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RESEARCH ARTICLE

Effects of dynamic text in an AAC app on sight word reading for individuals with autism spectrum disorder

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ABSTRACT
The purpose of this study was to investigate the effects of Transition to Literacy (T2L) software features (i.e., dynamic text and speech output upon selection of a graphic symbol) within a grid display in an augmentative and alternative communication (AAC) app, on the sight word reading skills of individuals with autism spectrum disorders (ASD) and complex communication needs. The study implemented a single-subject multiple probe research design across one set of three participants. The same design was utilized with an additional set of two participants. As part of the intervention, the participants were exposed to an AAC app with the T2L features during a highly structured matching task. With only limited exposure to the features, the five participants all demonstrated increased accuracy of identification of 12 targeted sight words. This study provides preliminary evidence that redesigning AAC apps to include the provision of dynamic text combined with speech output, can positively impact the sight-word reading of participants during a structured task. This adaptation in AAC system design could be used to complement literacy instruction and to potentially infuse components of literacy learning into daily communication.

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Augmentative and alternative communication; apps; autism spectrum disorder; literacy

Introduction

It is hard to overestimate the importance of learning how to read (Light & McNaughton, 2013). Literacy skills are particularly important for individuals with complex communication needs (Light & McNaughton, 2013) because literacy provides access to a full range of communication modalities – from written documents for school or work, to texting and email, to social media and apps (Caron & Light, 2016). Unfortunately, many individuals with complex communication needs who use augmentative and alternative communication (AAC), including individuals with autism spectrum disorders (ASD), enter adulthood without functional literacy skills (Mirenda & Erickson, 2000). Intrinsic factors, like limited speech and language skills observed with the diagnosis of ASD, place these individuals at risk for reading difficulty (Mirenda, 2008). It has been estimated that 30–50% of learners with ASD never develop functional speech (Shane et al., 2015) and the majority of individuals with ASD demonstrate language delays (Kjelgaard & Tager-Flusberg, 2001). Difficulties in these areas (i.e., in producing and/or comprehending language) are likely to have serious implications for literacy development and participation in common reading and writing instructional activities (Light & McNaughton, 2013). As prevalence rates for ASD continue to increase (Center for Disease Control, 2014) and mandates for access to the general curriculum for all students intensify (Office of Special Education Programs, 2016), there is a critical need to improve literacy outcomes for individuals with complex communication needs, including those with ASD.

Learning to read is a complex process requiring the integration of an array of skills (e.g., letter sound knowledge, decoding skills, sight word recognition, vocabulary knowledge, comprehension of text). Learning sight words is one skill that is necessary, but by no means sufficient, to ensure successful literacy learning (National Reading Panel, 2000). Instruction in sight word reading can include both regular words and irregular words, and should supplement, not replace, instruction in phonemic awareness (Adams, 1990). Sight word reading is important for individuals with ASD and complex communication needs because it (a) provides a foundation upon which more abstract reading skills can be built, (b) enables students to perform functional tasks (e.g., reading environmental signs, items on a menu, recipes) (Spector, 2011), and (c) gives individuals a sense of accomplishment related to literacy, building increased motivation for learning (Light & McNaughton, 2013).

Sight word instruction, ASD, and complex communication needs

Sight word learning is often the focus of literacy instruction for individuals with severe disabilities (Browder & Xin, 1998), yet limited research specifically focuses on individuals with

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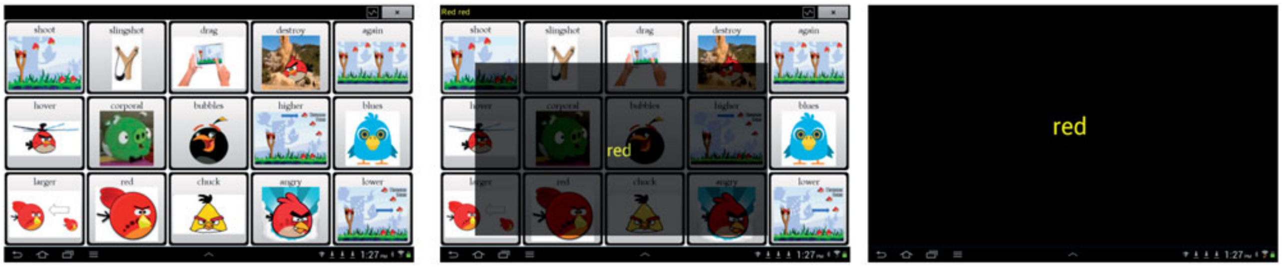

Figure 1. Example of the dynamic text feature within the graphics-based AAC grid display app. Upon selection of the graphic symbol with static text label (image on left), the text alone zooms out from the graphic symbol (image in the middle); the text then fills the screen for 3 seconds and the word is spoken (image on the right) before fading back into the graphic symbol.

ASD and complex communication needs (Spector, 2011). Sight word instruction for individuals with severe disabilities often includes words selected from lists of frequently encountered non-decodable words (e.g., *was, the*) and decodable words (e.g., *dog, ball*), taught through memorization drills (Weakland, 2013). In a review of the literature from 1980 to 2009, Spector (2011) found only nine single-subject studies targeting sight word instruction for individuals with ASD, only three of which involved individuals with ASD and complex communication needs. Research on the acquisition of sight words by these individuals (e.g., Caron, 2016; Eikeseth & Jahr, 2001; Hetzroni & Shalem, 2005; van der Meer et al., 2014) has varied with regard to intervention focus and specific sight words targeted. For example, the majority of studies have used pictures and/or text to teach sight words in various tasks including matching tasks (Fossett & Mirenda, 2006), computer-based instruction (Hetzroni & Shalem, 2005), flashcards and games (Crowley, McLaughlin, & Kahn, 2013), and mobile technology with systematic instruction (van der Meer et al., 2014). The studies have also varied in the intervention scaffolds used (e.g., fading, time-delay, and use of feedback). Despite these differences in interventions, the research consistently suggests that individuals with ASD and complex communication needs are able to acquire sight words when provided with instruction (Light & McNaughton, 2013).

AAC technologies to complement sight word instruction

Although literacy instruction (including sight word instruction) is imperative, improved features within AAC technologies could also be used to complement instruction and infuse literacy learning into daily communication. Typically, individuals with complex communication needs and limited literacy skills make use of AAC systems with picture symbols; these systems may not effectively support the transition to the use of orthography for communication. There is an urgent need to better understand how design features in AAC systems can support improved literacy outcomes for these individuals.

AAC systems, both high- and low-tech, commonly use graphic symbols (i.e., photographs or line drawings) to represent concepts. In most cases, the symbols are paired with a small static text label located above the symbol. As noted by Erickson, Hatch, and Clendon (2010) and Fossett and Mirenda (2006), static pairing of text and symbol may not support sight word learning. When text is paired with picture symbols in a static manner, learners may focus on the known picture symbols and not the unknown text (Fossett & Mirenda, 2006), thus potentially interfering with sight word learning (Didden, Prinsen, & Sigafoos, 2000; Erickson et al., 2010; Meadan, Stoner, & Parette, 2008). In traditional AAC technologies, the text label (or a smaller version of the paired text and graphic symbol) may also appear in the message bar when a graphic symbol from the grid display is selected; however, the appearance of the text in the message bar is subtle and may go unnoticed. Furthermore, the text in the message bar is displaced from the graphic symbol selected so that the relationship may not be evident to a user who is not yet literate. Therefore, it is not surprising to find that individuals with complex communication needs do not seem to automatically learn to read the majority of words that are paired with graphic symbols on their AAC displays.

Light, McNaughton, Jakobs, and Hershberger (2014) proposed redesigning AAC apps to better support literacy learning by individuals with complex communication needs. Learning to read, including learning to read sight words, is facilitated by the integration of (a) orthographic processing of the written text, (b) phonological processing of the spoken representation of the written text, (c) understanding of the meaning of the written word, and (d) use of context to support learning (e.g., Adams, 1990). The features investigated for the current study, the Transition to Literacy (T2L) software feature, incorporates adaptations to support these processes and include the following (see Figure 1): (a) presentation of dynamic animated text upon selection of the graphic symbol using motion to draw visual attention to the text (cf. Jagaroo & Wilkinson, 2008) and to support orthographic processing (left image in Figure 1), (b) origination of the text from the graphic symbol to support the association of the symbol and the text, thereby supporting understanding of the meaning of the text (middle image in Figure 1), (c) replacement of the graphic symbol by the text to make the word salient and mitigate the difficulties that may arise from static pairing of graphic symbols and text (right image in Figure 1), (d) pairing of the speech output with the appearance of the written word on the screen to support phonological processing of the text, and (e) targeting of sight words for the symbols within the learner's AAC system to ensure that concepts are known, thus supporting the association of meaning with the text. The broad context provided by the AAC display and the communication situation may also support learning. The exposure to text is infused into the individual's AAC system, thus ensuring that literacy learning is driven by the individual's interests and needs (Light & McNaughton, 2013). In addition, the T2L features may tap into the visual processing strengths and technology interests of many individuals with ASD (Mirenda, 2008).

The purpose of this study was to investigate the effects of dynamically displaying text along with speech output within a graphics-based grid display using an AAC app with T2L in order to support the transition to text from graphic symbols for individuals with ASD and complex communication needs. Specifically, the research questions were: (a) What is the effect of the AAC app with T2L on the acquisition of sight-word acquisition of 12 words, during a highly structured task, by individuals with ASD, complex communication needs, and limited literacy skills?, (b) Are the effects maintained once exposure to the AAC app with T2L features is terminated?, and (c) Do the participants generalize the sight-word skills to a text-only AAC grid display? It was hypothesized that the dynamic presentation of the written word paired with speech output, would support the acquisition, generalization, and maintenance of sight-word reading by individuals with ASD and complex communication needs.

Method

Research design

This study implemented a single-subject, multiple-probe, across-participants design with one set of three participants. The same design was then implemented with an additional set of two participants to investigate generalization of the results. During intervention, the participants were exposed to an AAC app with transition to literacy (T2L) software features (i.e., dynamic text and speech output upon selection of a graphic symbol), the independent variable in the study, during a highly structured task. The dependent variable, accurately reading 12 target words, was measured for the participants across all phases.

The study had four phases: (a) baseline, (b) intervention with the AAC app with T2L features, (c) maintenance, and (d) generalization with a text-only AAC display. Once stability of the dependent variable was achieved at baseline with the first participant, intervention began with this participant while the second and third participants remained in baseline. When an intervention effect was established with the first participant (i.e., the participant demonstrated an increase of at least 25% accuracy from the highest baseline point over three consecutive sessions), intervention was initiated with the second participant. The third participant remained in baseline until an intervention effect was established with the second participant. These procedures were repeated with the other two participants for replication of effects.

Participants

Ethics approval was obtained from the Human Research Protection Program prior to commencement of the study. Participants were recruited from schools in central Pennsylvania by requesting nominations from teachers and speech-language pathologists who worked with individuals with ASD and complex communication needs. Participant selection for the study included the following criteria: (a) presented with characteristics of ASD as described by the DSM-V (confirmed through assessment with the Childhood Autism Rating Scale Second Edition CARS-2; Schopler, Van Bourgondien, Wellman, and Love (2010), (b) were between 5 and 21 years old, (c) presented with speech that did not meet all of their daily communication needs, (d) were able to follow one-step directions, (e) were symbolic communicators who could use at least 10 spoken words, signs, or graphic symbols (e.g., PCS) expressively, (f) lived in homes in which English was the first language, (g) demonstrated unimpaired or corrected vision and hearing within normal limits per IEP or parental/teacher report, and (h) had limited literacy skills (i.e., were unable to decode words).

Participant profiles

Five boys with ASD and complex communication needs ranging in age from 6;3 (years; months) to 14;0 ($M = 10;6$) participated in the study. Four participants had a diagnosis of ASD and one (Tim) had been diagnosed with "ASD-like characteristics." All five of the participants scored in the moderate to severe range on CARS-2. All were Caucasian and participated in special-education classrooms with 1:1 paraprofessional support throughout the day. Their speech was inadequate to meet all of their communication needs, as judged by their teachers and speech-language pathologists. Two participants used aided AAC systems to communicate (Nikko and Wade) and three primarily communicated with restricted rote utterances (mostly requests) and delayed echolalic speech (Doug, Joe, and Tim). All were receiving speech and language services at the time of the study and had knowledge of 26 letter-sound correspondences; however, they scored below the first percentile on standardized language and literacy measures. See Table 1 for demographic information and Table 2 for current levels of literacy and language performance. Pseudonyms have been used to protect confidentiality.

Materials

Target words. All stimuli used across the phases of the study were based on a total of 15 words, 12 targeted for learning by all participants and three used by the researcher to model the operational components of the tasks. The words were selected through (a) discussion with the teachers, (b) consented review of participants' YouTube®[1] history for shared interests across participants, and (c) consideration of motivating, yet age appropriate, content. Ultimately, a common theme was identified across all participants: Angry Birds®.[2]

[1]YouTube is a video sharing website. https://www.youtube.com/

[2]Angry Birds was developed by Rovio Entertainment and was initially released as a game for Apple iOS – wherein colored birds with different features try and save their eggs. Its popularity led to many spin-off versions of the game for mobile technology, as well as an animated series and movie (*The Angry Bird Movie*, 2016). https://www.angrybirds.com/

Table 1. Participant demographics.

Participant	Age	Gender	Disability	Communication modes and supports	Educational placement and inclusion activities
Joe	10;9	M	Autism spectrum disorders (ASD)	Delayed echolalia and limited utterances using speech; visual schedules	Elementary school ASD support classroom with 1:1 support; included for gym, music, art, language arts, and social studies with 1:1
Nikko	13;4	M	ASD	iPad[a] with apps (GoTalk Now[b]); low-tech board with 20 sentences for commonly requested items; delayed echolalic or scripted speech; visual schedules	Middle school ASD support classroom with 1:1 support; included for gym, music, art with 1:1
Wade	14;0	M	ASD	iPad with apps (Proloquo2go[c], Assistive Express[d]); visual schedules	Middle school ASD support classroom with 1:1 support; included for gym, music, art with 1:1
Doug	6;3	M	ASD	Delayed echolalia and limited utterances using speech; visual schedules	Half day elementary school ASD support classroom with 1:1 support; half day Kindergarten with 1:1 support
Tim	10;3	M	Characteristics of ASD	Scripted speech; visual schedules	Included full day in a small language learning support elementary classroom with additional 1:1 support

[a]iPad Air is a product of by Apple Inc. Cupertino, CA. www.apple.com
[b]GoTalk Now is an AAC application created by Attainment Company. www.attainmentcompany.com/gotalk-now
[c]Proloquo2go is an AAC application created by Assistiveware. http://www.assistiveware.com/product/proloquo2go
[d]Assistive Express is an AAC application available in the iTunes store.

Table 2. Participant reading and language comprehension test scores.

Participant	CARS Assessment[a]	WRMT-III Standard scores[b]	TACL-3 Standard scores[c]	Dolch sight word inventory[d]	Estimated total sight word inventory[e]	Letter-sound knowledge inventory[f]
Joe	Severe ASD	Word Identification: 1; Word Attack: 1	Vocabulary Subtest: 1; Grammatical Morphemes Subtest: 1; Elaborated Phases Subtest: 1	57	200	26
Nikko	Severe ASD	Word Identification: 1; Word Attack: 1	Vocabulary Subtest: 1; Grammatical Morphemes Subtest: 1; Elaborated Phases Subtest: 1	64	250	26
Wade	Severe ASD	Word Identification: 1; Word Attack: 1	Vocabulary Subtest: 1; Grammatical Morphemes Subtest: 1; Elaborated Phases Subtest: 1	32	150	26
Doug	Moderate ASD	Word Identification: 1; Word Attack: 1	Vocabulary Subtest: 1; Grammatical Morphemes Subtest: 1; Elaborated Phases Subtest: 1	79	300	26
Tim	Moderate ASD	Word Identification: 1; Word Attack: 1	Vocabulary Subtest: 1; Grammatical Morphemes Subtest: 1; Elaborated Phases Subtest: 1	80	150	26

[a]Childhood Autism Rating Scale (2nd ed.; CARS-2), helps to identify and distinguish severity of Autism.
[b]Woodcock Reading Mastery Tests (3rd ed.; WRMT-III) is an assessment of reading skills. Word Identification and Word Attack subtests were administered. These subtests, when necessary, were adapted by providing a field of four choices to supporting the participants who could not speak to respond; comparisons to the text norms should be interpreted with caution. All participants scored <1%ile.
[c]Test for Auditory Comprehension of Language (3rd ed.; TACL-3) is an assessment of understanding of spoken language. No test modifications or adaptations were provided. All participants scored <1%ile.
[d]Dolch word inventory is estimated based on a screening of the 220 Dolch words from pre-primer to third grade.
[e]Sight word inventory is estimated based on (a) screening of Dolch words ($N = 220$), and (b) teacher report. The total includes the Dolch words read successfully plus personally relevant words like names, places, foods, movies, etc.
[f]Letter-sound knowledge inventory included a screening of 26 letter-sounds, the number listed includes a score out of 26.

The following criteria were used to select 15 words related to Angry Birds: (a) were no more than 10 letters in length, (b) represented a range of semantic relations (e.g., agents, actions, objects, descriptors), (c) were imageable, (c) had an initial letter shared with one other word in the 15-word set (e.g., Chuck and Corporal), (d) were not read accurately by the participants at baseline, and (e) had the potential to be used during communicative interactions to expand the participants' expressive communication. Three of the 15 words were used by the researcher to model the tasks: red, blues, and angry. The 12 sight words targeted with all participants were chuck, corporal, drag, destroy, lower, larger, higher, hover, slingshot, shoot, bubbles, and again. All words were introduced in lowercase letters.

Probe materials. Probes were conducted regularly during all phases to assess the participants' accuracy in reading the

12 target words. Materials for probes included laminated text cards, one for each word; and 2 in. × 2 in. graphic symbols for each of the target words, which were created by taking screenshots from the Angry Birds app (see Figure 1).

AAC technology and app. The T2L software features were introduced using a 15-button graphics-based grid display on the NOVA Chat 12™[3]. The NOVA Chat 12 hardware included a 12.2-inch LCD Samsung Galaxy Tablet®[4]. The 15-button display was programmed with the same graphic symbols as used within the probe tasks (i.e., symbols for the 12 target words and the three words used as models by the researcher).

T2L software features. As noted earlier, the T2L features to support sight word learning were conceptualized by Light et al. (2014) to provide a first step in the transition to text from graphics-based AAC technologies/apps for individuals with complex communication needs with limited literacy skills. Upon selection of a graphic symbol from the AAC grid display, the T2L features incorporated into the app provided a dynamic presentation of text, resulting in the replacement of the graphic symbols on the screen with the written text for 3 s and pairing of the text with speech output before the text shrank back into the graphic symbol and disappeared (see Figure 1, and the video demonstration at https://rerc-aac.psu.edu/research/r2-investigating-aac-technologies-to-support-the-transition-from-graphic-symbols-to-literacy/).

As noted earlier, the intervention phase of the study used the grid-based app with graphic symbols to expose the participants to the dynamic sight words. The generalization phase used the AAC app with a text-only grid display, that is, a static grid display with 15 written words but no symbols. The locations of the written words within the grid were rearranged so that none of the words were in the same location as their graphic symbol referents during intervention. Rearranging the grid ensured that the participants had to read the words to use the display; they could not rely on memorizing the location of the original graphic symbol within the grid.

Procedures

All of the sessions took place in a school classroom and were conducted by the first author. Each session lasted approximately 15 min. There were 3–4 sessions per week, depending on participants' schedules. Two intervention sessions often occurred on the same day with a break of at least 30 min between the sessions. The procedures for each of the four phases (baseline, intervention, maintenance, and generalization) are outlined in the sections that follow.

Baseline. Prior to baseline, all participants were trained to ensure that they were able to identify the graphic symbols for the Angry Birds vocabulary. Accuracy was assessed by having the participant select the correct graphic symbol from a field of four in response to the spoken instruction, "Point to ___." Once all participants consistently identified the Angry Birds symbols with a minimum of 90% accuracy over two consecutive sessions, baseline began.

During each baseline session, the participants were assessed on their accuracy in reading the 12 target words. Each participant completed a minimum of five baseline sessions prior to the start of intervention in order to establish a stable baseline. In this study, a stable baseline was defined as less than 40% accuracy over three consecutive sessions, with no increasing trend. During the probes, the researcher (a) pointed to each symbol and labeled the symbol aloud, (b) placed the target sight word, in text form, above the array of four symbol choices (including the symbol representing the target word, one with the same first letter as the target word, and two randomly selected from the remaining 10 targets), and (c) instructed the participant to read the word and to give/point to the picture that went with the word. Prior to starting the probe for each of the 12 target sight words, the researcher first provided two models of the task using two of the three words not targeted for intervention. The researcher provided no feedback during the probe.

Intervention. Each intervention session included two parts: (a) a probe to assess accuracy reading the target words, and (b) use of the AAC app with the T2L features to support sight word learning. The intervention sessions lasted approximately 15 min.

Probes. Each intervention session started with a probe to measure the participants' accuracy in reading the target words. The procedures for the probes during intervention were identical to those used during baseline. Once the participants attained criterion, intervention was terminated. Criterion was defined as a minimum of nine out of 12 correct trials during the probes at intervention, over two consecutive sessions.

Exposure to the T2L features through the AAC app. Once the probe at the start of the intervention session was complete, the researcher introduced the AAC app with T2L features during a highly structured, teacher directed, matching activity. The researcher started the sessions with two examples of matching the laminated graphic symbol for one of the three words (not targeted in the study) to the same picture symbol within the AAC grid display. In order to elicit the participant's selection of each of the 12 target symbols from the grid display, the researcher showed a graphic symbol of one of the 12 target words, and the participant was required to select the same symbol in the grid on the AAC app. Selection of the symbol resulted in activation of the dynamic text and speech output. After the text appeared dynamically (slowly animating from the graphic symbol), it stayed on the screen for 3 s while the speech output said the word and then disappeared (slowing animating back into the graphic symbol). The researcher required the participant to select the same symbol from the grid display again, stating, "One more time." This allowed two sequential exposures to the dynamic text and speech output for the same symbol. No feedback was provided during the task. The researcher did not provide instruction in the sight words nor did she draw the participant's attention to the dynamic text in any way. The 12 symbols/target words were presented in random order each

[3]NOVA Chat 12 is a voice output communication device available from Saltillo Corporation. https://saltillo.com/products/print/nova-chat-12

[4]Samsung Galaxy 12 is an Android tablet computer, developed by Samsung Electronics. www.samsung.com

session and these same procedures were repeated for all 12 symbols/target words. Upon completion of two selections per graphic symbol for all symbols, the order of the laminated target symbol cards was re-arranged and the procedures were repeated for each target, resulting in an additional two exposures (to the dynamic text and speech output) per word. Thus, there were a total of four exposures (3 s each) to each word, in each intervention session, for a total of 12 s of exposure to the dynamic text and associated speech output per word, per intervention session. Although written words were seen during the probe task, no feedback or output regarding pairing/labelling the written word was provided. Accordingly, the exposures were counted as the amount of time with the dynamic text on the screen. In order to maintain experimental control of the amount of exposure to the dynamic text, the participants only had access to the AAC app incorporating the T2L features during the intervention sessions.

Maintenance. Once the participants attained criterion in the intervention probes, intervention was terminated and the maintenance phase was initiated. The probes measuring maintenance followed the same procedures as the baseline and intervention probes. Due to school absences and summer-break, maintenance probes occurred at different times for each of the participants. Short-term and long-term measures of maintenance were commonly collected at 2–4 weeks and 8–16 weeks, respectively, after the completion of the intervention phase. The exact timing of each participant's maintenance measures is reported in the Results. One of the participants (Tim) moved before the study ended. He had completed short-term maintenance probes but not the probes for long-term maintenance.

Generalization. Generalization data were collected during baseline and after the intervention phase ended in order to determine whether participants generalized their sight word reading skills to a text-only display in three conditions: (a) probes in which the participant was asked to select a target word from the text-only display (of 15 words) in response to an oral label, (b) probes in which the participant was asked to select a target word from the text-only display when shown the symbol, and (c) probes in which the participant had the opportunity to use the text-only display to communicate about scenes depicting Angry Birds characters and events.

Oral label probe. For the oral label probes, the researcher first modeled the task using the practice words, by stating the directions (e.g., "Show me _____") and then pointing to the written word on the text-only display that corresponded to the word stated aloud. After providing two models of the task requirements, the researcher started the probe: She stated the directions ("Show me ____") and waited a maximum of 5 s for the participant to make a selection from the text-only grid display. These steps were repeated for all 12 target words, in random order.

Graphic symbol probe. The generalization probes with symbol cues followed the same procedures as those with oral cues, with one exception. Instead of stating the target word aloud, the researcher showed an Angry Bird symbol and instructed the participant to find the word that went with the symbol (from the 15-word text-only grid display).

Scene probe. The final generalization measure sought to explore whether the participants generalized use of the text-only grid display (with the words learned during intervention), to a functional communication task. The participants were required to comment on an Angry Birds scene by labeling or describing at least one of the five elements of the scene using the new sight words they had learned. For example, in one of the scenes Chuck appeared lower and larger than the birds in the slingshot. If the participant selected words from the text-only display representing any of the elements of the scene (i.e., <u>chuck</u>, <u>slingshot</u>, <u>lower</u>, <u>larger</u>, and/or <u>shoot</u>), the participant received a correct score for that scene. If the participant selected other words from the text-only display, the response was marked as incorrect. This generalization probe did not occur in baseline; generalization to communication with the text-only grid only occurred after the intervention phase was completed. The researcher began this probe by modeling the task by first stating the directions (e.g., "Look at this picture. What do you see?"), then pointing to one of the parts of the scene, and then selecting the corresponding word for that concept within the scene from the text-only grid display. After one model, the researcher presented the next scene and said, "What do you see?" After the participant selected a response (correct or incorrect) on the text-only display, the researcher expanded upon the response, using the selected word in a sentence. If the participant did not respond after 5 s, the next scene was presented. These steps were repeated for 12 scenes.

Procedural reliability. A graduate student in speech-language pathology completed the checks of procedural integrity. In order to ensure that all procedures were implemented as intended, all sessions were videotaped. A randomly selected sample, constituting a minimum of 20% of the video recorded sessions for each phase, per participant, was checked against a checklist of the standard procedures. The student was trained in the reliability procedures and, with the researcher, watched several sessions and completed the procedural checklist for each session. Disagreements were discussed and, upon reaching 90% agreement, the student independently watched a new randomly selected sample of sessions across participants and completed the procedural reliability checklist. Procedural integrity was calculated by dividing the number of steps performed correctly by the total number of steps required. Mean procedural reliability for baseline was 100%, intervention was 99% (range: 99–100%), maintenance was 99% (range: 98–100%), and generalization was 88% (range: 81–100%).

Measures and data analyses

The dependent variable for the study was the percentage correct during the sight word reading probes; specifically, the number of correct graphic symbols selected from a field of four when provided with a target written word, across 12 trials. Probes were conducted during baseline, intervention, and maintenance phases. A correct response during the

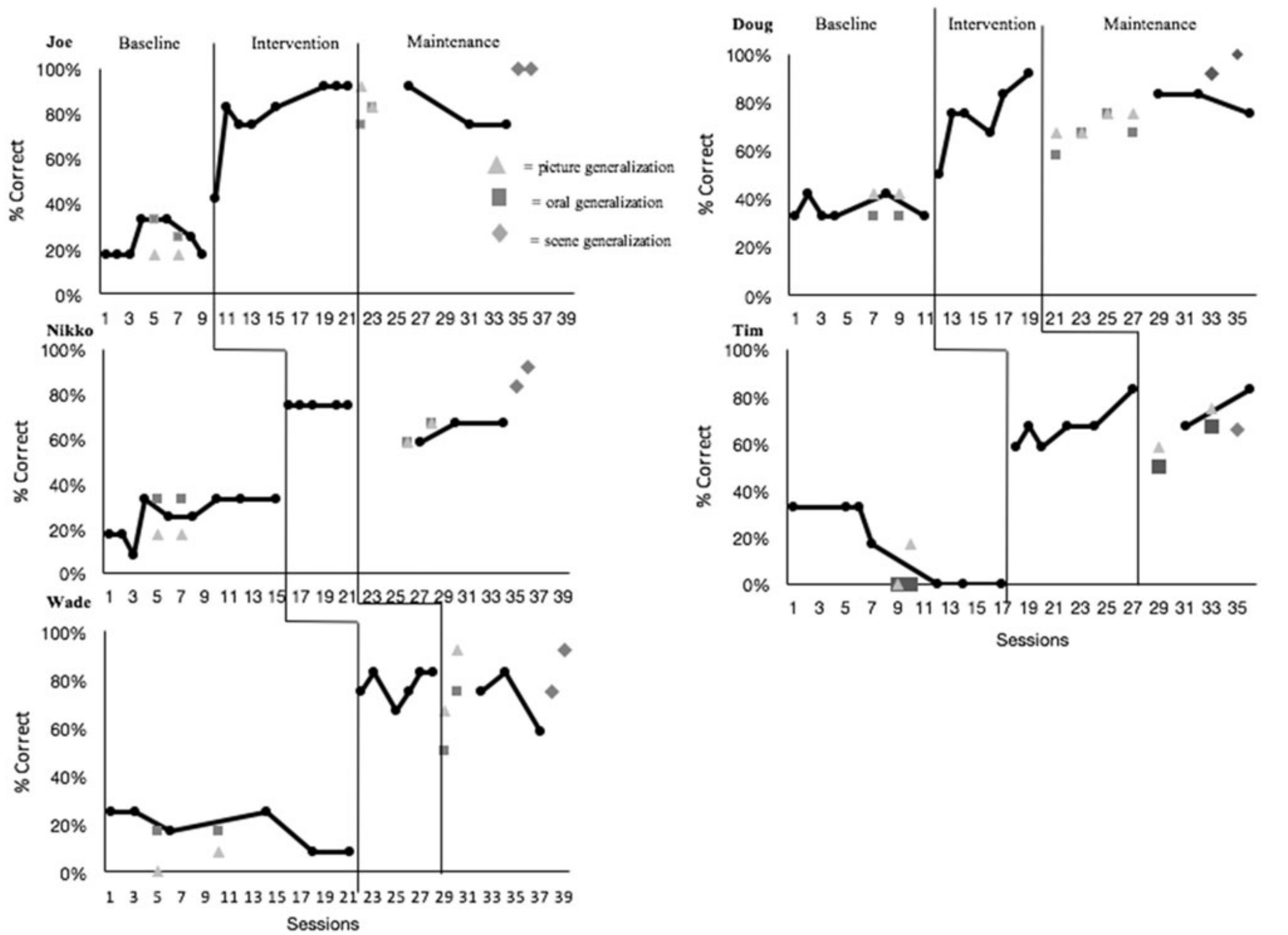

Figure 2. Percentage of sight words read correctly, per participant, out of 12 trials, in the probes at baseline, during intervention, and during maintenance and generalization.

probe tasks was defined as an independent selection of the graphic symbol corresponding to the written word within 5 s of the researcher's presentation of the word; an incorrect response was defined as either selection of a graphic symbol that did not correspond to the written word or lack of response within 5 s of the researcher's presentation of the written word. Data were also collected on the number of written words selected correctly from the text-only display during the generalization probes to assess the participants' generalization of the sight word reading skills to use of a text-only AAC display.

All sessions were videotaped; probe data were recorded live by the interventionist during the probes. In order to ensure reliability of the data, a second coder (a graduate student in speech- language pathology) was trained in coding procedures and used the videotaped sessions to perform reliability checks. During the training session, the research assistant and researcher watched a session together and coded the participant's responses as correct, incorrect, or no response within a 5 s time period. The coding from the videotaped sessions was compared to the data collected live by the researcher. Disagreements were discussed. Upon reaching 90% agreement during training, the research assistant then coded a randomly selected sample of a minimum of 20% of the probes across the study phases for each of the participants. Interrater agreement was calculated by determining the number of agreements divided by the number of agreements plus disagreements plus omissions. The mean interrater reliability per phase was: 100% at baseline, 100% at intervention, 91% for generalization, and 100% for maintenance.

Data on target-word reading accuracy were graphed separately for each individual across the four experimental conditions (i.e., baseline, intervention, maintenance, and generalization). The level, trend, and slope of the data in the intervention condition were compared to those at baseline to determine the effectiveness and efficiency of the app with T2L features. Non-overlap of all pairs (NAP), defined as the proportion of non-overlapping data between phases (Parker & Vannest, 2009), was also calculated. Parker and Vannest provided tentative NAP ranges for effect size: weak effect ranging from 0 to .31, medium effect ranging from .32 to .84, and large or strong effects ranging from .85 to 1.

Results

The results are presented per participant, according to the main research questions: (a) the effect of the AAC grid-based app with T2L features on the acquisition of sight-words during a highly structured task, (b) the maintenance of the intervention effects, and (c) the generalization of the acquired sight-words to a text-only AAC grid display. The percentage of correct responses in the baseline, intervention, generalization, and maintenance phases is displayed in Figure 2.

Effect of AAC app with T2L features on sight-word acquisition

At baseline, prior to exposure to the AAC app with T2L features, the participants performed with <36% accuracy when reading the 12 target words (chance levels of 25%): Joe performed with a mean of 23% accuracy at baseline, Nikko 25%, Wade 18%, Doug 36%, and Tim 17%. Per participant, the averages of the final three data points were calculated to determine gains from baseline. Joe improved to an average of 92% accuracy for a gain of +69%, Nikko to 77% for a gain of +50%, Wade to 82% for a gain of +62%, Doug to 81% for a gain of +45%, and Tim to 72% for a gain of +52%. Each of the participants improved their accuracy in reading the 12 sight-words as a result of exposure to the AAC app with T2L features as demonstrated by a positive trend after stable baselines, marked increases in the slope of data, and/or relative increases in level of accuracy of sight-word reading after intervention began. NAP was calculated for all participants, with each demonstrating 100% non-overlapping data between baseline and intervention (see Figure 2). Furthermore, the participants learned to recognize the 12 words after only minimal exposure to the dynamic text. On average, Joe required a total of 32 exposures of 3 s each (96 s total) to dynamic text for each written word, Nikko required 20 exposures (60 s); Wade, 24 exposures (72 s); Doug, 24 exposures (72 s); and Tim, 24 exposures (72 s). See Table 3.

All of the participants maintained their skills reading the target words above baseline levels. Due to school breaks and schedules, maintenance probes were conducted at different times for each participant. Joe maintained criterion levels for maintenance measures averaging 81% correct (probes conducted at 3, 8, and 10 weeks), Nikko averaged 64% correct (probes at 4, 7, and 10 weeks), Wade averaged 72% correct (probes at 4, 6, and 10 weeks), Doug averaged 80% correct (probes at 4, 6, and 10 weeks), and Tim averaged 75% correct for short-term measures (probes at 1 and 4 weeks; no long-term maintenance data were conducted for Tim, who had moved). It is important to note that the participants did not have any access to the AAC app with T2L features during the maintenance phase once intervention was terminated.

Three generalization tasks were conducted: (a) oral probes (researcher orally stated a target word for the participant to identify on the AAC text-only grid display), (b) symbol probes (researcher showed a symbol representing a word for the participant to identify on the text-only grid display), and (c) scene probes (researcher presented a scene that included five target concepts, with the participant required to communicate about one of the five target concepts in the scene using the text-only display). The participants all demonstrated gains in their accurate use of the 15-word, text-only grid display, demonstrating progress in a transition from a graphics-based grid display to a text-only display, across all three tasks.

Table 3. Number of exposures and total time of exposure to the dynamic text during intervention for the participants.

Participant	Total number of in sessions	Total number of exposures to dynamic text	Total dynamic text exposure time[a] per word (in seconds)
Joe	8	32	96
Nikko	5	20	60
Wade	6	24	72
Doug	6	24	72
Tim	6	24	72

[a]Exposures are counting the amount of time with the text on the screen (3 sec per activation).

Oral generalization probe. Oral generalization probes were conducted twice at baseline and twice post intervention for all participants. At baseline, Joe performed with a mean of 29%; Nikko, 33%; Wade, 17%; Doug, 33%; and Tim, 0%. After intervention, Joe performed with a mean of 79% accuracy; Nikko, 63%; Wade, 63%; Doug, 67%; and Tim 59%.

Graphic symbol generalization probe. Graphic symbol generalization probes were also conducted twice at baseline and twice post intervention for all participants. At baseline Joe performed with a mean of 17%; Nikko, 17%; Wade, 4%; Doug, 42%; and Tim, 9%. After intervention, Joe performed with a mean of 88% accuracy for this probe; Nikko, 63%; Wade, 80%; Doug, 71%; and Tim, 68%.

Scene generalization probe. For the scene generalization, probes were not conducted at baseline but were conducted twice post intervention for all participants except Tim. Joe performed with a mean of 100% accuracy; Nikko, 88%; Wade, 84%; Doug, 96%; and Tim, 66%.

Discussion

Despite the challenges that individuals with ASD and complex communication needs face in acquiring literacy skills, the five participants in this study all demonstrated increased accuracy when reading sight-words using an AAC app with T2L features to support sight-word learning during a highly structured task. This study is the first to evaluate the impact of AAC apps with dynamic text and speech output on the reading skills of individuals with ASD and complex communication skills, and provides preliminary evidence that redesigning AAC apps to include T2L features may positively impact the sight-word reading of individuals with ASD and complex communication needs. The findings contribute to the growing body of research documenting that these individuals can learn to read with appropriate supports (e.g., Caron & Light, 2016; Spector, 2011).

All of the participants demonstrated gains in reading the target sight-words, suggesting that incorporating T2L features into AAC apps to support sight-word learning may be effective for individuals with complex communication needs even when they are unable to decode words. The exposure to the AAC app with T2L features resulted in strong effects on sight-word performance (NAP greater than .85) (Parker & Vannest, 2009), with NAP calculations resulting in 100% non-overlapping data for all participants. Rasinski and Padak (2008) reported that "learners of average intelligence require approximately 35 exposures to a word before it can be easily recognized; less able learners will require about 55 exposures to a word before it can be recognized automatically" (p. 169). The five participants in this study learned to recognize the targeted sight words in 20 to 32 exposures to the dynamic text T2L features (approximately 1–2 min of exposure per word). In addition, the participants generalized their learning to a text-only AAC display – demonstrating the transition with 15 words from a graphic-based AAC display. Using a text-based display is a significantly more difficult task.

Potential effectives and efficiency factors

A number of factors potentially contributed to the effectiveness and efficiency of this intervention, including those related to the AAC app and those related to the participants' intrinsic characteristics. The design of the T2L features drew on the research in visual cognitive processing, literacy instruction, and instructional design (Light et al., 2014). According to Light and colleagues, the direct active pairing (both between the text and graphic symbol and between text and speech output) can support learning of the association between a written word and its referent (picture symbol and/or spoken word), following principles of effective sight-word instruction (e.g., Browder & Xin, 1998; Fossett & Mirenda, 2006). Specifically, the T2L features included the use of: (a) dynamic text to attract the learner's visual attention to the written word thus engaging orthographic processing, (b) active linking of the written word to its spoken referent (via the speech output) thus engaging phonological processing, (c) targeting of motivating and meaningful vocabulary known to the learner within the AAC display thus supporting meaning processing, and (d) targeting of vocabulary within familiar contexts (in this case the Angry Birds app), thus capitalizing on contextual support for learning (Light et al., 2014). Although the dynamic text originated at the point of selection of the graphic symbol, it ultimately replaced the symbol on the screen, potentially mitigating some of the problems that may occur when sight words are paired with pictures in a static manner (see Erickson et al., 2010 for further discussion). Because the AAC app included all of these T2L design features, it is not possible to evaluate the relative effects of any single feature. However, the results do suggest that the AAC app with these T2L features positively impacted the acquisition of sight words by the individuals with ASD and complex communication needs.

The positive gains made by the participants may have also been impacted by their intrinsic characteristics. The rapid rate of acquisition, despite limited exposures, potentially suggests that the AAC app with T2L features may tap into the visual processing strengths of individuals with ASD and build on the technology interests of many people with ASD (Mirenda, 2008). Furthermore, the participants in this study all had some previous experience with literacy instruction and knowledge of letter-sound correspondences, although they were not decoding and were not functionally literate. The participants demonstrated skills in the partial-alphabetic phase of literacy acquisition (Ehri, 1998), whereby they were able to make use of partial connections, including visual, context, and phonetic cues to identify written words (Ehri, 1998). These partial-alphabetic skills may have supported successful acquisition of sight-word reading through the AAC app with T2L features, as these features were designed to draw attention to orthographic, phonological, and contextual cues.

Over a short period of intervention, the five participants demonstrated increased accuracy reading the target sight-words. They maintained these effects post intervention, well above baseline levels, but they showed some decrease in performance during maintenance compared to intervention. Providing more exposure to the dynamic written words, setting a higher criterion for terminating intervention, and providing longer-term use of the AAC app (across environments and partners), could potentially support stronger maintenance and generalization outcomes. The exposure to the app occurred for a very brief and structured time each week. There was no complementary instruction on the target words; the only intervention was the brief exposure to the dynamic text (approximately 12 s per word, per session) through the T2L features when using the AAC app during a highly structured task. Intervention was designed this way to isolate the app with T2L features as the independent variable in this study, but this situation is not best practice. The app should be used to complement, not replace, literacy instruction. The T2L features may be of particular value as one component of a rich and robust literacy instruction program in which learners should have ongoing access to the app with opportunities for repeated use – resulting in a more effective and efficient support for literacy learning.

Limitations and future research

This study provides important data on the effects of an AAC app with T2L features on the sight-word reading of individuals with ASD, complex communication needs, and basic literacy skills. However, the study has a number of limitations that should be considered when interpreting the results. The study only included five participants, each of whom varied in terms of severity of ASD, primary modes of communication, age, and literacy goals. Future research is required to investigate the potential benefits of incorporating T2L features into AAC apps with other individuals with ASD and complex communication needs, with individuals with other disabilities, and with individuals who have a range of literacy skills. The independent variable in the study was the introduction of the AAC app with T2L features to support sight-word learning. This was an appropriate first step to investigate the effectiveness of this app design. Future research is required to compare the effectiveness of AAC apps with and without T2L features to determine the specific effects of these features. It is possible that the participants would have also acquired the sight words simply by selecting the graphic symbols repeatedly from a traditional AAC app with the static pairing of symbols and text.

The study established experimental control with three participants to determine the effect of the AAC app with T2L features on the acquisition of the target words; however, the generalization phase did not include five data points. The number of data points in this phase was limited in order to find a balance between methodological rigor and participant needs (Light & McNaughton, 2015). Generalization findings would have been strengthened if the probes had included a minimum of five data points per phase, as recommended by Horner and colleagues (Horner et al., 2005). In addition, the probe tasks for baseline, intervention, and maintenance used a closed set of choices. The closed set comprised only symbols for words that were targeted within the study, only one other word with the same initial letter as the targeted sight word, varied word lengths, and a limited array (i.e., choice from four photographs). The closed set of responses simplified the reading task (Barker, Saunders, & Brady, 2012), but it is possible that performance would have varied had the probes included an increased array size, more foils with the same initial letter or word length as the target word, and foils that were not included in the intervention. Although the results for generalization to the text-only grid display are promising, future research investigating these areas is warranted, including investigation into the lasting effects of the app with T2L features: Given the short-term nature of the intervention, results may have been impacted by a novelty effect associated with the T2L features.

Broader limitations and future directions. Successfully learning to read and write is not an isolated skill, but rather a complex process of integrating and applying component skills and knowledge (Adams, 1990). Reading requires readers to call on background experience, knowledge, and language understanding (Mirenda & Erickson, 2000). This study focused on an isolated skill – sight-word reading – with a small set of target words. Future research is required to investigate the effects of T2L features when used in conjunction with comprehensive literacy instruction, as well as the possible effects with larger word sets and other literacy skills.

Furthermore, the app was introduced in teacher-directed tasks, not through exposure during daily communicative interactions. Although the app contributed to the acquisition of sight-words in this structured context, future research is required to investigate the effects of the T2L features in daily communication and education tasks; this research should consider the app's effects on not only sight-word acquisition but also the communication process. Although incorporating T2L features into AAC apps provides the option of integrating literacy supports into meaningful communication, thereby providing increased opportunities for functional learning and potentially exposing individuals with complex communication needs to relevant text throughout the day (Light & McNaughton, 2015), it is possible that use of these features during daily interactions could present a distraction for either the user or for communication partners. Future research is required to investigate these issues.

Finally, there remain many questions regarding the specific realization of the T2L features. For example, research is needed to examine the optimum (a) speed of the smooth animation of the written word, (b) length of time that the text appears on the screen, (c) size of the written text, and (d) the decision to have the word appear in isolation or superimposed upon the graphic display. Furthermore, future research is required to explore how to best manage the transition to traditional orthography from symbol-based AAC displays, specifically, an investigation into the number of exposures that are typically required before a written word is acquired and therefore can replace the graphic symbol in the AAC display. These types of design features will no doubt impact the performance of individuals with complex communication needs; research is required to ensure that the design of AAC systems is research-based to maximize performance (Light & McNaughton, 2015).

Fossett and Mirenda (2006) suggest consideration of how graphic symbols (e.g., pictures) should be used during sight word learning, stating, "… the issue is not whether or not to use pictures when teaching sight word reading skills … the issue appears to be how to use pictures effectively to teach sight word recognition … " (p. 426). The results of this study suggest a change in how graphic symbols and text are used within an AAC system. To support sight-word acquisition, minor changes to the AAC system seem to have the potential to impact learning. Specifically, the dynamic text (as opposed to static text) with paired speech output, appearing from the graphic symbol and momentarily replacing the graphic-based grid display, supported acquisition of 10–12 sight words for the participants in the study. Despite the positive effects of the T2L features on sight word acquisition observed in this study, there may be other technology adaptations to better support the transition from graphic symbols to text. Future research is required to compare the relative effectiveness and efficiency of different AAC technology designs on the acquisition of literacy skills by individuals with complex communication needs, including those with ASD.

Conclusion

When discussing the heart of innovation, Kelley and Kelley (2013) state: "If you want to transform … you have to start by realizing that your current situation is not the only option" (p. 170). Graphics-based AAC grid displays have supported individuals with complex communication needs for decades. While technological changes have been made to hardware (e.g., lighter, more portable systems), AAC software, including apps, has remained relatively static in design – with releases of new iterations, yet often replications of what may be viewed as the only options. Research to explore innovative, evidence-based design changes to AAC systems to enhance language and literacy learning and improve communication performance is needed. This study provides preliminary evidence that redesigning graphics-based AAC software to include T2L features, when used in a highly structured manner, can result in improvements in sight-word reading for individuals with ASD, complex communication needs, and some literacy skills. Integrating T2L features into AAC technologies may support a more synergistic relationship between communication and literacy learning – ultimately leading to maximized communication and literacy outcomes for individuals with complex communication needs.

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References

Adams, M.J. (1990). *Beginning to read: Thinking and learning about print*. Cambridge, MA: MIT Press.

Barker, R., Saunders, K., & Brady, N. (2012). Reading instruction for children who use AAC: Considerations in the pursuit of generalizable results. *Augmentative and Alternative Communication*, *28*, 160–170. doi:10.3109/07434618.2012.704523

Browder, D., & Xin, Y. (1998). A meta-analysis and review of sight word research and its implications for teaching functional reading to individuals with moderate and severe disabilities. *Journal of Special Education*, *32*, 130–153. doi:10.1177/002246699803200301

Caron, J. (2016). *Effects of adapted instruction on the acquisition of letter-sound correspondences and sight words by pre-adolescent/adolescent learners with complex communication needs and autism spectrum disorder*. (Doctoral dissertation, Pennsylvania State University).

Caron, J., & Light, J. (2016). "Social media has opened a world of 'open communication:'" Experiences of adults with cerebral palsy who use augmentative and alternative communication and social media. *Augmentative and Alternative Communication*, *32*, 25–40. doi:10.3109/07434618.2015.1052887

Centers for Disease Control (2014). Prevalence of autism spectrum disorder among children aged 8 years – autism and developmental disabilities monitoring network, 11 Sites, United States, 2010. *MMWR*, *63*, 1–21.

Crowley, K., McLaughlin, T., & Kahn, R. (2013). Using direct instruction flashcards and reading racetracks to improve sight word recognition of two elementary students with autism. *Journal of Developmental and Physical Disabilities*, *25*, 297–311. doi:10.1007/s10882-012-9307-z

Didden, R., Prinsen, H., & Sigafoos, J. (2000). The blocking effect of pictorial prompts on sight-word reading. *Journal of Applied Behavior Analysis*, *33*, 317–320. doi:10.1901/jaba.2000.33-317

Ehri, L.C. (1998). Word reading by sight and by analogy in beginning readers. *Reading and Spelling: Development and Disorders*, *5*, 87–111.

Eikeseth, S., & Jahr, E. (2001). The UCLA reading and writing program: An evaluation of the beginning stages. *Research in Developmental Disabilities*, *22*, 289–307. doi:10.1016/S0891-4222(01)00073-7

Erickson, K., Hatch, P., & Clendon, S. (2010). Literacy, assistive technology, and students with significant disabilities. *Focus on Exceptional Children*, *42*, 1–16.

Fossett, B., & Mirenda, P. (2006). Sight word reading in children with developmental disabilities: A comparison of paired associate and picture-to-text matching instruction. *Research in Developmental Disabilities*, *27*, 411–429. doi:10.1016/j.ridd.2005.05.006

Hetzroni, O., & Shalem, U. (2005). From logos to orthographic symbols: A multilevel fading computer program for teaching nonverbal children with autism. *Focus on Autism and Other Developmental Disabilities*, *20*, 201–212. doi:10.1177/10883576050200040201

Horner, R., Carr, E., Halle, J., McGee, G., Odom, S., & Wolery, M. (2005). The use of single subject research to identify evidence-based practice in special education. *Exceptional Children*, *71*, 165–179. doi:10.1177/001440290507100203

Jagaroo, V., & Wilkinson, K. (2008). Further considerations of visual cognitive neuroscience in aided AAC: The potential role of motion perception systems in maximizing design display. *Augmentative and Alternative Communication*, *24*, 29–42. doi:10.1080/07434610701390673

Kelley, T., & Kelley, D. (2013). *Creative confidence: Unleashing the creative potential within us all*. New York: NY: Crown Business.

Kjelgaard, M.M., & Tager-Flusberg, H. (2001). An investigation of language impairment in autism: Implications for genetic subgroups. *Language and Cognitive Process*, *16*, 287–308. doi:10.1080/01690960042000058

Light, J., & McNaughton, D. (2013). Literacy intervention for individuals with complex communication needs. In D.R. Beukelman & P. Mirenda (Eds.), *Augmentative and alternative communication: Supporting children and adults with complex communication needs* (pp. 309–351). Baltimore, MD: Brookes Publishing Co.

Light, J., & McNaughton, D. (2015). Designing AAC research and intervention to improve outcomes for individuals with complex communication needs. *Augmentative and Alternative Communication*, *31*, 85–96. doi:10.3109/07434618.2015.1036458

Light, J., McNaughton, D., Jakobs, T., & Hershberger, D. (2014). *Investigating AAC technologies to support the transition from graphic symbols to literacy*. Rehabilitation Engineering Research Center on Augmentative and Alternative Communication. Retrieved from https://rerc-aac.psu.edu/research/r2-investigating-aac-technologies-to-support-the-transition-from-graphic-symbols-to-literacy/

Meadan, H., Stoner, J.B., & Parette, H.P. (2008). Sight word recognition among young children at-risk: Picture-supported vs. word-only. *Assistive Technology Outcomes and Benefits*, *5*, 45–58.

Mirenda, P. (2008). A back door approach to autism and AAC. *Augmentative and Alternative Communication*, *24*, 220–234. doi:10.1080/08990220802388263

Mirenda, P., & Erickson, K.A. (2000). Augmentative communication and literacy. In A. M. Wetherby & B. M. Prizant (Eds.), *Autism spectrum disorders: A transactional approach* (pp. 333–369). Baltimore: Paul H. Brookes Publishing Co.

National Reading Panel. (2000). *Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implication for reading instruction (NIH Pub. No. 004745)*. Washington, DC: US Department of Health and Human Services.

Office of Special Education Programs. (2016). *Thirty-eighth annual report to congress on the implementation of the individuals with disabilities education Act, Parts B and C. 2016*. Washington, DC: US Government.

Parker, R., & Vannest, K. (2009). An improved effect size for single-case research: Nonoverlap of all pairs. *Behavior Therapy*, *40*, 357–367. doi:10.1016/j.beth.2008.10.006

Rasinski, T., & Padak, N. (2008). *From phonics to fluency: Effective teaching of decoding and reading fluency in the elementary school* (2nd ed.). Boston, MA: Allyn & Bacon.

Schopler, E., Van Bourgondien, M., Wellman, G., & Love, S. (2010). *Childhood Autism Rating Scale* (2nd ed.). Los Angeles, CA: Western Psychological Services.

Shane, H., Laubscher, E., Schlosser, R., Fadie, H., Sorce, J., Abramson, J., … Corley, K. (2015). *Enhancing communication for individuals with autism: Guide to the visual immersion system*. Baltimore, MD: Brookes Publishing.

Spector, J.E. (2011). Sight word instruction for students with autism: An evaluation of the evidence base. *Journal of Autism and Developmental Disorders*, *41*, 1411–1422. doi:10.1007/s10803-010-1165-x

van der Meer, L., Achmadi, D., Cooijmans, M., Didden, R., Lancioni, G., O'Reilly, M., … Sigafoos, J. (2014). An iPad-based intervention for teaching picture and word matching to a student with ASD and severe communication impairment. *Journal of Developmental and Physical Disabilities*, *27*, 67–78. doi:10.1007/s10882-014-9401-5

Weakland, N. (2013). *Implementation of educational games-based instruction for improving sight word recognition* (Doctoral dissertation, Bowling Green State University).