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GRAPHIC-BASED AAC APPS TO SUPPORT TRANSITION TO LITERACY FOR INDIVIDUALS WITH AUTISM

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ABSTRACT

Literacy is the foundation for participation in recreational, vocational, and academic activities. Learning literacy skills allows individuals to comprehend text and helps to match meaning to words. Literacy instruction provides individuals the access to communication, thus increasing participation in their community. For individuals with disabilities and complex communication needs, specifically autism, gaining access to literacy instruction has previously been viewed as unimportant; receiving little attention. Recent changes in federal policy, however, have promoted teaching literacy to all students, including those with disabilities. Students with complex communication needs (CCN) who use augmentative and alternative communication (AAC) may require adapted literacy instruction in order to successfully access the general curriculum.

The purpose of the current study is to investigate the effects of an AAC system design change for content-specific literacy instruction. An AAC app with T2L features (i.e., dynamic text and speech output upon selection of a graphic symbol) was utilized to investigate the effects on sight word learning. This study was a single-subject multi-probe design across content-specific academic word sets. The results indicate improved sight word learning from baseline to intervention, and through maintenance. This study provides preliminary evidence that a simple design change to AAC systems can successfully support literacy learning and in turn, participation in the general curriculum.

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Chapter 1

Introduction

Autism. Autism spectrum disorder (ASD) is a developmental disability that hinders typical brain development and results in deficits in social interaction, communication, and behavior (Christensen et al., 2016). Many children who receive this diagnosis of autism also receive a comorbid diagnosis of intellectual disabilities and/or motor delays (Block, Block, & Halliday, 2006). Autism spectrum disorder is characterized by deficits in social and communication as well as restrictive and repetitive behaviors (Christensen et al., 2016).

Social interaction deficits are the most defining feature of ASD (Will et al., 2018). Difficulties in social functioning include challenges in both initiating and maintaining eye contact, joint attention, participating in reciprocal conversations, emotion recognition, empathy, and recognizing social cues from others. As individuals with ASD enter late childhood and adolescence, these social deficits become more pronounced. These social skill deficits have been associated with academic problems, depressive symptoms, as well as anxiety (Will et al., 2018). In addition to social deficits, individuals with ASD have behaviors that distinguish the diagnosis, this includes repeated body movements, flapping of the arms/hands, rocking body back and forth, as well as others. An individual with ASD may develop unusual attachments to objects (and not people), have extreme difficulty with change, and insist on routine (Block, Block, & Halliday, 2006).

Despite these unique behaviors and lack of typical language development, individuals diagnosed with ASD do not look physically different from typically developing children. The final characteristic of the diagnosis includes communication impairments. These impairments include both receptive (understanding and comprehension of language) and expressive (output of language and speech). Many individuals with ASD have significant difficulty with speech comprehension (Shane, et al., 2015). However, the severity of this difficulty can be masked by the individual's ability to follow daily routines consistently. Following these routines may make it seem like they are following spoken directions sometimes. Since comprehension precedes expression in language development, it is not surprising that those with moderate to severe ASD also tend to have difficulty with expressive language (Shane et al., 2015).

It is estimated that about 50% of individuals diagnosed with ASD do not use speech in a functional way (Shane et al., 2015). Individuals with ASD tend to use physical expression for communication since their functional spoken language can be insufficient. These physical expressions can include physiological reactions like shivering, and behaviors such as pulling a communication partner toward the object of desire. Because of these behaviors, the message can then be unclear compared to spoken language, since it is up to the communication partner to interpret the meaning of the behavior. This type of communication can lead to communication breakdown, and thus frustration may lead to disruptive behaviors (Shane et al., 2015).

This lack of spoken language can also have a severe impact on peer relationships, social closeness within families, academic achievement, and the ability to function independently.

AAC. Augmentative and alternative communication can provide communication supports to individuals who have expressive and receptive communication impairments secondary to their diagnosis of ASD. Augmentative and Alternative Communication (AAC) includes all of the different ways we share information without spoken language. AAC can include any type of system of communication that supplements (augments) or replaces (alternative) conventional spoken language, providing support for any individual who has a disability that causes complex communication needs (CCN), whether permanent or temporary

(Reichle et al., 2016). For example, AAC can be used for someone with a chronic disability like cerebral palsy, or used temporarily for someone in the hospital with a trach or tube.

AAC is often used in order to enhance or introduce social communicative behavior for children and adults without verbal speech abilities (Gilroy, McCleery, & Leader, 2017). For some individuals with severe speech or language problems, AAC may be used to help them communicate on a daily basis. However, others may use some speech and use AAC for longer sentences or in situations with unfamiliar communication partners. AAC can be helpful in school settings, work settings, as well as in comfortable communication situations such as talking with family and friends, as well as be active members of his/her community (Light & McNaughton, 2013). Some individuals who use AAC may bring their device with them at all times, while others may only use it for certain situations.

AAC supports can range from low-tech (e.g., printed photographs of preferred items), mid-tech (e.g., simple digitized output devices), and high-tech (e.g., iPads with AAC applications) (Reichle, Ganz, Drager, & Parker-McGowan, 2016). Research demonstrates AAC has positively impacted communication (e.g., requesting), social interaction (e.g., turn taking), and decrease challenging behaviors (Ganz, 2015). In addition, research indicates a preference towards use of higher tech devices like tablets and touchscreens, rather than some of the traditional low-tech options, like exchanging picture cards (Ganz, 2015; Gilroy, McCleery, & Leader, 2017).

The goal of AAC intervention is to assist individuals in maximizing their effective and efficient participation in a variety of activities (Reichle, Ganz, Drager, & Parker-McGowan, 2016). The main activity for young children in their formative years in engagement in education and educational related activities (e.g., playing with friend at or after school). Recent changes in federal policy have encouraged the importance of teaching the academic curriculum to all students, including those with disabilities (Erickson, Hanser, Hatch & Sanders, 2009). Those with disabilities may require AAC to communicate with peers and participate actively in the classroom. These students who require AAC must have access to the curriculum, be involved in class activities, while progressing through the general curriculum. Therefore, instruction in classrooms must be adapted to meet these students' needs (Erickson, Hanser, Hatch & Sanders, 2009).

Literacy for individuals with ASD who use AAC. Teaching literacy skills is the single most important thing we can do for individuals who use AAC (Lindsay, 1989). Literacy development is important for all, as the ability to read promotes independence and creates endless opportunities for educational and financial success (Light & McNaughton, 2013). Yet for individuals with ASD and CCN, this skill is even more important. Access to literacy opens doors in terms of communication, allowing the individual to generate their own thoughts, as well as text-based AAC options (e.g., texting, social media, emailing, and orthographic-based AAC systems).

Unfortunately, over 90% of individuals who use AAC do not acquire functional literacy skills upon graduation from high school (Foley & Wolter, 2010). A number of factors could be contributing to the poor outcomes including: (1) preconceived notions of readiness to succeed in learning literacy hinders individuals' progress from becoming literate (Browder & Xin, 1998). (2) lack of effective tools for learning (Koppenhaver et al., 1991), and (3) lack of teachers and related service providers trained to teach these individuals (Caron et al., 2018). As the number of children with ASD continue to rise, and continue to be included within special education and inclusive environments, there is an urgent need to find ways to support the acquisition of literacy skills.

A number of skills are required to become a reader. The ultimate goal of reading instruction is to give the student the necessary skills to accurately comprehend the meaning of text (Torgesen, 2002). Reading ability involves two general types of skills: (1) general language comprehension skills and (2) the ability to accurately identify individual words in print (Torgesen, 2002). The skills of decoding and comprehension are separate and both necessary to become a successful reader. Literacy is only accomplished when both are achieved (Gough, 1996). Single word reading, or sight word reading, is a key early literacy skill; if individuals fail at reading single words, they cannot comprehend or read connected text (Mandak et al., 2018). Research indicates that individuals with ASD have poorly developed single word recognition skills (Nation et al., 2006)

Sight Word Instruction. In sight word instruction, individuals must focus on pairing the orthography of the word (i.e., the written word) with the word's referent by sight (Mandak, Light & McNaughton, 2018). Sight word recognition is considered essential for individuals to be independent in community settings (e.g., "enter", "men", "women", "danger"). Sight word instruction is a literacy instruction approach that focuses on teaching word recognition, instead of the relationship between sounds and letters within words (Browder and Xin 1998).

Unfortunately, literacy outcomes for individuals who require AAC are very low. Providers often have low expectations or do not know how to adapt the curriculum to meet these individual's needs. Mirenda (2003) noted that teachers often regard individuals with ASD who require AAC as "too cognitively impaired," and therefore not ready for proper literacy instruction. Furthermore, nonverbal students without functional speech who require AAC for communication are at especially high risk for failure in certain literacy programs, based on the perception that reading is completely dependent upon the ability to phonetically sound out words (Mirenda, 2003). However, it is untrue that you need the ability to phonetically sound out words in order to learn to read.

In sight word instruction, students with ASD can be taught to identify words as simple logographs; only focusing on the letters and not making any relationship between letters and sounds in the word. This approach directly contrasts with the phonics-based approach (Spector, 2010). Sight word instruction has several potential benefits for students with ASD. They include: a) the potential to transfer the communicative intent of printed language, providing a sense of motivation surrounding learning to read (Broun, 2004); b) a more accessible starting point for students with ASD as opposed to a phonics-based approach, since these students likely have difficulty with abstract concepts (Light & McNaughton, 2013; Caron, 2016); c) the use of the words as a foundation on which to build understanding of more abstract concepts (Kaderavek and Rabidoux, 2004); d) the incorporation of sight words into a more comprehensive program that includes instruction in other topics such as phonemic awareness and phonics (Browder et al., 2006); e) sight word mastery may allow students who are unable to use an alphabetic principle to participate in more functional tasks that involve reading in their daily environment, including reading grocery lists, road signs, restaurant menus, directions, recipes, or a daily schedule (Spector, 2010).

AAC to support sight word learning. Traditionally, AAC has been used to supplement literacy instruction (e.g., all curriculum), yet the use of the AAC system to teach sight words has not been targeted. AAC systems may pose unique advantages to teaching both literacy and communication. For example, visual stimuli are particularly motivating for individuals with ASD

(Shane & Albert, 2008). Individuals with ASD tend to have strong processing skills, and these skills can lead to success in processing visual information even if spoken information if not properly understood (Wilkinson & McIlvane, 2013). Visual prompts on an AAC device offer a sustained referent, while spoken language is fleeting. The prolonged nature of visual stimuli on a device provides additional time to better process information. The use of these visual supports that AAC provides encourages concrete thinking, memorization skills, and visual-spatial skills that are frequently noticed in students with ASD. This compensates for areas of weakness within spoken language (Shane, Laubscher, Schlosser, & Fadie, 2015). AAC can successfully tap into the focus on visual modality, and build upon these individuals' strengths.

In addition to these visual strengths, many individuals with ASD often have their AAC system with them all day long, providing opportunities for literacy and language building throughout the day. With minor design changes, the device may have the potential to support literacy development, specifically sight word learning. Light, McNaughton, Jakobs, & Hershberger (2014) proposed incorporating transition to literacy (T2L) features into AAC technologies. The T2L feature draws upon theory and research to support language and literacy learning through the use of AAC and includes the following:

(a) Presentation of dynamic animated text upon selection of the graphic symbol using motion to draw visual attention to the text (Jagaroo & Wilkinson, 2008) and to support orthographic processing; (b) origination of the text from the graphic symbol to support the association of the symbol and thereby support understanding of the meaning of the text; (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; (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 a recent study done by Caron and colleagues (2018), five participants with severe ASD and complex communication needs learned 12 sight words through the exposure to dynamic text features (T2L) within a graphic grid display using AAC. The gains were observed only though exposure to sight words through the AAC device, no additional instruction. In addition, all of the participants were able to successfully transition from a graphic-based AAC grid display to a text only display (Caron et al., 2018). Similarly, Mandak and colleagues (2018) used the T2L software with visual scene displays for young children with ASD. Using the T2L feature during a book reading activity, they found that the young students with ASD were able to acquire sight words (e.g., bear, dog) (Mandak, Light, & McNaughton, 2017).

The previous studies included older individuals with ASD who had experience and success with sight word acquisition (most participants had a corpus of approximately 100 sight words prior to starting the study) (Caron et al., 2018), or included younger individuals with mild to moderate ASD and spoke (Mandak et al., 2018). The larger study that this participant is included in contributes new research towards a different population. Individuals included in this study all have a diagnosis of severe ASD, complex communication needs, and use AAC and have very limited literacy success (e.g., less than 25 known sight words). The study's purpose was to expand current research findings and better understand the implications of the T2L feature for this population. More specifically the research questions are: (1) what effect does an AAC app with the T2L feature have on sight word acquisition for individuals with ASD and CCN?; (2) are the effects of the application generalized to different graphic icons?; (3) are the effects maintained after exposure to the app with the T2L feature is terminated? It was hypothesized that the dynamic text paired with speech output would effectively support the acquisition, generalization, and maintenance of sight word reading of 12 sight words by individuals with severe ASD and CCN.

Chapter 2

Method

Research Design

This study employed a single-subject multiple-probe, across-word set design with one participant. It is important to note that this paper reports on results from one participant from a larger study (Caron et al., 2018). The larger study included four total participants with ASD. Exposure to the AAC app using transition to literacy (T2L) software features (i.e., such as dynamic text and speech output upon selection of graphic symbols) was the independent variable in the study. The student's accuracy of reading 12 motivating and meaningful words (four words across three word sets) was the dependent variable (specifically, the percentage correct when presented with four graphic symbols and one written word across 8 different trials, with each word presented twice).The dependent variable was repetitively measured before, during, and after treatment to determine the changes in behavior.

Participant

For the larger study, **i**ndividuals with ASD were recruited through outreach to teachers and Speech-Language Pathologists in Pennsylvania schools who worked with students with ASD and complex communication needs. To participate in the study, students had to meet the following criteria: (1) had an ASD diagnosis based on the DSM-V criteria (confirmed through assessment with the Childhood Autism Rating Scale Second Edition (CARS-2; Schopler, Van Bourgondien, Wellman, & Love 2010), (2) were ages 5-21 years old, (3) daily communication needs were not met through speech, (4) were able to follow one step directions, (5) could symbolically communicate with a minimum of 10 spoken words, signs, or graphic symbols, (6) English was the primary language used at home, (7) hearing and vision were unimpaired or corrected per teacher or parent report, (8) had limited literacy skills (e.g., not decoding, less than 30 sight words).

Jackson. The participant selected for discussion for this paper is a 17 years old male with ASD. Jackson attended a school that had one classroom for students with ranges of disabilities, including ASD. Jackson could successfully identify 26 letter-sound correspondences, but was not decoding, reading words together or connected text. He identified 15 sight words from the Dolch word list, but his teacher reported that Jackson had not made substantial progress when it came to literacy instruction. Jackson had no functional speech (used grunts if making vocalizations), so he mostly used physical communication, grunting, and gestures (e.g. nodding his head for "yes", shaking his head for "no", a thumbs up to signal agreement), as well as idiosyncratic signs and sign approximations to communicate with those around him. Jackson also had access to an iPad with the communication app called GoTalk Now (which the classroom was trialing at the time), but he did not use this consistently.

Table 1: Summary of demographic information for participant

	Participant
Age:	17 years old
Gender:	Male
Diagnosis:	Severe ASD
Instruction Setting:	Classroom
Expressive Language:	physical communication
	idiosyncratic signs

	grunting
	use of AAC app GoTalk Now on a trial basis
Literacy Skills:	15 sight words
	26 letter-sound correspondence

Materials

Target Words. 12 target words were selected based on interviews with family and teacher. They came up with words that were high-interest and meaningful Jackson and were selected using the following criteria: (1) the words were 4-8 letters in length; (2) the words could be graphically represented with either photos or line drawings; (3) 3 of the 4 words must share an initial letter with another word in the set (e.g., pliers, pager); and, (4) the participant could not accurately read the word at baseline. The 12 target words were divided into 3 separate sets with 4 words per set. Eat set was introduced separately, beginning with Set 1. The target words in each set included the following (see Table 2).

Table 2: Word Lists for sight word instruction

Sight Word Set 1	Sight Word Set 2	Sight Word Set 3
washer	harrow	camping
wrench	hose	camo
baler	pliers	pager
shovel	litter	lure

Probe Materials. Throughout the phases of this study, probes were conducted to evaluate the participant's accuracy in reading 12 words. In the probe, each target word was on a laminated text card. A 2"x2" graphic symbol representative of the target word was also provided. Screenshots from the AAC app were taken to provide the graphic symbol.

Intervention Materials. The materials used in this AAC intervention included three (12-page) books created in Microsoft PowerPoint and a graphic icon and grid-based app embedded on an AAC device.

PowerPoint books. The participant chose two out of the three books to work on per session. One book was an exact matching task using symbol stick image (matching a graphic representation of the term in technology). The other book included a photograph of the target word. The third book included a photograph with a character as well. Each book had the target word represented three different times, intermixed with other non-target words.

AAC Technology. Transition to literacy (T2L) software was used on a 12.2-inch LCD Samsung Galaxy Tablet® NOVA Chat 12 device. The T2L software to support sight word learning was theorized by Light et al. (2014) in order to provide a first stepping stone in the transition to text from a graphics-based AAC app for individuals with complex communication needs who also have limited literacy skills. The T2L feature includes (Caron et al., 2018):

> Selection of a graphic symbol from the available AAC grid display, enabling a dynamic presentation of text, resulting in the replacement of the graphic symbols on the screen with the written text for 3s and pairing of the text with a speech output before the text then shrinks back into the graphic symbol and disappears (see Figure 1 and see the video demonstration at http://rerc-aac.psu.edu/research/r2-investigating-aac-technologies-to-support-the-transition-from-graphic-symbols-to-literacy/). The dynamic presentation took

the traditionally static appearance of a written word and applied smooth movement (i.e., animation) in order to attract the learner's visual attention to the text version of the word (cf. Jagaroo & Wilkinson, 2008), thus potentially supporting orthographic processing of the written word. In addition, the text was paired with speech output upon selection of the graphic symbol on the screen, thus potentially supporting phonological processing of the spoken word.

Figure 1: T2L feature, dynamic text

Generalization Materials. The generalization phase used the AAC app with a text-only grid display—meaning a static grid display with 12 written words, but no symbols. The locations of the written words within the grid were re-arranged to ensure that none of the words were in the same location as their graphic symbol referents during the intervention phase. Rearranging the grid ensured that the participants had to read the words to use the display, therefore they could not rely on simply memorizing the location of the original graphic symbol within the grid.

Procedures

Each session lasted 15 minutes and was conducted by a researcher (the first author of the larger study, J. Caron). Approximately three to five sessions occurred each week, and wo sessions could occur in the same day. If two sessions did occur in one day, there would be a minimum of a 30-minute break between each session. The four phases of the study included baseline, intervention, generalization, and maintenance. Before baseline began, training for the researcher and individual with ASD occurred (i.e., trained the individual with ASD to recognize the line drawings for symbols used in the study).

Training the Graphic Icons. The participant needed to be able to identify graphic symbols for the relevant vocabulary used in the study with at least 90% accuracy over two consecutive sessions. In order to determine accuracy, the researcher would ask the participant aloud: “point to the ___.”

Baseline. The four phases of the study were: (a) baseline, (b) intervention, (c) generalization, and (d) maintenance. For the first session (to start the study), all three of the word sets were probed—establishing the first baseline points for each set. For the baseline probe, the researcher set out four of the target word’s pictures on the table in front of the participant and label them out loud orally. The researcher then gave the participant a yellow text card with the written word on it, and asked the participant to “give me the picture that matches this word”. The researcher used the prompt “give me the picture that matches this word.” The researcher modeled the task of matching the written word to the picture before this probe, using a word outside of the 12 target words. The researcher did not provide any positive or negative feedback during the probe. Correct and incorrect responses were recorded on a data sheet in order to get a score out of 8. Once a minimum of three baseline data points with the first word set was collected and stability of the dependent variable was achieved (i.e., 2 consecutive points with no increase in slope), intervention could begin with the second word set. Yet, due to the challenge of sight word learning, in this study, new sets of words were only introduced once treatment criterion was met.

Intervention. The intervention included 2 parts: (1) a probe to assess the participant's accuracy reading the target words and (2) using the T2L feature on the AAC app in order to support sight word learning.

Probes. The probe at the start of each intervention session was used to measure the participant's accuracy reading the target words. The baseline procedure used was the same procedure used in the probe previously. Intervention was terminated once criterion was reached. To reach criterion, during the probe the participant got 6 out of 8 correct, or 75% correct for two consecutive sessions. Each of the 4 words were marked on a data sheet. Probes are out of 8, and the graphs are a percentage correct out of 8 per word set.

T2L Features in AAC App. After establishing a stable baseline, the participant was introduced to the AAC device with the T2L feature by the researcher. More specifically, during the intervention sessions, the AAC app with the T2L feature was introduced after each probe. The device included a grid display with all 12 target words (Set 1, Set 2, and Set 3) included within the grid. However, only specific words from the target set were activated with the T2L feature (e.g., when working on Set 1, Set 2 and Set 3 words were available on the grid and could be verbally produced, but no dynamic text would display upon selection). During intervention, the researcher and student looked at the PowerPoint books (2 per session, one at a time). When the participant was presented with the target word via the book, he would then be prompted to touch the AAC device on the target word two times, producing the dynamic text and speech output. This makes for 6 AAC exposures of the target word per book, and two books per session means 12 total exposures per session. This was repeated for each set, across each intervention session. When the student selected the graphic symbol from the AAC system, if the word was targeted within the set, the T2L feature was activated, dynamic text appeared from the graphic icon, staying on the screen for 3 seconds, and the text was paired with speech output. The student was then instructed to select the symbol a second time to elicit the dynamic text and speech output, providing the student with two sequential exposures. The researcher did not provide any feedback or focus the student towards looking at the dynamic text. This provided 4 exposures per symbol/target word three times for a total of 12 exposures to dynamic text and speech output per intervention session. Once intervention criterion was established for Set 1 (i.e., a score of 75% for two consecutive sessions) and a stable baseline maintained, intervention with Set 2 began (and procedures were repeated for Set 3).

Generalization. After each intervention phase, generalization data was collected in order to determine if the student generalized the sight word reading to other photographs. The researcher presented a new photograph to the participant that corresponded to the target words in each set. This task was presented in order to see if the participant could learn beyond a direct match between the word and graphic icons used within the AAC system. This was done after each Set, after specific criterion was met for Set 1, Set 2, and Set 3 separately.

Maintenance. In order to measure maintenance, the same probe procedure used during baseline and intervention was followed. Maintenance occurred two weeks after exposure to all three sets in the intervention phase.

Data Analysis

The level, trend, and slope of the data in the intervention condition were compared to those at baseline to determine the success of the T2L app features (i.e., dynamic text appearing after selection of a graphic symbol and speech output labeling the text). Non-overlap of all pairs, or NAP, is defined as the proportion of non-overlapping data between phases. NAP summarizes data overlap from data point A to data point B. A nonoverlapping pair with have a data point larger than its original baseline data point. NAP equals the total number of comparison pairs showing no overlap divided by the total number of comparisons. It is calculated by hand from a SCR graph. When measuring and judging NAP, a score of 1.0 is considered perfect. Weak effects are demonstrated by an NAP score of 0-.65; medium effects are demonstrated by an NAP score of .66-.92; and strong effects are demonstrated by an NAP score of .93-1.0 (Parker & Vannest).

Chapter 3

Results

Results for Jackson's accurate identification of target sight words across the three word sets are presented below. The results are presented per word set across four phases (baseline, intervention, generalization, maintenance). Within each word set (1, 2, 3) the participant's baseline was consistently low. Once the intervention was introduced, the participant's accuracy increased.

Set 1 Performance

Figure 2 shows the percentage of 4 target words (Set 1: washer, wrench, baler, shovel) identified accurately across baseline, intervention, generalization and maintenance. The probes consisted of 8 trails for the dependent variable from Set 1 of the target words. Each word was presented twice. Baseline was established over six consecutive sessions. The mean percent accuracy for Set 1 baseline was 23% (range of 13% to 38%). The percent of accuracy during intervention was 100% (range of 100% to 100%) Set 1 had an increase of +77% correct after introduction to T2L feature (see table 4). NAP for Set 1 is 1.00 (strong effect).

Criterion for Set 1 was reached after five intervention sessions, including 60 exposures for a total of 3 minutes of word exposure (see table 3). In Set 1, the participant demonstrated a change in level and increase in trend from baseline to intervention. The participant demonstrated low levels of accuracy during baseline in Set 1. Once intervention started, there was a large increase in level of accuracy from baseline to the end of intervention. There is a steep slope change during the intervention stage. This slope during intervention compared to baseline data determines the effects of T2L instruction. The slope in baseline is unstructured. The slope in the intervention phase drastically increasing. The slope in maintenance phase is constant on 100% on both probes.

Jackson generalized Set 1 words at 23% in baseline to 100% in intervention, for a gain of +77%. Two maintenance probes were conducted after Jackson reached criteria for Seta 1, and the slope maintained at 100%.

Set 2 Performance

Figure 2 shows the percentage of 4 target words (Set 2: harrow, hose, pliers, litter) for Set 2, identified accurately across baseline, intervention, generalization and maintenance. Baseline was established over seven consecutive sessions. The mean percent accuracy for Set 2 baseline was 11% (range of 0% to 25%). The Set 2 percent accuracy during intervention was 92% (range of 75% to 100%). Set 2 had an increase of +81% correct after introduction to T2L feature (see table 4). NAP for Set 2 is 0.76, which is a medium effect.

Criterion for Set 2 was reached after six intervention sessions, including 72 exposures for a total of 3 minutes and 36 seconds of word exposure (see table 3). In Set 2, the participant demonstrated a change in level and increase in trend from baseline to intervention. The participant demonstrated low levels of accuracy in Set 2. Once intervention was started, there was a large increase in level of accuracy from baseline to the end of intervention. There is a steep slope change during the intervention stage. This slope during intervention compared to baseline data determines the effects of T2L instruction. The slope in baseline is decreasing. The slope in the intervention phase demonstrates a gradual increase.

Jackson generalized Set 2 words at 0% in baseline to 100% in intervention, for a gain of +100%. Two maintenance probes were conducted after the participant reached criteria for Set 2. However, the slope in maintenance phase is decreasing from 75% to 50%

Set 3 Performance

Figure 2 shows the percentage of 4 target words (Set 3: camping, camo, pager, lure) for Set 3 identified accurately across baseline, intervention, generalization and maintenance. Baseline was established over ten consecutive sessions. The mean percent accuracy for Set 3 baseline was 20% (range of 0% to 25%). The Set 3 percent accuracy during intervention was 92% (range of 75% to 100%). Set 3 had an increase of +72% correct after introduction to T2L feature (see table 4). NAP for Set 3 is 1.00 (strong effect).

Criterion for Set 3 was reached after six intervention sessions, including 72 exposures for a total of 3 minutes and 36 seconds of word exposure (see table 3). In Set 3, the participant demonstrated a change in level and increase in trend from baseline to intervention. The participant demonstrated low levels of accuracy in Set 3. Once intervention was started, there was a large increase in level of accuracy from baseline to the end of intervention. There is a steep slope change during the intervention stage. This slope during intervention compared to baseline data determines the effects of T2L instruction. The slope in baseline is stationary. The slope in the intervention phase is increasing.

Jackson generalized Set 3 words at 20% in baseline to 85% in intervention, for a gain of +65% .Two maintenance probes were conducted after the participant reached criteria for Set 3. The slope in maintenance phase is 100% for both probes.

Table 3: Word Exposure Time

	Word Set Total	Intervention Sessions Total	Exposure Total Time
Set 1	4	5	3 minutes
Set 2	4	6	3 minutes, 36 seconds
Set 3	4	6	3 minutes, 36 seconds

Table 4: Percentage gain score from baseline to intervention

	Average Baseline Data	**Average Intervention Data**	**Average Gain Score**
Set 1	23%	100%	+77%
Set 2	11%	92%	+82%
Set 3	20%	92%	+72%

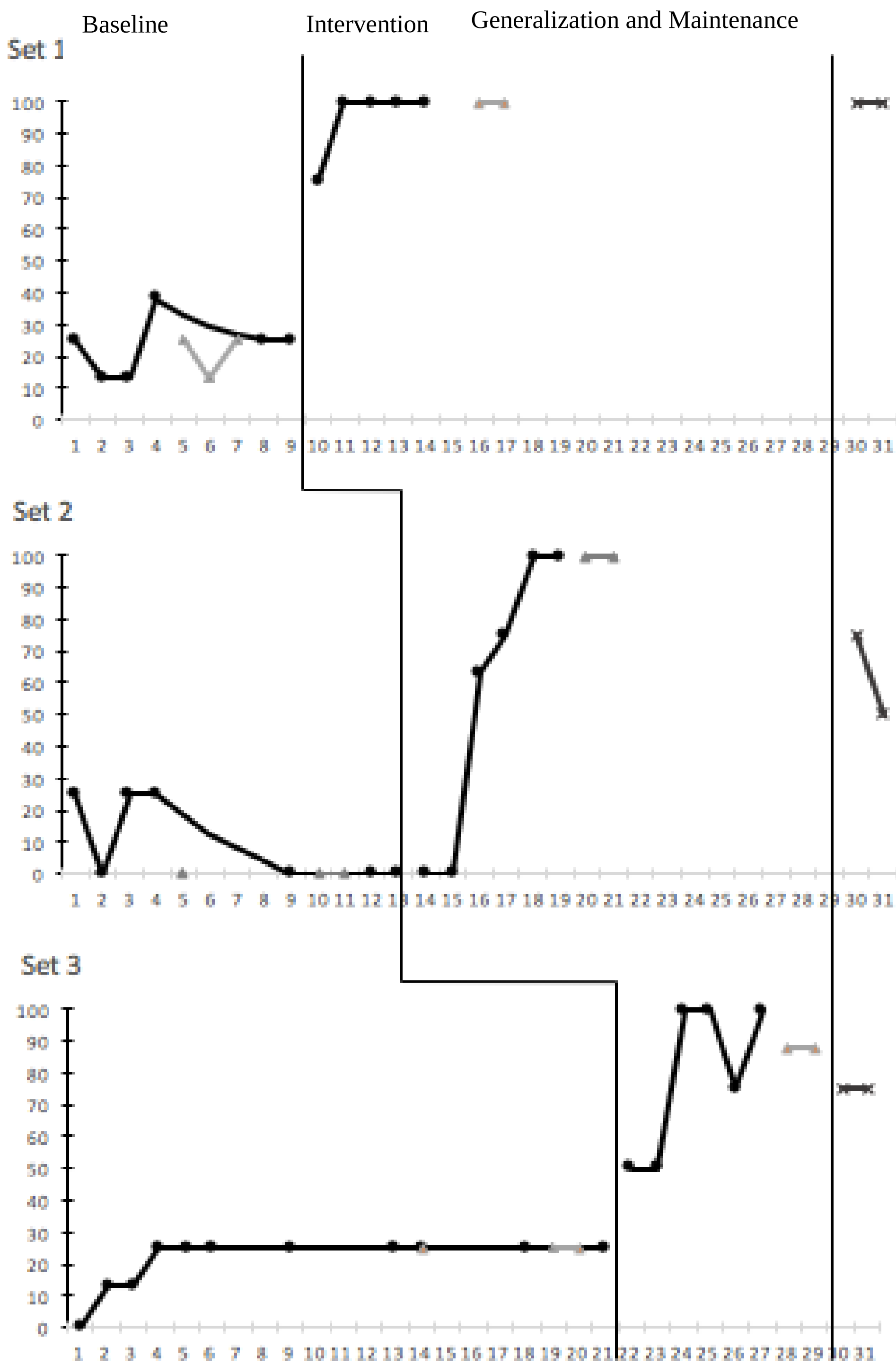

Figure 2: Percentage of academic sight words identified correctly

Chapter 4

Discussion

The purpose of this research study was to determine the effects of the T2L feature on an AAC device for the acquisition of 12 academic sight words for individuals with ASD and complex communication needs. One participant from the larger study has been discussed throughout this paper. AAC has proven to be effective to improve communication for those with ASD and CCN, and we hope to use it to capitalize on literacy skills and vocabulary ability for these individuals as well. Throughout the study, a positive relationship was demonstrated between the independent variable (T2L feature) and dependent variable (accuracy of academic sight word learning). The results from this study provide preliminary evidence that redesigning AAC system applications with the Transition to Literacy (T2L) features can positively impact sight word learning for individuals with ASD who are minimally verbal and possess severely limited language and literacy skills. The participant in this study demonstrated increased accuracy in reading 12 personally motivating, relevant sight words after the introduction of an AAC app with T2L features. The exposure to the app resulted in strong effects, as indicated by NAP scores (ranging from 0.76 to 1.00 across sets) for the participant (Parker & Vannest, 2009). The participant experienced an average gain of 77 (range: 72%-82%) between baseline and intervention for all three sets.

This study found similar results to other related recent research. Caron and colleagues (2018) used the same tablet and T2L software with participants with ASD and complex communication needs. The populations differ in literacy experiences; individuals in Caron et al., (2018) had previous literacy success with sight words, as each participant had a minimum of 32 sight words prior to the start of the study. The participants collectively had an average gain of

+55.6% after intervention, demonstrating similar findings to this participant. The main difference in findings between the participants in Caron et al.'s study with this current study was that Jackson needed less exposure time to each sight word [an average of 51 seconds per word (204 seconds per word set average/4 words per set)]. On average, participants from Caron's study needed an average of 74.4 seconds per word, with a total of 20 to 32 exposures to the sight word (Caron et al., 2018). Jackson needed an average of 68 exposures per word set before criterion was met, which is an average of 17 exposures per word.

In a different study using the T2L feature, Mandak and colleagues (2018) used the T2L feature in visual scene displays with younger children with ASD who had speech. Overall, the participants learned 10 sight words for average gains of +72.6%, similar to this participant. Finally, in a case study with one participant with ASD and CCN, the T2L feature was used in a grid-based AAC display to teach academic sight words (i.e., Landforms). Researchers found the individual learned 15 sight words, from an average of 25.3 exposures per word, with an average increase of 74.6 (ranging from 59% to 86%), demonstrating similar findings from the current case study (Filipovits, 2018).

It is stated that learners of an average intelligence require approximately 35 exposures to a word before it can be easily recognized, and less able learners will need about 55 exposures (Rasinski and Padak, 2008). The participant in this study learned to recognize the target sight words in an average of 17 exposures to the AAC app with T2L software features, indicating the T2L features support better sight word reading results. Previous research supports this as well, with their average number of exposures being 20-32 (Caron et al. 2018), 24 (Mandak et al., 2018), and 25 (Filipovits, 2018). These findings are summarized in table 5 below.

Table 5: Comparison across recent research using the T2L feature with participants with ASD

	Current Study (Participant: Jackson)	**Caron et al., 2018**	**Mandak et al., 2018**	**Filipovits, 2018**
Number of sight words	12	12	10	15
Average exposure time	51 seconds	74.4 seconds	36 seconds	76 seconds
Average number of exposures	17	20-32	24	25.3

Effectiveness of Intervention

Intrinsic factors. The participant's previous literacy instruction focused on letter-sound correspondence, sight word recognition, and sight word reading. Yet, he could only consistently identify 15 common sight words, and his teacher commented that he had not made much progress otherwise. Since Jackson began with very minimal literacy skills, participant motivation was likely the strongest intrinsic factor contributing to the effectiveness of the intervention. The participant received no literacy instruction on the 12 target words, thus isolating the AAC app with T2L features as the independent variable.

Extrinsic factors. Using twelve personally meaningful words was an extrinsic factor that could have contributed to positive outcomes. Since the participant in this study began with very minimal literacy skills, participant motivation was potentially a factor contributing to the effectiveness of the intervention. Prior to this study, teachers reported that Jackson wa only consistently identifying 15 common (Dolch) sight words, and his teacher commented that he had not made much progress with sight word learning over the years. Selecting sight words that were related to the participant's everyday life and interests allowed for the participant to apply these skills and words to his own life. Since the participant lives on a farm and enjoys playing with his cat, words like “shovel”, “baler”, and “litter” were chosen. These words are more meaningful and motivating than words like “is” and “the” since they can be physically represented in the participant’s own life. Selection of personally-relevant and highly motivating words was important to successful instruction, as meaningful materials have the potential to foster intrinsic motivation and increase engagement in literacy activities (Light & McNaughton, 2013).

In addition to the words selected for the study, additional extrinsic factors related to the system design changes, or the T2L feature, including: dynamic text, paired speech output, and relevant words within the AAC system, likely played a role in the success of Jackson in the acquisition of 12 sight words. As described by the RERC on AAC (rerc-aac.psu.edu) T2L app feature contains: (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 meaningful vocabulary known to the learner within the AAC display thus supporting meaning processing, and (d) targeting vocabulary within familiar contexts, thus capitalizing on contextual support for learning (Caron et al., 2018). The presentation of dynamic, animated text upon selection of a graphic symbol draws the user’s visual attention to the text (Jagaroo & Wilkinson, 2008). This links the orthographic text of the word to graphic symbol. Upon selection, the word is also spoken out loud by a speech generating piece of the app, which allows the user to gain access to the phonological processing information. Meaningful vocabulary was determined through interviews with teachers and looking at the participant’s interests, that way the participant was motivated to learn the words and pair them with their respective meaning. Finally, context of chosen vocabulary was considered so that the participant could better learn and make connections. For example, the participant could picture the word “shovel” being used in a context that was familiar to him.

Clinical Implications

Material considerations. Typically, in sight word instruction, photographs or line drawings are utilized and paired with the orthographic representation that is being targeted. Instead of pairing the orthographic word “computer” with the classroom computer by taping the label onto the physical computer, or using the picture communication symbol icon of a computer with text paired above the graphic representation, utilizing dynamic text with speech output draws the attention to the text instead of the graphic representation (Fossett & Mirenda, 2006). Clinicians should consider how they are presenting materials, both low and high-tech, in order to better support the acquisition of sight words. Although more research is needed related to high-tech considerations, clinicians should start with the most relevant vocabulary, as seen in this study, and activate the T2L feature for those words. As in this study, considerations are needed in terms of how many words have the T2L feature activated. Only four words were activated at once in this study. It is suggested that clinicians start small and then around 23 exposures (the average exposures it took for acquisition across 4 research studies presented in Table 5), the clinicians should probe to see if they should remove the graphic representation and transition to an orthographic representation within the AAC system.

The T2L feature is meant to supplement and not replace literacy instruction for these individuals. Future research must be done to explore the effects of the AAC app with T2L features when it is used in conjunction with literacy instruction. The simple design of the T2L feature allows for the opportunity to integrate these literacy supports into meaningful communication. This provides increased opportunities for functional learning, and potentially exposes these individuals with CCN to relevant text throughout their school day (Light & McNaughton, 2015). Conversely, it is possible that the T2L feature can present a distraction for the individual with CCN or for the partner when it is used in daily interaction. More research is needed in this area; yet if clinicians are not activating all graphic symbols at once, it seems this will not impede the communication rate or exchanges.

Inclusion of students with complex communication needs. Reading is so central to the K-12 curriculum, and therefore reading skills often define the success students can achieve in all areas of school (Spector, 2010). Too often students with ASD are excluded from the regular classroom. Until these individuals can acquire stronger literacy skills, more adapted and specialized instruction needs to continue to be provided. This intervention utilizing the AAC system is one way literacy instruction can be provided. Results from this study as well as from Caron et al. (2018) show that the T2L feature could very well be used in a structured academic-based approach to learning. The T2L features can be turned on for a specified duration of time, focusing on certain words for that intervention. The T2L feature is a simple software change that will not alter the software structure already on the AAC device. This simple change is thus easy to manage and use by those who are already familiar with the participant's AAC device, including family members, teachers, paraprofessionals, and therapeutic staff.

Future Research

The results of this study provide reason to believe implementing T2L feature into sight word instruction for individuals with ASD and complex communication needs provides successful results. More data from more participants would strengthen the validity of these results and help better understand the effectiveness of this intervention. Expanding the research to more participants, across ages, diagnoses, and reading abilities, would help to further generalize the results. Research should be done utilizing this intervention on younger individuals with complex communication needs when literacy instruction first begins. This could hopefully allow for individuals to become more successful in literacy skills at a younger age and avoid becoming a young adult about to age out of the school system with little functional literacy skill. Since sight word instruction is only part of proper literacy instruction, future research is necessary to see if other aspects of literacy instruction can be supported through AAC systems; such as decoding or letter-sound correspondences. Currently, the system is set up to continue the T2L feature activation until it is turned off. Future research is needed to see if the AAC system, through machine learning, could prompt a clinician to turn off the T2L feature and replace the graphic symbol with the orthographic representation once the individual has acquired that word. Machine learning (as in exposure count), could be used to support this prompting and replacement procedure. Yet, more research is needed to determine the number of exposures ideal across a range of diagnoses, as well as the number of graphic symbols that should have the T2L feature turned on at once.

Finally, since learning to read is not an isolated skill, future research should look into incorporating other reading instructional skills to help build on students' overall literacy ability. AAC implementation should not be used as a replacement, but a supplement to instruction. Further research is needed to determine the effects of the AAC app with T2L feature used in conjunction with proper literacy instruction.

Conclusion

Students with complex communication needs are required to be effectively taught necessarily skills, just like their typical peers. All students must have access to proper reading instruction consistent with the National Reading Panel (NRP), as stated by the No Child Left Behind Act of 2001 and the Individuals with Disabilities Education Improvement Act of 2004 (Whalon & Hart, 2011). This may require that the instruction be adapted. An AAC device, for individuals who use this to communicate, may be one way in which literacy intervention is adapted and incorporated throughout the day. Results from this participant in a larger study support the hypothesis that dynamic text paired with speech output upon selection of a graphic symbol on a device can improve sight word learning for individuals with ASD and complex communication needs. The re-design of AAC systems, to include the T2L feature, could potentially support individuals with CCN in meaningful communication and literacy instruction, prompting the transition from a graphic-based AAC system to an orthographic-based AAC system. This transition will potentially open doors to more generative language, supporting individuals to read and communicate what they choose.

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