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Which AAC Interface Design Facilitates Communicative Interactions for Persons With Nonfluent Aphasia?

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Structured Abstract

Clinical Question: Which augmentative and alternative communication (AAC) interface design strategy (i.e., grid display or scene display) will best facilitate communicative interactions for persons with chronic, nonfluent aphasia?

Method: Comparison Review

Study Sources: EBSCOhost (ASHA, PsycINFO, CINAHL Plus, ERIC), Academic Search Premier (PubMed, Science Direct, Google Scholar)

Search Terms: Several different combinations of the following terms were used: augmentative and alternative communication, aphasia, graphic symbols, and photographs

Number of Included Studies: 11

Primary Results:

Persons with aphasia are capable of using grid displays and scene displays for experimental communication purposes; however, there is a lack of generalization data.

Persons with nonfluent aphasia better comprehend and label personalized photographs compared to graphic symbols or line drawings.

Persons with nonfluent aphasia may utilize fewer cognitive-linguistic and working memory resources when operating a scene display, leading to more effective communication.

Persons with nonfluent aphasia have relatively preserved intellectual ability, recognition memory, visual-perceptual skills, and gestalt processing. This suggests that photographs within visual scenes may better facilitate communicative interactions than graphic symbols in grid displays.

Conclusions: The evidence suggests that the use of grid displays and scene displays by persons with aphasia can facilitate communication. More recent studies indicate that scene displays are easier to operate and use as a communicative tool secondary to the relatively intact recognition memory and gestalt processing of persons with nonfluent aphasia. However, there is a dearth of empirically-based research comparing the effects of interface design (i.e., grid displays and scene displays) across several outcome variables (e.g., conversational turns) in more natural communicative settings. Therefore, these conclusions should be applied clinically on a case-by-case basis. Specifically, interface design communicative trials and clinical expertise should be considered to develop a treatment plan that meets the needs of persons with aphasia and their caregivers.

Which AAC Interface Design Facilitates Communicative Interactions for Persons With Nonfluent Aphasia?

Kris L. Brock

Clinical Scenario

Rico is a seasoned practitioner responsible for (a) providing services to individuals with acquired neurological communication disorders and (b) supervising student clinicians in a bustling urban outpatient rehabilitation center. Currently, Rico has several new clients on his caseload with Broca's aphasia which may eventually become chronic in nature. Rico typically treats these patients using principles from Constraint Induced Language Therapy (Barthel, Meinzer, Djundja, & Rockstroh, 2008) and Social Participation Models (e.g., Simmons-Mackie, 2008). Last month, Rico started supervising two graduate student externs. The externs have been advocating for the inclusion of augmentative and alternative communication (AAC) strategies as a means to facilitate more difficult social interactions for their clients with aphasia. Rico remembers very little from his AAC course 15 years ago; however, he is concerned about substituting one language system (i.e., natural speech and language) with another language system (i.e., AAC). Moreover, Rico is concerned that AAC may facilitate learned nonuse of spoken language (Pulvermüller & Berthier, 2008). Rico's students, Rochelle and Cristina, explained that AAC strategies for persons with aphasia (PWA) do not have to replace natural speech. In fact, they stated that data indicate that AAC intervention may enhance natural speech (Dietz, Weissling, Griffith, McKelvey, & Macke, 2014). Moreover, AAC can supplement natural speech when the clients' words fail them in social contexts.

Rico, realizing he wanted to incorporate new therapies into his repertoire to improve the communication of his patients, decided to take his students' advice, however; he was unsure about the amount of time required to prepare and implement AAC intervention. Rather than incorporate AAC strategies with all of his clients, he conducted brief interviews with them to determine their level of interest in AAC intervention. Two clients were interested, but one of the caregivers stressed that she wanted her husband to "speak again" and not rely on photographs or graphic symbols to communicate.

Rico's client, MB, is a 60-year-old male who was referred to the outpatient clinic secondary to surviving a left hemisphere ischemic stroke in August 2015. Results from the diagnostic imaging indicated an infarction volume of 50 cm^3 in the superior middle cerebral artery territory (i.e., Brodmann Area 44, Broca's area). MB had right hemiparesis and used his left hand for daily living activities. Results from the Western Aphasia Battery–Revised (WAB–R; Kertesz, 2006) standardized assessment confirmed MB's diagnosis of severe Broca's aphasia (Aphasia Quotient 31.40). A dynamic assessment was conducted using principles from the Promoting Aphasics' Communicative Effectiveness (PACE) intervention paradigm. The purpose of the PACE assessment was to determine how well MB performed in a barrier task using several communicative modalities. Specifically, he discussed several pictures with a partner who was blinded to the pictures' content. Results revealed that MB's spontaneous natural speech was comprised of approximately 10 words; however, he also used gestures, drawings, and writing to communicate. Finally, Rico conducted a modified activity, Participation Inventory (see Beukelman & Mirenda, 2013), to determine (a) where MB participated socially and (b) how much support was required. Rico noted that MB is a partner-dependent communicator, but he wants to participate with more independence at his local Italian Athletic Club. Given Rico's limited experience with AAC intervention for PWA, he and his students searched the AAC literature to develop a research question and an appropriate intervention program for MB.

Clinical Question

Rico began by formulating a focused research question using the PICO framework (Richardson, Wilson, Nishikawa, & Hayward, 1995). This framework identified his population (P), the intervention (I), the comparison intervention (C), and the outcomes as a result of the intervention (O):

P – persons with severe, chronic Broca's aphasia
I – grid display
C – scene display
O – improvements in communicative effectiveness

Rico's question was: Do persons with nonfluent aphasia demonstrate superior communicative effectiveness (e.g., more conversational turns) during AAC interventions utilizing grid displays (graphic symbols) than during AAC interventions utilizing scene displays (photographs)?

Search for the Evidence

To begin his search, Rico developed several inclusion criteria to identify the most relevant articles in AAC and aphasia. Additionally, Rico recalled his students' explanation that the literature in this niche is relatively small but expanding quickly due to the development of new AAC techniques, technologies, and researchers. Therefore, Rico decided that broad criteria would identify relevant articles within and outside of the AAC field. Rico used the following inclusion criteria: (a) use of experimental, quasi-experimental, single-participant experimental design, or case study design; (b) include individuals with nonfluent aphasia; (c) include an AAC intervention using grid displays (including graphic symbols) or scene displays (including photographs); (d) include at least one communicative effectiveness outcome measure (e.g., conversational turns or navigation); and (e) include articles published between 2005 through the present.

After developing his inclusion criteria, Rico started the search process. Rico had access to several research databases because of his rehabilitation center's affiliation with a medical center; he specifically used EBSCOhost to search multiple databases simultaneously. Rico's search terms included the keywords augmentative and alternative communication AND aphasia AND graphic symbols AND photographs, resulting in only three hits. He completed his search again without the keywords graphic symbols AND photographs, which resulted in 56 full-text hits. Next, Rico followed the same search procedures for PubMed and Science Direct; these searches resulted in 29 and 44 hits, respectively. He then used Google Scholar with the same two keywords and found over 1,000 articles. Next, he completed a second search using all four keywords to identify only the most relevant articles which resulted in 321 hits. Finally, Rico reviewed the abstracts to determine which studies met his inclusion criteria. Appendix A includes the search process, the number of hits, and the number of original research articles selected.

Evaluating the Evidence

Rico and his student clinicians reviewed three to four articles each using the *Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence* criteria (OCEBM Levels of Evidence Working Group, 2011). This allowed his team to determine if the quality of research was robust enough to answer his clinical question. According to the OCEBM Levels, scientifically robust studies are rated a 1 (i.e., systematic reviews and randomized control trials), although these studies are expensive and difficult to conduct. Studies rated a 5 are the least scientifically robust (i.e., mechanical-based reasoning and expert opinion).

Rico did not find any systematic reviews because technological innovation (e.g., increased storage space and development of scene displays) and AAC interface design development has recently changed how PWA use and access these systems. Therefore, the evidence of AAC intervention for PWA appeared to be relatively new. Rico was able to review several research-based articles that varied in their level of evidence. Appendix B includes each study and relevant clinical characteristics to help Rico's team answer the PICO question.

Eleven studies were found, but only one study compared the effects of a grid display and a scene display on communicative outcome variables (Wallace & Hux, 2014). A second study compared the effects of graphic symbols (used in grid displays), personal photographs (used in scene displays), and nonpersonal photographs (used in scene displays) on word-picture matching accuracy. The remaining studies did not compare grid displays and scene displays; rather, one or more components of an interface design were investigated. For example, one study investigated the effect of the number of graphic symbols (grid display) per screen on identification accuracy and sentence construction accuracy (Petroi, Koul, & Corwin, 2014).

Two case-control studies were identified in the literature search (Level 3 evidence-inclusion of a control or control group). These studies investigated the effect of grid displays on direct communication outcomes (e.g., composing a graphic symbol message) or indirect communication outcomes (e.g., number of symbols per page and level of symbol location). Overall, these studies found that PWA were capable of manipulating graphic symbols and formulating messages using grid displays (Koul, Corwin, & Hayes, 2005; Petroi et al., 2014). However, one study observed that PWAs' symbol identification accuracy decreased as the complexity (number of symbols per page) of the grid display increased (Petroi et al., 2014). Therefore, the communicative performance of PWA may also decrease during typical interactions outside of experimental contexts when incorporating a complex grid display.

Four single-group or single-subject design studies (Level 4 evidence-no control group) indicated that some PWA were able to use grid displays and graphic symbols to form simple messages and phrases in experimental contexts. The data indicate that PWAs' ability to use grid displays falls on a spectrum (Koul et al., 2005; Koul, Corwin, Nigam, & Oetzel, 2008). Moreover, there are little data indicating PWA can use grid displays for typical communicative interactions outside of experimental contexts.

Six single-group or single-subject design studies (Level 4) indicated that scene displays and photographs facilitated the communicative abilities of PWA either directly (e.g., increased number of conversational turns) or indirectly (e.g., higher photograph identification accuracy than graphic symbol identification accuracy). Similar to the grid display evidence, the ability to use scene displays and photographs to formulate messages falls on a spectrum. Finally, only one study directly compared the two interface designs (Wallace & Hux, 2014). The results indicated that PWA were better able to navigate the scene display when compared to the grid display. While this study measured an indirect construct of AAC system use (navigation), it does have practical and clinical applications.

The Evidence-Based Decision

After completing his comparison review, Rico was unsure about which AAC interface design would best facilitate communication for his client with nonfluent aphasia. The studies investigating the effect of AAC interface design on the communicative ability of PWA indicate that, in experimental contexts, PWA are able to identify and manipulate *both* graphic symbols and photographs (Dietz et al., 2014; Koul et al., 2008). However, the evidence indicates that not all PWA are able to formulate phrases using graphic symbols and photographs. Their ability to create messages falls on a spectrum secondary to the interface design type and its complexity (Petroi et al., 2014; Wallace & Hux, 2014).

To identify an answer, Rico discussed the review with his students. Specifically, he noted that communicative interactions include a number of processing demands that are distributed across different tasks within a limited capacity system (Baddeley, 2000; Kahneman, 1973). Normal speakers appropriately process these demands (e.g., auditory comprehension and information processing) during typical communicative interactions; however, if speakers are presented with a dual task demand (e.g., story retell while simultaneously tracking mouse movements on a computer), language performance decreases (Kemper, Schmalzried, Hoffman, & Herman, 2010).

PWA that communicate with AAC systems incorporating grids and scenes are continuously engaged in a dual task demand: (a) operation of the AAC system and (b) engaging in conversation. The increase in cognitive demands is related to each interface design's complexity. Specifically, Rico's evidence indicated that as the number of symbols per page increased, the identification of graphic symbols decreased. Similarly, as the number of grid levels increased, the response latency of PWA increased (Petroi et al., 2014). Moreover, PWA prefer personal photographs over nonpersonal photographs and graphic symbols (McKelvey, Hux, Dietz, & Beukelman, 2010). However, one of his students noted that grid displays offer a greater number of diverse messages.

Rico had a difficult clinical decision to make, so he considered his client's cognitive–linguistic profile and his personal communication goal identified through the Participation Inventory: to communicate at the Italian Athletic Club. Rico knew that in addition to aphasia, MB had impairments in information processing and recall memory. Rico's evidence indicated that scene displays were easier for individuals like MB to navigate. This ease of navigation occurs because scene displays include easier-to-process photographs that utilize recognition memory rather than recall memory. Moreover, personal photographs not only provide more specific conversational content, but MB would be able to share more intimate details with his friends. Therefore, Rico determined that photographs within scene displays would best facilitate MB's communication in social contexts.

Author Note

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technology-based strategies (e.g., animation) across several communicative outcome variables for persons with aphasia and children with autism. He would like to thank his first graduate student AAC Seminar cohort at Fullerton for making his first semester an excellent experience.

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Pulvermüller, F., & Berthier, M. L. (2008). Aphasia therapy on a neuroscience basis. *Aphasiology, 22*(6), 563–599. doi:10.1080/02687030701612213

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Appendix A. Search Methodology for Studies Included in This Review

Database	Terms	Publication range	Hits	Original articles selected
EBSCOhost included hits from: (1) ASHA journals, (2) PsycINFO, (3) CINAHL Plus, (4) ERIC, and (5) Academic Search Premier*	(1) Augmentative and Alternative Communication (2) Aphasia	2005–2016	56	6
PubMed	(1) Augmentative and Alternative Communication (2) Aphasia	2005–2016	29	1
Science Direct	(3) Augmentative and Alternative Communication (4) Aphasia	2005–2016	44	1
Google Scholar	(1) Augmentative and Alternative Communication (2) Aphasia (3) Graphic symbol AND (4) Photographs	2005–2016	321	3

Note. This figure lists the search strategies and systematic steps required to identify relevant studies.

* Rico's outpatient center is affiliated with the local hospital that provides access to EBSCOhost, allowing him to simultaneously search five different databases, thereby decreasing his search time.

Appendix B. Empirical Articles, Experimental Conditions and Interventions, and Quality Ratings

Dietz, A., Weissling, K., Griffith, J., McKelvey, M., & Macke, D. (2014). The impact of interface design during an initial high-technology AAC experience: A collective case study of people with aphasia. ***Augmentative and Alternative Communication, 30*****(4), 314–328. doi:10.3109/07434618.2014.966207**	
Participants	*n* = 5; age range = 40–72 years; education = > 12 years; aphasia type = 3 Broca's, 1 Transcortical motor, 1 Transcortical sensory; post onset range = 21–252 months; 2 participants had prior AAC experience
Research design	Case series design
Interface design	Scene display
Experimental conditions	(1) Personally-relevant photographs with text, (2) personally-relevant photographs without text, (3) nonpersonally-relevant photographs with text, and (4) nonpersonally-relevant photographs without text
Outcome measure	Narrative retells to measure (1) expressive modality unit used: (a) spoken, (b) written, (c) drawn, (d) photograph, (e) text box, and (f) speak button; (2) repair trajectory or the average number of expressive modality units required to repair breakdown in conversation; and (3) perceived helpfulness of photographs.
Treatment integrity	99.25%–100%
Interrater reliability	80%–93% agreement
Outcomes	Residual natural speech used more than any other unit, followed by writing and personally-relevant pictures. Nonpersonally-relevant photos were more difficult to use for three out of five participants, possibly because unfamiliar information materials can be disorienting and frustrating. No clear pattern found for repair trajectory. PWA indicated that personally-relevant photographs were more beneficial to narrative retell than nonpersonally-relevant photographs.
Effect size	Unable to calculate
Quality rating	Level 4
Additional PICO information	Communication partner of PWA stated that personally-relevant photographs made the story retell more like a conversation. Personal photographs helped to explain the story. AAC did not hinder natural speech production.
Griffith, J., Dietz, A., & Weissling, K. (2014). Supporting narrative retells for people with aphasia using augmentative and alternative communication: Photographs or line drawings? Text or no text? ***American Journal of Speech-Language Pathology, 23*****(2), S213–S224. doi:10.1044/2014_AJSLP-13-0089**	
Participants	*n* = 4; age range = 42–70 years; education = > 12 years; aphasia type = Broca's; post onset range = 42–81 months; 1 participant had prior AAC experience
Research design	Case series design
Interface design	Scene display
Experimental conditions	Randomized presentation order of (1) personally-relevant photographs with text, (2) personally-relevant photographs without text, (3) line drawings with text, and (4) line drawings without text.
Outcome measure	Narrative retells to measure expressive modality units: (1) spoken, (2) picture (photos or line drawings), (3) text box, (4) synthesized speech, (5) written, and (6) drawn. Social validity data on perceived helpfulness of each experimental condition on narrative retell.
Treatment integrity	95%

Appendix B. (continued)

Interrater reliability	≥ 80% for all outcome measures
Outcomes	Residual natural speech most often used followed by technology-based AAC use (i.e., pictures, text box, and synthesized speech units). Nontechnology-based AAC (i.e., written and drawn units) was used least. Higher frequency of personally-relevant photographs used when compared to line drawings. PWA indicated that photographs and line drawings were helpful during narrative retell.
Effect size	Unable to calculate
Quality rating	Level 4
Additional PICO information	Technology-based AAC use did not hinder natural speech production.
Ho, K. M., Weiss, S. J., Garrett, K. L., & Lloyd, L. L. (2005). The effect of remnant and pictographic books on the communicative interaction of individuals with global aphasia. ***Augmentative and Alternative Communication, 21*****(3), 218–232. doi:10.1080/07434610400016694**	
Participants	*n* = 2; age = 71 and 77 years; education = 12–18 years; aphasia type = global; post onset = 1.5–3 months; no AAC experience
Research design	Single-subject alternating treatment design
Interface design	Communication book grid display
Experimental conditions	No AAC, graphic symbols in communication book, and remnants in communication book
Outcome measure	Conversational discourse variables (e.g., number of conversational turns and initiations)
Treatment integrity	98%
Reliability	Intrarater reliability: 74%–100% for all outcomes Interrater reliability: 75%–98% for all outcomes
Outcomes	Both graphic symbols and remnants within communication books increased the number of conversational turns and initiations when compared to the no-AAC condition. However, slightly more communication occurred in the remnant book condition than the graphic symbol book condition.
Effect size	Unable to calculate
Quality rating	Level 4
Additional PICO information	Grids containing graphic symbols in communication books do facilitate communication and should be used when remnants are unavailable or there is a need for more complex messages.
Hough, M., & Johnson, R. K. (2009). Use of AAC to enhance linguistic communication skills in an adult with chronic severe aphasia. ***Aphasiology, 23*****(7-8), 965–976. doi:10.1080/02687030802698145**	
Participants	*n* = 1; age = 56 years; education = not reported; aphasia type = nonfluent; post onset = 24 months; AAC experience not reported
Research design	Case study design
Interface design	Grid display

Appendix B. (continued)

Experimental intervention	AAC treatment protocol least to most prompt and cue hierarchy including some AAC modelling (Koul et al., 2005). Trial 1 = verbal model and demonstration Trial 2 = verbal cues + pointing + gestures + pantomime Trial 3 = yes/no questions Trial 4 = question the identity of the pictures Trial 5 = preparatory set Trial 6 = state prompt + silent demonstration Trial 7 = state prompt verbally and manually demonstrate
Outcome measure	Graphic symbol identification, navigation of all symbols, scenario role-playing (i.e., answer questions about daily living activities), and sentence-construction tasks. Pre- and post-intervention scores: WAB–R score (Kertesz, 2006), ASHA Functional Assessment of Communication Skills (Frattali et al., 1995), ASHA Quality of Life Communication Scale (Paul et al., 2004), and Communicative Effectiveness Index (Lomas et al., 1989).
Treatment integrity	Not reported
Interrater reliability	Not reported
Outcomes	Participant was able to locate/identify Level 1 though Level 4 individual graphic symbols independently with 80% accuracy. Independently navigated to all symbols with 80% accuracy. Answered daily living activities questions independently with at least 80% accuracy using graphic symbols. Independently generated graphic symbol sentences with at least 80% accuracy. Post-intervention gains noted for all four communication indexes.
Effect size	Unable to calculate
Quality rating	Level 4
Additional PICO information	Participant was capable of generating short graphic symbol messages for functional communication. However, the participant answered questions in a structured conversation. Typical conversations are not question-and-answer formats.
Hux, K., Buechter, M., Wallace, S., & Weissling, K. (2010). Using visual scene displays to create a shared communication space for a person with aphasia. ***Aphasiology, 24*****(5), 643–660. doi:10.1080/02687030902869299**	
Participants	*n* = 10 **Participant with aphasia:** age = 61 years; education = 12 years; anomic aphasia; post onset = 24 months; prior AAC experience **Typical communication partners:** *n* = 9; age range = 33–62 years; no aphasia experience; AAC experience not reported
Research design	Repeated measures design
Interface design	Scene display
Experimental conditions	Communication partners were assigned to a counterbalanced scene display sequence: (a) shared-scene displays, (b) nonshared scene displays, and (c) no-scene displays. Partners interacted with participant with aphasia in each condition for 4.5 minutes.

Appendix B. (continued)

Outcome measure	Discourse analyses: (a) the number of conversational turns, (b) the number initiations and responses, (c) the complexity of utterances; and (d) content units (e.g., correct information conveyed)
Treatment integrity	Not reported
Interrater reliability	77%–94% for all outcome measures
Outcomes	Greater number of conversational turns taken in shared-scene display condition than in the nonshared-scene display and no-scene display conditions. Similar results for the number of initiations and responses and correct content units; however, negligible differences noted in utterance complexity across all conditions.
Effect size	Unable to calculate
Quality rating	Level 4
Additional PICO information	PWA have relatively intact long-term (episodic) memory, making shared-scene displays a useful tool for facilitating communication.
Johnson, R. K., Hough, M. S., King, K. A., Vos, P., & Jeffs, T. (2008). Functional communication in individuals with chronic severe aphasia using augmentative communication. *Augmentative and Alternative Communication, 24*(4), **269–280. doi:10.1080/07434610802463957**	
Participants	*n* = 3; age range = 57–77 years; education = 16–21 years; aphasia type = 1 mixed, 2 Broca's; post onset range = 27–93 months; some low-technology-based AAC experience
Research design	Case series design
Interface design	Grid display
Experimental intervention	AAC treatment protocol least to most prompt and cue hierarchy including some AAC modelling (Koul et al., 2005). Trial 1 = verbal model and demonstration Trial 2 = verbal cues + pointing + gestures + pantomime Trial 3 = yes/no questions Trial 4 = question the identity of the pictures Trial 5 = preparatory set Trial 6 = state prompt + silent demonstration Trial 7 = state prompt verbally and manually demonstrate
Outcome measure	Graphic symbol identification, navigation of all symbols, scenario role-playing (i.e., answer questions about daily living activities), and sentence-construction tasks were completed using a grid display with four levels. Pre- and post-intervention scores: WAB–R score (Kertesz, 2006), ASHA Functional Assessment of Communication Skills (Frattali et al., 1995), ASHA Quality of Life Communication Scale (Paul et al., 2004), and Communicative Effectiveness Index (Lomas et al., 1989).
Treatment integrity	Not reported
Interrater reliability	Not reported

Appendix B. (continued)

Outcomes	Participant was able to locate/identify Level 1 though Level 4 individual graphic symbols independently with 80% accuracy. Independently navigated to all symbols with 80% accuracy. Answered activities of daily living questions independently with at least 80% accuracy using graphic symbols. Independently generated graphic symbol sentences with at least 80% accuracy. Post-intervention gains noted for all four communication indexes.
Effect size	Unable to calculate
Quality rating	Level 4
Additional PICO information	Caregivers were trained to use the intervention protocol and the AAC system. Anecdotal evidence indicated that caregiver training facilitated more accurate information exchange between caregivers and PWA. Increase in WAB–R auditory comprehension scores post- intervention may have been secondary to multimodality AAC treatment.
Koul, R., Corwin, M., & Hayes, S. (2005). Production of graphic symbol sentences by individuals with aphasia: Efficacy of a computer-based augmentative and alternative communication intervention. ***Brain and Language, 92*****(1), 58–77. doi:10.1016/j.bandl.2004.05.008**	
Participants	*n* = 10; age range = 32–86 years; education = < 15 years; aphasia type = 7 Broca's, 2 global, 1 normal language post-stroke; post onset range = 12–124 months
Research design	Multiple baseline design across behaviors (i.e., sentence complexity Levels I, II, III, IV, V)
Interface design	Grid display
Experimental intervention	Phase I: identification of all symbols Phase II: train participants to produce sentences of increasing grammatical sentences using a prompting and cue hierarchy: Trial 1 = verbal model and demonstration Trial 2 = verbal explanation Trial 3 = verbal cues + pointing + gestures + pantomime Trial 4 = yes/no questions Trial 5 = question and mand Trial 6 = preparatory sets Trial 7 = state prompt + silent demonstration Trial 8 = state prompt + state answer + silent demonstration Trial 9 = state prompt verbally and manually demonstrate Trial 10 = state prompt + step-by-step instructions with demonstration
Outcome measure	Identification of graphic symbols on Gus software; graphic symbol sentence production (Level I–V) Level I = agent + action or object + object ("boy eat") Level II = morphological inflections ("dog eats") Level III = agent + action + object or object + preposition + object ("girl eating the soup") Level IV = passive sentence or compound sentences ("The trash was dumped by the boy.") Level V = sentences containing nouns clauses, noun–phrase descriptors, or compound verb phrases ("The boy who had the blue jacket walked a dog.")
Treatment integrity	100%

Appendix B. (continued)

Interrater reliability	100% for all outcome measures
Outcomes	Individuals with severe Broca's or global aphasia are able to identify and combine graphic symbols to form sentences of varying syntactical complexity in experimental contexts. Five PWA produced Level III sentences. Three PWA produced Level II sentences. One participant produced no sentences correctly. Generalization probe data revealed poorer performance for all PWA. Participant without aphasia produced sentences from all levels.
Effect size	Unable to calculate without raw data
Quality rating	Level 3
Additional PICO information	Individuals with nonfluent aphasia are capable of producing graphic symbol sentences using a technology-based AAC system in an experimental context. Further data is required to determine how PWA generalize technology-based AAC systems outside of experimental contexts.
Koul, R., Corwin, M., Nigam, R., & Oetzel, S. (2008). Training individuals with chronic severe Broca's aphasia to produce sentences using graphic symbols: Implications for AAC intervention. ***Journal of Assistive Technologies, 2*****(1), 23–34. doi:10.1108/17549450200800004**	
Participants	*n* = 3; age range = 63–73 years; education = < 12 years; aphasia type = Broca's aphasia; post onset range = 12–106 months; no AAC experience
Research design	Multiple baseline design across behaviors (i.e., sentence complexity Levels I, II, III, IV, V)
Interface design	Grid display
Experimental intervention	Phase I: identification of all symbols Phase II: train participants to produce sentences of increasing grammatical sentences using a prompting and cue hierarchy: Trial 1 = verbal model and demonstration Trial 2 = verbal explanation Trial 3 = verbal cues + pointing + gestures + pantomime Trial 4 = yes/no questions Trial 5 = question and mand Trial 6 = preparatory sets Trial 7 = state prompt + silent demonstration Trial 8 = state prompt + state answer + silent demonstration Trial 9 = state prompt verbally and manually demonstrate Trial 10 = state prompt + step-by-step instructions with demonstration
Outcome measure	Identification of graphic symbols using a DynaMyte 3100 (Tobii Dynavox); graphic symbol sentence production (Level I–V) Level I = agent + action or object + object ("boy eat") Level II = morphological inflections ("dog eats") Level III = agent + action + object or object + preposition + object ("girl eating the soup") Level IV = passive sentence or compound sentences ("The trash was dumped by the boy.") Level V = sentences containing nouns clauses, noun–phrase descriptors, or compound verb phrases ("The boy who had the blue jacket walked a dog.")

Appendix B. (continued)

Treatment integrity	Not reported
Interrater reliability	100% for all outcome measures
Outcomes	PWA are able to identify and combine graphic symbols to produce sentences of varying syntactical complexity in experimental contexts. One participant produced Level III sentences. One participant produced Level IV sentences. One participant produced Level V sentences.
Effect size	Unable to calculate without raw data
Quality rating	Level 4
Additional PICO information	The results were variable across participants. Research needs to determine if experimental production of graphic symbol sentences can be generalized to typical communicative interactions.
McKelvey, M. L., Hux, K., Dietz, A., & Beukelman, D. R. (2010). Impact of personal relevance and contextualization on word-picture matching by people with aphasia. ***American Journal of Speech-Language Pathology, 19*****(1), 22–33. doi:10.1044/1058-0360**	
Participants	*n* = 8; age range = 25–86 years; education = 8–18 years; aphasia type = Broca's aphasia; post onset range = 4–234 months; some low-technology and high-technology AAC experience
Research design	Repeated measures design
Interface design	N/A; photographs and graphic symbols
Experimental conditions	Personally-relevant photographs, nonpersonally-relevant photographs, and graphic symbols
Outcome measure	Word-picture matching accuracy and picture stimuli preference
Treatment integrity	Not reported
Interrater reliability	Not reported
Outcomes	PWAs' word-picture matching performance significantly increased when presented with personally-relevant photographs when compared to nonpersonally-relevant photographs and graphic symbols. PWA preferred personally-relevant photographs.
Effect size	Word-picture matching (W = .875); Picture preference (W = .412)
Quality rating	Level 4
Additional PICO information	PWA preference for personally-relevant photographs supports the notion that autobiographical memory and recognition memory are relatively intact and can be used for communication purposes.
Petroi, D., Koul, R. K., & Corwin, M. (2014). Effect of number of graphic symbols, levels, and listening conditions on symbol identification and latency in persons with aphasia. ***Augmentative and Alternative Communication, 30*****(1), 40–54. doi:10.3109/07434618.2014.882984**	
Participants	*n* = 20 **PWA:** *n* = 10; age range = 46–68 years; education = 8–18 years; aphasia type = Broca's aphasia; post onset range = 26–123 months; nontechnology-based AAC experience **Matched controls:** *n* = 10; mean age = 57.42; education (mean years): 13.70 Independent *t* test indicated no significant (p < .05) differences between groups

Appendix B. (continued)

Research design	Mixed design
Interface design	Grid display
Experimental conditions	To determine the how the variables below effect the identification accuracy and response latency of single graphic symbols and subject-verb-object sentences: (1) Effect of the number of symbols per screen (4, 8, 12, and 16) (2) Effect of a three-level hierarchical grid display (Levels 1, 2, 3) (3) Effect of listening conditions (sustained attention, focused attention, divided attention)
Outcome measure	Identification accuracy, response latency, and participants' perceived difficulty
Treatment integrity	100%
Interrater reliability	100% for all outcome measures
Outcomes	Normal controls performed better than PWA on all tasks. Identification accuracy for single symbols and sentences decreased as the level of location of a symbol and number of symbols per screen increased. Response latency increased as the level of location of a symbol and number of symbols per screen increased. PWA perceived greater levels of task difficulty than controls.
Effect size	Partial Eta Squared: Group and the number of symbols per screen explained 53% (large effect) and 9% (small effect) of the single symbol identification variance, respectively. Group and level of location explain 51% (large effect) and 14% (medium effect) of the single symbol identification variance, respectively.
Quality rating	Level 3
Additional PICO information	Level of location explained more of the variance than number of symbols indicating that navigation across screens is more difficult than processing the number of symbols per screen.
Wallace, S. E., Dietz, A., Hux, K., & Weissling, K. (2012). Augmented input: The effect of visuographic supports on the auditory comprehension of people with chronic aphasia. ***Aphasiology, 26*****(2), 162–176. doi:10.1080/02687038.2011.628004**	
Participants	*n* = 21; age range = 37–85 years; education = 11.5–18 years; aphasia type = 9 Anomic, 5 Broca's, 3 Wernicke's, 2 Conduction, 2 Transcortical motor; post onset range = 6–120 months; some low-technology and high-technology AAC experience
Research design	Cohort repeated measures design
Interface design	N/A, photographs
Experimental conditions	No context photographs, low-context drawing with embedded no-context photographs, high-context photographs, and no photographs
Outcome measure	Auditory comprehension response accuracy
Treatment integrity	100%
Interrater reliability	Not reported
Outcomes	No significant differences in any conditions. Inspection of individual participant data revealed no patterns.

Appendix B. (continued)

Effect size	Partial Eta Squared = .057
Quality rating	Level 4
Additional PICO information	Photograph stimuli were not personally relevant
Wallace, S. E., & Hux, K. (2014). Effect of two layouts on high technology AAC navigation and content location by people with aphasia. ***Disability and Rehabilitation: Assistive Technology, 9*****(2), 173–182. doi:10.3109/17483107.2013.799237**	
Participants	*n* = 2; age range = 50 & 60 years; education: 16 years each; aphasia type = 1 nonfluent aphasia, 1 fluent aphasia; post onset = 17 & 15 months; no AAC experience
Research design	Single subject, phase change design (BCB'C')
Interface design	Scene display and grid display
Experimental intervention	Backward chaining with vanishing cues to facilitate navigation within each display
Outcome measure	Maximally Efficient Accuracy Score, Combine Accuracy Score, and Navigation Efficiency Score
Treatment integrity	Not reported
Interrater reliability	99.97%–99.97% for all outcome measures
Outcomes	Higher Maximally Efficient Accuracy Scores in scene display condition indicating a greater number of errorless navigations to a selected picture. Higher Combined Accuracy Scores in scene display indicating successful navigation. Higher Navigation Efficiency Scores in grid display condition indicating more difficulty.
Effect size	Nonoverlap of All Pairs (NAP): Participant 1: medium (66%–92%) to large (93%–100%) effect for scene display; weak (0%–65%) to medium (66%–92%) effect for grid display Participant 2: weak (0%–65%) to medium (66%–92%) effect for scene display; weak (0%–65%) effect for grid display Percent Nonoverlapping Data (PND): Participant 1: Questionable effectiveness for scene display (50%–70%); Not effective for grid display (0%) Participant 2: unreliable (< 50%) to high effectiveness (> 90%) for scene display; unreliable effectiveness (< 50%) for grid display
Quality rating	Level 4
Additional PICO information	Navigation was more transparent in the scene display condition. May lead to better communication secondary to being an easier to use interface.

Note. WAB–R (Kertesz, 2006), Western Aphasia Battery–Revised. Aphasia severity for all study participants was moderate to severe as rated by standardized measures [e.g., Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1983) and WAB–R)].