Rehabilitation Engineering Research Center on Augmentative and Alternative Communication RERC on AAC

Janice Light, Susan Fager, Christine Holyfield,
Erik Jakobs, Heidi Koester, & David McNaughton

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The need

- More than 5 million Americans have severe disabilities resulting in complex communication needs
  - Developmental disabilities
  - Acquired conditions
  - Degenerative disabilities
- More than 97 million people worldwide

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The challenge

- Without access to spoken, written, & digital communication, these individuals are severely restricted in their participation in society
  - Education
  - Employment
  - Health care
  - Family
  - Community living

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Augmentative and Alternative Communication

- AAC technologies offer the potential to
  - Enhance communication &
  - Increase participation
- Substantial advances in AAC over the past 40 years
  - But the potential has not been fully realized for many individuals with complex disabilities

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Barriers for individuals who require AAC

Many individuals with complex needs
- have only minimal movement and cannot reliably control technology
- are not literate and are excluded from the use of many technologies
- are overwhelmed by the substantial learning demands of many AAC technologies and abandon their use
- face significant societal barriers, especially when communication partners are unfamiliar and untrained in AAC

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Our vision

- Ensure that all individuals, including those with the most complex needs, have access to effective AAC technologies & interventions to realize
  - the basic human need,
  - the basic human right, and
  - the basic human power of communication

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RERC on AAC Team

- Individuals who rely on AAC & their families
  - Anthony Arnold, Dave Chapple, Chris Klein, Godfrey Nazareth, & Tracy Rackensperger
- Rehabilitation engineering team
  - Erik Jakobs, Heidi Koester, Tom Jakobs
- Rehabilitation scientists & clinicians
  - Janice Light, David McNaughton, Susan Fager

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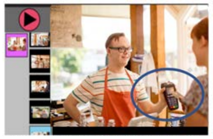
Research and Development Projects

- **Research Projects**
  - R1 Video VSD Intervention
  - R2 AAC Literacy Decoding Technology
  - R3 Motion in AAC User Interface Displays



- **Development Projects**
  - D1 Access Assistant
  - D2 Smart Predict
  - D3 Partner mTraining

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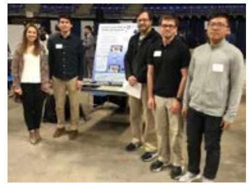
Training & Dissemination



- **Training Projects**
  - T1 Mentored R&D Lab Experiences
  - T2 Rehab Engineering Student Capstone Projects
  - T3 Student Research & Design Competition
  - T4 Doctoral Student AAC R&D Think Tank
  - T5 AAC Webcasts and Instructional Materials
- **Dissemination**
  - Website, webcasts, e-Blasts, presentations, publications, social media, etc.
  - AAC Consumer & Technology Forum
  - State of the Science conference

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NIDILRR-funded RERC on AAC

- The **RERC on AAC** conducts
  - **Research** to advance knowledge & enhance participation
  - **Development** to improve AAC technology solutions
  - **Training** to increase the knowledge of consumers, service providers, researchers, technology developers & policy makers
  - **Dissemination** to reach all stakeholder groups and bridge the gap between research and practice
    - To expand "what is possible"
    - To ensure "what is possible" becomes "what is probable"

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R1 Video Visual Scene Display (VSD) Intervention

David McNaughton, Janice Light, Erik Jakobs

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Participation goals

- Employment
- Higher education
- Shopping
- Community transportation
- Participation in community building volunteer activities

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Communication challenges

- Speech will not meet communication needs of
  - 40% of adults with autism spectrum disorders
  - 50% of adults with Down syndrome
- Less than 10% of adults with developmental disabilities who **need** communication supports **receive** communication supports

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Key Features

- Support **independent performance** of complex, multi-step skills in community settings
- **Easily learned and used** by persons with intellectual and developmental delays
- Provide **communication assistance** as needed
- Make use of **highly portable, commonly available** technology
- Easily developed for **individually selected goals** by typical support providers
  - family members, group home workers

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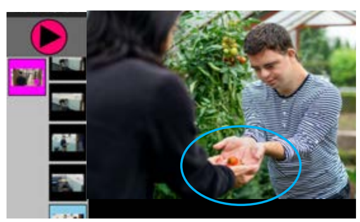
Video visual scene display (VSDs)

- Video modelling with communication supports
  - Participation + Communication
- Capture video of events/ interests
- Pause at key moments
  - Create visual scene at these junctures
  - Add hotspots with speech output



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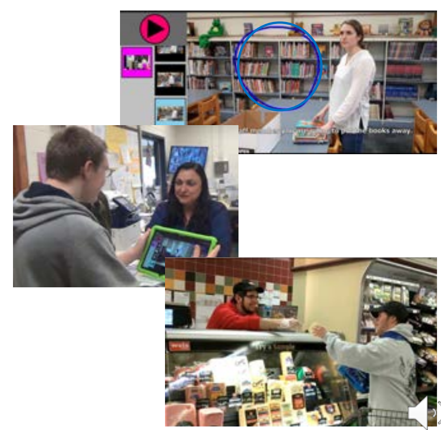
Research to date

- Single-case studies
- Improved outcomes in
  - Shopping
  - Riding public transportation
  - Working in a foodbank
  - Working in a library



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Video VSD – 2020-2025

- 3 large scale studies
- 72 participants
  - Intervention delivered by RERC on AAC team
    - 24 adults with IDD (Study 1)
    - 24 adults with ASD (Study 2)
  - Intervention delivered by family/caregivers, community professionals
    - 24 adults with ASD or IDD (Study 3)

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Greenhouse (19 steps)

- Walk to greenhouse
- One spoonful of fish food, spread around the top, watch to see they eat it, put fish food scoop away
- Get ruler, pencil and book, sit down by area 1 with tablet
- Plant 1 : write down plant name, measure plant, write down information
- Plant 2: write down plant name, measure plant, write down information
- Plant 3 : write down plant name, measure plant, write down information
- Sweep floor
- "I measured the plants and wrote it down"
- "What should I do now?"

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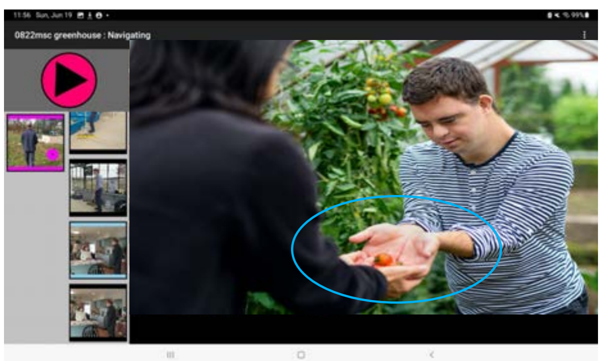

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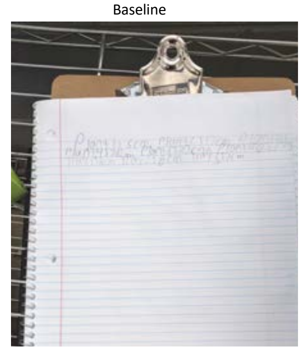
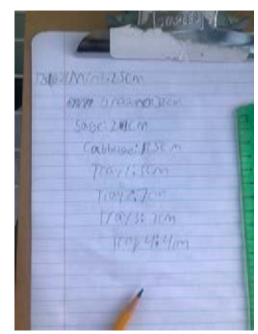
Writing samples

Baseline



With Video VSD



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	Video VSD
Easily learned and used by persons with intellectual and developmental delays	- 2 instructional trials
Support independent performance of complex, multi-step skills in community settings	- Independent performance of all 19 steps
Provide communication assistance as needed	- Appropriate use of 2 communication opportunities (task completion, next steps)
Make use of highly portable, commonly available technology	- Samsung tablet (and smartphone)
Easily developed and personalized by typical support providers (e.g., family members, group home workers)	- Study 3

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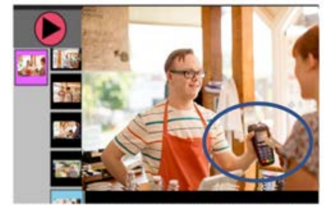
Video visual scene display (VSD)

Expected outcomes

- Supports for development and delivery of Video VSD interventions
  - Evidence-based protocol
  - Evidence-based online training module
- Tech transfer to manufacturers to support iterative development of Video VSD app



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R2 AAC Literacy Decoding Technology

Janice Light, Christine Holyfield, Erik Jakobs, David McNaughton

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Importance of Literacy

- Full participation in daily life means engaging meaningfully in social, academic, and vocational contexts
- Increasingly, engagement in such contexts is achieved in no small part by applying literacy skills

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Importance of Literacy

- For individuals who use AAC, literacy is further elevated in importance
- Using a keyboard option on AAC technologies allows for fully generative communication

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Literacy Challenges

- Most individuals with developmental disabilities who require AAC do not have functional literacy skills
- Support for AAC from many existing AAC technologies is limited

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T2L Sight Word Feature

- The T2L Sight Word Feature was developed and evaluated under the previous RERC on AAC (2014-2020)
- More than 50 children and adults (ages 3-55) participated in research evaluating the feature
- 91% of participants demonstrated significant gains

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T2L Decoding Feature

- Sight word reading is an important and functional skill
- However, it does not represent full functional literacy
- Designed with a goal of expanding the reach of AAC technology to building decoding skills

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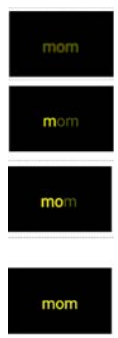
Theoretical support for the T2L Decoding Feature

- Text appears dynamically and enlarges
- Motion and enlargement drives visual attention to text
- Each letter highlighted in turn
- Luminance drives visual attention to letter
- Letter sound is spoken slowly as letter is highlighted
- Speech output supports phonological processing



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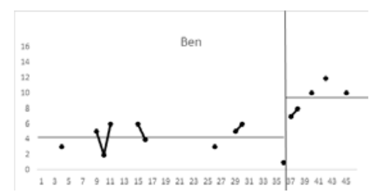
Research to date

- 5 single-case research studies completed to date
- 14 participants
- Improved outcomes in
  - Decoding programmed words
  - Decoding novel words
  - Encoding programmed words
  - Encoding novel words



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T2L Decoding – 2020-2025

- Series of single subject research designs
- 48 participants
  - Individuals with ASD
  - Individuals with IDD
  - Individuals with CP

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T2L Decoding

Expected outcomes

- A new technology intervention to support decoding skills
- Tech transfer to manufacturers to support iterative development of the T2L decoding feature in software and apps

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R3 Motion to improve AAC user interface displays

Janice Light, Krista Wilkinson, & Erik Jakobs

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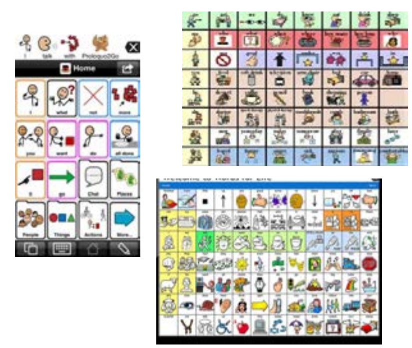
R3: Motion to improve AAC user interface displays

The problem

- Most AAC displays are complex
  - Impose significant visual, cognitive, & linguistic processing demands
- Many individuals who require AAC experience
  - Difficulty attending to key components of AAC displays
  - Difficulty learning new AAC symbols
  - Difficulty communicating in real world contexts



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Motion to improve AAC user interface displays

Proposed solution

- Motion is a powerful attractor of visual attention
- Harness motion to improve AAC user interface displays
  - Increase visual attention to key components of the display
  - Reduce visual distractions
  - Increase learning of target symbols
  - Improve communication performance

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Motion to improve AAC user interface displays

Hypotheses

- When motion is used in AAC displays, individuals with complex communication needs will demonstrate
  - Increased visual attention to target symbols
  - Increased accuracy learning & identifying target symbols
  - Increased accuracy using target symbols when communicating compared to static displays (i.e., the current state of practice)

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Motion to improve AAC user interface displays

Research Methods

- 4 studies of effect of motion on visual attention, learning, & use of AAC symbols
  - 2 studies of grid displays with picture symbols
  - 2 studies of grid displays with written text
- Design
  - Within-subjects experimental design with repeated measures
- Participants
  - 60 individuals with developmental disabilities (ASD, IDD)
- Independent variables
  - Type of AAC Display (static display vs. targeted motion)
  - Session (session 1-5)
- Dependent variables
  - Visual attention, symbol identification, communicative use

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Motion to improve AAC user interface displays

Materials

- Prototype displays of 12 new AAC symbols (picture symbols or text)
  - Static display (current state of practice)
  - Display with motion of symbol upon selection

Procedures

- In each condition, place display in front of participant
- Prompt participant to select target symbol
  - In static condition, no change to target symbol
  - In motion condition, smooth animation of target symbol
- Repeat procedures until all target symbols have been selected

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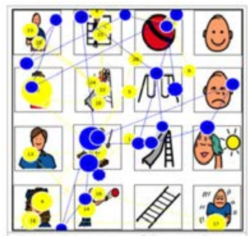
Motion to improve AAC user interface displays
Measures

- Visual attention
  - Measured using eye tracking research technology that rapidly samples position of eye in relation to areas within AAC display
    - Latency, duration, and sequence of visual fixations
- Symbol learning
  - Probe each target symbol ("Show me ______")
  - Collect data on accuracy of identification & rate of learning
- Pilot study
  - Conducted remotely due to COVID 19



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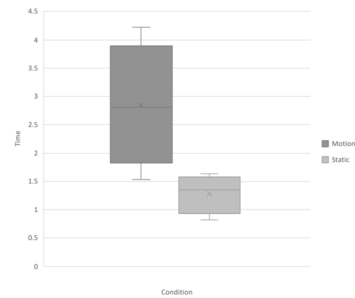
Visual attention to target symbol with static and motion displays (time in sec)



- Participant attended visually to target symbols for longer with motion vs static display
  - Mean of 2.84 sec per symbol in motion condition
  - Mean of 1.28 sec per symbol with static display
- Participant was more easily distracted with static display
  - Looked elsewhere at other parts of the display 71% of the time in the static condition

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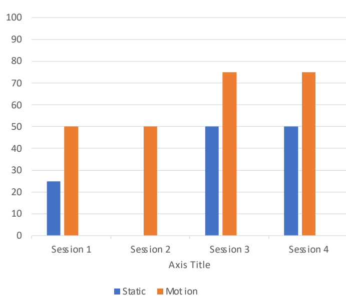
Percent accuracy identifying text symbols with static & motion displays



- Participant learned text symbols more quickly with the motion compared to the static display
- Participant was more accurate identifying text symbols with the motion than the static display
- These are only preliminary results; further investigation is required

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Motion to improve AAC user interface displays
Expected outcomes

- Scientifically-based design specifications for using motion in AAC displays
  - Maximize visual attention to key components of display
  - Minimize attention to distractors
  - Maximize learning of new symbols
    - Picture symbols
    - Written text
  - Enhance communication performance

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D1 Access Assistant Software to Improve Alternative Access Services

Heidi Koester, Susan Fager, Erik Jakobs, Tabatha Sorenson

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Access Assistant – Problem statement

Jim is a farmer in a rural Midwestern state, diagnosed with ALS. Living 400 miles from an AAC assessment center, he relied on his local speech-language pathologist (SLP) to support his needs as his disease progressed. Trying to provide Jim with a sophisticated, high-tech access method, he eventually received an eye-tracking device but struggled to use it successfully. His SLP was frustrated with the lack of support she had to select, implement, and monitor this complicated access method with Jim and often wondered if she had made the right access decision.

Jim and his SLP needed support to make appropriate access decisions and ensure his full access to communication.

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Challenges with Alternative Access

- Alternative access methods help people with motor impairments control technology
- But people don't always get methods that are the best fit for their needs
- Why not?
  - AT providers may not have needed knowledge and skills
  - Difficulty carrying out systematic, evidence-based assessment process
  - Existing assessment tools may be cumbersome, time-consuming, or incomplete

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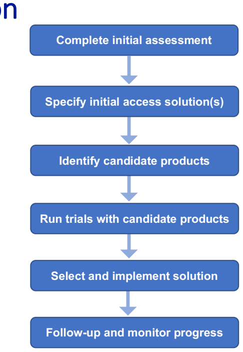
Access Assistant – Proposed solution

- Develop Access Assistant software
- Web-based tool to guide access assessments
- Improves the quality of the assessment process:
  - Leads teams through a repeatable, systematic process
  - Incorporates performance measurements for evidence-based decision-making
- Will be freely available



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Access Assistant – User-centered design timeline

1. Product Definition ✓

How
- User interviews
- Benchmarking

What
- List of requirements
- Personas
- Scenarios
- Basic workflow

oct 2020 – feb 2021

2. MVP Initial Design ✓

How
- Iterative ideation
- Wireframe design

What
- Refined product definition
- User-vetted wireframe UI
- Tech stack requirements

mar – may 2021

3. Refined Design and Content ✓

How
- 2 user studies
- Clinical content development

What
- Refined wireframe UI
- Tech stack selection

jun – nov 2021

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Access Assistant – Key themes from user interviews

- 8 practitioners and 3 end users
- 46 themes and corresponding requirements for the app
- A Holy Grail? Practitioners want a more systematic approach, but don't use the tools that are already available.

- Practitioner anxiety can be intense: *"I should know this, but I don't."* Design AA to take the worry out of assessments – welcoming, reassuring, fun, exploring.
- Speed/accuracy measurements aren't everything (but they still have value)
- Need option for self-defined test-drive tasks that are meaningful to user

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Access Assistant – Wireframe UI design

- Using Balsamiq tool for wireframe creation
- Explore workflows for planning ahead for an eval as well as conducting an eval.
- About 60 screens in the design!
- User study #1 → (N=4) positive feedback and opportunities for improvement
- Intense internal review of the workflows and design (2 clinical experts on the team)
- User study #2 → (N=8) provided confidence in direction and extensive feedback

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Access Assistant – Key results from user study #2

- 8 practitioners provided feedback based on wireframe demo
- High agreement that:
  - They'll use Access Assistant with their clients
  - It's easy to use
  - It covers the important aspects of the assessment process
  - Basic workflow is sound
- About a dozen user interface enhancements identified
- Combined with user study #1, we've had 12 practitioners review our design in detail

"Yeah, I would use this. I can't wait to use this."

"I like how it's set up!"

"If I had this when I first started, I wouldn't feel as intimidated going into my first assessment."

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Access Assistant – Current and Future Work

IN PROGRESS

Implement
- Code the Access Assistant app
- ReactJS tech stack

Clinical evaluation
- 24 people with severe motor impairments
- 24 practitioners

Deliver
- Refine the app
- Make freely available

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For more information

Contact Heidi Koester at hhk@kpronline.com
- Let us know if you want to give Access Assistant a try
- See our RESNA papers for more details on the user-centered design process:
  - kpronline.com/pubs
  - 2022: "Designing an app for alternative access assessments: using prototypes and user studies to evaluate and improve the design"
  - 2021: "Designing an app for computer access assessments: using interviews to uncover and define user needs"

- Thanks for being here!

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D2 *Smart Select*: A New Switch Access Method

Jon Brumberg, Susan Fager, Erik Jakobs, Heidi Koester, Arash Gonabadi, Tabatha Sorenson

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Smart Select- Challenge

- Some individuals with severe motor impairment have no or very limited access to AAC technology impacting their ability to pursue participation in family life, communication, work, and community.
- Access technologies for individuals with severe motor impairment are emerging (e.g., BCI) but thus far have had limited clinical use due to challenges associated with signal capture and acquisition.

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Smart Select- Previous work

- Despite advances in technology, most access solutions rely on a single signal or tool.
  - Previous RERC on AAC: Eye-tracking + Switch-scanning prototype
  - Leveraged both methods to improve access
    - 1st- Eye-tracking to narrow location of target in interface
    - 2nd-Switch-scanning to target of smaller group of items (versus full interface)
  - New project: Smart Select
    - Examine use of multiple signals to enhance access
    - Examine simultaneous use of access signals (EEG + EMG)

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Smart Select- Proposed solution

- This project will address the access needs of people who are unable to effectively use current alternative access methods, by developing and evaluating a new switch access method called *Smart Select* that uses machine learning to simultaneously combine brain EEG and muscle EMG signals.

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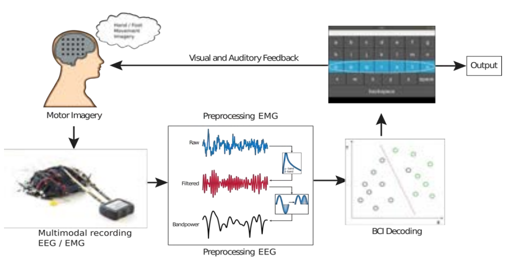
Smart Select- Prototype

***Smart Select* prototype**

- The main components are signal acquisition of EEG and EMG signals, pre-processing of EEG and EMG prior to decoder model fitting and prediction, followed by output to the AAC device



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Smart Select- Proof of concept development project

- Ready wireless prototype for clinical lab setting for testing
- Examine user-interface design to enhance BCI/EMG access learning
- Determine how to weight signals to optimize performance
- Iterative refinement/design phases
  - Participants- individuals with high level (cervical) spinal cord injury, brainstem impairment and amyotrophic lateral sclerosis
  - Refine/design process will examine and iteratively implement changes to user interface, calibration procedures, and signal processing

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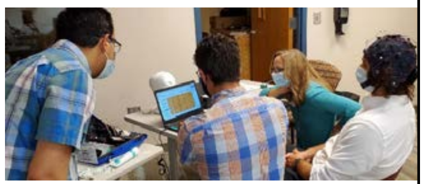
Smart Select- Current progress

- Development of trigger box to allow for synchronization of visual signal and EEG/EMG signals during calibration
- Calibration routine for EMG and EEG established and tested on participants without disability
- Confirmation of signal acquisition and ability to evaluate quality of calibration
- Identification of need to provide motivating participant feedback for calibration (ongoing future development)



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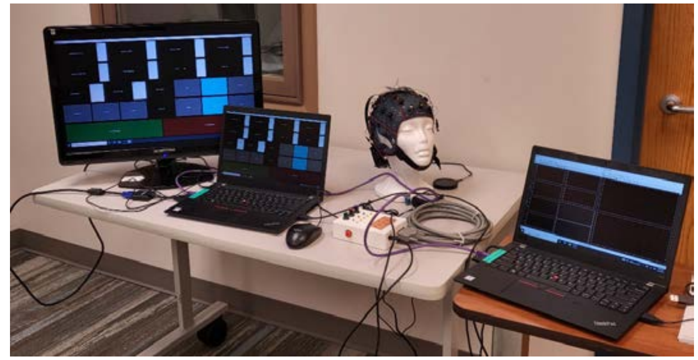

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Smart Select- Outputs

- Prototype feasibility/proof of concept
- Development of prototype ready for clinical and home settings
- Development of algorithms to enhance calibration and automatically weight signals based upon performance
- Develop user interfaces based on individual feedback and to enhance learning

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D3 – Mobile training in AAC for communication partners

Erik Jakobs, Janice Light, Susan Fager, Jessica Gormley,
Christine Holyfield, & David McNaughton

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Partner mTraining

The Problem

- Individuals who rely on AAC encounter numerous communication partners who lack training in AAC
  - These communication partners frequently preempt opportunities for communication
- As a result individuals who rely on AAC are unable to communicate and participate successfully
  - Education/ employment
  - Healthcare
  - Community

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Partner mTraining - Proposed solution

- AAC technology that
  - Supports stakeholders in quickly & easily creating mTrainings to teach partners AAC procedures for successful communication
  - Empowers individuals who rely on AAC and facilitators to deliver these mTrainings “just in time” as required to train communication partners
    - Pop-up within AAC technologies
    - Local computers
      - Password protected
    - Secure URL
      - Pushed to partner’s phone

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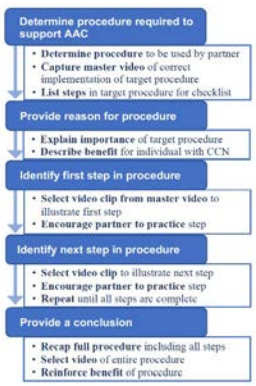
Partner mTraining - Development

- Prototype to enable stakeholders to quickly & easily create & deploy mTrainings for communication partners

- Partner trainings
  - Checklist of procedural steps
  - Video models of each step
  - Generic or personalized trainings
  - Library of mTrainings freely available to stakeholders



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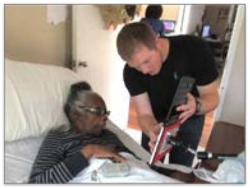
Partner mTraining - Evaluation



- Evaluation
  - Usability of app to create partner trainings
  - Effectiveness of partner mTrainings

- 4 studies
  - 2 studies to train healthcare professionals who interact with adults with acquired conditions
  - 2 studies to train educational & community personnel who interact with individuals with developmental disabilities

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Partner mTraining – Study #1

- **Training healthcare professionals in acute care settings** to interact with patients with acquired conditions
- **Setting up successful patient interactions**
  - Ready the environment (e.g., turn on lights, turn off TV)
  - Ready the patient (e.g., provide hearing aids, glasses)
  - Ready the communication supports (e.g., note how the patient communicates)
  - Interact using the communication supports (e.g., use short sentences, wait)

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Partner mTraining – Study #2

- **Training education professionals** to use aided AAC modeling to support children with developmental disabilities
- **Aided AAC modeling**
  - Provide a choice or introduce the activity
  - Interact with the student modeling the use of AAC symbols
  - Wait and provide the student with time to communicate
  - Respond to the student's communication attempts, modeling the use of AAC symbols

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Partner mTraining – Expected outcomes

- New technology that supports
  - Stakeholders in quickly & easily creating mobile trainings for communication partners
  - Individuals who rely on AAC & facilitators in delivering mTrainings to partners just in time as required
    - Resulting in improved communication & increased participation

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RERC on AAC - Anticipated Outcomes

- **6 R&D projects to advance knowledge & improve AAC technology solutions**
- **13 new research-based AAC technologies and interventions**
- **5 training projects to increase capacity in the AAC field**
- Improved physical access to AAC technologies for those with significant motor impairments
  - Improved access assessment (D1)
  - New multimodal access technique that combines BCI & EMG (D2)

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Anticipated Outcomes

- Reduced learning demands & increased usability of AAC technologies
  - Video VSD technology to increase participation in vocational / community activities (R1)
  - AAC decoding technology to increase literacy skills & enhance communication (R2)
  - Targeted motion to improve AAC user interface displays (R3)
- Increased successful participation in society
  - mTrainings in AAC for partners to reduce barriers (D3)
- Increased awareness & competencies in AAC for stakeholders
  - Training & dissemination activities

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Our vision

- Ensure that all individuals, including those with the most complex needs, have access to effective AAC technologies & interventions to realize
  - the basic human need,
  - the basic human right, and
  - the basic human power of communication

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Having the power to speak one's heart and mind changes the disability equation dramatically. In fact, it is the only thing I know that can take a sledgehammer to the age-old myths and stereotypes and begin to shatter the silence that looms so large in many people's lives (Williams, 2000; p. 249).

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- For more information, **please visit our website at rerc-aac.psu.edu**

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Questions?

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