Designing Effective AAC Systems: Research Evidence and Implications for Practice

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The Problem

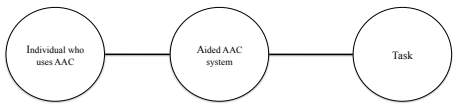
- Aided AAC systems offer the potential to enhance communication, language, & literacy development for individuals with complex communication needs
- This potential will only be realized if individuals with CCN are able to use their aided AAC system(s) effectively to communicate
- The design of the AAC system will significantly impact performance
- To date there has been only limited attention given to the design of aided AAC systems

Goals of the presentation

- Propose a preliminary model to guide thinking about the design of aided AAC systems
- Discuss relevant research
- Consider implications for designing effective aided AAC systems
- Describe directions for future research to advance understanding and improve practice

A model to guide the design of aided AAC systems

- There are many factors that will influence an individual's ability to use an aided AAC system effectively, including
  - Variables related to the individual
  - Variables related to the task
  - Variables related to the AAC system(s)



Impact of Individual, Task and System Variables

- These individual, task, and system variables will potentially affect
  - Rate of learning
  - Accuracy of selection
  - Efficiency of selection
  - Fluency /automaticity of performance
  - Preference/ acceptance of the system
  - Overall communicative effectiveness
- The variables will no doubt interact to affect performance
- They may have differential effects at different stages of learning / use of aided AAC systems

Variables related to the individual

- An individual's performance using aided AAC will be affected by his/her skills as well as psychosocial factors including
  - Motor skills
  - Cognitive skills
  - Language skills
  - Sensory perceptual skills
    - Especially visual perceptual skills
  - Motivation, attitude, confidence, resilience, etc.

Effects of motor skills on system design

- Many individuals who require AAC have motor impairments, including limitations in
  - Range of motion
  - Resolution/precision of selection
  - Force/strength, etc
- Motor skills may impact system design
  - For example, the individual's range and resolution of movement may affect
    - Number of targets
    - Size of targets
    - Layout of targets, etc

Effects of visual processing on system design

- Aided AAC systems place a heavy load on visual processing
  - This area has largely been neglected to date
- Many individuals who require AAC are at risk for a range of visual problems, e.g.
  - Visual acuity
  - Visual fields
  - Oculomotor function e.g. strabismus, nystagmus
  - Light sensitivity
  - Color sensitivity
  - Cortical visual impairment
- Some individuals with CCN may present with atypical patterns of visual processing e.g., individuals with ASD

Effect of visual processing on system design

- Visual processing skills may impact system design, e.g.,
  - Size of symbols required
  - Number of symbols possible
  - Complexity of symbols
  - Location of symbols
  - Arrangement of symbols
  - Foreground /background contrast
  - Color, etc

Effects of variables related to the individual

- It is critical to ensure that aided AAC systems are designed to
  - accommodate the individual's skills
  - minimize the effects of any impairments
  - provide necessary scaffolds to maximize performance

Variables related to the communication task

- An individual's performance using aided AAC will also be impacted by the communication task
- Aided AAC systems are used to fulfill a wide range of communication tasks
  - E.g., Face to face, one on one interaction
  - Group interactions
  - Written communication
  - Telecommunication, etc.
- These tasks impose a variety of demands

The effects of the communication task

- Performance will be affected by task demands
- Communication tasks require divided attention
  - Attention to the communication process
  - Attention to the operation of the AAC system
- Typically performance deteriorates under conditions of divided attention

An example of communication task demands

- Face to face interaction requires the individual to
  - Monitor the partner
  - Understand the partner's communication
  - Formulate an appropriate message
  - Plan the communication message using AAC
  - **Locate & recognize appropriate concepts on the aided AAC system as required**
  - **Select these concepts**
  - Monitor the output
  - Monitor the partner to ensure comprehension, etc.

Implications of task demands

- Communication performance is apt to deteriorate if the individual must devote significant resources to operating the aided AAC system
  - Therefore, it is critical to minimize the demands of operating the aided AAC system
- One way to reduce the demands is through improved design of aided AAC systems

Variables related to the aided AAC system

- Communication outcomes will be affected significantly by the design of the aided AAC system itself
- Careful construction of this physical "space" is critical to maximize its utility for the individual
- The design of aided systems is more amenable to change than
  - Variables related to the individual or
  - Communication task demands

Current practice in the design of aided AAC systems

- Typically, clinicians are left to design AAC systems based solely on their own intuition.
- As a result, AAC systems may not meet the needs and skills of individuals with CCN within daily communicative tasks
  - Communication performance may be negatively affected
- When practitioners are aware of the issues related to the design of aided systems, they will be better positioned to design more effective systems to maximize communication performance

Components of aided AAC systems

- Communication performance will be affected by a range of variables related to aided AAC systems, including variables related to each of the following components
  - **Display**
  - Selection technique
  - Output

Variables related to the AAC system display

- Design of the AAC system display involves consideration of 4 interrelated components
  - **Concepts** to be provided
    - The underlying meanings provided as vocabulary in the system
  - **Representation** of these concepts
    - The actual symbols used to represent these concepts
  - **Organization** of concepts
    - The underlying groupings of concepts within the system
  - **Presentation** of these concepts
    - The physical layout of the concepts within the display

Concepts

- The underlying concepts or vocabulary provided in the system may influence ease of learning / use
- Variables related to the concepts include
  - Concrete versus abstract concepts
    - Concrete concepts are easier to learn and recall than abstract ones
  - Personalized versus nonpersonalized concepts
    - Familiar personalized concepts are easier to learn and recall than nonpersonalized ones
  - Animate versus inanimate concepts
    - Infants and very young children are more apt to recognize and respond to animate than inanimate concepts

Representation of concepts

- The representations used for these concepts may also influence ease of learning and use
- Variables related to representations include
  - Conceptualization underlying the representation
    - What is the idea underlying the representation?
  - Actual realization of this conceptualization
    - How is the representation drawn?

Conceptualizations underlying the representations

- Individuals with CCN may think about language concepts in ways that differ significantly from the conceptualizations depicted in traditional AAC symbol sets (Light, Worah, et al., 2008)
  - Developmental differences
  - Cultural differences
  - Differences related to disability / experience
- Individuals with CCN may find it easier to learn and use symbols that reflect their own conceptualizations of vocabulary items (Worah, McNaughton, Light & Benedek-Wood, 2008)

Realization of the conceptualization

- The actual realization of the conceptualization will also affect learning and use
  - How is the representation drawn / realized?
- Different realizations may impact
  - Appeal
  - Interest
  - Understanding of meaning, etc.

Organization of the concepts

- The underlying groupings of concepts may also influence learning & use
  - Groupings across pages
  - Groupings within pages
- Variables related to organization include
  - Size of groupings
  - Type of groupings

Organization of the concepts

- Young children may group concepts in different ways than adults do
  - Size of groupings
    - Children only grouped 2-3 concepts together
      - They did not consider larger groupings
  - Type of groupings
    - E.g., schematic, taxonomic, alphabetical, idiosyncratic
    - Children are more apt to group items schematically (Fallon, Light & Achenbach, 2003)
- Individuals with CCN may find it easier to learn /use systems that reflect their own organization

Presentation of the concepts

- The physical presentation of the concepts may also influence ease of learning and use
- Variables related to presentation include
  - Permanence
    - Fixed versus dynamic displays
  - Layout
    - Visual scene displays versus traditional grid displays
  - Coherence
    - Unified versus fragmented /segmented display

Presentation of the concepts

- Variables related to presentation also include
  - Number of symbols presented
  - Size of symbols
  - Spacing between symbols
  - Location of symbols
    - Centrality
  - Symmetry of the presentation
  - Color

Application of the Model: Grid Presentation

- Perceptual cues in the **presentation** of the display can be used to support or scaffold its underlying **organization**
- The relation between perceptual characteristics of the presentation – the AAC system variables – and the visual skills of the user of AAC.

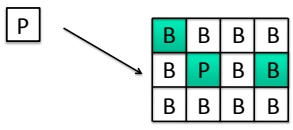
Perceptual Cues in Presentation Can Support Understanding of Underlying Organization

• Some search is necessary whenever the geography of the display is not yet learned, like when....

- the display is new
- the display is updated
- the display is rarely accessed

• How can we improve strategies for decision making in presentation and organization, to foster efficient symbol finding?

- Cognitive science tells us:
  - As the size of an array increases, it takes longer to find any individual stimulus in the array
  - But, we can use perceptual cues (like color) to effectively reduce the search array



Manipulating perceptual structure in the presentation of concepts to highlight the underlying organization of those concepts:

- Color coding is already a component of recommendations concerning linguistic organization of concepts (e.g., by word-class categories; Goossens' et al, 1999)
- We can also use color and symmetry cues to highlight an underlying organization related to thematic categories (body parts
- Or we can use color and symmetry cues to highlight an underlying organization of concepts related to taxonomic categories (animals)
- There may be times when coloring the background is not clinically useful. In that event, we can use the internal color composition to create symmetry

The Relation between Perceptual Characteristics of the Presentation – the AAC system variables – and the Visual Skills of the User of AAC

- Visual skills may impact design of AAC systems
  - Visual acuity
    - May impact size, number, spacing of symbols
  - Visual processing – search/attention span
    - May impact number of items on the display
  - Visual fields/neglect & visual field preferences
    - May impact location of the system as well as the location & arrangement of symbols within the display
  - Visual processing – overselective attention
    - May impact choices about the shape or features of items on a display, or about our intervention targets where necessary

Visual acuity and Symbol Size, Number, or Spacing

- User skill:
  - See the symbols, at the size/spacing they are presented
  - Differentiate the symbols from one another given how far apart they are spaced
- Decision about display presentation:
  - Acuity affects choices about the size, number, or spacing of symbols
- Clinical implications/troubleshooting:
  - If client makes apparently random selections, across the display, test for acuity to make sure the symbols are large enough AND far enough apart

Visual attention and Number of Symbols on the array

- User skill:
  - The user will have some maximum number of symbols s/he is willing to search through before tiring/giving up
  - When the # of symbols exceeds that number, some of those symbols may not be used
- Decision about display presentation:
  - This affects choices about the number of symbols
- Clinical implications/troubleshooting:
  - If client makes frequent, unexplained errors or uses only a subset of symbols
    - Reduce the # of available symbols until reliable responding
    - Gradually re-introduce symbols to assess span

Visual Field and Location of Symbols on the Array

- User skill:
  - If the user has visual field neglect, s/he may only see items in certain locations
  - Particularly true for users with limited head control and a mounted display
- Decision about display presentation:
  - This affects choices about the locations of symbols
- Clinical implications/troubleshooting:
  - If client consistently does not use symbols in certain spots
    - Re-confirm breadth of visual fields
    - Adjust display location to see if newly placed symbols now used

Visual Preference and Location of Symbols on the Array

- User skill:
  - If the user has a preference for a certain part of an array (for instance, centrally-presented stimuli), s/he may only see items in certain locations
- Decision about display presentation:
  - This affects choices about the location and number of symbols
- Clinical implications/troubleshooting:
  - If client consistently uses a subset of symbols, in a single or limited location
    - Move symbols to place well-used symbols in less-used locations; does symbol preference change?

Overselective Visual Attention and Features or Shape of Symbols

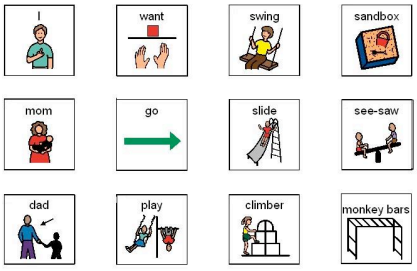
- User skill:
  - Overselective visual attention can be an over-focus either on parts of a symbol (the stem on top of the apple) or on the overall global shape. Users who respond on the basis of these local or global features will make seemingly random errors
- Decision about display presentation:
  - This affects choices about the features or shape of symbols
- Clinical implications/troubleshooting:
  - If client shows random selections
    - Evaluate whether errors show shape or feature similarities to target
    - Assess to determine if client can distinguish between stimuli
    - You may have to either change symbols or do targeted intervention to teach the necessary distinctions

Application of the Model: VSD Presentation

Traditional grid layout

- Vocabulary represented by separate AAC symbols in "boxes", organized in rows and columns
- Concepts are presented separately from one another

Traditional grid display – Playing at the Park



Visual Scene Displays (VSDs)

- A visual scene is a picture, photograph, or virtual environment that depicts and represents a situation or experience
  - Digital photos presenting visual scenes of the child's experiences
- Language concepts are embedded under "hot spots" in visual scenes
- VSDs can be implemented
  - On dynamic display speech generating devices (SGDs)
  - As low tech systems

Research with Typically-developing Children

- Typical 2 year olds and 3 year olds performed more accurately using Visual Scene Displays than traditional grid layouts
  - Many individuals with CCN are functioning at levels similar to these children, or below
- Typical 4 & 5 year olds demonstrated similar performances with non-personalized Visual Scene Displays and grid layouts

Drager, et al., 2003, 2004; Light et al., 2003

Research with Children with Disabilities (Light, et al., 2007)

- Children aged 6-40 months with significant communication disabilities
  - Down Syndrome, Cerebral Palsy, Autism
- Intervention involved developing appropriate AAC systems for each child, including the use of VSDs
- All children were able to use VSDs on initial introduction once use was modeled
  - seemed to be more interested and motivated when scene displays were used to integrate AAC and play, book reading, music
- All children demonstrated significant increases in their turn taking and expressive vocabularies

Variables related to the AAC system display

- The advantage of VSDs for beginning communicators may relate to several variables related to the AAC system display, including:
  - **Concepts** to be provided
    - The underlying meanings provided as vocabulary in the system
  - **Representation** of these concepts
    - The actual symbols used to represent these concepts
  - **Organization** of concepts
    - The underlying groupings of concepts within the system
  - **Presentation** of these concepts
    - The physical layout of the concepts within the display

Concepts

- The underlying concepts or vocabulary provided in the system may influence ease of learning / use
  - Concrete versus abstract concepts
  - Personalized versus nonpersonalized concepts
  - Animate versus inanimate concepts
- VSDs represent familiar and personalized events and activities, maximizing meaningfulness of representations
- Language concepts are presented in familiar context, providing support for understanding and learning
- VSDs can provide motivating and interesting contexts

Representation of concepts

- Variables related to representations include
  - Conceptualization underlying the representation
  - Actual realization of this conceptualization
- In VSDs, concepts are related visually and conceptually as in life
- Symbols derive meaning from both:
  - The specific representation
  - The relation of the representation within the scene

Organization

- Variables related to organization include
  - Size of groupings
  - Type of groupings
- Type of groupings may include:
  - Schematic
  - Taxonomic
  - Alphabetical
  - Idiosyncratic, etc.

Presentation

- Variables related to presentation include
  - Permanence
  - Layout
  - Coherence
  - Number of symbols presented
  - Size of symbols
  - Spacing between symbols
  - Location of symbols
  - Symmetry of the presentation
  - Color

Interaction of VSDs with Individual Variables

- Visual skills
  - Reduce complexity for very young children,
  - Remove background to increase contrast for children with visual impairments

Interaction of VSDs with Individual Variables

- Motor and cognitive / language skills will affect the number, size, and type of hotspots / vocabulary
- Options include:
  - Single image with a single hotspot
  - Single image with a few hotspots
  - Single or multiple images with multiple hotspots

Summary: The challenge

- The design of aided AAC systems will impact the communication effectiveness of individuals with CCN
  - initial learning of the aided AAC system
  - functional use
  - development of automaticity over time
- Currently clinicians must design aided AAC displays with limited guidance
  - Limited research evidence to guide decision making

Future research

- Urgent need for future research
  - To determine effects of specific display characteristics on performance
    - Initial performance
    - Performance over time with learning
  - To determine the interactions among various display characteristics
  - To determine effects of display characteristics with individuals who require AAC
    - wide range of disabilities and ages

Vision for the future

- With a better understanding of the effects of display characteristics, we will be better able to design aided AAC systems that
  - Are easy to learn
  - Maximize accuracy of performance / minimize errors
  - Maximize efficiency
  - Minimize conscious processing demands
  - Minimize fatigue
  - Maximize development of automaticity /fluency of use
  - And thereby enhance communication and social interaction

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