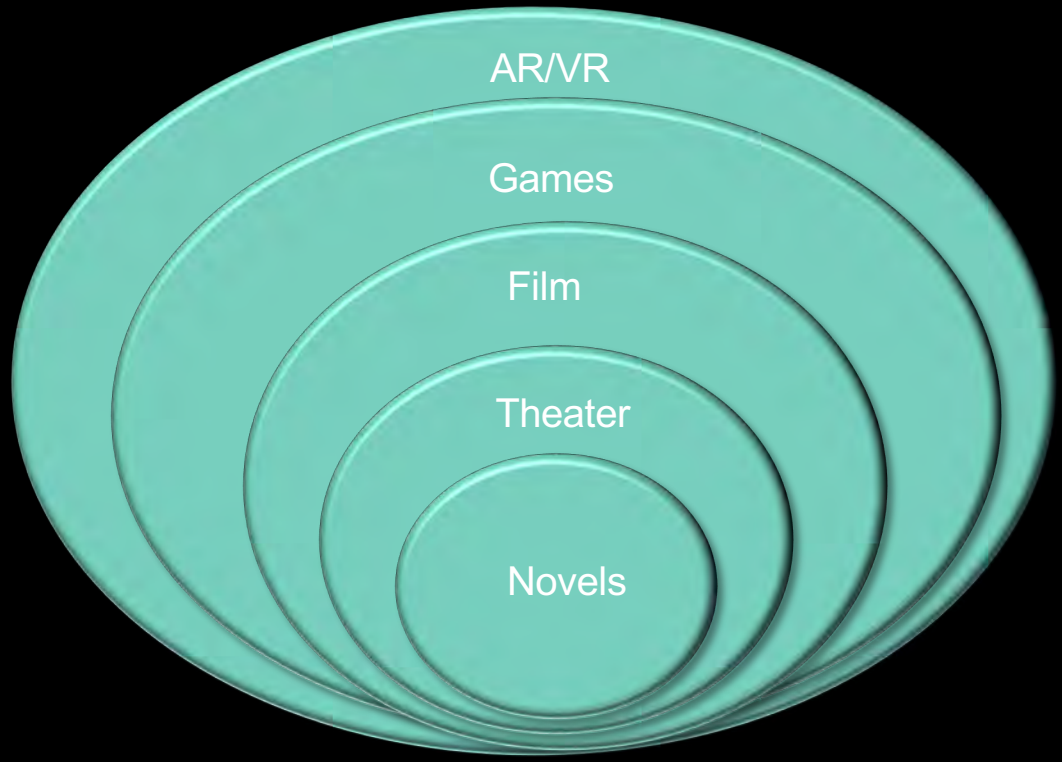
Active Involvement: XR systems provide users with immersive experiences that maximize cognitive engagement.

Feedback: learning is reinforced by direct, immediate and relevant feedback that reinforces the experience and the lessons learned.

Engaging and Motivating: the dynamic nature of VR/AR systems provides users with agency and can provide immediate rewards for progress.

Team Training: Multiuser experiences can provide and leverage group skill building.

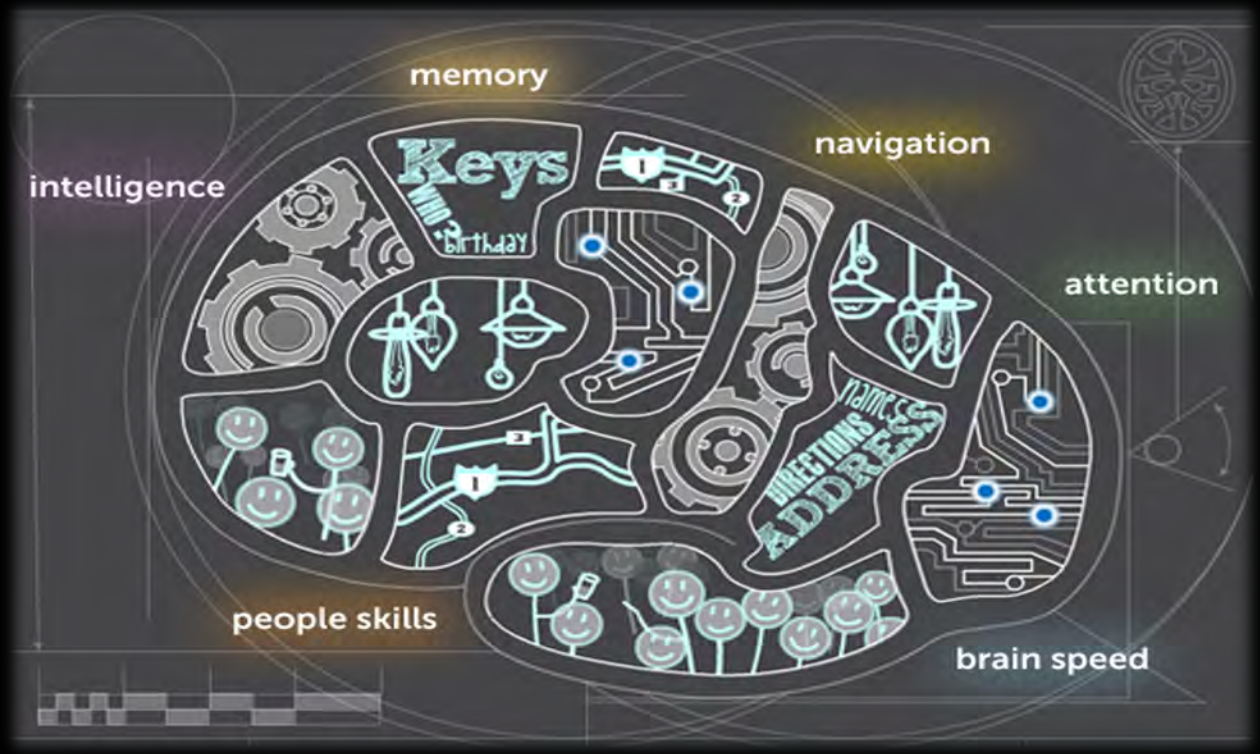
Cost Effective: XR systems extend the reach and reduce the cost of face-to-face training.



Wired for Narrative Stories

Research shows that STORY:

- Provides superior retention
  (memory and recall)
- Provides improved understanding
- Creates context and relevance
- Creates empathy
- Promotes engagement and participation
- Enhances the creation of meaning and personal relevance



VR Technology Has Evolved

1987

First general purpose and commercially available VR systems.

My 37 Year Journey….

1984 – Stanford University

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

Development and early evaluation of the *Virtual Iraq/Afghanistan* exposure therapy system for combat-related PTSD

Social Attention in a Virtual Public Speaking Task in Higher Functioning Children With Autism

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

Behaviour Research and Therapy xxx (xxxx) xxx–xxx

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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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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.

13 Years Ago

Mitigating Post Traumatic Stress With Virtual Reality

2008 Sichuan Earthquake

Three Years Ago

Mitigating Post Traumatic Stress With Virtual Reality

2017 Mexico City Earthquake

Happinss®

One year ago…

Mitigating Stress
With Virtual Reality

Nashville Tornado

Sarah Tico

Sarah Hill

XR 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 Procedure Training

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

Virtual Patients for Clinical Skill Training

Virtual Standardized Patient Simulators

Mursion's virtual standardized patient (VSP) simulators offer medical educators a powerful way to enhance both technical and interpersonal skills.

- Improving the communication skills of a doctor delivering a negative diagnosis
- 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

Mursion

Children's Hospital LOS ANGELES

USC University of Southern California

Todd Chang. MD

CHLA Emergency Department

Pediatric Resuscitation

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

Preparation and Training for Difficult Situations

XR technology will *significantly* impact Medical Care

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

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

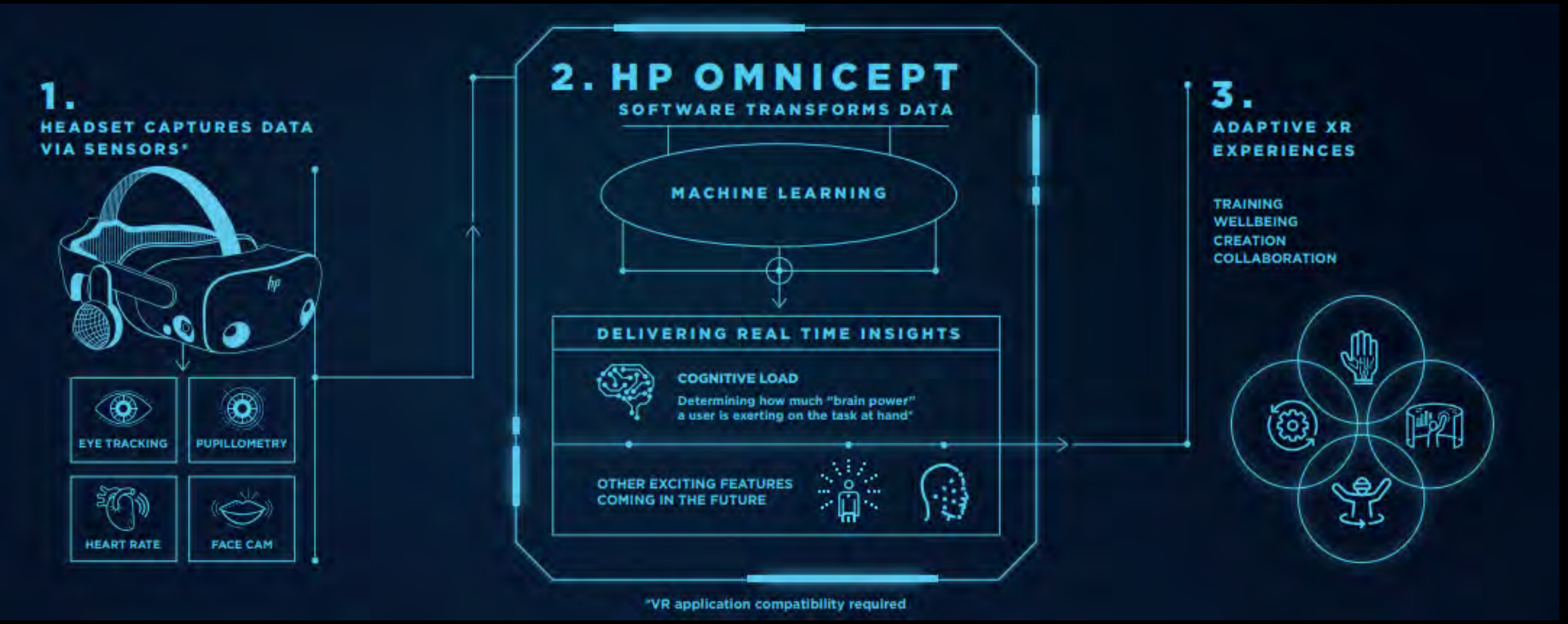
Standardized Environments for Neurocognitive Evaluation

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.

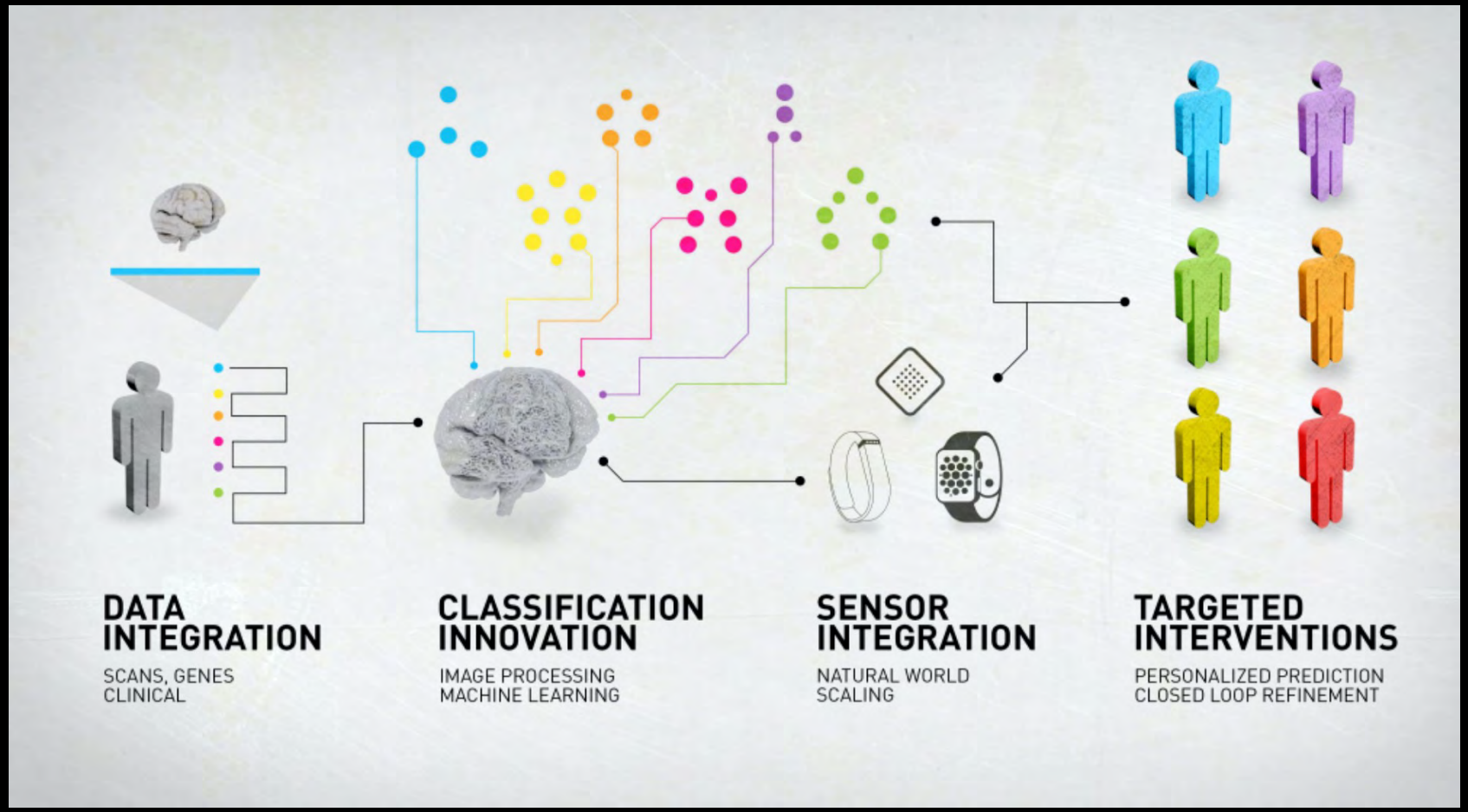
BioMarkers - Cognitive and Emotional State

Collecting and analyzing psychophysiological responses in VR



Lea Williams

Stanford
HEALTH CARE



PMHW
Stanford Center for Precision Mental Health & Wellness

New Approaches for Cognitive Assessment

Standardized Environments for Neurocognitive Evaluation

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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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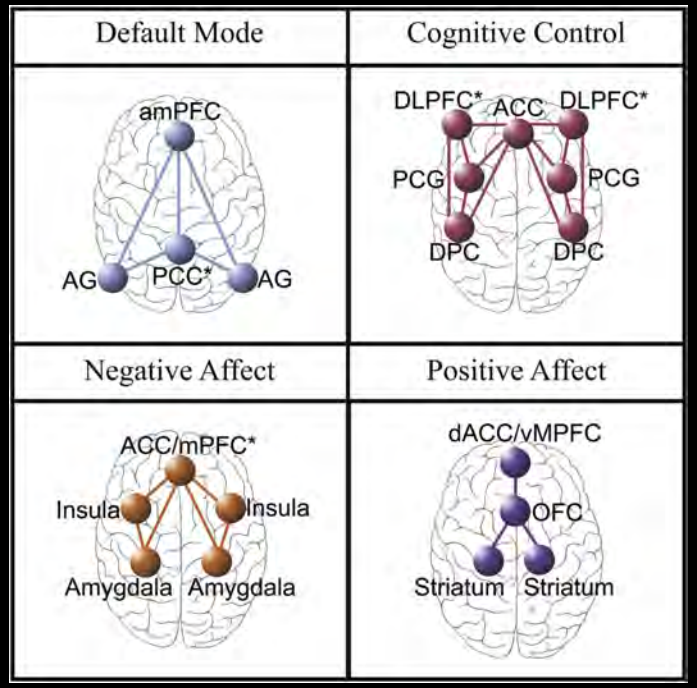
Behavior change

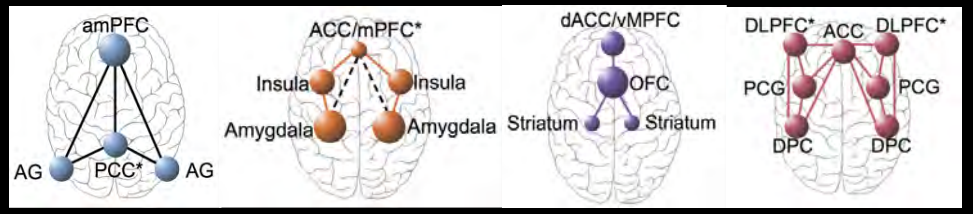
ABSTRACT

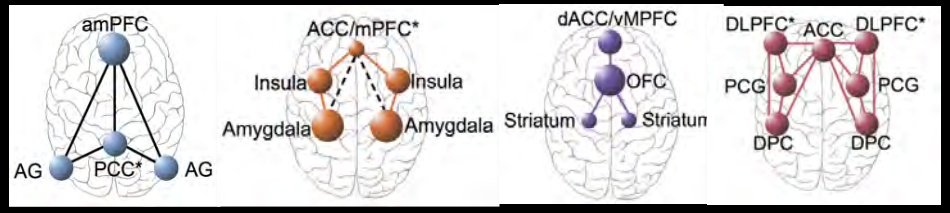
Precision medicine models for personalizing achieving sustained behavior change are largely outside of current clinical practice. Yet, changing self-regulatory behaviors is fundamental to the self-management of complex lifestyle-related chronic conditions such as depression and obesity - two top contributors 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.



VIRTUAL HUMAN INTERACTION LAB

We use brain circuit biotypes to connect brain imaging with VR





Neuroimaging measures

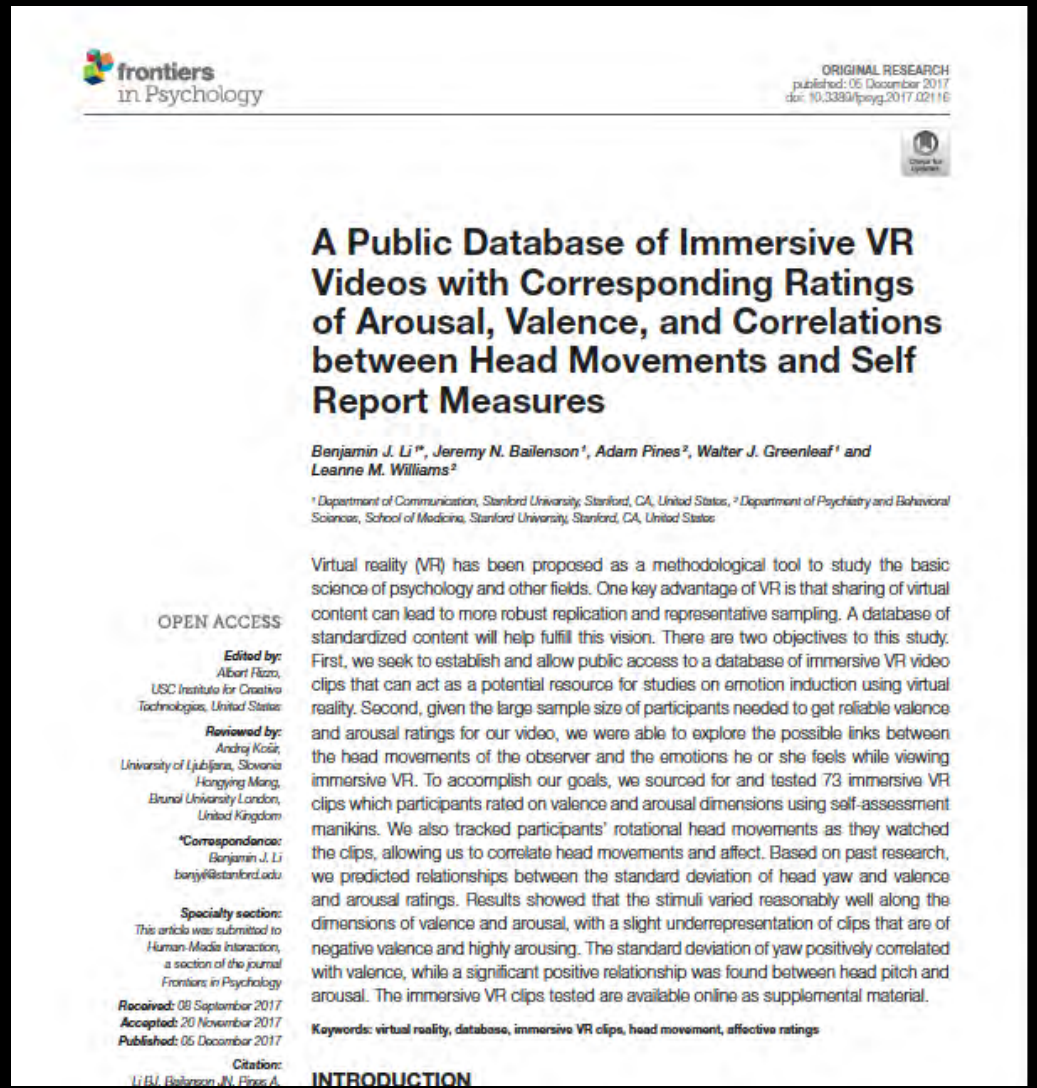
1. Scan brain at rest
2. Emotion regulation task
3. Cognitive control task

Virtual Reality:

1. Relaxing scene
2. Emotion regulation task
3. Cognitive control game

A Public Database of VR Environments

With corresponding ratings of arousal, emotional valence, and other measures



frontiers in Psychology

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

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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. There are two objectives to 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 induction using virtual reality. Second, given the large sample size of participants needed to get reliable valence and arousal ratings for our video, 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 sourced for and tested 73 immersive VR clips which participants rated on valence and arousal dimensions using self-assessment manikins. We also tracked participants' rotational head movements as they watched the clips, allowing us to correlate head movements and affect. Based on past research, we predicted relationships between the standard deviation of head yaw and valence and arousal ratings. Results showed that the stimuli varied reasonably well along the dimensions of valence and arousal, with a slight underrepresentation of clips that are of negative valence and highly arousing. The standard deviation of yaw positively correlated with valence, while a significant positive relationship was found between head pitch and arousal. The immersive VR clips tested are available online as supplemental material.

Keywords: virtual reality, database, immersive VR clips, head movement, affective ratings

OPEN ACCESS

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INTRODUCTION

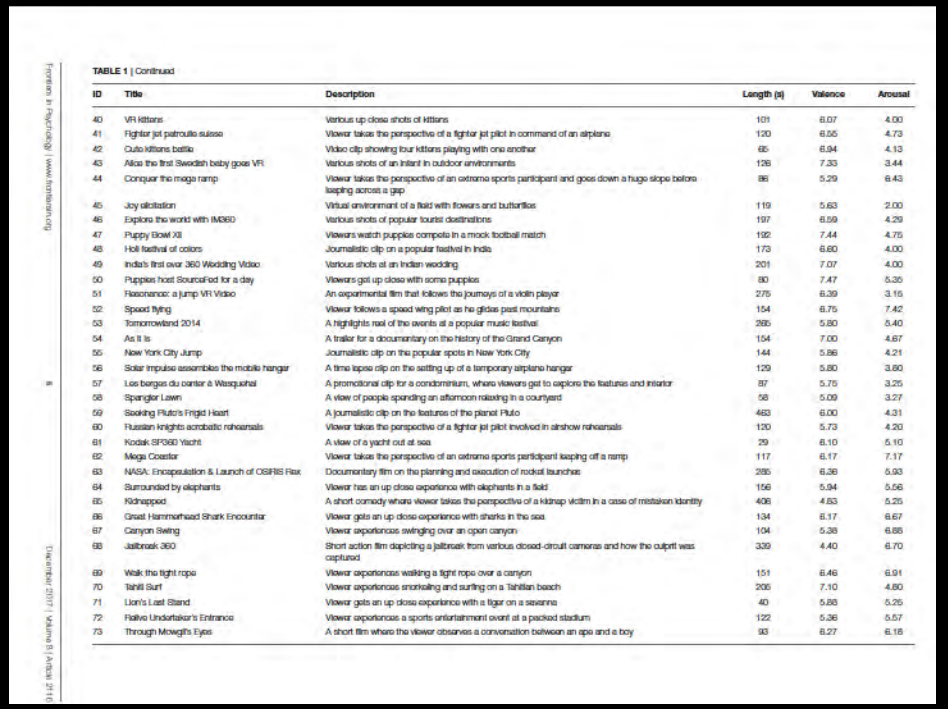

TABLE 1 | Continued

ID	Title	Description	Length (s)	Valence	Arousal
40	VR kittens	Various up close shots of kittens	101	8.07	4.00
41	Fighter jet patrouille suisse	Viewer takes the perspective of a fighter jet pilot in command of an airplane	120	6.55	4.73
42	Cute kittens battle	Video clip showing four kittens playing with one another	65	6.94	4.13
43	Alice the first Swedish baby goes VR	Various shots of an infant in outdoor environments	126	7.33	3.44
44	Conquer the mega ramp	Viewer takes the perspective of an extreme sports participant and goes down a huge slope before leaping across a gap	86	5.29	6.43
45	Joy elicitation	Virtual environment of a field with flowers and butterflies	119	5.63	2.00
46	Explore the world with IM360	Various shots of popular tourist destinations	197	6.59	4.29
47	Puppy Bowl XII	Viewers watch puppies compete in a mock football match	192	7.44	4.75
48	Holi festival of colors	Journalistic clip on a popular festival in India	173	6.60	4.00
49	India's first ever 360 Wedding Video	Various shots at an Indian wedding	201	7.07	4.00
50	Puppies host SourceFed for a day	Viewers get up close with some puppies	80	7.47	5.35
51	Resonance: a jump VR Video	An experimental film that follows the journeys of a violin player	275	6.39	3.15
52	Speed flying	Viewer follows a speed wing pilot as he glides past mountains	154	6.75	7.42
53	Tomorrowland 2014	A highlights reel of the events at a popular music festival	285	5.80	5.40
54	As It Is	A trailer for a documentary on the history of the Grand Canyon	154	7.00	4.67
55	New York City Jump	Journalistic clip on the popular spots in New York City	144	5.86	4.21
56	Solar Impulse assembles the mobile hangar	A time lapse clip on the setting up of a temporary airplane hangar	129	5.80	3.80
57	Les berges du center à Wasquehal	A promotional clip for a condominium, where viewers get to explore the features and interior	87	5.75	3.25
58	Spanglor Lawn	A view of people spending an afternoon relaxing in a courtyard	58	5.09	3.27
59	Seeking Pluto's Frigid Heart	A journalistic clip on the features of the planet Pluto	463	6.00	4.31
60	Russian knights acrobatic rehearsals	Viewer takes the perspective of a fighter jet pilot involved in airshow rehearsals	120	5.73	4.20
61	Kodak SP360 Yacht	A view of a yacht out at sea	29	6.10	5.10
62	Mega Coaster	Viewer takes the perspective of an extreme sports participant leaping off a ramp	117	6.17	7.17
63	NASA: Encapsulation & Launch of OSIRIS Rex	Documentary film on the planning and execution of rocket launches	285	6.36	5.93
64	Surrounded by elephants	Viewer has an up close experience with elephants in a field	156	5.94	5.56
65	Kidnapped	A short comedy where viewer takes the perspective of a kidnap victim in a case of mistaken identity	406	4.83	5.25
66	Great Hammerhead Shark Encounter	Viewer gets an up close experience with sharks in the sea	134	6.17	6.67
67	Canyon Swing	Viewer experiences swinging over an open canyon	104	5.38	6.88
68	Jailbreak 360	Short action film depicting a jailbreak from various closed-circuit cameras and how the culprit was captured	339	4.40	6.70
69	Walk the tight rope	Viewer experiences walking a tight rope over a canyon	151	6.46	6.91
70	Tahiti Surf	Viewer experiences snorkeling and surfing on a Tahitian beach	206	7.10	4.80
71	Lion's Last Stand	Viewer gets an up close experience with a tiger on a savanna	40	5.88	5.25
72	Rallye Undertaker's Entrance	Viewer experiences a sports entertainment event at a packed stadium	122	5.26	5.57
73	Through Mowgli's Eyes	A short film where the viewer observes a conversation between an ape and a boy	93	6.27	6.18

VIRTUAL HUMAN INTERACTION LAB

XR technology will *significantly* impact Medical Care

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

Some Examples – XR in Use Today

Preoperative Planning & Image Guided Surgery

New Approaches to Physical Medicine & Rehabilitation

Stroke and Traumatic Brain Injury

Physical / Occupational Therapy

REAL™

Adam Elsesser

Gita Barry

New Approaches to Mental Health

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

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
- 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

RISK AVOIDANCE TRAINING

Refusal skill training, Situational Confidence

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

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

- Social Anxiety Disorder
- Depression
- Chronic Pain
- Mild Cognitive Impairment
- Autism Spectrum Disorder
- ADHD

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

FireflyVR

David Lobser - Light Clinic

Virtual Hospital Tours Used To Relieve Pre-procedure Anxiety

Senior Care

Multiple Programs - One Platform

General Wellness Programs

Acute Pain Relief + Chronic Pain

Stress

Addiction

DTx Programs

Anxiety / Depression

Acute + Chronic Pain

Rx Adherence + Efficacy

BehaVR

BALANCE Foundation

Mindfulness

Relax

Regulate

Cloud-based System

Dynamic Experience | Biometrics Service | Analytics | Permissions & Security | Social VR Engine*

Aaron Gani

HEALTH AND WELLNESS

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

Leveraging Mirror Neurons

Ability to change attitudes and behavior after “being” one’s future self.

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Portable Telemedicine Platform

Digital Therapeutic Platform for Pain & Behavioral Health

On-board at multiple sites of care

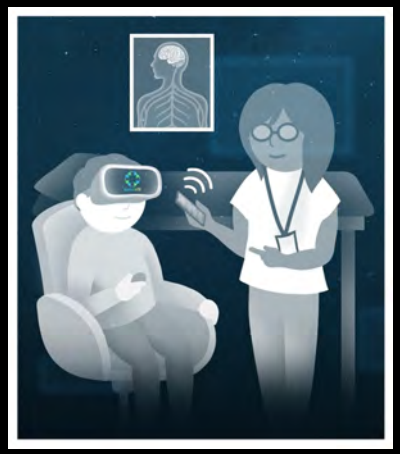
Patient-centric, progressive experience across sites of care

Orebro OMPSQ assessment for persistent pain / future disability risk

Pain Neuroscience Education + acute pain relief for all patients

Integration with Wearables

Triage to identify good surgical candidates



- Health Retailer
- Physical Therapy Clinics
- Employer Clinics
- Primary Care

- Home

BehaVR

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

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?

XR Technology
Trends Impacting The Future

XR - A Key Component

Combination Therapy - Digital Health Platform

Medication with clinical benefit

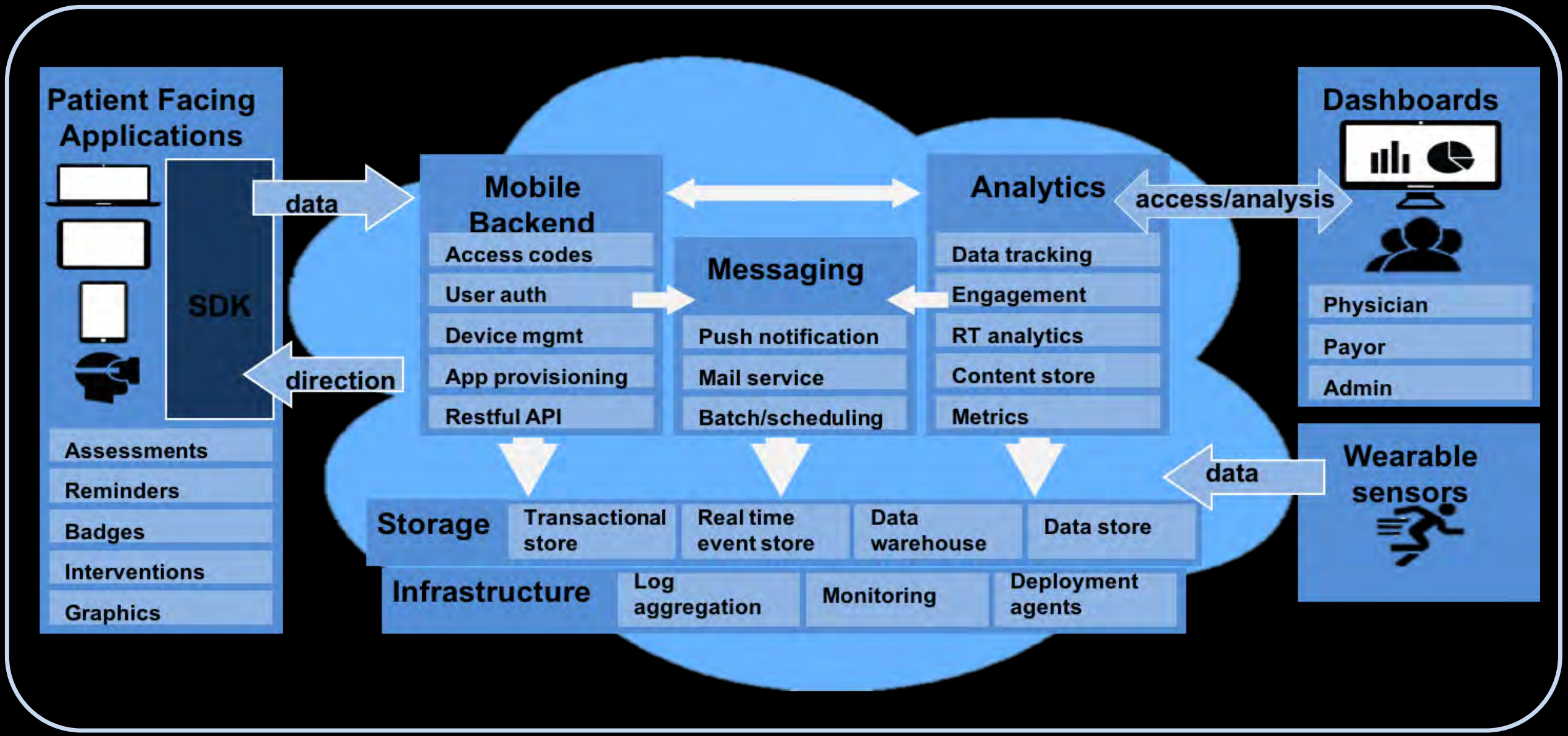
+

XR system designed to enhance medication efficacy

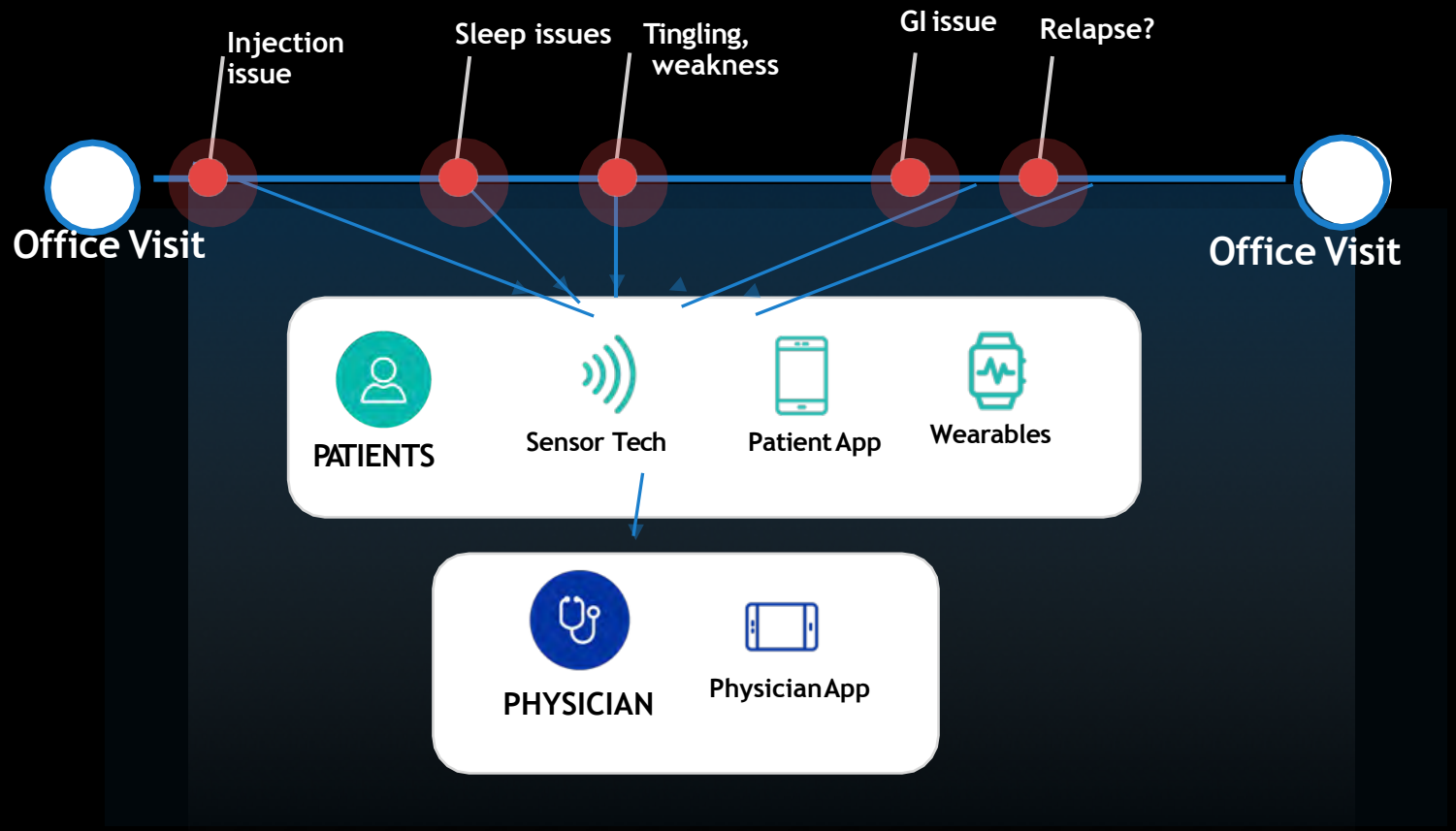
=

Prescribed combination product with enhanced efficacy

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



A data stream for physicians to manage patients between visits



Focus on issues **disease worsening, new symptoms**

Includes specific **Rx compliance tracking** capabilities

Includes **Alerts** to **Care Team** and **integrates at POC**

Actionable, avoid events, costs, ROI path to payment

octave

The CHLA residency program and hospital use VR as part of a required curriculum for interns - required prior to setting foot in the emergency department.

Pediatric Resuscitation Training

Considerable Activity

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 Mitigation

Relatively Underdeveloped – Significant Opportunities

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 Mitigation

Digital Therapeutics for Senior Care

Improved Assessments and Diagnostics

Addressing Isolation and Loneliness

Acute and Chronic Pain

Depression and Anxiety Disorders

Physical and NeuroRehabilitation

Design for Disabilities

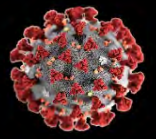
Post-Discharge Follow-up

Staff Training: not just procedures, but empathy

Covid-19 - The Impact on XR Technologies and Applications

XR Systems are poised to dramatically impact several vertical markets

The need to address Covid-19 is accelerating the process



Regulatory and conceptual barriers are dropping

Investments and deployments are continuing

Remote work and Telemedicine is gaining acceptance

Increased focus on Mental Healthcare

Migration from LBE to Healthcare

Greater sensitivity towards disinfection

In Summary

XR Technology Impacts All Sectors of HealthCare

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

Recent changes in cost and access make VR/AR technology affordable

VR/AR systems are currently used for - prevention, evaluation, treatment, and chronic disease management

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

Digital Therapeutics for Medicine

The Digital Health Revolution

Emerging and Confluent Technologies

Overall Landscape of XR Technologies

Neuroscience – Why XR Has Impact

History of VR - and Why it Matters

Current Status – Where There is Traction

Future Perspective and Predictions

IVRHA International Virtual Reality Healthcare Association

VR AND HEALTHCARE SYMPOSIUM - EUROPE

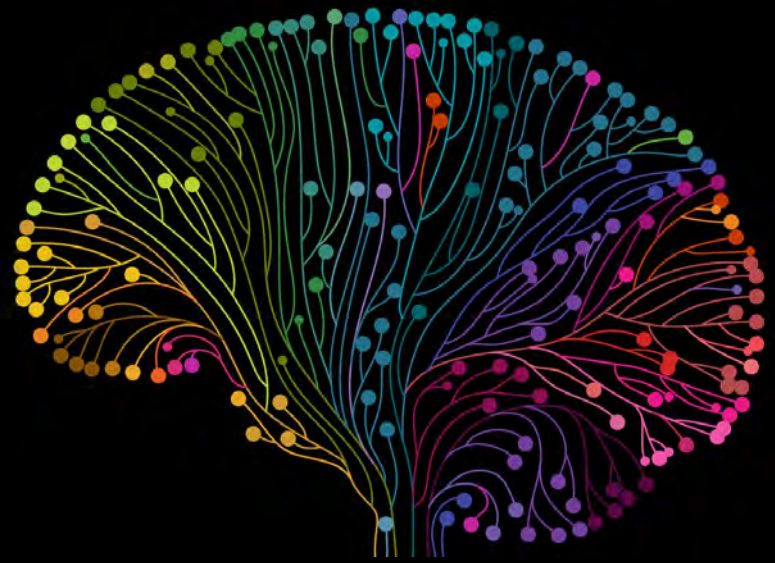
Dublin Ireland

Machine Learning, Biosensing, Virtual Reality Technology

Converging to Transform Healthcare

Walter Greenleaf PhD

Stanford University VIRTUAL HUMAN INTERACTION LAB



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National Mental Health Innovation Center
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