Innovation in Mobile Technology for Augmentative and Alternative Communication: Targeting Advanced Speech and Language Outcomes for Learners with Severe Autism

Oliver Wendt, Ph.D.
Assistant Professor

University of Central Florida
College of Health Professions and Sciences
School of Communication Sciences and Disorders

Disclosure Statement

- Three pre-commercial products, SPEAKall!®, SPEAKmore!®, and SPEAKplay!® will be shown in this presentation
  - Oliver Wendt is the inventor and Purdue University holds IP rights.
  - Evaluation versions currently available at no cost
  - No commercial availability
  - Examples in this presentation will use SPEAKall! but can be replicated with a variety of other AAC devices/apps.
Agenda

- Development of Mobile Technology & AAC Interventions:
  - Functional Communication and Natural Speech Production
  - Parent-implemented Intervention
  - Emerging Language and Generative Language Training
  - Targeting Motor Access on Mobile Devices
  - Resources

Minimally-verbal Learners with Autism

- 1 in every 54 diagnosed with ASD (CDC, 2020)
- About 14% of special education students (USDoE)
- Autism includes a “delay in, or lack of the development of spoken language” (American Psychiatric Association, 2000)
- About 30-50% of children diagnosed with an autism spectrum disorder (ASD) remain minimally verbal (Tager-Flusberg & Kasari, 2013)
- Candidates for intervention in augmentative and alternative communication (AAC)
AAC for Autism includes…

- Manual signs and gestures
- Pictographic symbols sets/systems
  - Picture Exchange Communication System (PECS)
- Speech generating devices for synthesized and/or digitized speech
  - Dedicated
  - Tablets
- Evidenced-based speech-language learning devices (tablets)

Industry Changes

<table>
<thead>
<tr>
<th>Pre-2010</th>
<th>Post-2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2,000-$10,000 high device price tags</td>
<td>$0-$300 lower app price tags</td>
</tr>
<tr>
<td>Prescriptive therapist led</td>
<td>Do It Yourself parental experimentation</td>
</tr>
<tr>
<td>Isolation learner device</td>
<td>Shared Community between learner, parent, clinicians</td>
</tr>
</tbody>
</table>

Integration of language research with leading edge technology
Why Choose Tablets?

- iPads and other tablet devices are
  - Lightweight and portable
  - Cost-efficient compared to dedicated SGDs
  - Easy to program
  - Highly motivating to use
  - Socially appealing (peer acceptance)

- But: examine candidacy!

Autism Apps Market is a Noisy Place
Autism Apps Can be Noisy Places

New Opportunities through Mobile Technologies: SPEAKall!

- Preschool core vocabulary
- Simple swipes to navigate vocabulary
- Highly iconic symbols
- Randomization for symbol learning
- Drag & drop or 1-touch Activation
- Content sharing & synchronization
- Very customizable interface

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FUNCTIONAL COMMUNICATION & NATURAL SPEECH PRODUCTION

Teaching Requesting

- Establishing functional communication initial AAC goal
  - Meeting basic wants and needs
  - Motivational considerations
- Often accompanied by fear “my child won’t learn to speak”
- Popular and promising strategies:
Experiment: Parents using Modified PECS on iPad

- Multiple Probe Design across participants (Horner & Baer, 1978)
  - Generalization probes taken throughout baselines and all subsequent intervention phases
- Dependent measures:
  - Requesting skills: number of correct requests during 20-trials session
  - Emerging speech: intentional word approximations or full word utterances
    - Does AAC prevent natural speech acquisition?

Intervention Protocol

  - iPad Phase I (Ph 1): One-Symbol Activation
  - iPad Phase II (Ph 2): Distance and Persistence
  - iPad Phase III (Ph 3): Discrimination Between Symbols
  - iPad Phase IV (Ph 4): Sentence Structure
    - Added more rigorous speech elicitation, parent and child read “sentence strip” together
  - iPad Phase V (Ph 5): Responding to “What do you want?”/ Increasing Spontaneity
    (Boesch, Wendt, Subramanian, & Hsu, 2013a,b)
**Parent Training**

- Modeling of intervention steps
- Role-playing with clinician
- Cheat-sheets & videos

**Participant Characteristics**

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age/Gender</th>
<th>Dx*</th>
<th>Communication Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>7 yrs./Female</td>
<td>severe autism</td>
<td>some echolalia and scripted speech, less than 15 functional words</td>
</tr>
<tr>
<td>P2</td>
<td>8 yrs./Male</td>
<td>moderate-severe autism, dual diagnosis: Down syndrome</td>
<td>no vocalizations, no functional speech</td>
</tr>
<tr>
<td>P3</td>
<td>6 yrs./Male</td>
<td>severe autism</td>
<td>vocalization and jargon, no meaningful words, no functional speech</td>
</tr>
</tbody>
</table>

*based on ADOS and CARS scores
Participant P1
Baseline

Participant P1
Phase 1 – One-symbol Requests
Participant P1
Phase 2 – Distance and Persistence

Participant P1
Phase 3 – Symbol Discrimination
Participant P1
Phase 4 – Sentence Structure

Participant P1
Phase 5 – “What Do You Want?”
Participant P1
Phase: iPad Fadeout

Participant P1
Maintenance and Generalization
Effects on Requesting

Effects on Speech Production
Replication

- Teach requesting & speech production: Modify traditional PECS protocol for infusion of mobile application
- Multiple Baseline Design across settings (Baer, Wolf, & Risley, 1968)
  - Intervention repeated across clinic, home, and school environments plus final maintenance phase
- Dependent measures:
  - Requesting skills: number of correct requests during 20-trials session
  - Emerging speech: word approx. or word utterances

Participant Characteristics

<table>
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<tr>
<th>Participant</th>
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</tr>
</thead>
<tbody>
<tr>
<td>“1”: Male, 10 yrs.</td>
<td>severe autism</td>
<td>limited speech – vocalizations, gestures</td>
</tr>
<tr>
<td>“2”: Male, 13 yrs.</td>
<td>severe autism</td>
<td>limited speech – vocalizations, jargon</td>
</tr>
<tr>
<td>“3”: Male, 10 yrs.</td>
<td>severe autism</td>
<td>highly echolalic, jargon, no functional, meaningful words</td>
</tr>
<tr>
<td>“4”: Male, 12 yrs.</td>
<td>severe autism</td>
<td>mainly nonverbal with few vocalizations, some gestures</td>
</tr>
</tbody>
</table>

*based on ADOS and CARS scores
iPad and AAC app
Participant 3 – Baseline

iPad and AAC app
Participant 3 – Middle Stages
iPad and AAC app
Participant 3 – End

Participant 3 – Requesting
Conclusions

- Emphasize to caretakers: AAC does not prevent speech!
  - Role for shaping echolalic utterances
- Include parents for maximizing benefits of AAC intervention
- Comorbidity likely moderator variable
- Generalization to novel stimuli occurs
- Mostly taught symbolic communication, need to follow-up with early language support
EMERGING LANGUAGE AND GENERATIVE LANGUAGE TRAINING

Generative Language Through Matrix Training in Autism

What is matrix training?

- Language intervention
  - Systematically build up vocabulary and teach longer word combinations
- Generative approach to instruction
  - Words are arranged in matrix format, some multiword phrases are taught and others develop without direct instruction
  - Linguistic elements (e.g., nouns, verbs, etc.) are presented in systematic combination matrices
    - Induce generalized rule-like behavior
Theory: Matrix Training

Objects

- Ball
- Cup
- Spoon
- Fork
- Apple

Actions

- Point to
- Drop
- Take out
- Put in
- Shake

Theory: Matrix Training

Objects

- Ball
- Cup
- Spoon
- Fork
- Apple

Actions

- Point to
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- Take out
- Put in
- Shake
Theory: Generalization

Objects

- Ball
- Cup
- Spoon
- Fork
- Apple

Actions

- Point to
- Drop
- Take out
- Put in
- Shake

Theory: Generalization

1. Hear Prompt
2. Watch Video
3. Select Symbols
4. Animated Feedback
5. Success = Stars

Matrix Training Interface

Engaging • Reinforcing • Motivating

Prototype version on iTunes

Supported by NIH grant 1 R43 DC015422-01
Intervention Example

SPEAKmore! Intervention

Video: Generalization
Social Validity Survey

<table>
<thead>
<tr>
<th>Social Validity Survey Results (1-low to 5-high)</th>
<th>(n = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriate to use with a variety of language difficulties</td>
<td>4.4</td>
</tr>
<tr>
<td>More advantageous than lower tech options (i.e., communication boards)</td>
<td>4.4</td>
</tr>
<tr>
<td>Confidence in using SPEAKmore! ® as an intervention tool</td>
<td>4.2</td>
</tr>
<tr>
<td>No undesirable side effects</td>
<td>4.3</td>
</tr>
<tr>
<td>Could be appropriately used with a variety of language development difficulties</td>
<td>4.4</td>
</tr>
<tr>
<td>Confidence in using SPEAKmore! ® as an intervention tool</td>
<td>4.2</td>
</tr>
<tr>
<td>Recommending SPEAKmore! ® on a tablet for generative language learning</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Conclusions

- Results are indicative of a viable intervention
- Role of technology for implementing matrix training
- Future directions:
  - (a) teaching more complex semantic relationships for the high performance learners
  - (b) teaching more of a variation in language targets for the typical performing learners, for example, agent-action, adjective-object combinations;
  - (c) teaching simpler matrices to the low performing learners, for example, 4x4 symbol combinations.
MOTOR ACCESS ON MOBILE DEVICES

Spin-off Project: Targeting Motor Access

- Start AAC on mobile devices as early as 12-24 months (Davidoff, 2017)
- Difficulty with fine and gross motor control seen in about 80% (Hilton et al., 2012; Isenhower et al., 2012)
- Many young infants need better developed fine motor skills to operate mobile devices with strong proficiency (Wendt et al., in press)
Project Goals

- Design an application to enhance motor functioning of the young child or first time AAC user to maximize operational competence
- Serious game design to develop a series of gesture-based games that directly target the difficulties in learning complex and multi-step motor skills to access content on mobile AAC devices

Motor Access Example
Target Gestures

Training on critical gestures of
1. Directed and Sustained Touch
2. Drag and Drop
3. Vertical and Horizontal Swipe

(Wrobleski, 2001)

Gamification Element “Rocket”

Targeted Touch
Gamification Element
“Bubbles”

Targeted Touch &
Touch and Hold

Gamification Element
“Dino”

Drag & Drop
Swiping
Usability Survey

<table>
<thead>
<tr>
<th>Questionnaire Item</th>
<th>User Rating Mean (n=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I found the various functions in the SPEAKplay! app were well presented and integrated.</td>
<td>4.5 (“strongly agree”)</td>
</tr>
<tr>
<td>2. I would imagine that most clients and their caretakers would learn to use the SPEAKplay! app quickly.</td>
<td>4.8 (“strongly agree”)</td>
</tr>
<tr>
<td>3. Once I learned to set up SPEAKplay! and used it with my client, I felt confident using it as an intervention tool.</td>
<td>4.4 (“agree”)</td>
</tr>
<tr>
<td>4. The amount of time needed to learn, understand, modify, or develop a specific function of the SPEAKplay! app was appropriate.</td>
<td>4.9 (“strongly agree”)</td>
</tr>
<tr>
<td>5. The look and feel of the SPEAKplay! interface is comparable to other AAC/educational game apps.</td>
<td>4.4 (“agree”)</td>
</tr>
</tbody>
</table>

Based on Reimers & Wacker, 1988

Usability Survey

<table>
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<th>Questionnaire Item</th>
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</tr>
</thead>
<tbody>
<tr>
<td>6. The three game activities in the SPEAKplay! app offer a fun and motivating experience for my client(s).</td>
<td>4.8 (“strongly agree”)</td>
</tr>
<tr>
<td>7. The SPEAKplay! app offers meaningful training to work on the motor access skills (e.g., targeted and sustained touch, swiping, dragging, etc.) for my client to better operate a mobile platform.</td>
<td>4.8 (“strongly agree”)</td>
</tr>
<tr>
<td>8. The SPEAKplay! app would be appropriately used with a variety of language development difficulties (e.g., autism, developmental language disorder, general language delay, etc.)</td>
<td>4.8 (“strongly agree”)</td>
</tr>
<tr>
<td>9. I would recommend the SPEAKplay! app for use as a tool to support the clinical AAC intervention of a client.</td>
<td>4.8 (“strongly agree”)</td>
</tr>
</tbody>
</table>

Based on Reimers & Wacker, 1988
Conclusions

- Adopting the principles of ‘serious game design’ into the SPEAKplay! interface creates a motivating and engaging experience
- Utility of this framework goes beyond targeting motor skills in AAC users with severe autism
- Often times, AAC intervention sessions are focused on repetitive, basic tasks -> game design to maximize effects
- Potential of serious game design in enriching mobile technology AAC interventions

Parent Perspectives
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  - Purdue Kinley Trust

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Questions ???

Contact Information

Oliver Wendt, Ph.D.
College of Health Professions and Sciences
School of Communication Sciences and Disorders
4364 Scorpius Street
Orlando, FL 32816-2215
E-mail: oliver.wendt@ucf.edu
Resources Site

https://padlet.com/bswslp7/hpkfmgg85wpo

For SPEAKall!, SPEAKmore!, and SPEAKplay! please email: oliver.wendt@ucf.edu

Recent Article with Intervention Protocol (Open Access)