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Utilization of Mobile Technology Applications to Promote Early Literacy in Children with Complex Communication Needs

Hanna Nicole Browder
University of South Dakota

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Pilot Study: Utilization of Mobile Technology Applications to Promote Early Literacy in Children with Complex Communication Needs

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Author:
Hanna Browder UG

Supervisor:
Kyle Brouwer CCC-SLP Ph.D.

Committee Members:
Elizabeth Hanson CCC-SLP Ph.D.
Elizabeth DeVelder CCC-SLP

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ABSTRACT

Pilot Study: Utilization of Mobile Technology Applications
to Promote Early Literacy in Children with Complex Communication Needs

This pilot study was conducted to determine the methods and project data for the effectiveness of the mobile application Accessible Literacy Learning (ALL) in teaching individuals who are nonverbal or have complex communication needs phonological awareness and emergent literacy skills. The researchers used a single-subject experimental design and followed the procedural suggestions given by the application using the teacher-assisted format. Participants for this study were between the age of two and eight years old and have exhibited severe language communication delays and excluded children with severe cognitive delays. Participants received two to four weeks of intervention two to four times a week for twenty minutes per intervention session. During each intervention session, each participant received two complete Accessible Literacy Learning sessions and were given prompts at the end of the intervention session to determine their progress.

Our procedures and methods are based on the research performed by Janice Light and David McNaughton, the developers of Accessible Literacy Learning. This study differs because it analyzes the effectiveness of the methods used in the application and the results of knowledge-of-response feedback versus response-contingent feedback. Our focus for this study was dependent on the needs of the child, which ranged from sound-blending and letter-sound correspondence. The results of this pilot aim to prove necessity for a full-scale study to investigate whether the application Accessible Literacy Learning is an effective tool in the field of speech-language pathology in teaching sound-blending and letter-sound correspondence to children who are nonverbal or have complex communication needs.

KEYWORDS: Literacy, Phonological Awareness, Teletherapy, Accessible Literacy Learning

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1. Literature Review

The current study aims to determine the effectiveness of the mobile application Accessible Literacy Learning (ALL) in teaching emergent literacy and phonological awareness skills to individuals with complex communication needs (CCN). A complex communication need (CCN) is used as a broad term for individuals who have severe speech, language, or communication difficulties (National Academies of Sciences, Engineering, and Medicine et. al., 2017). The following literature review will begin by presenting an overview of research related to the use of mobile technologies for literacy instruction and an introduction to Accessible Literacy Learning. Next, the current research for literacy instruction for children with complex communication needs (CCN). Then, the use of two non-traditional intervention contexts, mobile technology and teletherapy, will be discussed as it relates to providing high quality intervention for children with CCN. Mobile technology and instructional design considerations will be discussed. Finally, because this study investigated the instructional design of ALL, research related to instructional feedback will be presented to provide a framework for evaluating the application's critical elements that contribute to its effectiveness.

Mobile Technologies to Support Literacy Learning.

The use of mobile technologies in the education system and in speech-language intervention is becoming a popular modality for delivering literacy instruction (Campanella, 2012 as cited in Criollo-C, Luján-Mora, and Jaramillo-Alcázar, 2018). The use of mobile technologies in the classroom setting is becoming even more prevalent. It is recommended by the U.S. Department of Education (2020) that technology be incorporated into instructional time in the educational setting. Delivering speech-language intervention and providing literacy

instruction via mobile technologies allows for "flexibility, collaboration, motivation, accessibility and portability" of the means of instruction (Campanella, 2012 as cited in Criollo-C, Luján-Mora, and Jaramillo-Alcázar, 2018).

The current study aimed to investigate a mobile technology designed to teach early literacy skills to children with CCN. Accessible Literacy Learning (ALL) is a reading program that has recently been developed into a tablet and PC mobile application (Accessible Literacy Learning, 2015). ALL is described as an accessible way for caregivers, teachers, and speech-language pathologists to teach emergent literacy skills to children with CCN (Accessible Literacy Learning, 2015). ALL includes evidence-based literacy intervention strategies such as: sufficient time allocation for instruction, appropriate instructional content and procedures, adaptations to allow active participation from an individual, and positive rapport and motivating instruction (Light & McNaughton, 2012).

Emergent Literacy Instruction and Children with Complex Communication Needs.

The current body of research suggests there is a significant achievement gap between children with complex communication needs and their peers despite, in many cases, similar skill capacities (Iacano & Cupples, 2004). For example, Iacano & Cupples (2004) found that around 90% of individuals with CCN between the ages of fourteen and twenty had phonological awareness and letter-knowledge skills comparable to six to nine-year-olds. A variety of factors may influence their ability to develop adequate emergent literacy skills, including access to high-quality instruction and the opportunity to learn during critical developmental periods (Iacano & Cupples, 2004).

Light and McNaughton (2010) propose that one likely constraint on academic achievement for children with CNN is access to efficient communication. Traditionally, early

literacy is taught in the classroom setting and a student's understanding is marked by their oral confirmation. For neurotypical children, oral language production facilitates efficient communication between educator and learner. In addition, children with CCN do not receive the same quantity of quality instruction as their peers, in part because their school days include specialized instruction in other areas. This is problematic because students with CCN are likely to need more early literacy instruction than their peers (Light & McNaughton, 2010).

In addition, teacher training may be constraining the early literacy achievement of children with CCN. Kent-Walsh & Light (2003) conducted a qualitative study investigating the training of educators of children with CCN. During their interviews, the consensus of the educators was that their training was inadequate to provide high-quality intervention for children with CCN. In addition, the educators stated that they were not trained or equipped with the appropriate techniques or materials to teach literacy skills to students with CCN. Although the educators understood the importance of using alternative approaches and providing a variety of response modalities for students with CCN in the subject of literacy, they felt they were failing to provide high-quality instruction due to the lack of resources and time for individualized instruction (Kent-Walsh & Light, 2003).

Light and McNaughton's research (2012) suggests that individuals with CCN benefit from appropriate adaptations to instruction and unique literacy skill sequences. They suggest that sound-blending should be mastered before letter-sound correspondence. Letter-sound correspondence is fundamental to the development of fluent reading and writing. It also aids in developing sight-words and decoding unfamiliar words in more advanced reading and writing. The mastery of letter-sound correspondence and phonological awareness is vital for individuals who are nonverbal or have complex communication needs because it expands the selection for

augmentative and alternative communication devices. For children with CCN, it is important they have the opportunity to express their understanding. In ALL, this is achieved by pointing (or in some instances, gazing, or gesturing) at the correct picture to demonstrate understanding. The same applies for letter-sound correspondences. The letters that occur frequently are short vowels, and lowercase letters are taught first, whereas long-vowels, similar sounds and shapes, and upper-case letters are taught later (Light & McNaughton, 2012).

Light and McNaughton (2012) found that children with CCN learn most effectively when they follow a specific set of instructional procedures: modeling of the target skill, guided practice, followed by repetitive independent practice. In guided practice, the instructor first models the target skill and chooses the correct answer while the participant observes. Second, the instructor helps the participant perform the skill successfully by helping them choose the correct answer. Lastly, the participant engages in independent practice, where the participant attempts the skill without aid from the instructor. The instructor provides feedback to the participant during the independent practice stage. If the participant selects the correct answer, the instructor provides praise and confirmation of their choice. If the participant selects the incorrect answer, the instructor acknowledges the error and proceeds to repeat the modeling and guided practice phases.

In an example case study, an 8-year-old girl with a variety of disabilities received 16 months of intervention and a total of 55 hours of instruction (Light, McNaughton, Weyer, & King, 2008). During this time period, the participant mastered twenty letter-sound correspondences, mastered decoding, and learned over sixty sight-words in addition to performing shared reading activities and reading independently. Not only did they find that the

intervention improved her literacy skills but also her communication skills utilizing her augmentative and alternative communication device.

Light and McNaughton (2012) expanded on previous findings with a more extensive study that included ten participants between the ages of 3-4 years who had significantly delayed literacy skills and complex communication needs. All participants received intervention using the mobile application for a maximum of two times a week for forty-five minutes per session. The results of this study showed that all participants had gained some mastery of letter-sound correspondence and phonological awareness skills, in addition, most were able to use these skills to their daily life. It was later reported that most participants were able to read and understand simple sentences and apply the learned skills during reading and sentence building activities.

Mobile Technology and Complex Communication Needs.

Mobile Technology & Augmentative and Alternative Communication. Mobile technologies (e.g., mobile phones, mobile tablets, laptop computers) are often used with individuals who have CCN in speech-language pathology. While the use of mobile apps is a newer area of study in the field of speech-language pathology, it is becoming more popular with clinicians, clients, and parents. In 2012, over 70% of clinicians utilized an iPad or tablet in their speech-language intervention sessions and more than 90% of clinicians reported the iPads and tablets to be a helpful tool to achieve IEP and treatment goals (Epps et al., 2012). Researchers have also observed a positive response from students and parents, stating that the students demonstrated increased motivation during intervention sessions (Epps et al., 2012).

Mobile tablets have primarily been used for augmentative and alternative communication devices for people with CCN. Augmentative and alternative communication (AAC) devices are devices of varying technological capacities (high or low-tech devices) that display pictures or

words utilized by the individual to communicate without verbalization. When an individual has proficiency in reading and writing, they are able to use AAC devices that are more complex and customizable to their individualized needs (Light & McNaughton, 2012). In 2010, researchers found that younger participants with CCN had more success when communicating using an iPad or tablet, rather than utilizing a traditional Picture Exchange Communication System (PECS) (Flores, Musgrove, Renner, Hinton, Strozier, Franklin, & Hill, 2010). The authors asserted that the participants in this study were inclined to use a tablet to communicate because it was more socially acceptable by their peers, had better portability, and was more customizable in comparison to the PECS binder. In a 2015 study, two out of three 10-year-olds with Autism Spectrum Disorder demonstrated faster acquisition of skills taught in a traditional classroom and increased participation when using an app in comparison to their baseline data (Xin & Leonard, 2015). The authors concluded that children with limited verbal communication or those with CCN may be more inclined to participate and actively learn in class when utilizing an iPad as a communication device in comparison to a low-tech AAC device (Xin & Leonard, 2015).

Mobile applications that are currently used for teaching literacy instruction are not specifically designed for children with CCN or at-risk learners. An example of one of these mobile applications is 22Learn (22Learn, 2010). 22Learn is a reading instruction application company that is founded upon the commonly used techniques in public education settings for neurotypical students (22Learn, 2010). Another example is Reading for All Learners, which is a mobile application that is proven to hold a child's attention but was not designed for children with CCN or nonverbal (Reading for All Learners, 2004). These applications were successful with children who were neurotypical, proficient in literacy skills, or had disabilities such as

deafness or blindness; but the mobile applications failed to integrate recommended methods for the students with CCN.

Benefits & Disadvantages of Mobile Technologies with Complex Communication Needs. There are many benefits to integrating mobile technologies into augmentative and alternative (AAC) intervention. AAC intervention provides an engaging, organized, and cohesive method for children and adults with CCN to learn literacy (Light & McNaughton, 2013). The use of AAC intervention does not interfere with an individual's ability to learn verbal communication, rather it provides an alternate modality and may also be used to supplement verbal communication. (Light & McNaughton, 2013). The use of mobile applications and interventions allows access to instruction for those who were previously underserved or were not given proper instruction in the public education systems (Light & McNaughton, 2013).

However, the rapid development and implementation of mobile technologies during intervention is not without its challenges. Light and McNaughton (2003) pointed out that this technological revolution may be putting the focus on getting people with CNN to use the best technology, rather than using the best means of communication or learning tools that have the features needed by the individual. Due to the ease of accessibility, there is concern that children with CCN could be ill-fitted with AAC devices or intervention because a speech-language pathologist or educator is not consulted. Even if the child is matched with an appropriate device or application, there is no guarantee that the device will increase participation, learning, or communication skills without support (McNaughton & Light, 2013).

Teletherapy and Complex Communication Needs. Due to the unforeseen pandemic of 2020, the current project's methods were adapted to include teletherapy. Teletherapy is "the application of telecommunications technology to the delivery of speech language pathology and

audiology professional services at a distance by linking clinician to client or clinician to clinician for assessment, intervention, and/or consultation" (ASHA, 2020). While teletherapy is still an emerging intervention context within the speech-language pathology literature, the results to date are promising. For example, Fairweather and colleagues (2016) investigated if teletherapy was an effective context for intervention for individuals who otherwise would not have access to services. The researchers conducted a semi-structured interview with eleven school executives and speech therapists to determine the effectiveness of teletherapy services (Fairweather, 2016). Their research suggested that all students exhibited an improvement in their speech and language via teletherapy, supporting teletherapy as a valuable tool for speech-language pathologists (Fairweather, 2016). The researchers also found that the parents were more involved and gained more understanding in comparison to traditional intervention (Fairweather, 2016).

To date there is inadequate research conducted related to teletherapy for children with CCN or more significant disabilities. Therefore, the current research can inform this body of literature. In a 2001 study, four clients who had Down syndrome were given intervention twice a week via teleservices for intervention for their respective needs (McCullough, 2001). The clients maintained steady growth in their targeted skills throughout the intervention process, similar to what was expected during traditional face-to-face intervention (McCullough, 2001). In addition to the participants' success, the parents also reported feeling more confident in their abilities to continue teaching once the sessions concluded because of their heavy involvement in the intervention process (McCullough, 2001). While this is promising, updated research results are needed to support teletherapy services for children with CCN and more significant communication disabilities.

Instructional Design

One important consideration to the current study is the feedback provided by ALL (Accessible Literacy Learning, 2015). Instructional design aims to ensure the quality of instruction by taking into account the goals, learning needs, and development of lessons for each client, while using the best tools, resources, and knowledge to provide proper instruction (Krouse, 2015). Part of instructional design is the process of providing feedback, or the verification and elaboration of an answer (Mason & Bruning, 2001). Verification notifies the participant whether the answer was correct or incorrect, whereas elaboration allows for explanation of why the answer was incorrect (Mason & Bruning, 2001). There are eight common types of feedback that are discussed in the research, which are listed in the table below (Gilman, 1969; Kulhavy & Stock, 1989; Merrill, 1987; Overbaugh, 1994; Pressey, 1950; and Schimmel; 1988 as cited in Mason & Bruning, 2001, p. 5-6).

Feedback Types. In this study we focused primarily on knowledge-of-correct-response feedback (KCR) and response-contingent/elaborated feedback. ALL utilized KCR feedback during the intervention process and implemented response-contingent or elaborated feedback in the second portion of their study with Clients A and B.

Table of Feedback Types

No-Feedback	Provides the learners with the performance score with no reference to individual test items
Knowledge-of-Response	Tells the learner whether their answers are correct or incorrect. Does not provide any information that would further the learners knowledge or provide additional insight.
Answer-Until-Correct	Modification of knowledge-of-response feedback. Provides verification but no elaboration and requires the learner to remain on the same item until the correct answer is chosen.
Knowledge-of-Correct-Response*	Provides individual item verification and supplies the correct answer. No elaborative information.
Topic-Contingent	Provides item verification and general elaborative information concerning the target topic. If incorrect, return to learning material where the correct information is located. Depends upon learners to locate the correct answer within the instructional materials
Response-Contingent/ Elaborated*	Provides both verification and item-specific elaboration. Provides knowledge of correct response, response contingent feedback, gives response-specific feedback that explains why the incorrect answer is wrong and why the correct answer is correct.
Bug-Related	Provides verification and addresses specific errors. Rule sets to identify and correct a variety of common errors. Does not provide learners with the correct response, only assists
Attribute-Isolation	Provides item verification and highlights to the target concept. Focuses learners on key components of the concept.

(Gilman, 1969; Kulhavy & Stock, 1989; Merrill, 1987;Overbaugh, 1994; Pressey, 1950; and Schimmel, 1988 as cited in Mason & Bruning, 2001, p. 5-6)

Knowledge of Correct Response Feedback. ALL uses a simple form of feedback, known as knowledge-of-response (also referred to as knowledge of correct response, KCR feedback (Mason & Bruning, 2001). Knowledge-of-response feedback involves "tell[ing] learners whether their answers are correct or incorrect. While this type of feedback is essential for verification purposes, it does not provide any information that would further the learners' knowledge or provide additional insight into possible errors in understanding" (Mason & Bruning, 2001, p. 5). Although KCR feedback may be an effective means of providing feedback for higher skilled

learners, it is not an effective means for lower skilled learners. Higher skilled learners often have more "extensive prior knowledge and enhanced metacognitive skills" that allow them to self-monitor, guide their own learning, and ask for clarification or elaboration when needed (Schimmel, 1988 as cited in Mason & Bruning, 2001). Lower skilled learners may "select feedback that provides them with the correct answer as opposed to the type of feedback that promotes the greatest learning" and tend to be "less confident in their own academic skills and less aware of their metacognitive processes" (Mason & Bruning, 2001, pp. 12). For lower performing participants, KCR feedback has consistently been proven to not be an effective feedback strategy (AECT, 2003). In fact, it was found that participants with lower abilities did not benefit or master skills that received knowledge-of-response feedback (Hanna, 1976). The effects of knowledge-response-feedback in the instance of the research will be discussed in later sections, however it is important to note that this is the simplest form of feedback and is not recommended (Mason & Bruning, 2001).

Response-Contingent/Elaborated Feedback. Response-contingent feedback is when the instructor "provides both verification and item-specific elaboration … to providing knowledge of the correct response, response-contingent feedback gives response-specific feedback that explains why the incorrect answer was wrong and why the correct answer is correct" (Mason & Bruning, 2001, p. 6). Response-contingent feedback provides more information to the participant, which fosters their understanding and prevents similar mistakes. In addition, it has been observed that although elaborated and KCR feedback have no differences for students with higher ability, elaborated feedback was highly successful for participants of lower abilities in comparison to KCR feedback (Hanna, 1976). Therefore, in the current study, the researchers

created an altered feedback stage, in which they implemented response-contingent feedback rather than the KCR feedback provided by ALL.

Summary

In summary, children with CCN are at risk for delayed literacy development due to environmental factors such as communication efficiency, curriculum demands, and educator training. Mobile technologies may provide more opportunities for replicable high quality literacy instruction, and teletherapy may be a viable option for increasing access to educational services. However, more research needs to be conducted to inform progress towards these positive outcomes. Therefore, the current study will investigate the following research questions:

1. In children with CCN, is the mobile application Accessible Literacy Learning effective in improving letter-sound correspondences?
2. Is there a difference in early literacy skills development between Knowledge of Correct Response (KCR) feedback and response-contingent/elaborated feedback?

3. Methods

IRB Approval

The study *Utilization of Mobile Technology Applications to Promote Early Literacy in Children with Complex Communication Needs - IRB-19-130,* received IRB approval by The University of South Dakota. **Decision:** Approved **Category**: 4. Collection of data through noninvasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving x-rays or microwaves. Where medical devices are employed, they must be cleared/approved for marketing. (Studies intended to evaluate the safety and effectiveness of the medical device are not generally eligible for expedited review, including studies of cleared medical devices for new indications.) **Associated Approvals:** Research Involving Children, Advertisement, Date-Stamped Cover Letter, Date-Stamped Parental Consent

Participants

The current study consisted of two participants who had CCN due to a genetic syndrome. The first participant was a six-year-old male diagnosed with Joubert syndrome[1] who will be referred to as Client A. The second participant was a four-year-old female diagnosed with Joubert syndrome who will be referred to as Client B. Joubert Syndrome does not cause

[1] "Joubert syndrome is an autosomal recessive genetic disorder that affects the area of the brain that controls balance and coordination. The most common features of Joubert syndrome are lack of muscle control (ataxia), abnormal breathing patterns (hyperpnea), sleep apnea, abnormal eye and tongue movements and low muscle tone

intellectual disabilities but can result in unintelligible and limited verbal communication. Client A and Client B were given intervention via teletherapy post March 2020.

Identifier	**Age**	**Sex**	**CCN**
Client A	6 years	Male	Yes
Client B	4 years	Female	Yes

Recruitment for this study was conducted through the University of South Dakota Scottish Rite Speech-Language and Hearing Clinic. Eligible participants' guardians were contacted and received a cover letter (Appendix A) and an informed consent letter (Appendix B).

To participate in the study, participants needed to meet the following inclusion criteria: two through eight years of age; be primarily English speakers; have a complex communication need; must be available for intervention a minimum of two times a week for four weeks. Participants also needed to meet the following exclusion criteria: no known intellectual disability, severe cognitive delays, or hearing loss of any degree.

Design

The current study implemented a single-subject design to answer the research questions. First, a stable within-participant pre-intervention baseline was established to control for testing effects and maturation. Second, the participants progressed through the developmentally sequenced phonological awareness and letter-sound correspondence tasks, which were the independent variables. The dependent variables, letter-sound correspondence performance and phonological awareness performance were measured at regular intervals throughout the study.

Procedures

*Phase One: Baseline Assessment***.** Each child was given a skills assessment in the form of a PowerPoint presentation. These assessments were designed to replicate the format and curriculum of ALL (Appendix C). For participants A and B, their limited verbal abilities and intervention being via teletherapy, the researchers found it best to create a PowerPoint presentation to gather baseline data. The PowerPoint slides contained audio recordings created by the researchers. Instructions were given and each option was read aloud, in similar format to the intervention style provided by ALL. Hence, the participant had a fair opportunity to express their knowledge and understanding of the skills without having to rely on their verbal abilities.

Phase Two: ALL Intervention. Client A and B were given intervention via teletherapy using the Zoom platform. Both participants received intervention four times per week for approximately twenty minutes per session for two weeks.

For each ALL-activity display, the participant was given five seconds to complete the task and select the correct picture. If the participant selected the incorrect picture, the application highlights their selection in red, repeats the directions, and immediately selects the correct picture for the participant. No praise in the form of audio or visual effects is given. If the participant selects the correct answer, the picture is highlighted in green, the question is restated as well as their choice. The participant is then rewarded with visual and audio effects. This process repeats ten to fifteen times (ten times for word-decoding, fifteen times for letter-sound correspondences) and if the child receives a mastery of over 80% on two separate occasions, the child has mastered the skill in the mobile app and is able to move on to the next level or stage.

Researchers collected data in this phase by utilizing the PowerPoint Presentation that was used during the baseline to track progress. In addition, researchers collected the students in-app intervention data to compare to the assessment data to track differences and similarities in their progression. The in-app intervention data was collected by documenting which activity screens the participants got correct or incorrect.

Accessible Literacy Learning Skills Table

	Skill Descriptions	Level Descriptions	Examples
Sound-Blending	The ability to build words from individual sounds by blending the sounds together in individual sequences	Simple blending - Blending with three letters	Cup, Mad, Sit, Pup P-U-P Select the picture that says “P-U-P”
Letter-Sound Correspondence Stage 1	LSC involves knowledge of the sounds represented by the letters of the alphabet and the letters used to represent the sounds.	Focuses on the letters a, m, t, p, o, and n because of their frequency in simple words, as well as separating letters that look or sound similar.	a, n, t, g /æ/
Letter-Sound Correspondence Stage 2	LSC involves knowledge of the sounds represented by the letters of the alphabet and the letters used to represent the sounds.	Focuses on c, d, u, s, g, h, i, f, b, l, e, r, w, k. Order is influenced by frequency in simple words, as well as separating letters that look or sound similar	b, n, v, c /k/
Letter-Sound Correspondence Stage 3	LSC involves knowledge of the sounds represented by the letters of the alphabet and the letters used to represent the sounds.	Focuses on the letters v, y, z, j, q	v, i, h, w /v/

Phoneme Segmentation	The ability to break words down into individual sounds	Simple Segmentation - breaking down the word run to r-u-n	Cat, Pup, Mad, Sad Which one starts with /p/
CVC Word Decoding	Associate each letter with its sound. Hold the sounds in sequence in memory. Blend them together to determine the word. Retrieve the meaning of the word.	Student must recognize letters in consonant-vowel-consonant words (CVC)	Bug, Hug, Wig, Gap Point to the picture. *Hug is written out and highlighted*
Advanced Word Decoding	Associate each letter with its sound. Hold the sounds in sequence in memory. Blend them together to determine the word. Retrieve the meaning of the word.	Must recognize the consonants and vowels in CCVC (ex: twin), CVCC (ex: ramp) and CCVCC (ex: clamp) words.	Grass. Bus, Small, Nip Point to the picture. *Grass is written out and highlighted*

Phase Three: Response-Contingent Feedback. In the third phase, response-contingent feedback, as opposed to KCR feedback, was provided to the participants. This phase was implemented because the researchers observed stagnant results with ALL intervention alone and the KCR feedback that was provided by the app. The app mode was set to "Teacher Assisted", the materials (choices and correct answers) were provided by the app, and the caregiver provided prompts and feedback. The caregivers were instructed by the researchers on how to provide prompts for the students and how to give corrective feedback for the participants (Appendix D). The caregivers were also given a script (Appendix D) to reference their feedback on and how to give feedback for correct and incorrect responses. Aside from these changes, intervention

methods and materials used remained the same as that in the second phase of intervention sessions.

Research Integrity

The study upheld research integrity through a variety of measures. For the KCR feedback (Phase Two), the caregivers were instructed to not provide the participant with additional feedback or instruction. Three researchers observed the caregiver and participant during intervention to ensure consistent methods and procedures were being followed. For the response-contingent feedback (Phase Three), the caregivers were provided a script (Appendix D) with instructions on introducing the activity as well as steps for providing feedback. Again, the three researchers observed during these intervention sessions to ensure consistent methods and procedures were being followed.

Data Recording & Reliability

Data was recorded during the session with pen and paper by all three researchers and discussed and compared immediately after the session concluded. If there were discrepancies among the researchers, the recordings of the sessions were reviewed. Once there was a consensus amongst the researchers, data was recorded in a locked, password protected Excel spreadsheet that was only shared amongst the researchers.

4. Results

Client A

During initial placement assessments, Client A correctly identified all letter-sound correspondences except b and d. He exhibited mastery of CVC decoding but was not proficient when decoding words including consonant clusters (e.g., CCVC, CVCC, and CCVCC). Therefore, intervention focused on b and d letter-sound correspondence and decoding words with consonant clusters. Based on his responses, the researchers determined that he would be best placed in the letter-sound correspondence Stage 2 of ALL with emphasis on b and d, and word-decoding Stage 2. These sessions began with data collection, then proceeded to letter-sound correspondence and word decoding intervention.

Letter-sound correspondence. A stable baseline was obtained over three sessions for both b and d, that is, he selected b correctly 0% of the time and he selected d correctly 7% of the time. The participant had at least a 25% chance of guessing the correct letter (i.e., of one of four options) during each baseline measure, however his average baseline performance was below that level. During Phase 2, his performance increased but was inconsistent. It was evident that this skill did not reach mastery, he selected b correctly 27.5% of the time and he selected d correctly 22.5% of the time. Upon implementation of the elaborated feedback phase, Client A exhibited improved accuracy and consistent responses, he selected b correctly 68% of the time and he selected d correctly 88% of the time.

The ALL in-app data is included to demonstrate the difference in acquisition of skills between the intervention sessions and the PowerPoint Presentation. Although the PowerPoint Presentation was in similar format (instructions, prompts, and choices), the participant was not

consistent across platforms. It was evident that this skill improved within the app, during the intervention session, both letter-sound correspondence b and letter-sound correspondence d were above mastery during both Phase 2 and Phase 3.

Word decoding. A stable baseline was obtained over three sessions for both CVC Word Decoding and Advanced Word Decoding, that is, he correctly identified CVC Word Decoding 0% of the time and he correctly identified Advanced Word Decoding 7% of the time. The participant had at least a 25% chance of guessing the correct letter (i.e., of one of four options) during each baseline measure, however his average baseline performance was below that level. During Phase 2, his performance increased but was inconsistent. It was evident that this skill did not reach mastery, correctly identified CVC Word Decoding 27.5% of the time and he correctly identified Advanced Word Decoding 22.5% of the time. Phase Three was not implemented for CVC Word Decoding or Advanced Word Decoding due to time constraints on the study.

The ALL in-app data is included to demonstrate the difference in acquisition of skills between the intervention sessions and the PowerPoint Presentation. Although the PowerPoint Presentation was in similar format (instructions, prompts, and choices), the participant was not consistent across platforms. It was evident that this skill improved within the app, during the intervention session, both CVC Word Decoding and Advanced Word Decoding were above mastery during both Phase 2 and Phase 3.

Client A Letter-Sound Correspondence

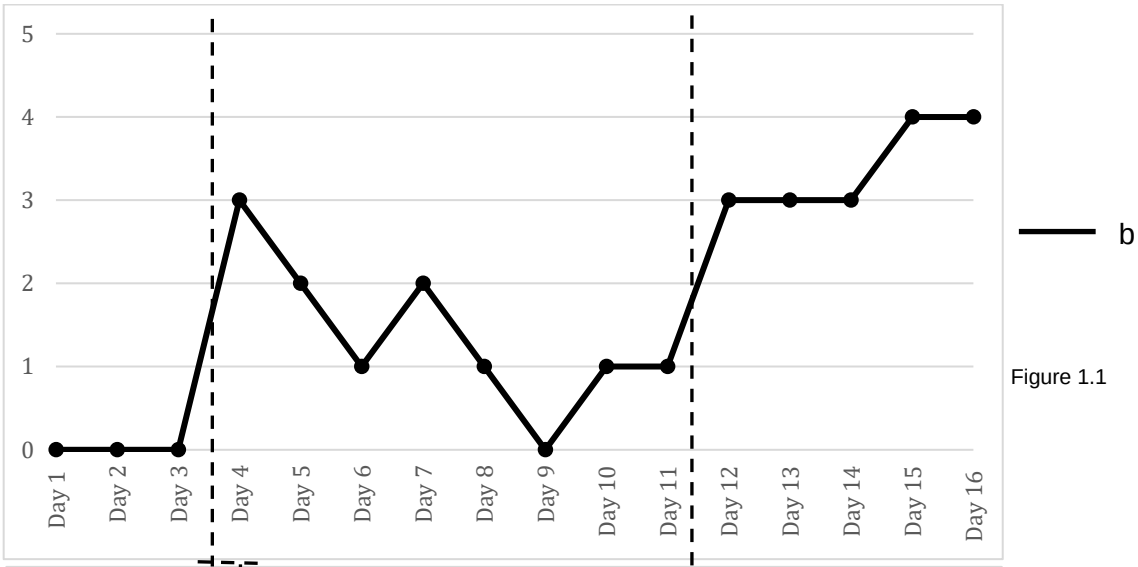


Figure 1.1

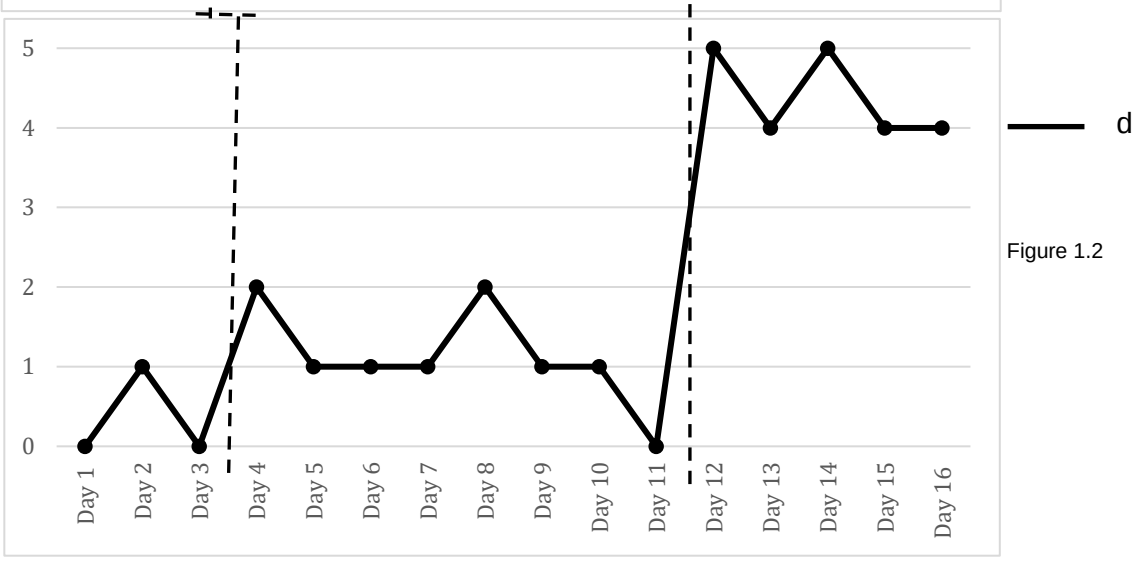
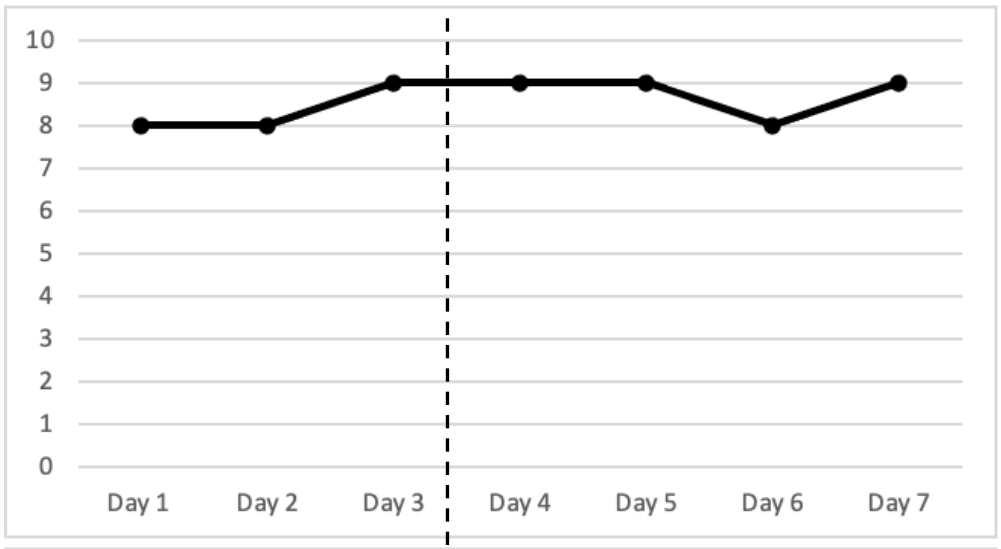
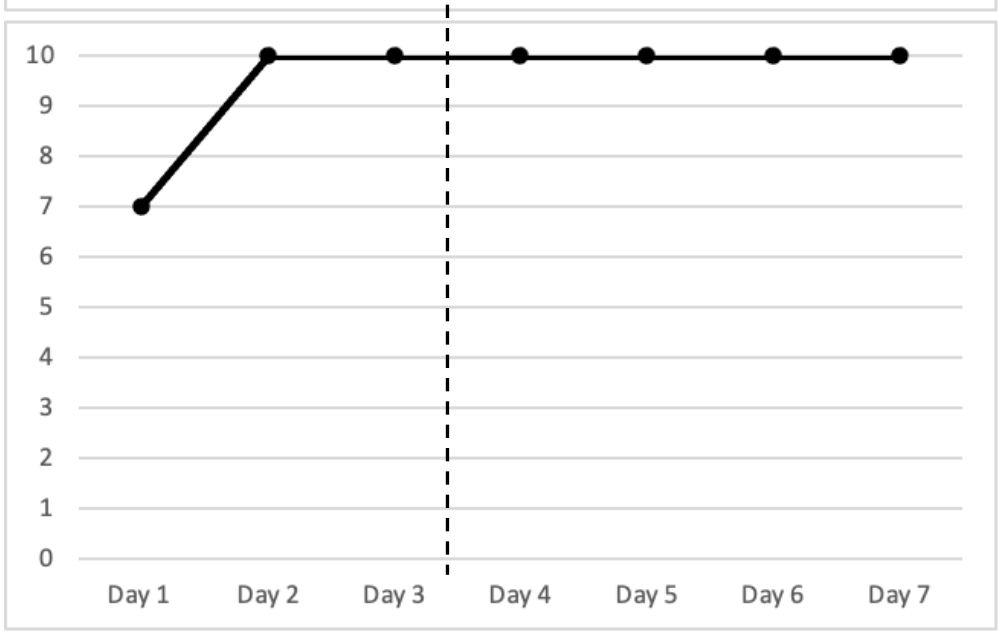


Figure 1.2



In-App Data
LSC b

Figure 1.3

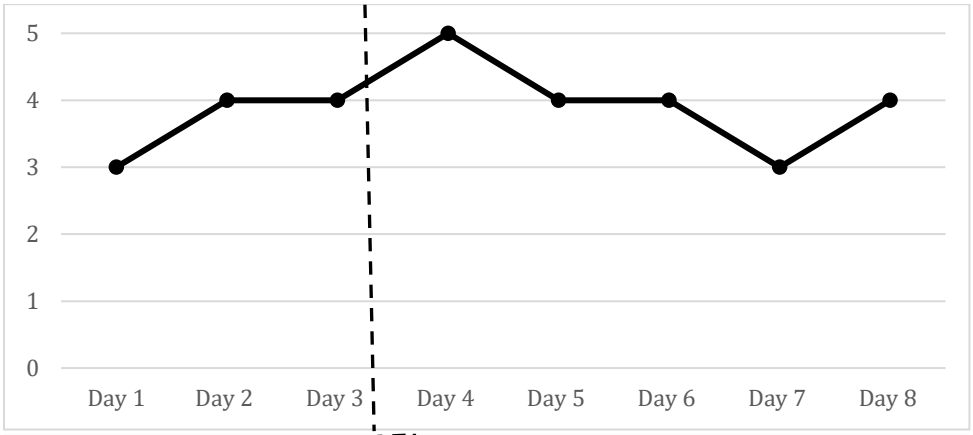


In-App Data
LSC d

Figure 1.4

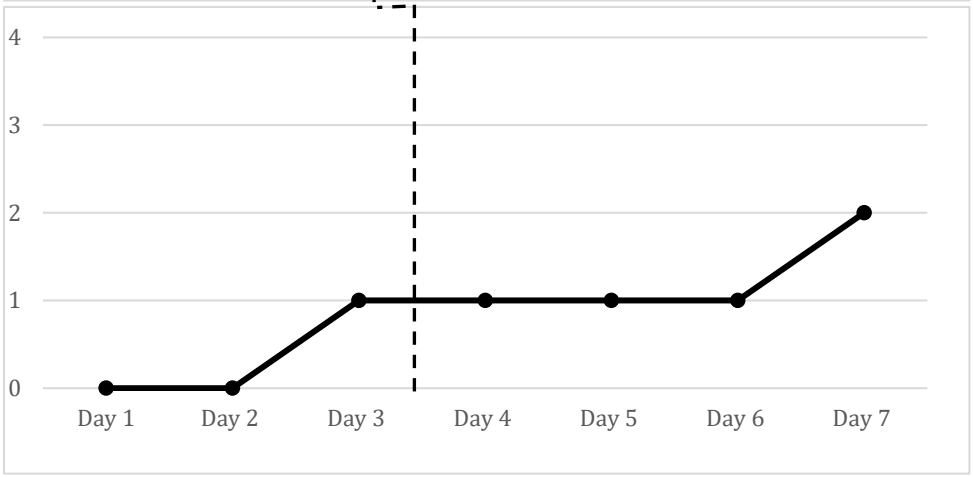
Client A Letter-Sound Correspondence “b” (figure 1.1) and “d” (figure 1.2). Client A Letter-Sound Correspondence in-app data collection “b” (Figure 1.3) and “d” (Figure 1.4) Client A was given intervention for thirteen days. The first three days were dedicated to baselines. On day eleven, intervention was stopped, and the alternative feedback script was implemented for days twelve through sixteen.

Client A CVC Word Decoding and Advanced Word Decoding



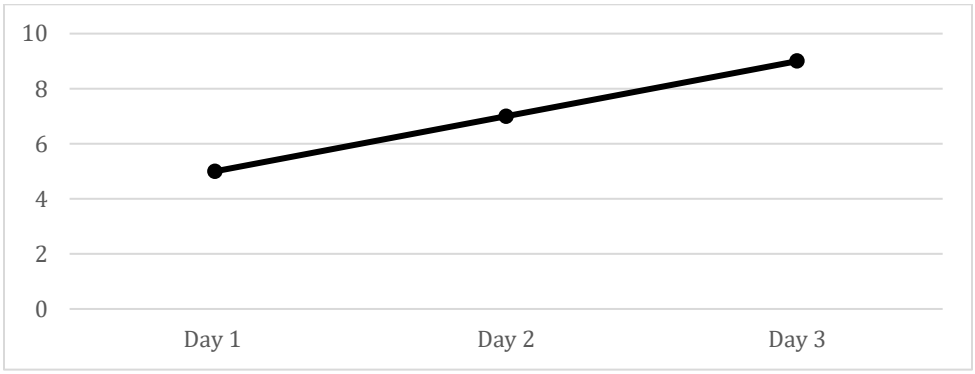
CVC word decoding

Figure 1.5



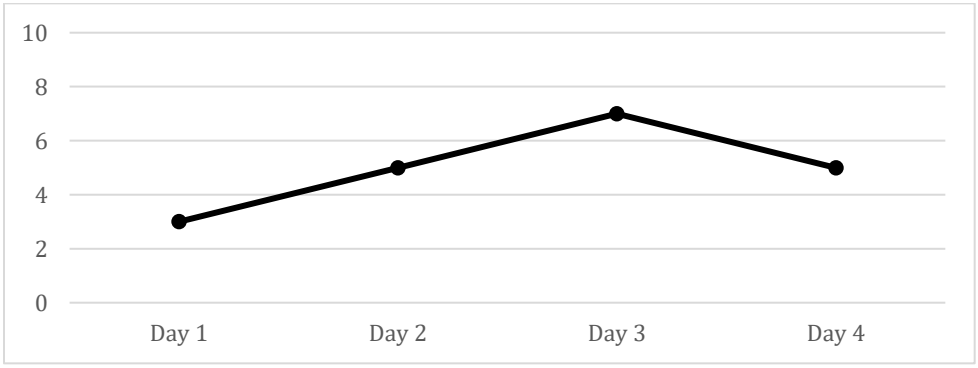
Advanced word-decoding

Figure 1.6



CVC word decoding in-app ALL data

Figure 1.7



Advanced word decoding in-app ALL data

Figure 1.8

Client B

During initial placement assessments, Client B did not display mastery of Stage One Letter-sound correspondence. Based on her responses, the researchers determined that she would be best placed in the letter-sound correspondence Stage One of ALL. She primarily focused on letters a, m, and t. These sessions began with data collection, then proceeded to letter-sound recognition intervention.

Letter-sound correspondence. A stable baseline was obtained over three sessions for a, m, and t, that is, she selected a correctly 11% of the time, m correctly 4% of the time, and t correctly 5% of the time. The participant had at least a 25% chance of guessing the correct letter (i.e., of one of four options) during each baseline measure, however her average baseline performance was below that level. For letter a, Phase 2 was implemented, and she achieved an accuracy of selecting correctly 53% of the time.

For letters m and t, the researchers omitted Phase 2 and moved directly to Phase 3. Client B no longer demonstrated interest in learning letter-sound correspondence a, so the researchers chose letters from the same difficulty level to implement Phase 3. Upon implementation of the Phase 3, Client A exhibited improved accuracy and consistent responses for letters m and t. Researchers utilized the ALL app to collect data due to the participants motivation levels and participation when using the PowerPoint Presentation, explaining why she had ten opportunities to choose the correct answer. Graphs of her performance (Figure 2.1, 2.2, and 2.3) show better consistency within the app when the researchers provided the altered feedback compared to when the participant received feedback provided by the ALL app.

Client B Letter-Sound Correspondence

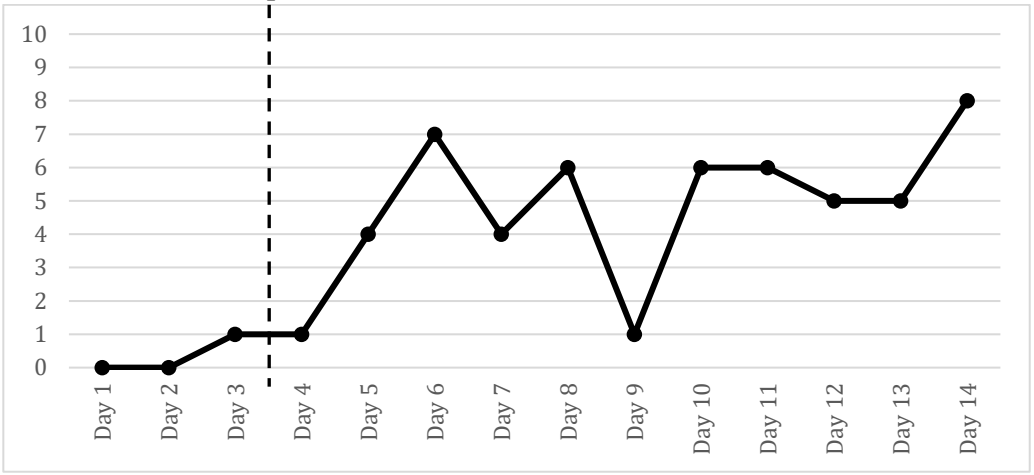


Figure 2.1

Client B Letter-Sound Correspondence "a" (figure 4.1). Client B was given intervention for 10 days but was not given the alternative feedback that is seen for letters "m" and "t". In the baselines, Days 1-4 there was a maximum correct of three. Researchers later switched to recording her progress in the intervention because she was unresponsive to the assessments to compare to the baselines.

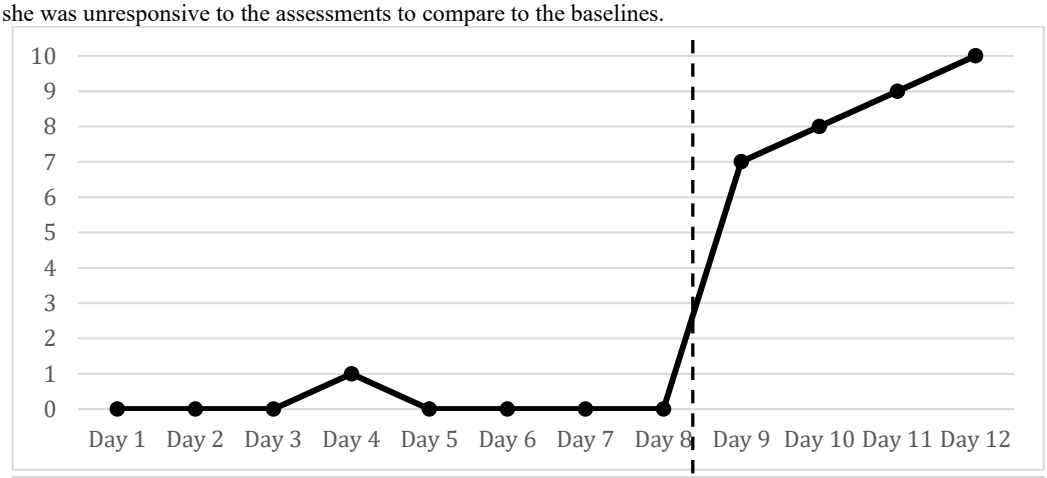


Figure 2.2

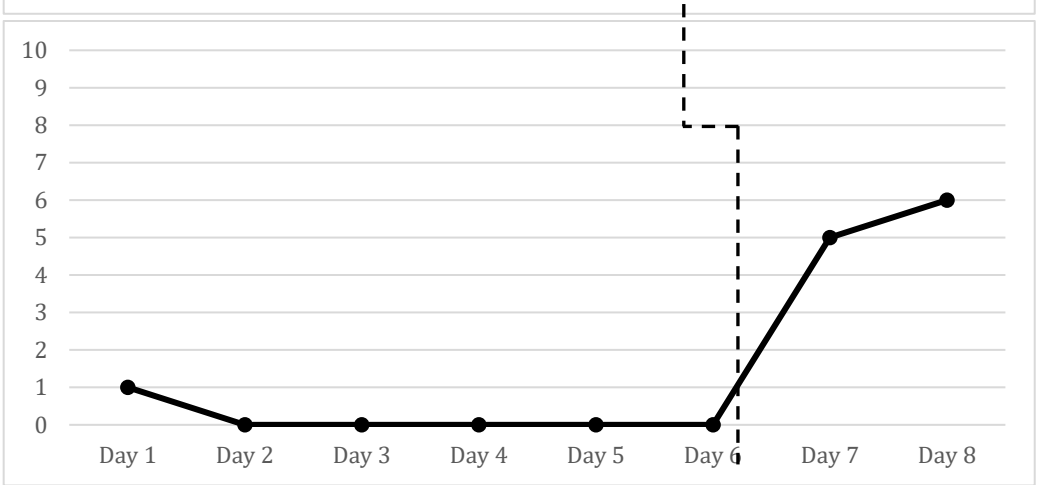


Figure 2.3

Client B Letter-Sound Correspondence "m" (Figure 2.2) and "t" (Figure 2.3). Figure 2, client had eight days of data collection and four days with the alternative feedback. Figure 3, client had six days of data of data collection and two days of alternative feedback. Although researchers did not have ALL intervention, when compared to Figure One data, it can be assumed that data for "m" and "t" would have been approximately the same, inconsistent.

5. Discussion

The current study investigated the effectiveness of ALL in facilitating early literacy skills in two children with CCN. In addition, the researchers compared the effects of KCR feedback to response-contingent feedback. In this section, we will first discuss the answers to the research questions. Next, critical evaluations of ALL will be discussed in light of the results presented. Finally, clinical applications, future areas of research, and limitations of the study will be discussed.

Question 1: In children with CCN, is the mobile application Accessible Literacy Learning effective in improving letter-sound correspondence skills? In the current study, ALL proved to be a valuable structural tool in facilitating the learning of letter-sound correspondence for children with CCN. The ALL format was engaging and provided good structure. ALL follows evidence-based practices for providing letter-sound correspondence intervention to children with CCN, such as following appropriate instructional content and procedures, providing adaptations to allow active participation from the users, and providing positive and motivating instruction (Light & McNaughton, 2012).

In Phase Two, the researchers did not provide any additional feedback and relied solely on the instruction and KCR feedback provided by ALL. Both participants in this phase did not show significant improvements or mastery of targeted skills. In both letter-sound correspondence (Figure 1.3 and 1.4) and word-decoding (Figure 1.7, Figure 1.8), Client A demonstrated mastery in the ALL-mobile app. However, as seen in word decoding (Figure 1.5, Figure 1.6) and letter sound correspondence (Figure 1.1, Figure 1.2), the skill did not generalize. While the in-app data is consistently reaching mastery, the same is not seen in his assessment data despite the

methods of delivery are similar. The only difference between the in-app intervention data and the assessment data is in letter-sound correspondence, where letter b and d are placed on the same activity screen during the assessment, whereas this is not the case in the in-app intervention. It was apparent that Client A, in Phase 2, was unable to distinguish between letters b and d when they are shown simultaneously.

Client B, for letter-sound correspondence a (Figure 2.1), had inconsistent results during the Phase 2 intervention. The similarities are seen despite the participants' differences in communication abilities, baseline knowledge, and intensity and methods of intervention given during the course of this study.

Data for both participants showed similar trends- displaying inconsistent results in their data during the KCR Phase 2 intervention. Both exhibited little to no improvement when there was not additional instruction or response-contingent feedback. The participants did not exhibit improvement in their skills using this app, likely because the feedback was inadequate and did not facilitate improved understanding of the concept. The data suggest that without assistance from a trained caregiver, educator, or speech-language pathologist, ALL does not appropriately provide feedback to adequately facilitate letter-sound correspondence knowledge to children with complex communication needs.

Question 2: Is there a difference in early literacy skills development between Knowledge of Correct Response (KCR) feedback and response-contingent/elaborated feedback? As discussed, KCR feedback provides individual item verification and supplies the correct answer with no elaborative information, whereas response-contingent feedback provides verification and item-specific elaboration (Gilman, 1969; Kulhavy & Stock, 1989; Merrill, 1987;Overbaugh,

1994; Pressey, 1950; and Schimmel, 1988 as cited in Mason & Bruning, 2001, p. 5-6). It is evidence-based practice to utilize response-contingent feedback when providing instruction on early literacy skills to children with CCN. This is evident in the prior CCN early literacy research, documented by Hanna 1976, Schimmel, 1988; Mason & Bruning, 2001; AECT, 2003; and Light & McNaughton, 2012.

Clients A and B demonstrated slow and unstable progress as the Phase 2 (ALL with programmed KCR feedback) progressed. In Phase 3 (response-contingent/elaborated feedback phase), the researchers developed a feedback script similar to that used by the ALL application, but replaced the KCR feedback with response-contingent/elaborated feedback (Appendix D).

Results demonstrated that after implementing the altered feedback script (Appendix D), both participants had significant gains in their letter-sound correspondence skills. During Phase 3 intervention, Client A consistently differentiated between letter ‘b’ and letter ‘d’ (Figure 1.3, Figure 1.4), which is a clear contrast to Phase 2 (Figure 1.1, Figure 1.2). Client B exhibited a more rapid acquisition of letter-sound correspondence knowledge in Phase Three (Figure 2.2, Figure 2.3) compared with the KCR Phase 2 (Phase 2.1). Again, these findings are consistent with previous research, suggesting that KCR feedback is an inadequate form of feedback when providing literacy intervention to children with CCN. This data suggests that ALL could be more successful if more explanatory feedback was implemented.

Phase 3 of the study suggests that ALL is a sufficient structural tool for providing literacy intervention to participants with CCN. The results of this study did not support the assertion that ALL is sufficient for independent practice (Accessible Literacy Learning, 2015). By relying on the ALL application to provide independent instruction, the participant is not receiving adequate feedback or instruction that would result in master or complete comprehension of the skill.

However, the data suggest that when using this application, a trained caregiver or speech-language pathologist should be facilitating the intervention and providing response-contingent feedback.

Clinical Applications & Further Studies.

With the development of the iPad and similar tablets, there has been an influx of caregivers and educators purchasing mobile applications with the intention of helping children who have CCN learn to read and write or to provide a means of communication. Although there has been research performed on methods to provide literacy intervention to children with CCN, there are limited to no studies that focus on mobile applications that are designed to instruct emergent literacy skills to children with CCN. Most mobile applications that currently exist are designed to be a tool for a trained speech-language pathologist to use with their regular lesson plans, intervention methods, and feedback procedures. The aim of this app is to allow for children with CCN to either learn at home independently, in the classroom, or with a speech-language pathologist.

This study is not sufficient evidence to prove or disprove ALL's efficiency in teaching emergent literacy skills, therefore more research into the ALL-mobile application should be performed. ALL is an effective structural tool when a trained caregiver or speech-language pathologist is providing intervention to a child with CCN. However, the data suggest that the application ALL does not provide enough corrective feedback or produce consistent enough results without direction, feedback, and supervision from a licensed speech-language pathologist or trained caregiver. It is imperative that more research is performed on the topic of mobile apps being used as a tool for teaching emergent literacy skills. ALL provided a useful context,

however, based on the results and data gathered the mobile app could be improved by increasing its flexibility and choices for clinicians, and by including a wider range of feedback.

Limitations.

Utilization of Mobile Technology Applications to promote Early Literacy in Children with CCN, has potential limitations. There are three major limitations in this study that should be addressed in future research surrounding this topic. (1) Due to practical childcare arrangements, this study included three caregivers who varied in engagement and personality style during the study. This likely introduced variability within the study which makes generalization outside of this study difficult. The researchers attempted to minimize this limitation by providing scripts, instruction, and feedback to the caregivers. (2) A PowerPoint Presentation was used for the participants to collect baseline and intervention data. Since this allowed for the participant to choose their answer from four choices, there is a 25% chance of simply guessing correctly. (3) This study could be improved upon in future research by including a wider selection of participants with different syndromes or causes for a CCN. Future studies should also conduct intervention sessions face-to-face in order to determine if there are differences in acquisition of skills amongst the participants.

6. Conclusion

ALL is a great resource and structural tool for teaching literacy skills to children with CCN. The mobile app uses evidence-based techniques and procedures that are recommended in the field of speech-language pathology to instruct literacy skills to children with CCN. However, changes could be made to make the app more effective, such as implementing response-contingent feedback instead of KCR feedback.

The researchers believe that the app, Accessible Literacy Learning, has great potential. Once the necessary changes were made, such as implementing response-contingent feedback, an immediate increase in skills and understanding from participants was observed. With minor changes, the addition of corrective feedback and second chances, and providing explanation for the children when they are incorrect- the mobile application Accessible Literacy Learning has the potential to be a great clinical tool and learning opportunity for children with CCN. Given the data collected and the suggestions proposed, a full-scale study is warranted to determine if Accessible Literacy Learning is an appropriate and reliable tool to utilize when teaching literacy skills to children with CCN.

Appendix A

IRB Cover Letter

UNIVERSITY OF
SOUTH DAKOTA

DEPARTMENT OF COMMUNICATION SCIENCES AND DISORDERS
Speech, Language, and Hearing Center
USD Scottish Rite Children's Clinics, Vermillion
414 East Clark Street • Vermillion, SD 57069
605-677-5474 • 605-677-5767 fax
csd@usd.edu • www.usd.edu/csd

Date:

Dear Parent or Guardian:

Your child is invited to participate in a research study. The purpose of the study is to investigate the effectiveness of iPad application, Accessible Literacy Learning, as a tool for intervention for preschoolers and school-aged children to improve their letter knowledge (sounds and names) and vocabulary skills.

We are inviting you to be in this study because your child has been identified as having a complex communication need or utilizes an augmentative and alternative communication device and shows significant delays in emergent literacy or phonological awareness skills.

If you agree to participate, the researchers will administer The Phonological Awareness Test-2, Peabody Picture Vocabulary Test, and the Goldman-Fristoe Test of Articulation to your child prior to intervention. Each session is expected to last approximately 15-20 minutes and will occur in a quiet environment without distractions that is convenient to the child. Sessions may be conducted outside of the clinical setting. These sessions are planned to occur three times a week for six weeks. If your child is a current client, no additional appointments are required. Sessions will be structured as followed: 1) The clinician will administer baseline and data-collection items, 2) Structured app-based intervention will be provided, 3) Post-intervention measures will be collected.

We will keep the information you provide confidential, however federal regulatory agencies and the University of South Dakota Institutional Review Board (a committee that reviews and approves research studies) may inspect and copy records pertaining to this research.

All assessments, intervention sessions, and result data will remain within the University of South Dakota Scottish Rite Speech Language & Hearing Clinic database, CounselEar. Voice recordings will remain confidential with the use of password protected iPads and will be deleted after review. If we write a report about this study, we will do so in such a way that your child cannot be identified.

If you consent to having your child being video and audio recorded during the sessions, it will be protected on a University of South Dakota Scottish Rite Speech-Language and Hearing Clinic's iPad which is password protected. These files will be deleted upon review after all data is collected.

There are no known risks from being in this study, and your child may benefit from the study by gaining communication skills. We hope that others may benefit in the future from what we learn as a result of this study.

Your participation in this research study is voluntary. If you decide not to be in this study, or if you stop participating at any time, you will not be penalized or lose any benefits for which you are otherwise entitled.

If you have any questions, concerns or complaints now or later, you may contact us at the number below. If you have any questions about your rights as a human subject, complaints, concerns or wish to talk to someone who is independent of the research, contact the Office for Human Subjects Protections at 605-658-3743.

Kyle L. Brouwer, Ph.D., CCC-SLP
Associate Professor
Department of Communication Sciences and Disorders

University of South Dakota
414 E Clark St
Vermillion, SD 57069
(605) 677-5772
Fax: (605) 677-5767

Appendix B

INFORMED CONSENT
The University of South Dakota

TITLE: **Utilization of Mobile Technology Applications to Promote Early Literacy in Children with Complex Communication Needs**

PROJECT DIRECTOR: *Dr. Kyle Brouwer*
PHONE #: *605-677-5474*
Department: *Communication Sciences and Disorders*

Invitation to be Part of a Research Study

Your child is invited to participate in a research study with an iPad application called Accessible Literacy Learning. In order to participate, your child must be between two and seven years in age and have severe language delays. Your child's participation in this research project is voluntary. Please take time to read this entire form and ask questions before deciding whether to take part in this research project.

What is the study about and why are we doing it?

The purpose of the study is to evaluate the effectiveness of a mobile application on early literacy skills and speech production. A maximum of 20 people will take part in this research study. We hope to teach children these skills that will carry over into their future literacy and speech production success.

What will happen if you take part in this study?

If you agree to allow your child to take part in this study, your child will be given a GFTA-3, PPVT, Phonological Awareness assessment, and a hearing screening. A baseline will be established during the first three sessions. Treatment will begin after the baseline is established. This treatment is a children's literacy correspondence app called "Accessible Literacy Learning". The treatment will take place for 15-20 minutes a session, three times a week, for six weeks- a total of 18 sessions and approximately 4 to 6 hours. If your child is a current client, no additional treatment session is required. Literacy skills (blending, phoneme identification) will be assessed with a non-standardized list of skills taken from the Accessible Literacy Learning app. We will test their literacy skills pre-test, mid-test, and post-test. We will contact the preschool teacher regarding her curriculum to see if there is an overlap of the skills being taught.

Upon your consent, your child will be audio and video recorded during the research session for review of the data collected and temporarily stored on a University of South Dakota Scottish Rite clinical iPad, which will be deleted upon review.

If your child is a new client, provide case history for your child and agree to intervention at a time and place that is (doable) in your child's schedule. If your child is a current client, case history and intervention times will be accessed through the clinic's database, CounselEar.

Your Participation in this Study is Voluntary

Your child's participation is voluntary. You may choose to withdraw your child from the research at any time or may discontinue participation at any time without penalty or loss of benefits to which your child is otherwise entitled. The decision whether or not to participate will not affect you or your child's current or future relations with The University of South Dakota.

You do not have to answer any questions you do not want to answer.

What risks might result from being in this study?

There is some risk associated with being part of this study. However, this risk is no greater than that experienced in everyday life. There is a small risk of data breach associated with the optional audio and video recording of your child.

How could you benefit from this study?

Participation in this study may provide early literacy benefits for the participant. With the use of iPads, particular early literacy skills will be targeted during therapy sessions and the participant may carry over these behaviors into future reading and speech production.

How will we protect your information?

The records of this study will be kept private to the extent permitted by law. In any report about this study that might be published, you nor your child will be identified. The participant's study record may be reviewed by government agencies, USD Office of Human Subjects Protection and The University of South Dakota- Institutional Review Boards.

Any information that is obtained in connection with this study and that can be identified with your child will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means of keeping all data in a locked drawer and restricting access to only research personnel. If we write a report or article about this study is written, the study results will be described in a summarized manner so that the participant cannot be identified.

If you consent to having your child being video and audio recorded during the sessions, it will be protected on a University of South Dakota Scottish Rite Speech-Language and Hearing Clinic's iPad which is password protected. These files will be deleted upon review after all data is collected.

If we write a report or article about this study, the study results will be described in a summarized manner so that your child cannot be identified.

How will my information be used after the study?

After this study is complete, study data may be shared with other researchers for use in other studies or as may be needed as part of publishing our results. The data we share will NOT include information that could identify you or your child.

What are the costs to you to be part of the study?

Your child will not have any costs for being in this research study. If your child is a current client, there is no additional cost to participate in this study. The only cost associated with this study is the cost of travel to get to the Scottish Rite Speech Language and Hearing Clinic at The University of South Dakota.

Contact Information for the Study Team and Questions about the Research

You may ask any questions you have now or later.

The researchers conducting this study are:

Kyle Brouwer, Ph.D., CCC-SLP
Hanna Browder, UG.
Laura Neff, B.S.
Kelsey Koala, B.S.

4. 605-677-5475
5. You may call this number if you have questions, concerns, or complaints about the research.

If you have questions regarding your rights as a research subject, you may contact The University of South Dakota- Office of Human Subjects Protection at **(605) 677-6184**.

- You may also call this number about any problems, complaints, or concerns you have about this research study.
- You may also call this number if you cannot reach research staff, or you wish to talk with someone who is independent of the research team.
- General information about being a research subject can be found by clicking "Information for Research Participants" on the web site:

http://www.usd.edu/research/research-and-sponsored-programs/research-participant-information.cfm.

Your Consent

Before agreeing to be part of the research, please be sure that you understand what the study is about. We will give you a copy of this document for your records [or you can print a copy of the document for your records]. If you have any questions about the study later, you can contact the study team using the information provided above.

(Optional) I understand by signing below, I am consenting to have my child audio and video recorded during each intervention session. I understand that these recordings will be stored by the University of South Dakota Scottish Rite Speech-Language Hearing Clinic for review of the sessions. I understand that this information will be reviewed by the research team for accurate data collection and deleted after the review session. I understand that this is an optional item of consent and my child will still be allowed to participate in this study if I decline to have their audio and video information recorded during the session.

Subject's Name: _____

_____

_____

Signature of Legal Guardian (used to consent on behalf of the subject) Date

I understand that by signing below, I volunteer to participate in this research. I understand that I am not waiving any legal rights. I have been provided with a copy of this consent form. I understand that if my ability to consent or assent for myself changes, either I or my legal representative may be asked to re-consent prior to my continued participation in this study.

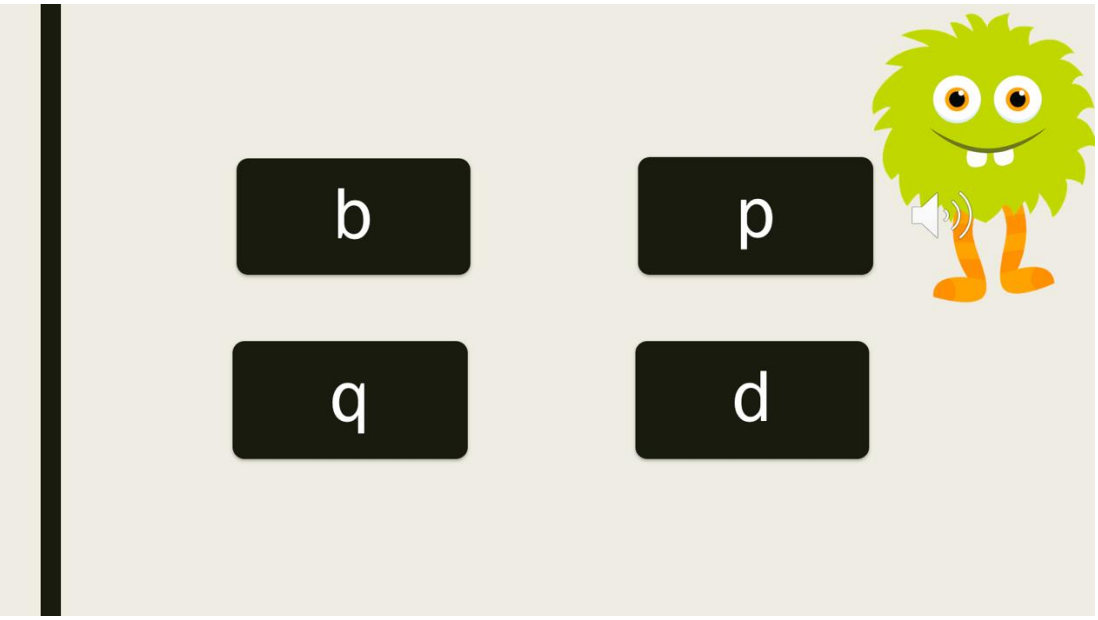
Subject's Name: _____

_____

_____

Signature of Legal Guardian (used to consent on behalf of the subject) Date

Appendix C



Baseline and Assessment PowerPoint: Letter-Sound Correspondence - /b/

Appendix D

Instructional Step	**Script – Letter-Sound Correspondence**
Introduce the Task	"We are going to learn about the sounds that letters make" Point to the letter and say its sound Trace the letter with the child's finger in the air and say the sound Read aloud all four words on the page Point to the letter and say its sound
Model-Letter Sound Correspondence	"Let's practice, look at the letters and I am going to pick the one that makes the sound _" Select the correct letter Give an example word that starts with that letter, emphasize the target letter
Independent practice	"Pick the letter that makes the sound __" Allow the child time to pick the answer
Feedback for Correct Response	"Good job!" Give an example word that starts with that letter, emphasize the target letter. Have the child trace with their finger the letter in the air
Feedback for Incorrect Response	"Nice try, but that letter doesn't say __, try again!" Allow the child another chance to select the correct answer. If they select the correct answer, press the check mark. If the child selects the wrong answer, help them click the correct answer. Have them trace with their finger the letter in the air and say the sound of the letter aloud. If the child is consistently mixing up 2 or more letters, explain to them what sound each of the letters are. Trace both letters and explain the differences between them if they are similar.

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