LiveWell RERC
2020 Update on Emerging ICT Developments

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Rehabilitation Engineering Research Center for
Information and Communication Technology Access

NIDILRR – 2015-2020

National Institute on Disability, Independent Living and Rehabilitation Research
US Department of Health and Human Services

Partner Institutions

National Institute on Disability, Independent Living, & Rehabilitation Research (NIDILRR)
Agency for Community Living
US Department of Health and Human Services

http://www.livewellrerc.org/

The LiveWell RERC team...

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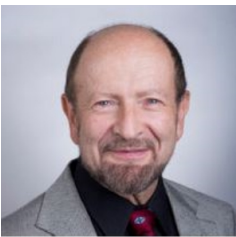
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LiveWell RERC – Twofold Mission

- <u>Promote ICT access</u> to existing and emerging technologies for all people regardless of ability

- <u>Develop and validate ICT applications</u> to improve the capacity for independent living and community participation.

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ICT today facilitates...

- Community Participation
- Independent Living
- Rehabilitation
- Healthcare
- etc., etc.

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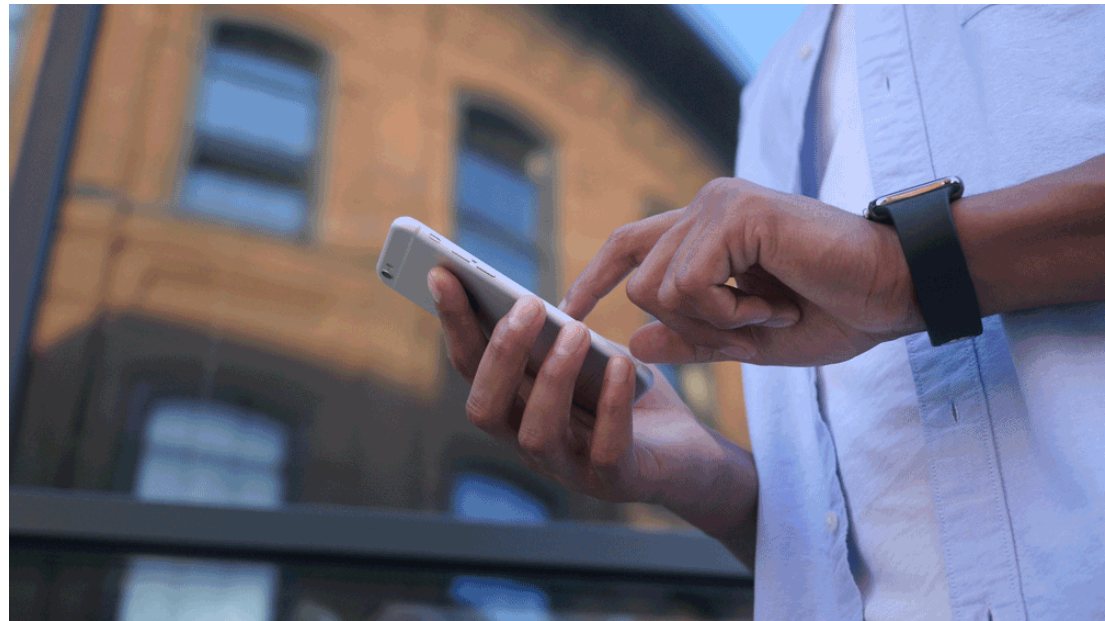
Digital market...a maturing market

2012 - 2018 – "Cute Point Solutions"

- An interesting idea, became small company with a solution that occasionally got enough traction to become a real company

Gartner Hype Cycle
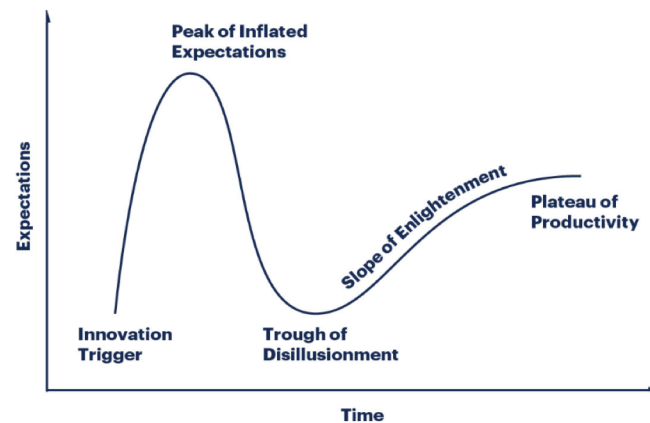
2018 - today – "Next Generation Phase"

- Companies beginning to have deeper & broader impact into the ecosystem
- 2019 there were 53 public digital health mergers & acquisitions totaling $8.2B

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Digital Health:

The broad scope of digital health includes categories such as:

mHealth, mRehab, Wireless Health, Health 2.0, eHealth, Health IT , Big Data, Health Data, ePatients, Cloud Computing, Wearable Computing, Quantified Self & Self-tracking, Gamification, Precision Medicine, Telehealth, Telemedicine, Genomics, Personalized Medicine, Connected Health, etc., etc.

LiveWell definition:

Consumer use of digital health technologies to better manage & track their own health and wellness related activities enhancing independent living and community participation.

HIMSS launches new definition of digital health:

Digital health connects and empowers people and populations to manage health and wellness, augmented by accessible and supportive provider teams working within flexible, integrated, interoperable, and digitally-enabled care environments that strategically leverage digital tools, technologies and services to transform care delivery.

LiveWell RERC – Projects

Research Projects
- R1 – Blue Sky Discovery of User Needs
- R2 – Barriers and Facilitators to Adoption
- R3 – Behavioral Informatics for Safety

Development Projects
- D1 – Tech/Policy Watch
- D2 – Tech/Apps A) Tech Factory B) App Factory
- D3 – Behavioral Informatics for Safety

KT/Training Projects
- T1 - Capacity Building and Training
- T2 - Industry, Clinical and Regulatory Engagement

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Consumer Advisory Network

Developed web portal to engage people with disabilities in identifying research & development needs for mHealth/mRehab.

Today, over 1,500 individuals with disabilities in network

- Low vision/blind
- Hard of hearing/deaf
- Dexterity/mobility
- Intellectual/cognitive
- Communication difficulties

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Consumer Advisory Network

Recent surveys

| Disability Type		Survey of User Needs (n=1068)	Smartphone Usability (n=970)	mRehab apps (n=375)
Low vision/blind		24%	19%	24%
Hard of hearing/deaf		36%	43%	44%
Dexterity/mobility		81%	87%	83%
Intellectual/cognitive		48%	44%	45%
Communication difficulties		15%	17%	10%

Surveys provide insight into identifying emerging issues and lead to focus group research and usability testing.

As FDA now requires involvement of end users in device design and testing we have engaged national/international nonprofits (*AgeWell, ITIF*) & corporate clients (*Google, Microsoft, Samsung, Verizon*)

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Accessibility User Research Collective
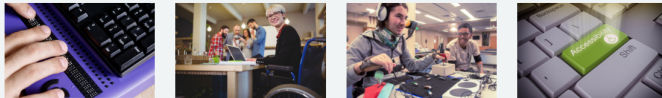
Connecting people with disabilities to research at Microsoft in order to help build more accessible products.

The Accessibility User Research Collective (AURC) is a U.S.-based national community of people with all types of disabilities interested in helping make Microsoft technology more accessible and usable.

The AURC is organized and maintained by assistive technology & accessibility researchers at Shepherd Center.

https://accessibilityuserresearchcollective.org/

- Microsoft collaboration

- Over 900 members with disabilities included in collective database

- To date, over 50 usability and survey/interview projects either completed or underway

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Provider Advisory Network

Provider Type		n=505	Percent
Physician, PA, NP, Nurse		26	5.1%
Physical Therapist		72	14.3%
Occupational Therapist		104	20.6%
Speech-language Pathologist		166	32.9%
Recreational Therapist		57	11.3%
Mental Health (Psychologist/SW/Counselor)		54	10.7%
Other professions		26	5.1%

Developed web portal to engage rehabilitation providers in identifying research & development needs for mRehab.

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Article

Clinician Perspectives on mRehab Interventions and Technologies for People with Disabilities in the United States: A National Survey

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Abstract: Mobile health and mobile rehabilitation (mHealth and mRehab) services and technologies have attracted considerable interest from healthcare providers, technology vendors, rehabilitation engineers, investors and policy makers in recent years. Successful adoption and use of mHealth/mRehab requires clinician support and engagement, including the ability to identify appropriate use cases and possible barriers to use for themselves and their patients, and acquire adequate knowledge and confidence using mHealth/mRehab interventions. This article reports results from a survey of rehabilitation clinicians in the United States on their attitudes, experience, expectations and concerns regarding mHealth/mRehab interventions and technologies. Over 500 clinicians in physical, occupational, speech, recreation and psychological therapy professions, among others, participated in the survey. Respondents reported that an overwhelming majority of their patients need additional therapy after discharge from inpatient environments, and over half of outpatients need additional therapy between visits. A large majority reported prescribing specific exercises and interventions for patients to work on outside of the clinic. However, only 51% reported being comfortable integrating mRehab technology into their practice; and only 23% feel knowledgeable about rehabilitation technology currently available. Technologies to support mRehab are maturing rapidly. Clinicians recognize the need for mRehab, but their knowledge and confidence prescribing mRehab represents a significant barrier to adoption.

Keywords: mobile health, mHealth, mRehab, disability, rehabilitation, information and communication technology

Acceptance of mRehab approaches

- 74% providers reported pts need additional tx after discharge

- 55% providers reported pts need additional tx between visits to outpatient programs

- 51% providers comfortable integrating standalone mRehab into practice

- 23% reported being knowledgeable about mRehab technologies

- 12.5% providers already using coaching or therapy mgmt platforms

- Morris, J.; Jones, M.; Thompson, N.; Wallace, T.; DeRuyter, F. Clinician Perspectives on mRehab Interventions and Technologies for People with Disabilities in the United States: A National Survey. *Int. J. Environ. Res. Public Health* 2019, *16*, 4220

- Morris, J.; Jones, M.; DeRuyter, F.; Putrino, D.; Lang, C.E.; Jake-Schoffman, D. LiveWell RERC State of the Science Conference Report on ICT Access to Support Community Living, Health and Function for People with Disabilities. *Int. J. Environ. Res. Public Health* 2020, *17*, 274

- Jones, M.; DeRuyter, F.; Morris, J. The Digital Health Revolution and People with Disabilities: Perspective from the United States. *Int. J. Environ. Res. Public Health* 2020, *17*, 381

- Jones, M.; Collier, G.; Reinkensmeyer, D.J.; DeRuyter, F.; Dzivak, J.; Zondervan, D.; Morris, J. Big Data Analytics and Sensor-Enhanced Activity Management to Improve Effectiveness and Efficiency of Outpatient Medical Rehabilitation. *Int. J. Environ. Res. Public Health* 2020, *17*, 748

https://www.mdpi.com/journal/ijerph/special_issues/mHealth_mRehab

App Factory

An "open shop" response to an RFP, leveraging expertise within the disability Assistive Technology (AT) community, using the rapid development & testing cycle of the mobile app ecosystem

Jones M, Mueller J & Morris J (2017) App Factory: A flexible approach to rehabilitation engineering in an era of rapid technology advancement, Assistive Technology, 29:2, 85-90, DOI: 10.1080/10400435.2016.1211201

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App Factory – results as of August 2019:

- 9 calls for proposals
- 95 proposals submitted
- 39 (41%) submitted apps funded
- 32 (82%) funded apps completed & published
- 4 still in development; 3 abandoned
- Average direct cost per published app $19,535
- 89% developer apps & 43% academia apps published
- 889,442 downloads/installs of published apps to date

Current Apps

- AccessLyve
- BEST Suite: CompleteMyToDos
- BEST Suite: Kids
- BreatheWell Wear
- CoTrain
- Durham Audio Described Art (DADA)
- EyeRemember Wear
- FootNoter
- Guidelines for the Care of People with Spina Bifida
- iMup: A Body Position Tracker for iOS

- MyEmotionality
- One Thing Straight
- PicTalker
- Pow!r Mount Plus
- Project Neglect
- ReadAble Storiez
- Seeing Eye GPS
- SpeakUp: An SPL Meter
- Speech2RTT Communicator
- SwapMyMood
- Tummy Time Fun

http://www.livewellrerc.org/app-factory-livewell-rerc-and-health-and-function-drrp

LiveWell 2020 Student App Challenge

- Open to students (middle/high school, and college) or non-professional developers, SME collaboration, and meets LiveWell mission

- Focus on health & function, accessibility, money management, navigation, home automation & control, personal communication, and access to public announcements & notifications.

- Winning app submissions will receive a cash award.

- Submissions due: May 1st, 2020

- More info: https://duke.qualtrics.com/jfe/form/SV_78km0xKKW6yUvOt

- Announcement of winning submissions: June 1st, 2020

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AccessLyve
Live Performance Accessibility App

Developed by Arts Access International – a suite of free live performance accessibility applications for macOS and iOS.

AccessLyve **provides real-time audio streaming specifically for people who are blind, have low vision, or are hard-of-hearing.**
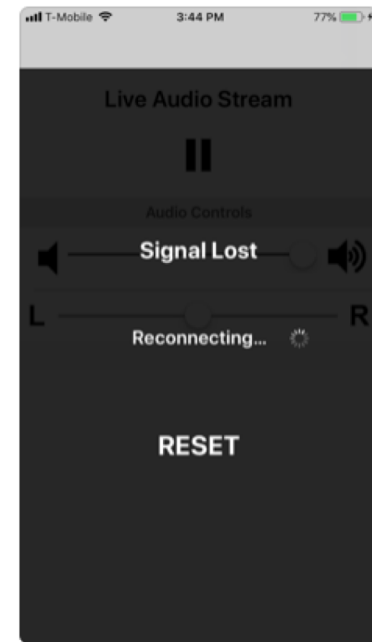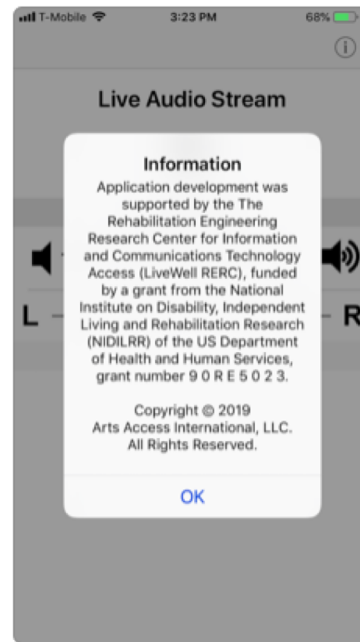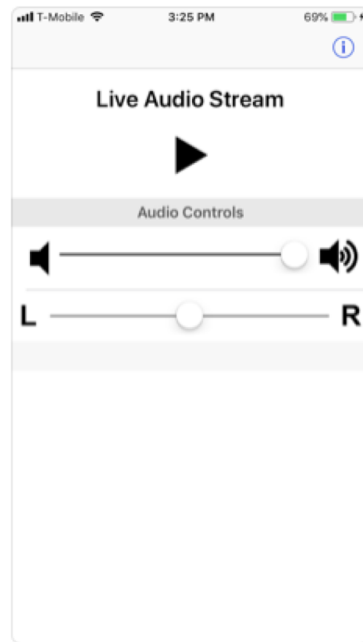
No Internet connection is required

https://www.artsaccessintl.com/
https://itunes.apple.com/us/app/accesslyve/id1288727429?mt=8

AccessLyve
Live Performance Accessibility App

PicTalker
iOS based communication app

App for individuals with complex communication needs to share the events of their day through images, videos, and audio

Focuses on user developing 'narratives' independently or with the aid of a communication partner to facilitate communication interactions

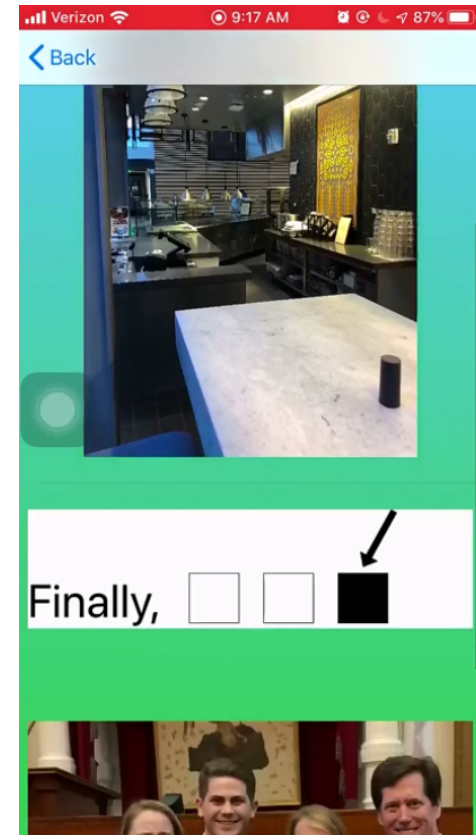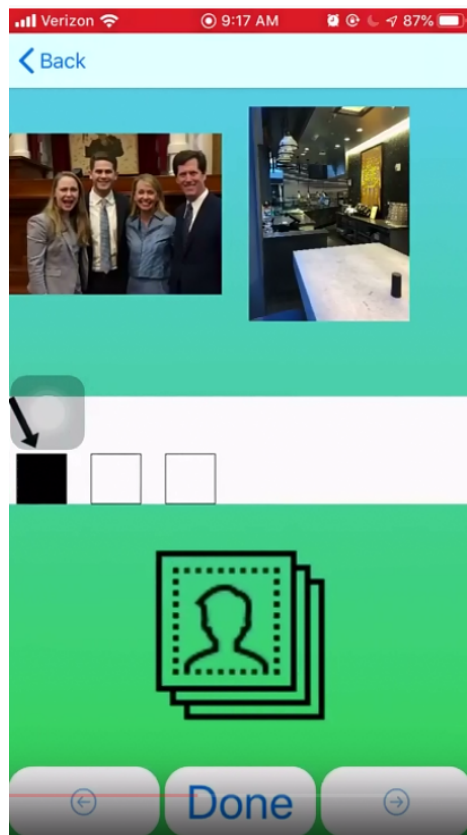Allows for text, icon, or voice annotation of pictures
- How did you feel? Who were you with?
- Where were you? What were you doing?

Novel approach:
- Allows users to pre-select between icon or text-based user interface
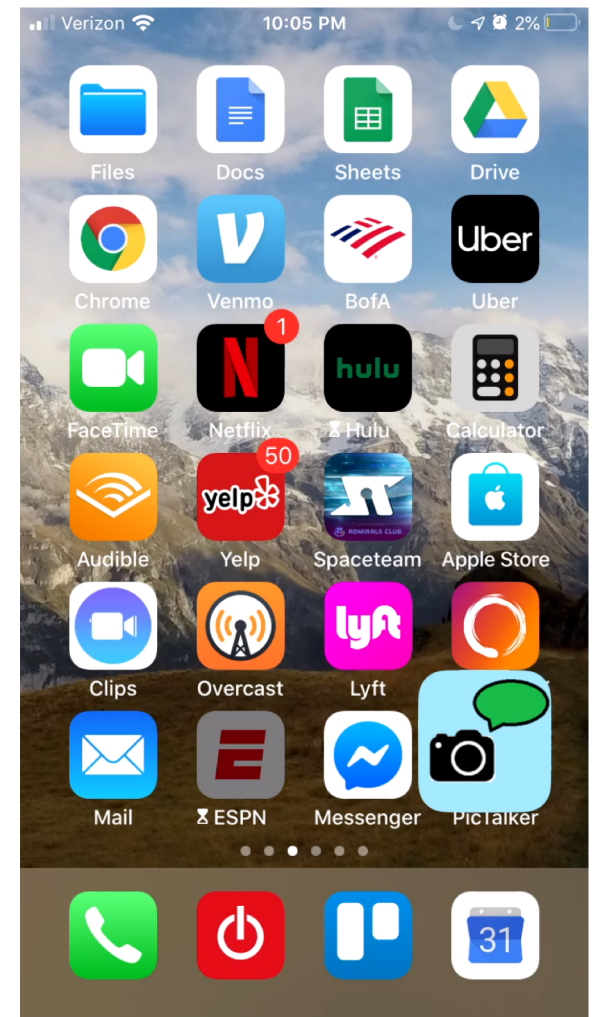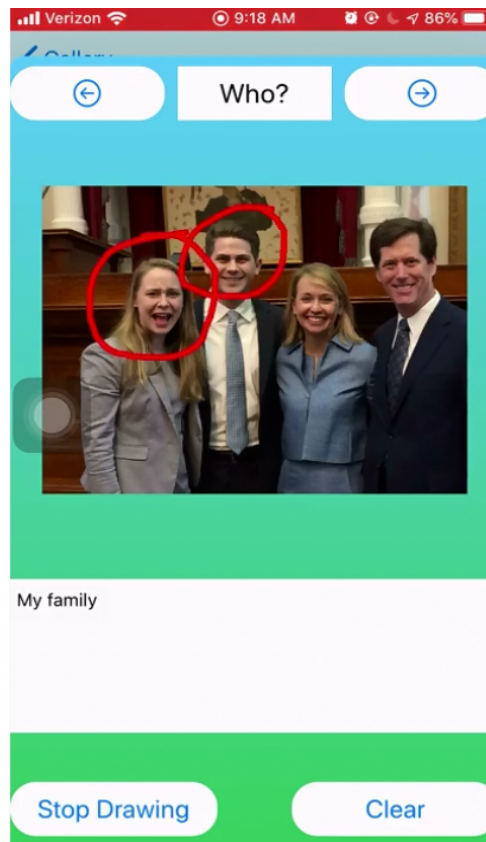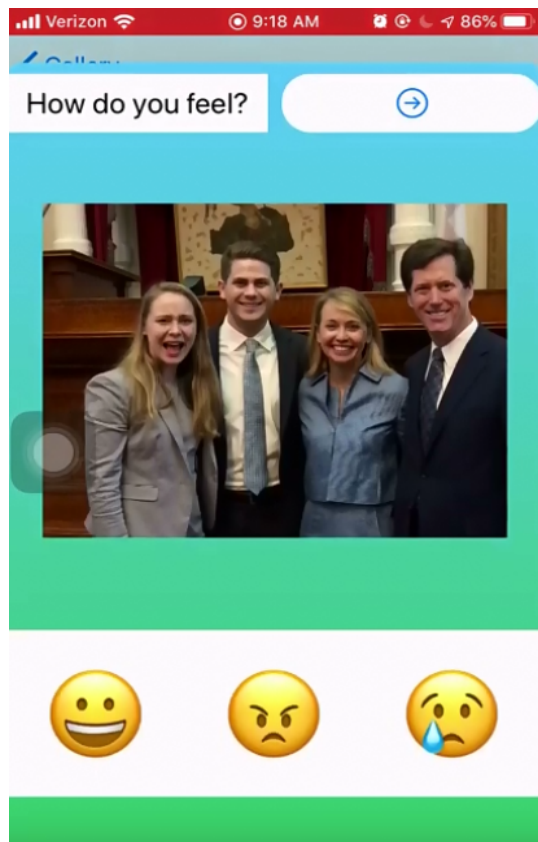- Developing 'stripped down' version for users in need of simplistic user interface

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PicTalker
Screenshots - Narratives

PicTalker
Screenshots - Annotation
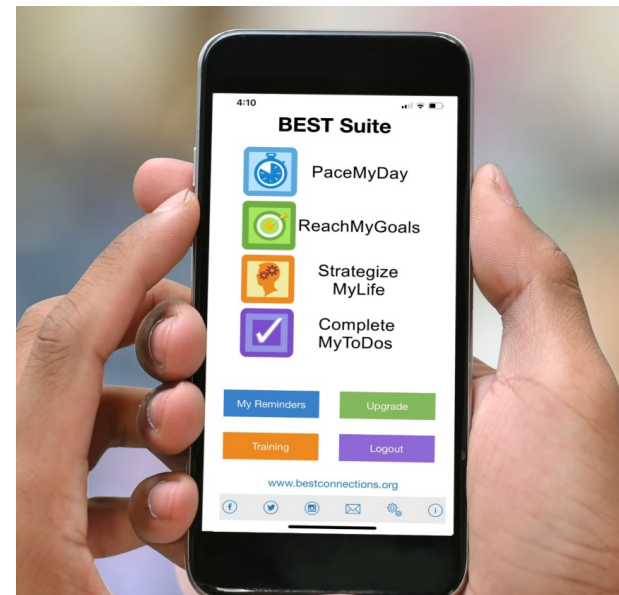
CompleteMyToDos
iOS Task Management App

Developed by Michelle Wild at BEST and funded by LiveWell RERC.

CompleteMyTodos an iOS task management app that integrates into a suite of already existing apps called **BEST Suite.**
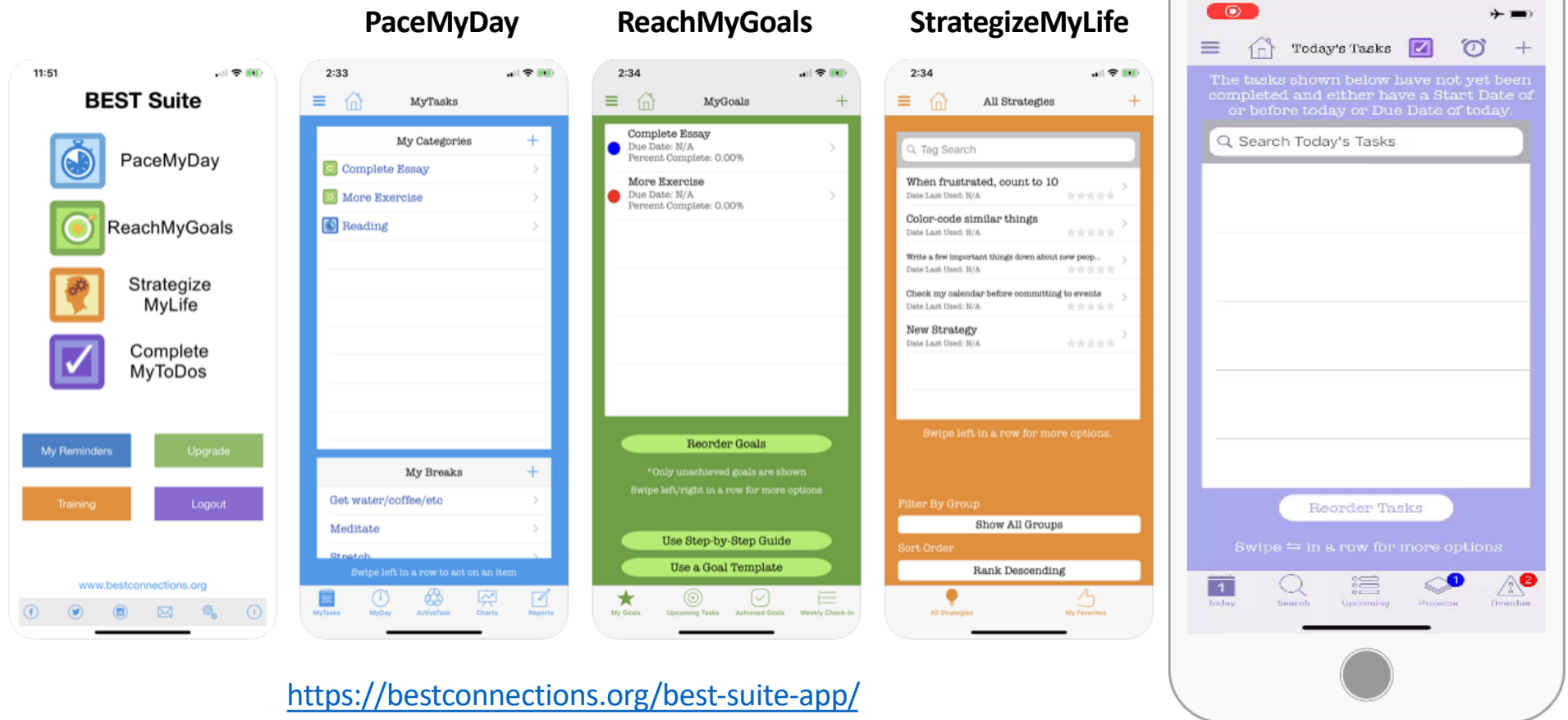
BEST Suite helps people with brain injuries and other cognitive challenges learn to optimize their energy, self-regulate behavior, set goals, track strategies, and get more done at home, school, and work.

BEST — Brain Education Strategies Technology

https://bestconnections.org/best-suite-app/

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CompleteMyToDos
iOS Task Management App

PaceMyDay **ReachMyGoals** **StrategizeMyLife**

CompleteMyToDos

https://bestconnections.org/best-suite-app/

iMUp
### Accelerometer-based positional classification system

Studies support that wearable device-measured activity in hospitalized patients can predict readmission risk, length of stay, and disability

Problem:
- Clinicians and researchers rely on devices that cannot offer movement classification flexibility within specialized populations
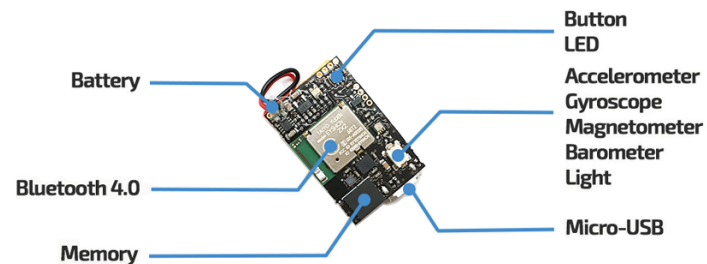
Aim:
- Develop techniques to classify laying, reclining, sitting, standing, and walking in a hospitalized population
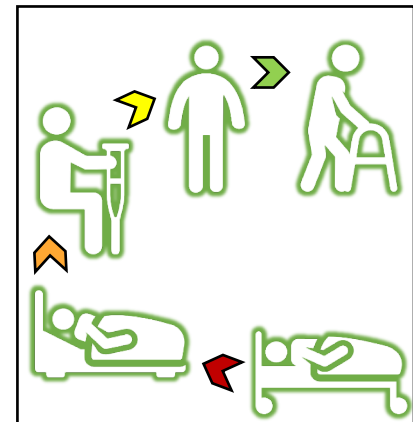
iMUp
Development

- Built on iOS based platform to capture data from commodity accelerometer in real time – Mbient MetaMotionR sensor

- Machine learning algorithms are applied to raw accelerometer data to identify movement

- Subjects wear one sensor on the middle thigh and another under the clavicle

Battery
Bluetooth 4.0
Memory
Button
LED
Accelerometer
Gyroscope
Magnetometer
Barometer
Light
Micro-USB

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iMUp
Preliminary results – healthy older adults (n=30)

Results demonstrated that the algorithm accuracy was 95% overall at classifying positions

Geriatric LOSO: 95% correct

	Laying	Reclining	Sitting	Standing	Walking	
Laying	84.7	14.6	0.7	0	0	[459]
Reclining	3.6	95.1	1.3	0	0	[468]
Sitting	0.2	2.2	96.5	1.1	0	[461]
Standing	0	0	0.2	99.1	0.7	[442]
Walking	0	0	0	0.6	99.4	[475]

Truth

Response

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iMUp
Preliminary results – hospitalized adults (n=8)

- Testing more challenging – data did not match healthy adult training data

- Unlike training data, hospitalized test did not have three distinct laying/reclining/sitting classes

- Modifications in response – collapsed laying/reclining into one class & collected new training data sampling reclining at 0º, 15º, 30º, 45º, 60º

Subject 05: 96.7%

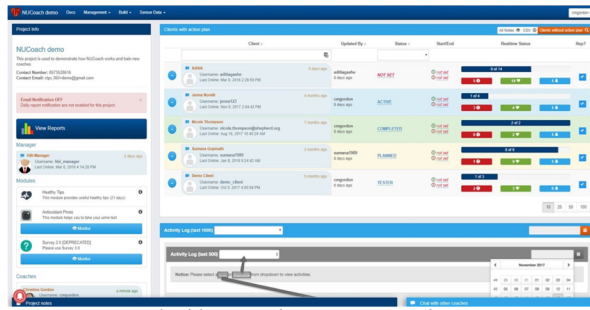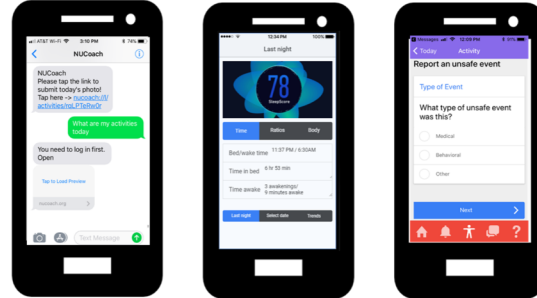|	Laying/Reclining	Sitting	Standing	Walking	
Laying/Reclining	92.1	7.9	0	0	[38]
Sitting	0	100	0	0	[18]
Standing	0	0	100	0	[19]
Walking	0	0	0	100	[15]

Truth (y-axis) / Response (x-axis)

NUCoach

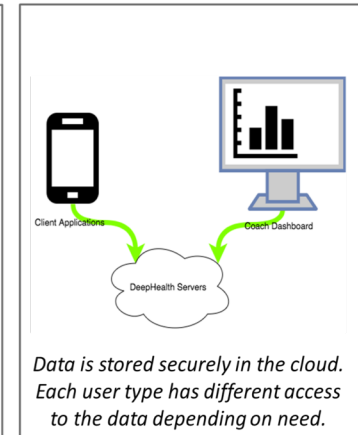## Modular Health Coaching Platform

Coaching console

Manage project, build action plans, monitor and communicate with participants and team members

Mobile app

Coach participants with messages and feedback, collect survey data, connect with companion apps for sensor data collection

Data is stored securely in the cloud. Each user type has different access to the data depending on need.
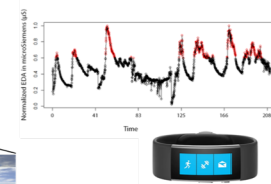
Connected devices

Activity trackers + HR monitors

Bed sensor for sleep + stress recovery

Camera for physical exercise

Skin conductance for stress monitoring

We can add just about any connected device or service

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NUCoach
Modular Health Coaching Platform

Sleep, Stress, & Safety Study

The Emfit QS sleep sensor is installed under the TBI survivor's mattress

Military mTBI survivors wear a Misfit Vapor Android watch for activity tracking & access to BreatheWell deep breathing app

Survivors/caregivers receive sleep feedback sleep & report unsafe events

NUCoach
Modular Health Coaching Platform

NUCoach
- Developed/piloted within LiveWell – 2015-2017

XWell
- commercialized as Xwell through NEU – 2017

Novowell
- New company spin-off – 2018

FirstMatrix Health
- New Boston healthcare startup – 2019
- Acquired Novowell May 2019

GaitBox
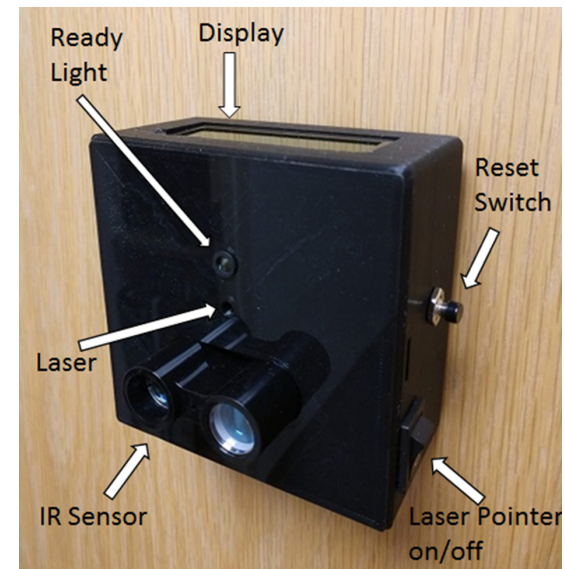## Inexpensive, accurate gait speed measurement device

Gait Speed test is a measure of an individual's speed while walking and mobility

It is a strong predictor of functional status and survival amongst older adults
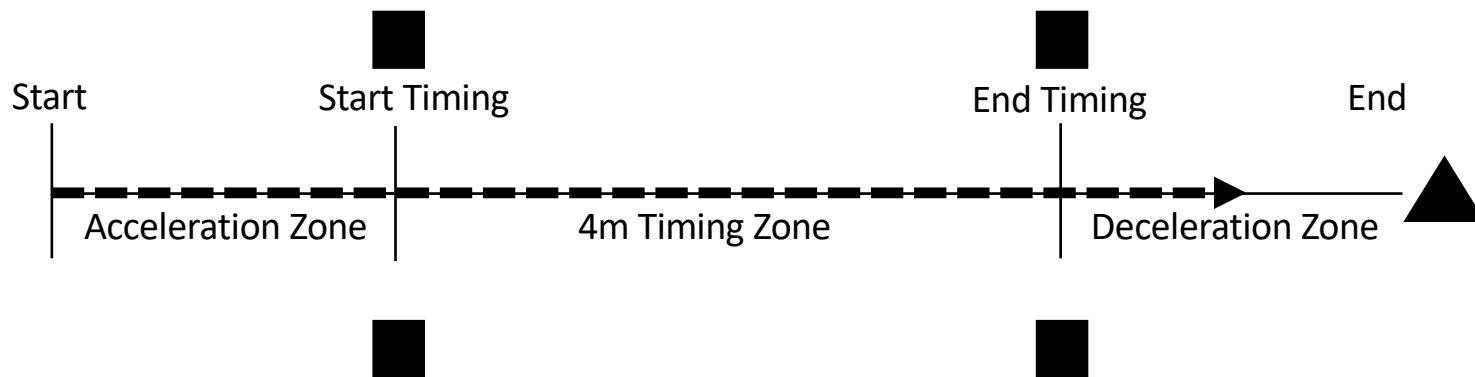- Test data collected in cardiac rehab, neurology (MS, ALS, TBI, SCI), etc. settings

Clinical *gold standard* is measurement with stopwatch and measuring tape
- The test is frequently error prone between people timing and not following protocols
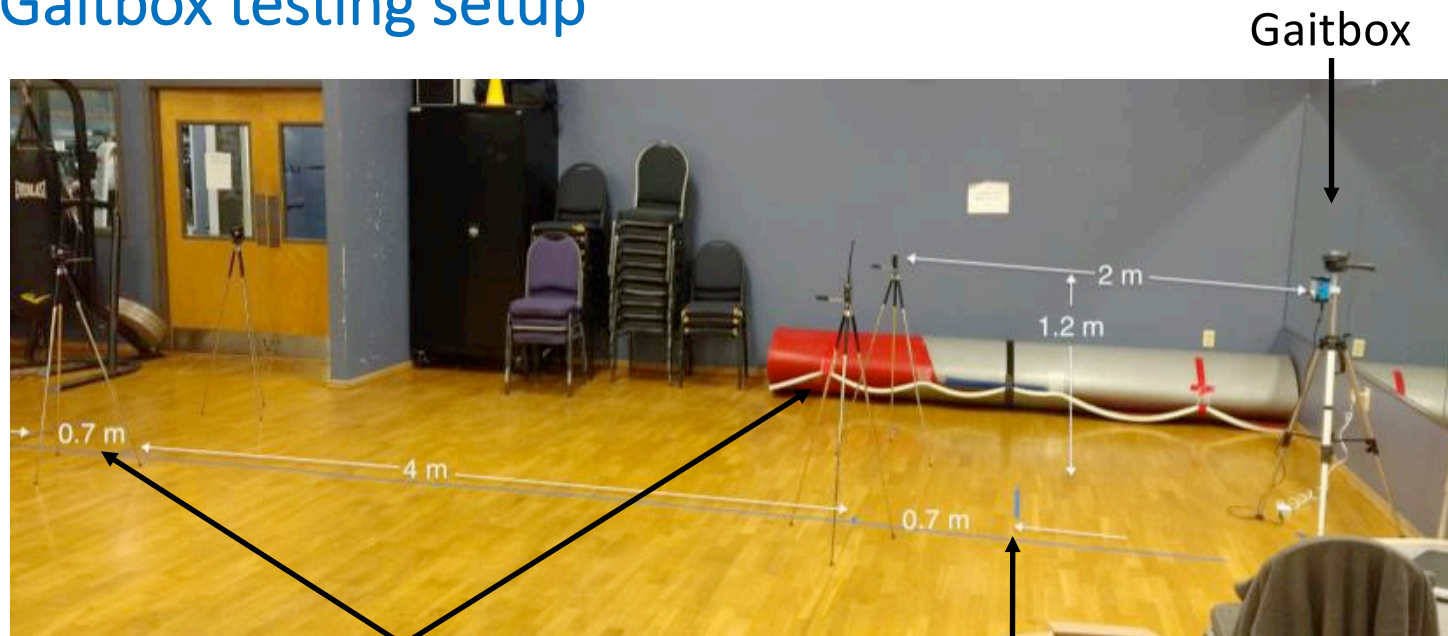
GaitBox
Gaitbox testing schematic

Start   Start Timing   End Timing   End

Acceleration Zone   4m Timing Zone   Deceleration Zone

Key:
Gait Box

Sprint System

GaitBox
Gaitbox testing setup

Gaitbox

2 m

1.2 m

0.7 m

4 m

0.7 m

Sprint System Speed Trap
(Brower Timing TC-System)

Marker

B   A
IR Beam
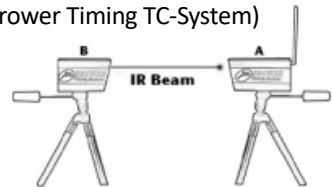
GaitBox
Validation Studies to date

Results show device is highly reliable

4 m walk test
- 35 healthy older adults
- Device showed 0.995 correlation to Sprint System and 0.966 correlation to human timers

10 m walk test
- 44 subjects represented SCI, MS, and otherwise healthy populations
- Device showed 0.988 (p<0.0001) correlation to Sprint System (break beam sensor device – research grade device)
- Difference in means of 0.008 $\pm$ 0.041 (P=.22)
- No systematic bias across all gait speed measurements

Smart Home Stress Assist - SHSA
Amazon Echo skill for those with PTSD & TBI

Goal:

- Create an Amazon Echo skill to assist military service members with traumatic brain injury (TBI) and post-traumatic stress disorder (PTSD) in managing the onset of post-traumatic stress
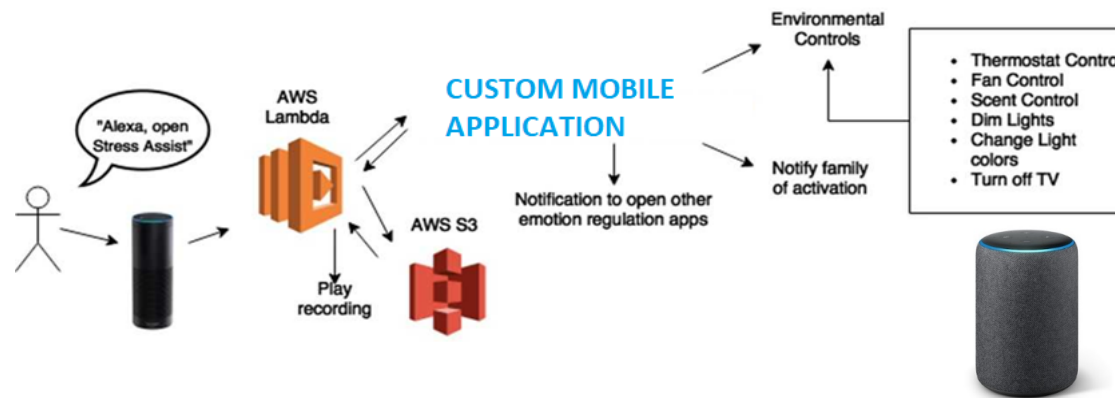
Project Components:

- Controlling physical environment via smart home control
- Communicating with family about system activation
- Activating guided exercises (or other grounding techniques)
- Obtaining survey data after system activation

Smart Home Stress Assist - SHSA
Beta Configuration & Current Development

- Converting from Echo to EchoPlus with built-in hub
  - Removes need for 3rd party platform such as Samsung SmartThings to control devices
- Developing custom mobile application to act as avenue for user customization
- Will further reduce cost/complexity of system from a user perspective
- Will require additional development on a custom mobile application

The Rehabilitation Engineering Research Center for Information and Communication Technology Access (LiveWell RERC) is funded by a 5-year grant from the National Institute on Disability, Independent Living and Rehabilitation Research in the U.S. Department of Health and Human Services (grant number 90RE5028).

The opinions are those of the LiveWell RERC and do not necessarily reflect those of the U.S. Department of Health and Human Services or NIDILRR.

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