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Language and learning: Cognitive science considerations in the design of AAC technologies for children and adults

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Our goals today around language learning and use

- To challenge AAC stakeholders with issues that will affect the future of the field.
- To introduce concepts and questions from related research fields that must be examined by AAC stakeholders.
- To question the status quo and propose additional directions for AAC research.

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Common Ground

- Language learning and use is a challenge for all people with complex communication needs
  - young children with developmental disabilities
  - adults with acquired or chronic disabilities
- For children, we address language acquisition and development
- For adults, we address language recovery, loss or degeneration

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Many of the challenges related to AAC language learning and use are similar for these groups of people with CCN

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What do we know?

- AAC has a positive impact on communication, language & literacy outcomes
  - Gains in
    - turn taking, requesting, commenting, receptive & expressive vocab, message complexity, intelligibility, participation, etc.
    - number of communication partners
  - Gains that come at no risk to speech dev't or recovery
  - Gains demonstrated
    - across the entire age span
    - across a wide range of disabilities
    - across environments

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Challenges from cognate fields

Can we improve AAC technology design, and thereby improve outcomes, by examining research from cognate fields?

For example, research about:

1. Quantitative and qualitative shifts across language stages
2. Working memory and dual task demands
3. Visual cognitive processing

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Challenge #1: Changes in language skills over time

- Across the life span, individuals experience substantial changes in their language skills
  - Children develop more complex language skills over time
  - Some adults with acquired disabilities may experience sudden loss and then recovery of some language function
  - Some adults with acquired disabilities may experience gradual loss of language function over time

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How can we map internal language systems on to AAC systems?

- Because of the changes in language competence levels due to development or adult language impairments
  - Individuals with CCN require modifications in their AAC technologies over time
    - Vocabulary / representations
    - Organization /layout
    - Selection, output etc

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What does the research on child language development suggest?

- Children's language systems
  - differ significantly from those of adults
  - change significantly over time as they develop
- At each stage of language development, children demonstrate
  - Quantitative differences
  - Qualitative differences

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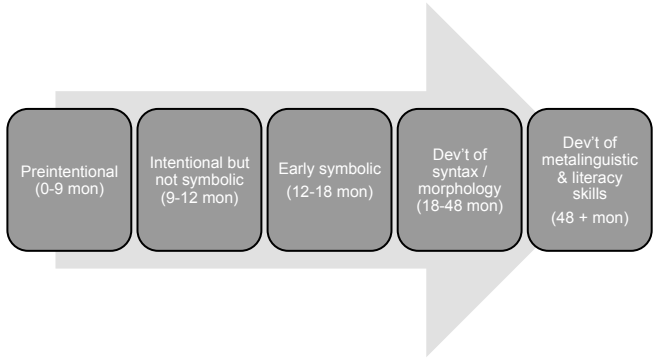
Sequence of language development



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Qualitative differences: Semantics and AAC representations

Research question:

How do young children think about & represent early emerging language concepts?

(Light, Worah, et al., 2012)

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Methodology

- Participants
  - 60 preschool children from different cultural backgrounds
- Procedures
  - Children were asked to draw 10 early emerging abstract language concepts
  - Children were also asked to name AAC symbols for these concepts

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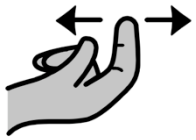
Children's representations differed significantly from AAC symbols

PCS for "come"

- Only 10% identified symbol for come
  - Others thought it was "pointer finger", "a boo-boo", "two driveways & a hand", etc



Child's representation of "come"

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Children's representations differed significantly from AAC symbols

PCS for "big"

- 0% correct
  - Others thought it was "ants", "sludge", "coloring", "blacktop for basketball", "chocolate", "germs", etc

Child's representation of "big"
Most of the children drew a person that was big –powerful, capable

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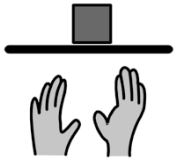
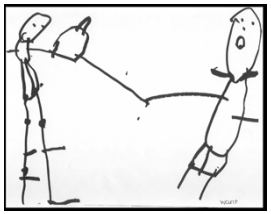
Children's representations differed significantly from AAC symbols

PCS for "want"

- Only 4% correct
  - Others thought it was "a TV", "cut off hands", "hands and soap", etc



Child's representation of "want"



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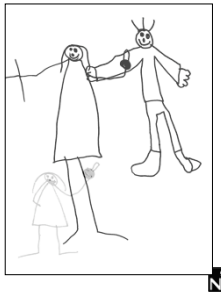
Children's representations differed significantly from AAC symbols

PCS for "who"

- 0% correct
  - Others thought it was "a back of a head", "a boy eating spaghetti", "a hair cut", "a 7 with ears", etc

Child's representation of "who"
"Girl says, 'Mom, who is that?' 'This is your new daddy.'



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Children's representations differed significantly from AAC symbols

- Preschoolers represent language concepts in very different ways than traditional AAC symbols
  - Reflect very different underlying conceptualizations/ meanings
  - Include depictions of entire scenes or events
    - Embed the concepts in context
  - Include complete objects / people in these scenes
    - Do not include "parts" of objects or people
  - Usually include familiar people, objects & experiences
- Results robust across different cultural groups

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Qualitative differences: Semantics & AAC representations

- Children think about the world in ways that are quantitatively & qualitatively different than adults
  - Neurotypical adults tend to rely on their semantic memory system to define concepts
  - Young children learn language through their experiences
    - They are more apt to draw on these experiences
      - Use their episodic memories

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Qualitative differences: Semantics and AAC representations

Research question:

How do adults with acquired language impairments represent language concepts?

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What does the research tell us for adults who use AAC?

For adults recovering language from TBI, orthography (which is overlearned) should be used instead of symbols for language representation system.
(Fried-Oken and Doyle, 1992)

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Lang representation for adults with progressive aphasia

- The adult who is losing language because of primary progressive aphasia retains single word reading during loss of word retrieval skills.
- AAC systems should include simple words & phrases. (Fried-Oken, Rowland, et al, 2011)

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- For the adult with chronic aphasia, personally relevant, contextualized photographs rather than non-contextualized iconic drawings or non-personally relevant, contextualized photographs should be used. (Hux, Dietz & Beukelman, 2010)

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Qualitative differences: Vocabulary layout

Research question:

How do we effectively map the internal language system of individuals with CCN to the external AAC technology?

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What does research tell us for adult AAC users?

- For the adult with static aphasia, the layout affects performance.
- For locating symbols, the navigation bar multi-level system appears to increase efficiency and symbol accuracy compared to the traditional grid multi-level system (Seale, Garrett, & Figley, 2007).

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What does research tell us for children who use AAC?

- Infants (9-12 mon) show greater attention & interest in photo VSDs than traditional grid displays (Wilkinson & Light, in progress)
- Toddlers are more accurate locating vocabulary using VSDs than grid displays (Drager, Light, et al., 2003)

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What does research tell us for children who use AAC?

- 4 & 5 year olds perform with similar accuracy locating vocabulary using VSDs or grid displays
  - Perform more accurately with VSDs or grids than iconic encoding (Light, et al., 2004)

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What does research tell us for children who use AAC?

- 4 & 5 year olds require access to technologies that support
  - More complex language & communication
  - Development of metalinguistic skills
  - Development of literacy skills
- Preschoolers with CCN can learn literacy skills with appropriate intervention (Light & McNaughton, 2012)
  - They require access to AAC technologies with traditional orthography to support language & literacy development and enhance participation

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Challenges for AAC technology development

- How do we design AAC technologies that accommodate language changes easily
  - With a child's language dev't?
    - From early symbolic development to literacy
  - With an adult's language recovery, loss, or degeneration?
- How do we know when to adjust features to accommodate these changes?

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Challenges for AAC technology development

- How do we map the internal language systems of individuals with CCN on to AAC technologies?
- Can we draw on AAC technologies to provide scaffolding support to individuals with CCN as their language skills change?

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Challenge #2: Working memory & multiple task demands for individuals who use AAC

- Successful use of AAC technology requires significant working memory demands.

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What is working memory (WM)?

- The ability to hold in mind and mentally manipulate information over short periods of time.
- Storage and processing functions that are active at any given moment.
- Involves many cognitive processes
  - Attention
  - Concentration
  - Sequencing skills
  - Requires motor and sensory skills

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Examples of WM

- Remembering a new telephone number while we are trying to find a pen and paper to write it down.
- Driving and trying to follow directions that we were just given: 'Go L, then take the next R, then go L at the store.'
- Remembering a sentence that the teacher says to write down, and spelling the individual words with your best handwriting.
- Measuring and combining ingredients when you have just read the recipe but are no longer looking at the page.

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Consider WM demands for the person who uses AAC

- Learning the name of the new toy and trying to find its symbol on a grid with 10 buttons.
- Answering a question on the history test with your auditory scanning system.
- Answering a question about recent medical procedures by using eye gaze to navigate through screens to find the correct button.
- Your bus driver is lost. You need to give directions to her about where you live by finding the sequence of messages to hit on the SGD.

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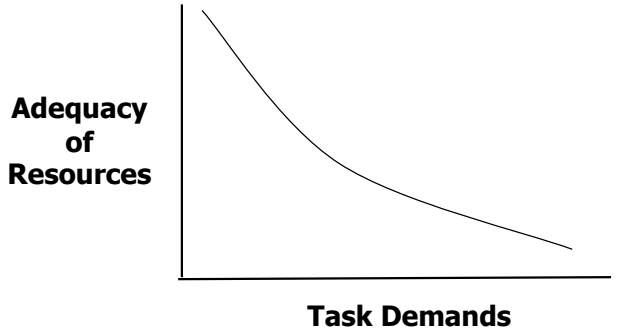
Working Memory

(Boudreau & Costanza-Smith, 2011)



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All of our AAC technologies tax working memory and require considerable resources during language formulation for both children and adults

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What does the research tell us for adult AAC users?

- When presented with a dual task demand (following a circle on screen with a mouse) and retelling a story, language is degraded in older adults. (Kemper & Herman, 2006)
- WM sees age related changes in elders.
- Older adults cannot store as much or process as much complex information because of changes in executive control. (Salthouse, 1991)

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What does the research tell us about WM for children?

- WM capacity increases with age, until adolescence.
- Adult capacities are more than double that of a 4-year-old child.
- WM is impaired in many children with DD, and will not reach typical adults levels.

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WM intervention strategies

(The Centre for Working Memory and Learning; University of York)

WM tx in the classroom

1. Evaluate the working demands of the learning activities
2. Reduce WM loads if necessary
3. Reduce processing demands
4. Frequently repeat important information
5. Use memory aids
6. Develop memory-relieving strategies

AAC technology research

1. Evaluate the cognitive WM demands of the AAC device
3. Reduce operational & cognitive demands of the AAC device
5. Reduce processing demands of the AAC device
7. Provide opps for repeated device operations
9. Provide automatic processes for L generation (prediction, wd completion)
10. Organize language for user's strengths

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Challenges for AAC technology development

- How do we design AAC technologies to lessen the working memory demands?
- How can we optimize device learning with working memory challenges?

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Challenge #3: Visual Cognitive Processing

- Aided AAC systems typically rely on the visual modality (e.g., Wilkinson & Jagaroo, 2004)
  - Effectiveness will depend, at least in part, on
    - Effectiveness & efficiency with which information in aided AAC displays can be perceived, identified, & extracted by communicators & partners
  - Understanding visual-cognitive processing is critical to designing effective AAC technologies & interventions (Wilkinson, Light & Drager, in press)

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Visual cognitive processing demands of AAC displays

- Different AAC displays impose different visual cognitive processing demands (Wilkinson, Light & Drager, in press)
  - AAC displays may support or impede communication depending on designs

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What does the visual cognitive research suggest?

- Individuals process scenes very rapidly
  - At a speed of 200 milliseconds or less
- They recognize the overall context as well as the elements of the scene in the first glance
  - Context simplifies the discrimination of objects in the scene
  - Decreases the number of possibilities to be considered
- Scenes exploit real-world experiences and support recognition / activation of experience-based schemas
  - (e.g., Braun, 2003; Fletcher-Watson, et al., 2008; Oliva & Torralba, 2007; Venturino & Gagnon, 1992).

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What does the research on visual cognitive processing suggest?

- Performance locating isolated symbols in arrays is much worse than performance with scenes
  - Even though the arrays of symbols are "simpler" in terms of the number of elements (e.g., see Wilkinson, et al., in press)

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Visual cognitive processing and AAC displays

Question #1:

What is the effect of VSDs versus grid displays on the visual attention of infants /beginning communicators?
(Wilkinson & Light, in progress)

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Methodology

- Procedures
  - Split screen presentation
    - Photo VSD vs grid
    - Position counterbalanced across trials
  - Eye tracking technology to measure visual attention /interest

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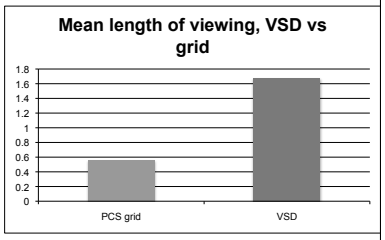
Type of display affects visual attention of infants

- Infants looked first & longest at photo VSD compared to PCS grid
- Results suggest strong preference for photo VSDs compared to grid displays of symbols by infants at "first words" stage Preliminary results (Wilkinson & Light, in progress)



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Visual cognitive processing and AAC displays

Question #2:

What elements in scenes attract visual attention?

(Wilkinson & Light, in progress)

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Viewing patterns

(Light areas indicate where participants looked most; dark areas where they looked least)

Original **Viewing pattern**

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Viewing patterns

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Visual cognitive processing and AAC displays

Question #3:

What is the effect of people in visual scenes on visual attention /processing?
(Wilkinson & Light, 2011)

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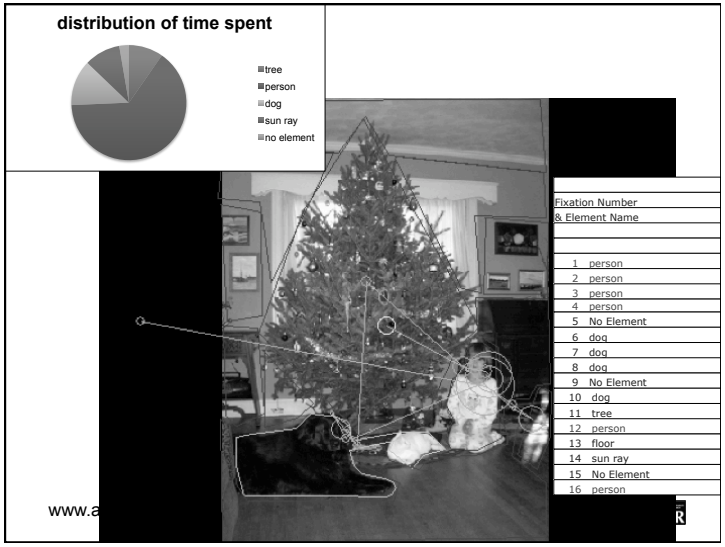

Effects of humans in scenes
(Wilkinson & Light, 2011)

- Attention is drawn to the humans in the scene
  - more rapidly than virtually all other elements
  - for proportionally longer than virtually all other elements
- Results are robust across photo scenes
  - even when humans are very small
  - even when there are multiple competing items

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Challenges for AAC technology development

- How do we design AAC displays that
  - minimize the visual cognitive processing demands and
  - maximize effectiveness and efficiency of performance?
- How can we exploit visual cognitive processing preferences to engage individuals with CCN?

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Cautions

- Much of the research from these cognate fields focuses on neurotypical participants
  - Individuals with CCN may process information differently or in similar ways
    - Effects of different disabilities
    - Effects of concomitant sensory perceptual / motor impairments
    - Effects of age / life experience
    - Effects of environment / culture

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Where do we go from here?

- These 3 challenges are examples of the many language and cognitive science considerations in the design of AAC technologies for children and adults.
- Next steps for us to discuss:
  - What are the most important issues to address first?
  - Do we take the lowest hanging fruit or greatest challenges?
  - How can the research have the greatest impact on individuals with CCN?

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Questions for discussion

In light of these issues,

- What are the greatest opportunities ahead for the field of AAC?
- What are the most significant challenges or needs facing the field of AAC?
- What are the most important AAC research and development priorities?

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