Research & Development Project Update of the Rehabilitation Engineering Research Center on AAC

D. Beukelman, S. Fager, M. Fried-Oken, T. Jakobs, J. Light, & D. McNaughton

ATIA 2017

The partners

- **InvoTek, Inc.**
  - Tom Jakobs, co-Investigator
- **Madonna Rehabilitation Hospital**
  - David Beukelman, co-Investigator
  - Susan Fager, co-Investigator
- **Oregon Health & Science University**
  - Melanie Fried-Oken, co-Investigator
- **Pennsylvania State University**
  - Janice Light, Principal Investigator
  - David McNaughton, co-Investigator

ATIA 2017

The need

- There are millions who have severe disabilities resulting in complex communication needs (CCN)
  - Developmental disabilities
  - Acquired disabilities
  - Degenerative disabilities

ATIA 2017

Goals of the session

- To discuss the goals of the RERC on AAC and share our progress to date
  - 3 research projects
  - 4 development projects
  - 5 training and dissemination projects
- To seek input from you as stakeholders regarding our activities to date
- To brainstorm needs and directions for future research, development, training, and dissemination

ATIA 2017

RERC on AAC Research projects

Advancing knowledge to improve outcomes

Access R1: Investigating brain computer interface (BCI)

- **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
    - Safe, reliable and usable BCI systems in the home
    - Use with clinical populations
    - Support for effective use

ATIA 2017

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.

ATIA 2017

Access R1: Expected outcomes

- Increased functionality of RSVP Keyboard™
- Increased user satisfaction with access method
- Reduced workload and fatigue
- Evidence-based training programs for all BCI users

ATIA 2017

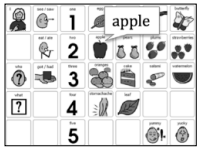
Lang Tech R2: Investigating AAC technologies to support literacy

- **Team**
  - Penn State/ InvoTek/ Saltillo
- **The problem**
  - More than 90% of individuals with CCN enter adulthood without literacy skills (Foley & Wolter, 2010)
  - Current AAC technologies do not support the transition from graphic picture symbols to literacy

ATIA 2017

Transition to Literacy (T2L) Software Features

- **Transition to literacy (T2L)** software feature
  - Individual selects a picture symbol from AAC display
  - Written word appears dynamically
  - Written word is spoken by the app
- 2 apps
  - Grid-based T2L app developed by Saltillo (Hershberger)
  - VSD T2L app developed by InvoTek (Jakobs)
    - Incorporated into SnapScene by TobiiDynavox



ATIA 2017

T2L feature for AAC apps A first step in the transition to literacy

- T2L apps are intended to **complement, not replace** literacy instruction
- Current T2L apps
  - only support sight word acquisition
  - are a **first step** in technologies that provide a direct bridge from picture-based systems to literacy
- Future developments are required to further support the full transition to literacy

ATIA 2017

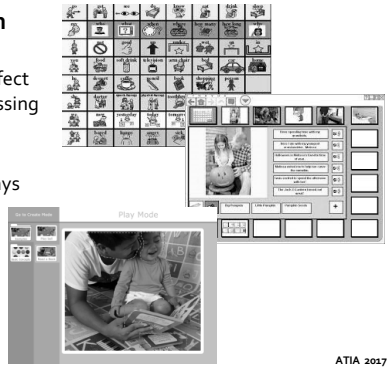
HCI R3: Investigating cognitive processing demands of AAC interfaces

- **Team**
  - Penn State, Madonna, InvoTek/ Saltillo
- **The problem**
  - Most AAC displays are <u>not</u> research-based and are poorly designed
    - Impose significant visual cognitive processing demands
    - Impede communication performance

ATIA 2017

HCI R3: Investigating cognitive processing demands of AAC interfaces

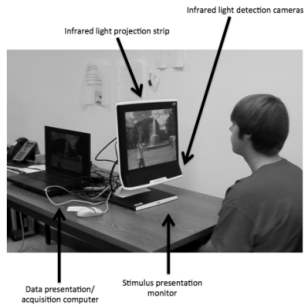
- **Engineering solution**
  - Define display characteristics that affect visual cognitive processing demands
  - Determine optimal designs for AAC displays to maximize communication



ATIA 2017

HCI R3: 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



ATIA 2017

HCI R3: Investigating visual cognitive processing demands of AAC interfaces

3 studies with children with CCN

- Goal
  - Evaluate effect of menu layouts on visual attention & navigation accuracy & latency
    - Top horizontal, bottom horizontal, right vertical, left vertical
  - Children with ASD, IDD, DS
- Procedures
  - Free viewing of VSDs
    - Determine elements of displays that capture visual attention
  - Cued viewing
    - Location of target VSD for navigation

Eye tracking data during navigation for participant with Down syndrome using VSDs

ATIA 2017

Studies with adults with CCN

HCI R3: Investigating visual cognitive processing demands of AAC interfaces

Selecting Visual Scene Displays:

Personal relevance

Age and gender

ATIA 2017

Rationale

- Visual Scene Displays (VSD) are increasing used to support communication for children and adults with complex communication needs.
  - Mobile technology contains cameras to capture "the moment"
  - Many SGDs can efficiently manage VSDs by onboard cameras, access to the web, and memory files
  - Web-based image resources (Google Image)

ATIA 2017

Web-based Resources: Google Images

—Search based on an image

Examples of the 503 images identified by Google Images

ATIA 2017

Purpose

- The purpose of this study was to investigate the eye tracking patterns of adults with and without disabilities who were cued to identify a VSD that represented activities such as:
  - Sleeping
  - Eating
  - Drinking
  - Writing
  - Reading

ATIA 2017

Examples of Visual Scene Displays

ATIA 2017

Procedures

- Equipment: Eye-Tracking with T-60 (Tobii)
- Stimuli: Screens containing 4 VSDs with adults of 3 age groups engage in an activity
  - Young female adults
  - Middle-aged female adults
  - Older female adults
  - Individuals with Stroke or TBI

ATIA 2017

Heat Map/Gaze Plot

ATIA 2017

Future Directions

- Future research will complete ongoing investigations of typical older males as well as males and females with neurological conditions.
- Future research will investigate the influence of race on VSD selection.

ATIA 2017

Eye-Gaze Plot Analysis of Visual Scene Displays with Vertical and Horizontal Menu Options

ATIA 2017

- The purpose of this study was to investigate the eye tracking patterns of adults with and without disabilities to were cued to identify a VSD that represented activities in vertical and horizontal menu bars

ATIA 2017

HCI R3: Investigating cognitive processing demands of AAC interfaces

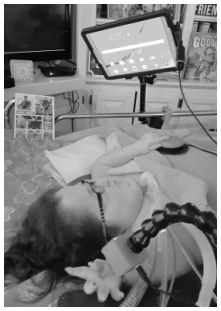
- **Expected outcomes**
  - Scientifically-based design specifications for AAC displays for children & adults with CCN
    - Minimize cognitive demands
    - Maximize communication

ATIA 2017

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



ATIA 2017

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.

ATIA 2017

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

ATIA 2017

Access D1: Developing multimodal access technologies – Clinical Evaluation

+ **Preliminary Investigations:**
  + Document current multi-modal 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

ATIA 2017

Developing multimodal access technologies

- Case study illustrations:
  - Alison, Tiffany
- Two 3-D tracking systems in design
  - 1st gen 9-axis sensor system completed. Seeking funding to create robust movement learning system
  - 1st gen camera-based hardware design completed. Firmware and software underway.
- Expected outcome: New genre of access technology

ATIA 2017

Future Directions

- Developing multimodal (eye tracking and switch scanning) prototype
- Document the learning curve associated with learning a multimodal input strategy
- Systematic studies comparing single vs. multimodal access strategies (alternating treatment design)

ATIA 2017

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 photo VSDs; fail to capture dynamic events
  - Video offers potential to capture dynamic events but current AAC technologies only support passive video viewing

ATIA 2017

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

ATIA 2017

Lang Tech D2: Developing technologies with video visual scene displays

- Study #1 (Tara O'Neill)
  - Investigate effects of video VSD app on independent participation in community-based activities / employment by adolescents with CCN
  - Preliminary case study results demonstrate significant increases in successful independent participation

ATIA 2017

Lang Tech D2: Developing technologies with video visual scene displays

- Study #2 (Jessica Caron)
  - Investigate the effects of video VSD app on frequency & effectiveness of social interactions by school-aged children with ASD
  - Preliminary results demonstrate substantial increases
    - Frequency of turns
    - Initiations

ATIA 2017

Lang Tech D2: Developing technologies with video visual scene displays

- Output
  - New research-based video VSD app that
    - integrates communication into video
    - enhances communication and participation of children & adults with CCN

ATIA 2017

Access D3: Developing AAC technologies with smart prediction

- **Team**
  - Oregon Health & Science University, InvoTek, Saltillo
- **The problem**
  - Slow communication speed violates conversation rules and isolates people who rely on AAC.
  - Communication partners have contextual knowledge, but no way to support written AAC message construction.

ATIA 2017

Access D3: Developing AAC technologies with smart prediction

- **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.

Access D4: Developing a Cognitive Demands Checklist for AAC Technologies

- **Team**
  - Oregon Health & Science U.
- **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

HCI D4: Developing a Cognitive Demands Checklist for AAC Technologies

- Our goal: Develop, evaluate, and distribute the AAC Cognitive Demands Checklist (CDC) to
- Assist clinicians with person-technology matching
- Help developers understand the cognitive demands of AAC technologies and design improved products

HCI D4: Developing a Cognitive Demands Checklist for AAC Technologies

- **Engineering solution**
  - Examine feature lists for existing AAC devices and software/apps
  - Identify requisite cognitive skills and propose checklist items
  - Determine domain and content relevance of features for a range of AAC technology
  - Develop scale to rate the cognitive load of each feature
  - Launch web-based checklist

ATIA 2017

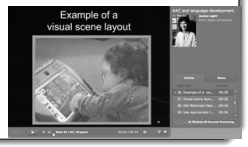
RERC on AAC
Training & dissemination

Training & Dissemination

- Professionals (pre-service and in-service)
- Persons with complex communication needs
- Family members

T2. Webcasts & MOOC

- 12 webcasts on AAC
  - Quizzes for preservice training
  - CEUs for inservice education
  - Research to practice
  - First person narratives

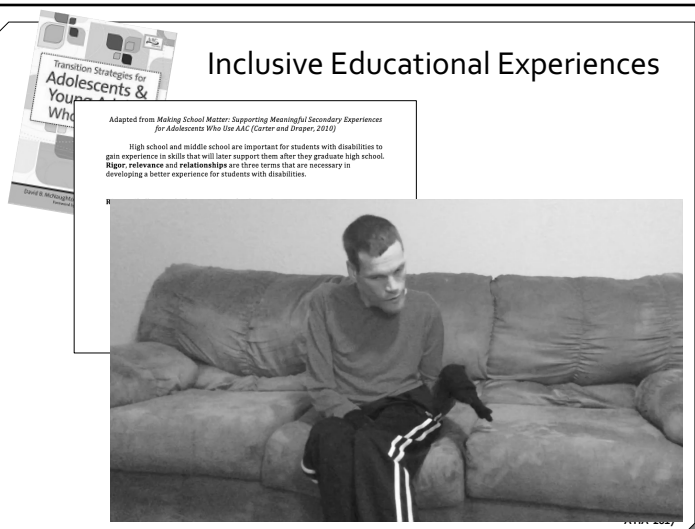


MOOC: Massive Online Open Course

- Modules on range of AAC topics
  - E. g., early intervention, transition, funding, literacy, access for individuals with minimal movement
- Materials
  - Readings: Open access articles, summaries
  - Webcasts: presentations, "first person" accounts
  - Activities: Answers to FAQs, think/pair/share activities
- Assessment
  - Quizzes, AAC materials
    - CEUs, course credit (at home institution)

ATIA 2017

Inclusive Educational Experiences



Doctoral Student AAC Research Think Tank

- 3 days in May, 2017
- Penn State University
  - State College, PA
- Presentations and activities for Doctoral students with strong interest in AAC
- Please complete survey at rerc-aac.org

ATIA 2017

Dissemination
rerc-aac.org

ATIA 2017

Outcomes of the RERC on AAC to date

- Initiated 17 new research studies to advance knowledge and improve outcomes for individuals with CCN, including both children and adults with a diverse range of disabilities
- Developed 5 new engineering solutions to advance AAC technologies and improve outcomes for individuals with CCN, including individuals with a wide range of needs and skills
- Mentored a total of 59 students in our labs, including 31 engineering students and 28 rehab scientists
  - 10 of these students recognized with national /international awards this year

Outcomes of the RERC on AAC to date

- Published 19 peer-reviewed publications
  - 12 papers in peer-reviewed journals
  - 7 peer-reviewed conference proceedings
- Completed more than 13 presentations in the past year at state, national, and international conferences to disseminate results and build capacity in the field
- Organized a virtual forum of individuals who use BCI at an international conference
- Submitted several new grant proposals and continued work on 4 other grants to extend our RERC work even further

Our vision

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

Discussion

- How can we enhance our current research, development, training, and dissemination activities?
- What are the priorities for future
  - Research
  - Development
  - Training and dissemination?

RERC-AAC.ORG

- We are grateful to all of the individuals who use AAC and their families who have contributed to the RERC on AAC.
- The contents of this presentation were developed under a grant from the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR grant number #90RE5017) to the Rehabilitation Engineering Research Center on Augmentative and Alternative Communication (RERC on AAC).
- NIDILRR is a Center within the Administration for Community Living (ACL), U.S. Department of Health and Human Services (HHS). The contents of this presentation do not necessarily represent the policy of NIDILRR, ACL, HHS, and you should not assume endorsement by the Federal Government.

RERC on AAC