RERC on AAC: Overview of Research, Development and Training Objectives

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The partners

1. **InvoTek, Inc.**
   - Tom Jakobs, co-Investigator

2. **Madonna Rehabilitation Hospital**
   - Susan Fager, co-Investigator
   - David Beukelman, co-Investigator

3. **Oregon Health & Science University**
   - Melanie Fried-Oken, co-Investigator

4. **Pennsylvania State University**
   - Janice Light, Principal Investigator
   - David McNaughton, co-Investigator
The need

- 4+ million Americans with severe disabilities resulting in complex communication needs
- Developmental disabilities
- Acquired disabilities
- Degenerative disabilities
The challenge

- Many individuals with CCN are severely restricted in their participation in society
  - Education
  - Employment
  - Health care
  - Family
  - Community living
Our vision

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

Research
- Access R1: Brain-computer interface (BCI) with enhanced language modeling
- LangTech R2: Technologies to support the transition from graphic symbols to literacy
- HCI R3: Visual cognitive processing demands of AAC interfaces

Development
- Access D1: Multimodal technologies to improve access
- LangTech D2: AAC technology to support interactive video visual scene displays
- LangTech D3: AAC technology with smart prediction
- HCI D4: Cognitive demands checklist for AAC technologies and apps

Training
- Mentored research and lab experiences, AAC webcasts and MOOC, AAC Incubator (Rehab Engineering Capstone and Hack-a-Thon), RESNA Student Design Competition, Doctoral student Research ThinkTank

Dissemination
- Website, webcasts, YouTube channel, e-blasts, presentations, publications, consumer publications, blogs, technical assistance, exhibit booth, State of the Science conference
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• AAC webcasts and MOOC
• AAC Incubator/ Engineering learning factory
• RESNA Student Design Competition
• Doctoral student Research ThinkTank
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Our rehabilitation engineering & science team

Principal Investigator
Janice Light

Lifespan Strand:
Research and Development-
Children
Janice Light
Tom Jakobs
Access.D1  LangTech.R2  HCI.R3
LangTech.D2  HCI.R3

Lifespan Strand:
Research and Development-
Adults
Melanie Fried-Oken
Steven Bedrick
Access.R1  LangTech.D3  HCI.D4

Training and Dissemination
(Knowledge and technology transfer)
David McNaughton
Pam Kennedy
Godfrey Nazareth

Penn State University
Invotek, Inc.
Madonna Rehabilitation Hospital
Oregon Health & Sciences University
Northeastern University

Expert Advisory Board and Key Stakeholders
Collaborations

- Inclusion of individuals with disabilities and family members in all RERC activities
- Active collaborations with AT manufacturers, mainstream industry, professional organizations, IHEs, educators/rehab professionals & NIDRR funded projects to maximize impact
RERC on AAC
Research projects
Access R1: Investigating brain computer interface

Team
- Oregon Health and Science, Northeastern

The problem
- Brain-computer interface (BCI) provides a potential means for individuals to control a computer using only their brain waves, but limited information on
  - Use with clinical populations
  - Support for effective use
Access R1: Investigating use of a BCI with enhanced language modeling

**HOW BCI WORKS**

+ You are fitted with an EEG cap that acquires your brain signals. You watch a screen with letters.

+ When a letter that you want appears on the screen, your brain wave (the P300 event related potential) changes.

+ This is averaged over time and is interpreted as a ‘keystroke’.

+ A language model confirms that the ‘keystroke’ is a statistically possible selection.
How the RSVP Keyboard™ works
Access R1:
The AAC technology problems

- BCI for communication is very slow.
- Spelling with BCI is often inaccurate.
- Language modeling has not been applied to an RSVP spelling paradigm previously.
- It is very difficult to attend to the BCI task for long periods of time.
Access R1: Engineering solutions

- **Increase speed and spelling accuracy:** Change the language model probabilities and add an autotyping function.
- **Increase attention to the task:**
  - Provide cognitive training programs to people as they learn to use BCI
  - Study 1: Process-specific attention training
  - Study 2: Mindfulness meditation
A Language Model (LM) is a way of assigning probability to strings of symbols (words, letters, etc.).

Using a large collection of real-world text, an LM learns patterns of language.

“President of the United _________”

“FRED WAS Q_”

Often we think of an LM in terms of conditional probability (Given X, what is the probability of Y).
Access R1: Research hypotheses and design

Study 1: Ps will attain better selection accuracy scores and spelling performance with enhanced LMs.

Study 2 and 3: Ps’ selection accuracy and spelling performance will improve after a 6-week training period with either process-specific attention training or mindfulness meditation.

Design

Series of single subject experimental designs

5 Individuals each with ALS, spinal cord injuries, brainstem stroke (N=15)
Access R1: Independent and dependent variables; data analysis

**Independent Variables**
- Study 1: Enhanced language model
- Study 2: Attention training
- Study 3: Mindfulness meditation training

**Data analysis**
- Comparison of level, trend, slope & variability of data at baseline to intervention

**Dependent Variables**
- Highest level completed on a copy-spelling task
- Selection accuracy score
- Correct characters/minute
- Total error rate
Access R1: Expected outcomes

- Increased functionality of RSVP Keyboard™
- Increased user satisfaction with access method
- Reduced workload and fatigue
- Evidence-based attention training programs for all BCI users
Lang Tech R2: Investigating AAC technologies to support literacy

Team
- Penn State/ InvoTek/ Saltillo

The problem
- More than 90% of individuals with CCN enter adulthood without literacy skills
- Current AAC technologies do not support the transition from graphic picture symbols to literacy
Lang Tech R2: Investigating AAC technologies to support literacy

Engineering solution

- AAC apps to support the transition from graphic symbols to literacy
  - Individual selects a picture symbol from AAC display
  - Written word appears dynamically next to graphic symbol representation
  - Written word is spoken by the app
Lang Tech R2: Investigating AAC technologies to support literacy

- Research hypothesis
  - Individuals with CCN will increase their literacy skills as a result of using the AAC app

- Design
  - Series of single subject experimental designs
  - Individuals with ASD, CP or IDD
Lang Tech R2: Investigating AAC technologies to support literacy

- Independent variable
  - AAC app to support literacy (grid & VSD)

- Dependent variable
  - Number of written words read accurately

- Data analysis
  - Comparison of level, trend, slope & variability of data at baseline to intervention
Lang Tech R2: Investigating AAC technologies to support literacy

Progress to date
- Prototype apps developed
- Data collection in progress

Expected outcomes
- 2 new research-based AAC apps known to improve literacy skills for individuals with CCN
  - Grid-based app
  - VSD-based app
HCI R3: Investigating cognitive processing demands of AAC interfaces

Team
- Penn State, Madonna, InvoTek/ Saltillo

The problem
- Most AAC displays are not research-based and are poorly designed
- Impose significant visual cognitive processing demands
- Impede communication performance
HCI R3: Investigating cognitive processing demands of AAC interfaces

- Engineering solution
  - Define display characteristics that affect visual cognitive processing demands
  - Determine optimal designs for AAC displays to maximize communication
HCIR3: Investigating cognitive processing demands of AAC interfaces

- Research methods
  - Series of studies to investigate visual cognitive processing demands of different display characteristics with individuals with CCN
  - Eye tracking research methods
HCI R3: Investigating cognitive processing demands of AAC interfaces

- Eye tracking research technology
  - Rapidly samples position of eye in relation to AAC display
  - Latency of fixation
  - Duration
  - Sequence of visual fixation
HCI R3: Investigating cognitive processing demands of AAC interfaces

+ Progress to date
  + Data collection in progress to investigate demands of different navigational layouts

+ Expected outcomes
  + Scientifically-based design specifications for AAC displays
  + Minimize cognitive demands & maximize communication
RERC on AAC
Development projects
Access D1: Developing multimodal access technologies

+ Team
  + InvoTek, Inc., Madonna, Penn State, Saltillo

+ The problem
  + Focus has remained on single access methods despite advanced in access technologies (eye/head tracking, touch interfaces, specialty switches).

+ Challenges with focusing on a single access method
  + Fatigue due to over-use
  + Inefficiency
  + Heavy reliance/focus on methods such as dwell that require vigilance and precise motor execution
Access D1: Developing multimodal access technologies

+ Goals of the project
  • Design multi-modal technology so that the best access method is always available.
    • E.g., Use a head tracker with dwell for accessing an onscreen keyboard; use an eye-blink for desktop selections.
  • Min. the shortcomings of an access method.
    • E.g., Use an eye tracking for large cursor movements and head tracking for small, corrective cursor movements.
  • Unintentional movements don’t cause errors.
    • E.g., Thumb movement causes a switch closure only when the hand is still.
Access D1: Developing multimodal access technologies

**Engineering solution**

- Develop multi-modal solutions specific to individual with SSPI
- Develop 3-D movement tracking system capable of measuring eye, head, and gestures (e.g., jaw or finger movement)
- Proposed system will provide universal access to wide range of computer and smart/mobile technologies
- SDK (Software Development Kit) to integrate this technology into AAC devices
Access D1: Developing multimodal access technologies – Clinical Evaluation

**Preliminary Investigations:**
- Document current multimodal use by persons with CCN (what technology is used, why, challenges associated, impact on participation)
- Evaluate custom solutions through case study series

**Systematic evaluation of movement tracking system**
- 45 participants (15 children with CP, 15 adults with CP, 15 adults with cervical SCI)
- Alternating treatment design (5 single access and 5 multimodal access counterbalanced sessions)
- Target acquisition task
- Dependent measures - accuracy, rate and movement across tasks
- Individual feedback and personal preference/potential benefit of 3-D multimodal system
Access D1: Developing multimodal access technologies

+ Progress to date
  + Survey of multi-modal use by individuals with CCN (currently data collected on 5 with SCI, 2 with ALS, and 3 with CP)
  + Case study illustrations:
    + Alison, Tiffany, Cloe
  + Expected outcomes
    + New genre of access technology
Lang Tech D2: Developing technologies with video visual scene displays

Team
- Penn State, InvoTek

The problem
- Many individuals with CCN benefit from visual scene displays (VSDs)
- Current AAC apps with VSDs are limited to static photos
- These static VSDs fail to capture dynamic communication routines
Goals of the project

- To develop a mobile technology AAC app that supports video visual scene displays
- To investigate the effects of the video VSD app on communication by individuals with CCN
Lang Tech D2: Developing technologies with video visual scene displays

**Engineering solution**

- Capture video of daily routines
  - Via built in cameras & wireless import
- Allow pause of video
- Create VSDs at these junctures
- Create hotspots with speech output
Lang Tech D2: Developing technologies with video visual scene displays

+ **Clinical evaluation**
  + Series of single case studies
  + Investigate the effects of the video VSD app on the frequency & effectiveness of communication by individuals with CCN
Lang Tech D2: Developing technologies with video visual scene displays

Progress to date
- Initial prototype developed
- Systematic review of potential clinical applications of video VSD
- Data collection in progress

Expected outcome
- New research-based app that supports video VSDs
Access D3: Developing AAC technologies with smart prediction

Team
- Oregon Health & Science University, InvoTek, Saltillo

The problem
- Communication speed is very slow for people with SSPI.
- Communication partners have contextual knowledge, but no way to support written AAC message construction.
Goals of the project

- Develop a unique AAC system that incorporates the communication partner’s knowledge into the AAC device prediction list.

The end result:

- Increased speed and informativeness of face-to-face conversations,
- More control for AAC user in social interactions.
Access D3: Developing AAC technologies with smart prediction

- Engineering solution
  - Develop a unique AAC system that incorporates the communication partner’s knowledge into the AAC device prediction list.
  
- The end result:
  - increased speed and informativeness of face-to-face conversations,
  - More control for AAC user in social interactions.
Clinical evaluation

The study will evaluate impact of Smart Prediction on conversation (rate, informativeness, satisfaction) compared to standard prediction.

Testing will occur in the community, in supported employment sites or other community environments in Portland, OR.
Access D3: Developing AAC technologies with smart prediction

+ Progress to date
  + Prototype apps have been designed and tested.
  + Initial clinical evaluation is underway.

+ Preliminary Results
  + First AAC user:
    + Preferred using the app to her present AAC device.
    + Regulated effort by waiting for partner to complete her prediction suggestions.
Access D4: Developing a Cognitive Demands Checklist for AAC Technologies

Team
- Oregon Health and Science

The problem
- Communication technology should be matched to the cognitive needs and abilities of the user
- Current feature matching tools do not address the cognitive demands of AAC use
- We have not examined the cognitive demands of AAC technologies and apps
Our goal: Develop, evaluate, and distribute the Cognitive Demands Checklist (CDC)

The CDC will be a valid, reliable tool to:
- Assist clinicians with person-technology matching
- Help developers understand the cognitive demands of AAC technologies and design improved products
HCl D4: Developing a Cognitive Demands Checklist for AAC Technologies

- Engineering solution
- Examine existing AAC devices and software/apps
- ID requisite cognitive skills and propose checklist items
- Determine domain and content relevance of items for a range of AAC tech.
- Launch web-based checklist
HCI D4: Developing a Cognitive Demands Checklist for AAC Technologies

+ **Clinical evaluation and testing**
  + Validate checklist content with national AAC stakeholders
  + Revise checklist based on stakeholder feedback
  + Researchers complete checklist for existing AAC technologies to establish intra-rater reliability
  + AAC stakeholders complete checklist for existing AAC technologies to establish inter-rater reliability
HCI D4: Developing a Cognitive Demands Checklist for AAC Technologies

+ **CDC tech transfer and distribution**
  + Web-based application
  + Available on multiple websites
  + Free of charge to AAC stakeholders
  + Marketed through AAC stakeholder groups and industry conferences
  + Added to GPII shelf of Raising the Floor Consortium
  + Eventually available in multiple languages and in Braille format
  + Broad accessibility (universal design)
Access D4: Developing a cognitive demands checklist

- Progress to date
- Expected outcomes
  - (addressed in previous slide)
RERC on AAC
Training & dissemination
Training: Challenge (photos)
Experienced
• naive vs experienced

Practicality
• applied vs theoretical

Goals
• Breadth vs depth
Merging traditional techniques with iDevices and AAC strategies for Severe Speech Sound Disorders

Jessica Gosnell Caron
T2) Webcasts & MOOC
MOOC: Massive Online Open Course

- **Modules**
  - Early intervention, transition, funding, literacy, access for individuals with minimal movement

- **Materials**
  - Readings: Open access articles, summaries
  - Webcasts: presentations, “first person”
  - Activities: Answers to FAQs, think/pair/share

- **Assessment**
  - Quizzes, AAC materials
    - CEUs, course credit (at home institution)
Transition

Transition Strategies for Adolescents & Young Adults Who Use AAC

David B. McNaughton & David K. Beukelman
Peer Reviewed by Bruce J. Heuer
Adapted from Making School Matter: Supporting Meaningful Secondary Experiences for Adolescents Who Use AAC (Carter and Draper, 2010)

High school and middle school are important for students with disabilities to gain experience in skills that will later support them after they graduate high school. Rigor, relevance and relationships are three terms that are necessary in developing a better experience for students with disabilities.
Training & Dissemination: Rehabilitation Engineering & Science team

Mary Frecker

Tom Jakobs

Chris Klein

David McNaughton

Godfrey Nazareth
T3) AAC Incubator

Focus groups of persons who use AAC

Student design teams
- Learning Factory
- Hack-a-Thon

RESNA SDC
- Prototypes
- Feedback to manufacturers
- Presentations, publications
T4) RESNA Student Design Competition

Play it By Ear (California Lutheran University)

To prevent injury to the ear and damage to the hearing aid, we took the hearing aids off the ears and placed them in a protective clamshell pouch that could be attached to the front of the player’s uniform.

Sticky Solution-An Assistive Device to Apply Sealing Tape onto an Insulation Foam (Duke University)

The goal of our project, Sticky Solution, was to create a device that enables employees with disabilities at OE Enterprises, Inc. to separate and linearly apply an accurate, wrinkle-free piece of sealing tape to an insulation foam.
T5) Doctoral Student Research Think Tank
(Summer, 2017)
Dissemination
Maximizing the literacy skills of individuals who require AAC (webcast)
Outcomes of the RERC on AAC

+ 7 high quality research & development projects
  + Increase technical & scientific knowledge in AAC
+ More than 10 new innovative AAC technologies / products
  + Designed & tested in our 5 engineering labs
  + Evaluated with individuals with CCN
    + Useable and accessible by people with diverse needs & skills
+ Transferred successfully to the marketplace (in conjunction with Center on KT4TT)
Targeted outcomes of the RERC on AAC

- State of the art multidisciplinary training in AAC
  - More than 150 rehab engineering & science students

- Comprehensive dissemination plan to improve services & results
Funding source

- Grant #H133E140026
- Janice Light, PI
- October, 2014 – September 2019
- https://rerc-aac.psu.edu/
ATIA business

- **CEUs – Session Code: AAC-37**
  - More info at: [www.atia.org/CEU2016](http://www.atia.org/CEU2016)
  - For ACVREP, AOTA and ASHA CEUs, hand in completed Attendance Forms to REGISTRATION DESK at the end of the conference. Please note there is a $15 fee for AOTA CEUs.
  - For general CEUs, apply online with The AAC Institute: [www.aacinstitute.org](http://www.aacinstitute.org).

- **Session Evaluation: URL (to be provided by ATIA Education)**
  - Please help us improve the quality of our conference by completing your session evaluation form.

- **Handouts**
  - Handouts are available at: [www.atia.org/orlandohandouts](http://www.atia.org/orlandohandouts)
  - Handout link remains live for 3 months after the conference ends.