Validity of a New Measure of Phonemic Awareness that Does Not Require Spoken Responses in Children with Complex Communication Needs

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by

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A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science
Department of Communication Sciences and Disorders
College of Behavioral and Community Sciences
University of South Florida

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Date of Approval:
June 21, 2017

Keywords: augmentative and alternative communication, phonemic awareness, alphabetic
principle, complex communication needs, dynamic assessment

Acknowledgments

The completion of this thesis could have not been accomplished without the support from the following people:

I would like to thank my Major Professor, Dr. R. Michael Barker. Dr. Barker, thank you for supporting and encouraging me throughout this process. Your knowledge and expertise in the field of augmentative and alternative communication is what really sparked the beginning of this project.

I would also like to thank Dr. Carolyn Ford for being a part of my committee and answering any questions I had throughout this process.

Thank you, Ms. Cara Babon, for being a member of my thesis committee. Your passion in the field of augmentative and alternative communication has inspired me and made me into the clinician I am today.

Finally, I would like to thank my friends, family, and classmates who have supported me throughout this process. Your kind words of encouragement did not go unnoticed!

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Abstract

Children with complex communication needs (CCN) routinely have difficulty attaining appropriate literacy skills. Two indicators of literacy development are the alphabetic principle and phonemic awareness (Byrne & Fielding-Barnsley, 1989). The acquisition of minimal literacy skills such as letter sound knowledge can give children with CCN the opportunity to communicate and generate their own messages, instead of being reliant on vocabulary provided by others. In order to identify appropriate intervention approaches, nonverbal assessments of phonological and phonemic awareness for individuals with CCN are needed.

The purpose of this study was to determine the reliability of the Dynamic Assessment of the Alphabetic Principle, as well as determine to what extent the performance of DAAP was associated with other measures of phonological and phonemic awareness and emergent reading skills. The DAAP was administered over the course of one to five session to seven participants with an assortment of developmental and language disorders. In addition to the DAAP, participants were administered a letter-sound knowledge task, a sound matching task that evaluated awareness of first sounds of words and separately evaluated awareness of the last sounds of words (i.e., either sound matching from the Comprehensive Test of Phonological Processing – 2nd edition [CTOPP-2; Wagner, Torgesen, Reshotte, & Pearson, 2013] or initial sound matching and final sound matching from the Phonological and Print Awareness Scale [PPA; Williams, 2014]).

The reliability of the DAAP was calculated in two different ways. First, Cronbach alphas were calculated to estimate the reliability of items within subscales and between the subscales.

Reliability of the items within each subscale ranged from .96 to .99 and the reliability of the items between each subscale ranged from .87 to .99. Overall the alpha between all four of the subscales was .96. Next, bivariate correlations were calculated between each subscale score. Values ranged from .82 to .99, and all were significant according to bootstrapped 95% confidence intervals that did not contain 0. This information indicated that there was a high degree of internal consistency for the items and the subtests for the DAAP.

To evaluate the extent to which performance on the DAAP was associated with other measures of phonemic awareness, Bivariate Pearson correlations with standard significance values and bootstrapped 95% confidence intervals were calculated. The scores on the onset, rime, coda, and vowel subtests of the DAAP were correlated with sound matching first (SM-First), sound matching last (SM-Last) and sound matching chance (SM-chance) variables. The rime subtest of the DAAP was found to be significantly correlated with SM-First variable. Furthermore, the rime and vowel subscales of the DAAP were found to be significantly correlated with SM-Last variable. All four subtests of DAAP were significantly correlated to SM-chance variable.

Lastly, to evaluate the performance on the DAAP in association to other measures of emergent reading skills, bivariate Pearson correlations were calculated between the subtests of the DAAP and letter sound knowledge (LSK). Scores on LSK was significantly related to rime, coda, and vowel.

The data suggest that the DAAP is a reliable assessment. Furthermore, many conventional measures of phonological awareness and emergent reading skills were significantly correlated with subtests of DAAP. The pattern of the results suggests that the DAAP may be a reliable tool for measuring acquisition of the alphabetic principle in children with CCN.

Chapter One:

Literature Review

In 2012, the Programme for the International Assessment of Adult Competencies (PIAAC) conducted the Survey of Adult Skills to measure proficiency in key information-processing skills ("Survey of Adult Skills," n.d.; Goodman, Finnegan, Mohadjer, Krenzke, & Hogan, 2013). The authors concluded that 36 million people in the United States cannot read, write, or do mathematics above the third-grade level (Goodman, et al., 2013). Furthermore, individuals with low literacy skills cost the United States an estimated 225 billion dollars each year in terms of workforce non-productivity, crime, and loss of tax revenue due to unemployment (Goodman, et al., n.d.).

Considering the high cost of low literacy skills, appropriate teaching and assessment are vital. One group of individuals who routinely have difficulty attaining appropriate literacy skills are those with complex communication needs (CCN) who communicate using augmentative and alternative communication (AAC; Foley, 1993). There is no typical person with CCN and they vary widely in cognitive and linguistic functioning (Light & McNaughton, 2013). Importantly, even those with average intelligence have difficulty attaining conventional literacy skills (Sturm & Clendon, 2004).

Literacy skills impact how effectively individuals who communicate through AAC use their communication devices in educational, vocational, and community settings (Foley, 1993). Even though AAC devices are adaptable to fit each individuals' needs, they are constrained by the environmental context and the vocabulary that is pre-programmed into the communication

device (Barker, Bridges, & Saunders, 2014). For example, if an individual using an AAC device with pre-programmed vocabulary went to a movie theater, the individual could only ask for tickets to movie titles that included vocabulary words that are also on his or her device. Minimal literacy skills, often defined as 2nd grade decoding, opens the door to infinitely generative language (Buekelman & Mirenda, 2013). It is through adequate reading and writing skills and the knowledge of how to use them on his or her device, that a person can communicate effectively in unpredictable settings without being dependent on vocabulary programed by another person. This highlights the importance of overcoming the literacy barriers of individuals who communicate with AAC.

It is estimated that 1.3% of individuals, or roughly 4 million Americans, are unable to communicate using natural speech, and thus need an augmentative and alternative communication device (Beukelman & Mirenda, 2013). Despite the large number of people who need and use AAC systems, there are still significant communication needs that are unmet in the area of language and literacy. One major area involves assessment of pre-literacy and literacy skills. Currently, descriptions of literacy assessments for individuals who use AAC report different approaches for different skills, and for children with different disability profiles; thus, a comprehensive understanding of how to measure which skills, and for whom, is not currently known (Barker, Saunders, & Brady, 2012). Moreover, the literacy assessments given to individuals who use AAC often are frequently clinician-created, informal, and lack overall standardization, making comparisons between individuals difficult and their validity questionable (Barker, Saunders, & Brady, 2012). Filling this gap of inadequate assessment tools for this population will go far in addressing literacy acquisition concerns.

Phonemic Awareness and the Alphabetic Principle

Phonemic awareness and alphabetic principle have been identified as the best two predictors of how well children will acquire literacy (Share, Jorm, Maclean, & Matthews, 1984). Byrne and Fielding-Barnsley (1989) define the alphabetic principle as knowledge of the fact that phonemes can be represented by letters, such that whenever a particular phoneme occurs in a word, and in whatever position, it can be represented by the same letter. Furthermore, the alphabetic principle includes the relations between sounds that are embedded within whole spoken words and letters within print (Barker, et al., 2014). In order for a child to be able to read and write, he or she has to understand the alphabetic principle and attend to the elements constituting the words (Sandberg & Hjelmquist, 1996).

The alphabetic principle, in combination with phonemic awareness, promotes acquisition of literacy (Byrne & Fielding-Barnsley, 1989). Phonemic awareness is a more sophisticated and difficult aspect of phonological awareness. Phonological awareness manifests as the ability to attend to and make judgments about the general sound structure of language (Schuele & Boudreau, 2008). Phonemic awareness, more specifically, refers to aspect of phonological knowledge that involves isolating and manipulating individual sounds or phonemes (Schuele & Boudreau, 2008). Examples of phonemic awareness include matching, deleting, moving, blending, or segmenting phonemes (Barker, Bridges, & Saunders, 2014). Several standardized assessments, such as the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotee, 1999) and the Gray Diagnostic Reading Tests, 2nd Edition (GDRT-2; Bryant, Wiederholt, & Bryant, 2004) have used components of phonemic awareness to assess one's reading acquisition skills. However, these assessments require the participants to use verbal responses and do not include information on how to score a response when the child's

speech output is distorted in some way (Barker, Bridges, & Saunders, 2014; Gillam, et al., 2011). Very few assessment options for phonological awareness are available to individuals with complex communication needs (Barker, et al., 2012).

Literacy Assessments for Individuals with Complex Communication Needs

Characteristics of Ideal Assessments. For individuals with CCN that use augmentative and alternative communication, standard assessments of phonological awareness are difficult and often require modifying verbal responses (Barker, et al., 2014). Modification of responses often include pointing, scanning, or yes/no answers (Gillam, Fargo, Foley, & Olszewski, 2011). It is possible that differences in response modality may influence the results from the given assessment. Currently, there is limited research on the impact that adaptations have on response interpretation (Gillam, et al., 2011). However, it is without doubt that the modification of responses does influence the psychometric properties of these standardized assessments. Furthermore, the standardized assessment methods often use elaborate verbal instructions that may not be understood by individuals with language delays (Barker et al, 2014).

Barker, Bridges, and Saunders (2014) give four features of an ideal assessment of phonemic awareness for individuals with CCN. The first feature includes designing an assessment that does not require a verbal response. This type of assessment could include responses in the form of touch-responses or supports for providing responses via scanning. The second feature should include very limited verbal instructions to ensure task comprehension. Third, the assessment should be dynamic, so the individual can be given feedback on every item and thus learn the task given in the assessment. Lastly, the assessment should be computerized to fully automate the assessment process, increase procedural fidelity, and facilitate an objective measurement of responses (Barker, Bridges, & Saunders, 2014). Formal attempts to develop

assessments with some of these features have been made (Iacono, 2004; Iacono & Cupples, 2002; Gillam, Fargo, Foley, & Olszewski, 2011; Vandervelden & Siegel, 2001).

Previous Published Measures of Phonemic Awareness Appropriate for Children with CCN. Following is a general description of five different measurement approaches of phonemic awareness described in the literature.

Assessment of Phonological Awareness and Reading.. Iacono and Cupples (2002) created a series of reading, phonological awareness, and vocabulary listening comprehension tests to assess single word reading skills and phonological awareness in individuals with CCN called the Assessment of Phonological Awareness and Reading (APAR). The reading component of APAR includes a real word recognition task, nonword recognition task, and word comprehension task. The phonological awareness component included an auditory test of real word blending, nonword blending, phoneme counting, and phonemic analysis. All of the tasks were presented visually and required the participant to respond by choosing yes/no, a picture, or a number.

Although APAR has demonstrated some evidence of construct validity, several of aspects of APAR can be improved (Barker, et al, 2014). Importantly, APAR represents attempts to modifying existing static approaches so that they no longer require speech responses (Barker, et al, 2014). Furthermore, APAR contained complex verbal instructions which may be difficult for participants to comprehend. For example, during the reading nonwords component of the assessment, the instructions included *"I am going to show you some made up words. Each time I'll show you two, like these [present cards for practice item]. Notice that neither of these is a real word. Still, I can read them aloud. Can you show me which one says 'mok'?"* (Iacono & Cupples, 2002). Individuals with limited receptive language skills, such as intellectual

disabilities, may have difficulty understanding instructions such as these. In addition, APAR did not provide any feedback during the assessment to aid participants in learning the task. Finally, some of the assessment provides abstract pictures or symbols that may require significant pre-teaching.

A nonverbal phoneme deletion task administered in a dynamic assessment format. Gillam, Fargo, Foley, and Olszewski (2011) designed a nonverbal dynamic task of phoneme deletion with a systematic prompting and scoring system. The dynamic task was compared to the same measure administered using a static format. The participants of the study were typically developing children in early elementary school. For the nonverbal dynamic phoneme deletion task, the participants were given a word and asked to delete phonemes in various word positions and syllable shapes. The participant chose the answer by pointing to one of the four pictures given. The traditional static phoneme deletion task was presented without pictures to the same typically developing children who received the dynamic version of the test. The dynamic and static deletion tasks were found to be highly correlated; this suggests that pointing to answers may be more difficult than speaking, but the use of picture support may offset that difficulty.

Even though the task was given in a dynamic format, included limited verbal directions, and did not require verbal directions, the task was not computerized. Furthermore, the study only assessed a phoneme deletion task and did not include other commonly used methods to assess phoneme awareness. Although the study has many of components of an ideal literary assessment for individuals with severe speech impairments, a fully developed literacy assessment in a computerized format would be more optimal.

Phonological processing in written word learning. Vandervelden and Siegel (2001) assessed the appropriateness of a series of alternative assessment tasks of phonological

processing for individuals who use AAC. The assessment included tasks such as rhyme judgment, phonological recoding, and phoneme awareness. The response method for the assessment required participants to point to various pictures or respond with yes/no. Before the assessment begun, the participants were given a picture recognition task to ensure optimal comprehension of the stimuli. Each task contained a practice trials with corrective feedback proceeded by testing trials with no corrective feedback.

Vandervelden and Siegel's assessment of phonological processing demonstrated some evidence of concurrent validity, but still can be improved. Even though the assessment provided a nonverbal response method, learning what each picture represents as well as understanding the instructions and task may be taxing on the participant's memory. Furthermore, the assessment is not dynamic, therefore the participant does not have the opportunity to learn the task given in the assessment. Finally, the assessment is not computerized. If the assessment was computerized, it would ensure procedural fidelity, facilitate an object measure of responses, and fully automate the assessment process.

Phonological and Print Awareness Scale (PPA). The Phonological and Print Awareness Scale (PPA; Williams, 2014) is research-based standardized measure of early literacy skills, such as print and phonological awareness. The PPA Scale uses a receptive, multiple choice format that does not require a spoken response. Subtests of the PPA include rhyming, print knowledge, initial sound matching, final sound matching, sound-symbol, and phonemic awareness.

Even though evidence of content, construct, convergent, and discriminant validity were reported for the PPA, the assessment does not satisfy all of the components of an ideal assessment for individuals with CCN. Five of the subtests of the PPA use pointing as a response mode. The final subtest, phonemic awareness, requires the examinee to tap out the number of

syllables in a given word. This may be difficult for an individual who has limited fine motor skills. However, the assessment does not require any verbal responses, which fulfills the first component of an ideal assessment for individuals with CCN. With the assessment being typically administered in 10-15 minutes, the PPA is intended to be brief. Each subtest of the PPA provides the examinee with three trials. After the three trials, no further feedback is given. Because the PPA is not a dynamic assessment, the examinee has limited opportunities to learn the task. Lastly, the assessment is not computerized to automate the assessment process.

Dynamic Assessment of Phonemic Awareness via Alphabetic Principle (DAPA-AP). Barker, Bridges, and Saunders (2014) developed a computerized assessment that took a different approach to assess the alphabetic principle and phonemic awareness simultaneously, Dynamic Assessment of Phonemic Awareness via Alphabetic Principle (DAPA-AP). DAPA-AP is based on a seminal series of studies on the development of the alphabetic principle in preliterate children (summarized in Byrne, 1998). Byrne's studies focused on assessing the alphabetic principle using procedures that did not require decoding skills. Furthermore, the Byrne study required spoken responses and primarily focused on onsets (Byrne & Fielding-Barnsley, 1989). In this study, the participants were children at the pre-reading stage of literacy development. A forced-choice technique was used to teach the participants to read one of five-word pairs that contained the onsets /m/ and /s/. After the teaching segment of the study, the participants then were assessed for sound identity and awareness in eight untaught printed words. For example, the word "mum" was given in print format. The examiner would then provide the participant with a forced-choice question (Does this say "sum" or "mum"?). The participant then responded to the question verbally.

The DAPA-AP used elements of the Bryne and Fielding-Barnsley (1989) study, but eliminates the speech requirement by reversing the roles of the spoken and printed words (Barker, et al., 2014). Trials in the DAPA-AP were presented in a computerized format. For each trial, participants listened to an audio recording of a single spoken CVC syllable that was printed on the screen (e.g., sum). Two CVC syllable choices that differed only by the target sound (e.g., sum & mum) were also printed on the screen. The participant responded to the task by touching the printed word on the screen. Because the DAPA-AP is a dynamic assessment, participants were given feedback and/or prompts as needed in order to learn the task given. By requiring the participant to isolate the target phonemes within a spoken syllable, phonemic awareness was targeted (Barker, et al., 2014).

The five phonological awareness assessments summarized in this section all offer participants an alternative response modality to spoken responses. However, the DAPA-AP (Barker, et al, 2014) is the only assessment that satisfies all of the components of an ideal assessment for individuals with CCN. First, the DAPA-AP does not require participants to respond verbally. Second, limited verbal instructions are given in the DAPA-AP, thus comprehension demands are low. Third, the DAPA-AP uses a dynamic component to ensure the participants understand the task presented. For example, participants were given prompts as needed throughout the assessment. Additionally, all of the response items consist only of letters. Using letters has been shown to aid children in demonstrating phonological awareness (Boyer & Ehri, 2011; Ehri et al., 2001). Lastly, the DAPA-AP is computerized to ensure accurate administration as well as to facilitate an objective measure of responses. Finally, reduced administration time is important for children who may quickly fatigue (Barker et al., 2014).

Statement of Purpose

The purpose of this study was to determine to what extent the Dynamic Assessment of the Alphabetic Principle (DAAP; the most updated version of the DAPA-AP) measures the construct of phonological awareness by assessing its concurrent and convergent validity in children who have CCN. Concurrent validity refers to how well one measure is correlated with other well-established measures of the same underlying construct (Bhattacherjee, 2012). Convergent validity refers to an assessment's association between the construct that is purported to be measured and other constructs that are related (Bhattacherjee, 2012). Other measures of phonological awareness and literacy were used to establish the DAAP's concurrent and convergent validity, respectively. With the purpose of the study in mind, participant recruitment focused on selecting minimally-verbal children in the pre-literate stages of learning to read. Reliability was established by measuring the internal consistency of the DAAP items and subtests. Based on previous research (Barker et al., 2014), it was hypothesized that the DAAP would exhibit adequate reliability in this population. Concurrent validity was evaluated by calculating correlation coefficients between the DAAP subtests and two other measures of phonological awareness. Based on previous research (Barker et al., 2014), it was hypothesized that scores on the DAAP would be highly correlated with these measures, demonstrating high concurrent validity. Convergent validity was evaluated by calculating correlation coefficients between DAAP scores and a measure of early literacy skill. Again, based on previous research (Barker et al., 2014), it was hypothesized that the DAAP would be highly correlated with other measures of reading, demonstrating high convergent validity. Questions addressed in this study are:

1. Does the DAAP reliably measure phonemic awareness using the alphabetic principle?

2. Is performance on the DAAP associated with performance on other measures of phonemic and phonological awareness?

3. Is performance on the DAAP associated with performance on other measures of emergent reading skills?

Chapter Two:

Methods

Participants

Seven children with an assortment of developmental and language disorders participated in the current study. All participants benefited from the use of some type of AAC system, ranging from low tech (e.g., picture exchange communication system) to high tech (e.g. iPad application for communication). Furthermore, all participants used methods of direct selection when using their AAC system. All participants had vision and hearing within normal limits, according to parent report. Demographic information for each child is presented in Table 1. The sample consisted of 4 females and 3 males. The average age was 8.2 years ($SD = 3.1$, range from 4.4 to 12.1). Two children were diagnosed with Down Syndrome, one was diagnosed with Mosaic Down Syndrome, one child had epilepsy and developmental delay, two children had apraxia, and one child was diagnosed with autism. Four of the children were Caucasian or white, one was multi-racial or other, and the parents of two children did not report their race.

Procedure

A female researcher administered all assessments in a quiet, private, space at the University of South Florida Speech and Language Clinic. Sessions were approximately an hour and full administration of the assessments took between one to five sessions depending on the participant's endurance. Participants received verbal praise and/or visual praise (e.g. smiley faces on the tablet) as needed during each session. Two components were included in this study: standard assessments and the DAAP. The DAAP included a pre-training trials before each

subtest. After the pre-training trials, the researcher would give the participant the following directions: *The tablet is going to say some words. Touch the word that you hear.* If the participant needed to be redirected to the task, the researcher would encourage them to select an answer by saying phrases such as *Which word?, What do you hear?,* or *Use your pointer finger.* All other assessments were administered in accordance with published instructions.

Assessments Administered

In addition to the DAAP, participants were administered a letter-sound knowledge task, a sound matching task that evaluated awareness of first sounds of words and separately evaluated awareness of the last sounds of words (i.e., either sound matching from the Comprehensive Test of Phonological Processing – 2nd edition [CTOPP-2; Wagner, Torgesen, Reshotte, & Pearson, 2013] or initial sound matching and final sound matching from the Phonological and Print Awareness Scale [PPA; Williams, 2014]).

Letter-Sound Knowledge. The letter sound knowledge (LSK) task consisted of 26 items and was adapted from the Curriculum Based Measurement for Early Literacy (Speece, Case, & Molloy, 2011). Before beginning the task, participants were given a practice page consisting of three letters, /s/, /b/, and /a/. Letter-sound letter knowledge were taught to each participant during the practice segment. The examiner then gave the instructions: *I am going to say some sounds and I want you to point to the letter that says the sound I say.* After the practice page was given, four more pages consisting of 5 to 7 lowercase letters were administered to all of the participants. All vowel sounds were pronounced as short vowel sounds.

Comprehensive Test of Phonological Processing – 2nd Edition (CTOPP-2). The sound matching subscale of the CTOPP was administered to 5 of 7 participants in this study. The sound matching subscale is split into two distinct parts: initial and final sounds. Each evaluated the

participants' ability to match a given spoken word and corresponding a picture to another spoken word and corresponding picture based on the target word's onset or coda, respectively. The alpha coefficient for sound matching is .93.

Phonological and Print Awareness Scale (PPA). The PPA Scale (Williams, 2014) was administered to two participants in this study in accordance with the published test manual. The participants responded to test questions by pointing or touching. Although all the entire assessment was administered, this study uses data from only two of the subtests: initial sound matching and final sound matching. These two subtests provide information very similar to that of the CTOPP-2 sound matching test. In the initial sound matching and final sound matching subtests, participants were instructed to choose the picture that began or ended with the same speech sound as the target word spoken by the examiner. Although not reported for an individual subtest, the overall alpha coefficients for the PPA are > .90.

Dynamic Assessment of the Alphabetic Principle. The DAAP was administered via Paradigm Experiments (*Perception Research Systems,* 2007) on an 11" Dell tablet computer. Auditory stimuli were digital recordings by an adult female with a mid-western English accent. Visual stimuli were presented in the form of printed words or nonwords in lowercase, black 72-point Bold Arial font. Nonwords were chosen to minimize the possibility of being recognized by sight. The DAAP consisted of four subtests: coda, vowel, onset, rime. All subtest included six real word or nonword pairs in CVC (consonant, vowel, consonant) format. Each real word and nonword pairs isolated the targeted segment by contrasting words that only differed in that segment. This allowed for the targeted segment that only possible choice for a correct selection. A list of real word and nonword pairs used in the DAAP are shown in Table 2.

The participants were required to listen to the spoken stimulus and choose the

corresponding printed word. For instance, in the onset subtest, the two printed word choices had different onsets, but the same rime (e.g., med and sed). In order for the participant to answer correctly, he or she would need to notice that the spoken word "sed" begins with /s/ and that printed "sed" differed from "med" in the onset position. Both the vowel and coda subtests also differed by a single phoneme. The rime subtest, however, differed in both the consonant and final vowel (e.g. "mog" and "mib").

The DAAP includes two types of trials- testing and teaching- which are arranged in blocks of six trials. The two spoken nonwords of the pair were presented in quasi-random order across trials with the constraint that the same syllable was not presented more than two consecutive trials. Each spoken nonword was presented three times. During each trial of test blocks, the computer presented the spoken target word, while displaying a small black box in the center of the screen. Touching the black box produced printed non-word choice stimuli in the upper two corners of the screen, while continuing to present the spoken syllable every two seconds. If the correct printed nonword was selected, a smile face appeared in the middle of the screen. If an incorrect printed nonword was selected, the screen turned black and then continued to the next stimulus. The second type of block attempted to teach the participant the task by replacing the black box with a printed nonword target that was displayed along the other two printed choices. The teach blocks provided participants the opportunity to identify or match the printed nonwords and therefore learn the relationship between the printed and spoken nonword.

Each nonword pair was presented in either one non-prompted block (6 trials total) or a combination of three non-prompted and prompted blocks (18 trials total). Block one was always non-prompted. If participants failed to meet the criterion on block one, a second and third block was presented. Block two was always prompted. If criterion was met on block two, then block

three was non-prompted. However, block three was prompted if the criterion was not met on block two.

Figure 1 shows each scoring pathway through the blocks for the syllable pair, "mib/sib". Participants could receive 0-3 points per block. For 3 points, the participant must have answered 5 of the 6 trials correctly. The participants received 2 points if he or she did not meet the criterion on Block 1 (less than 5 of 6 correct), met the criterion on Block 2 (a prompted block), and then met the criterion on Block 3 (non-prompted block). To receive 1 point, the participant must have not met the criterion on Block 1, met the criterion on Block 2, and not met criterion on Block 3 (a non-prompted block); or not met the criterion on Block 1 and Block 2, but the met the criterion on Block 3 (a prompted block). For 0 points, the participant must have not met any of the criterion on any of the 3 blocks.

Points for nonword pairs were summed within each subtest and divided by the number of nonword pairs in that subtest. Possible scores for each subtest ranged from 0 to 3. A participant with a subtest score of three needed very few prompts. A score of approximately two meant that the participant responded correctly only after a prompted block for most items. A score of approximately one meant that a participant only met criterion on a prompted block and not after the prompts were removed. Therefore, a participant with a score of one did not learn from the prompts. A score close to zero meant that the participant did not show any evidence of identity matching and rarely met criterion on prompted blocks.

Chapter Three:

Results

General Description of Outcomes

Given the small sample size, results for each individual child are presented in Table 1. Complete data were obtained for all but two participants. Only the vowel subtest of the DAAP was only administered to 5 of the 7 participants. The average number of items correct on the LSK was 18 ($SD = 8.5$), with a range of 5 to 26 items correct. The average percent correct for SM-First was 31% ($SD = 19\%$), with a range of 0 to 54% correct. The average percent correct for SM-Last was 12% ($SD = 19\%$), with a range of 0 to 50% correct. Average scores for the DAAP subtests were 1.3 ($SD = 1.3$), 0.9 ($SD = 1.2$), 1.0 ($SD = 1.3$), and 0.8 ($SD = 1.2$) for onset, rime, coda, and vowel, respectively. Scores ranged from 0 to 3 for all but vowel, where the maximum was 2.7.

Data Analysis Approach

Because of the very small sample size, in addition to traditional parametric Pearson's correlations, this study also reports bootstrapped 95% confidence intervals around the correlation estimates. Bootstrapping is a resampling technique that is robust to violations of normality and low power that are associated with small sample sizes. More specifically, bootstrapping is a technique where k samples of n size are drawn randomly with replacement from the collected data. These bootstrapped samples are used to create a confidence interval around the estimates derived from the sample data. One thousand samples were estimated from the sample of 7 participants. The confidence intervals reported indicate that the correlation estimate fell within

that interval in 950 of the 1000 bootstrapped samples. As with traditional confidence intervals, intervals around a correlation estimate that do not contain zero are interpreted as statistically significant.

Reliability

Cronbach alphas were calculated to estimate the reliability of items within subscales and between the subscales. All estimates are shown in Table 3. Overall, reliability was excellent for the DAAP. Specifically, reliability of the items within each subscale ranged from .96 to .99, as seen in the diagonal of Table 3. Moreover, alphas calculated between each subscale were high; they ranged from .87 to .99, as seen above the diagonal in Table 3. Lastly, overall the alpha between all four of the subscales was .96.

As a final indicator of reliability, bivariate correlations were calculated between each subscale score. These are presented below the diagonal in Table 3. Values ranged from .82 to .99, and all were significant according to bootstrapped 95% confidence intervals that did not contain 0. This information, combined with the high alpha values, indicates that there was a high degree of internal consistency for the items and the subtests for the DAAP, which are good indicators of a measure with high reliability.

Correlations between DAAP and Measures of Phonological Awareness

Bivariate Pearson correlations with standard significance values and bootstrapped 95% confidence intervals were calculated to evaluate the extent to which performance on the DAAP was associated with other measures of phonemic awareness. Specifically, scores on the onset, rime, coda, and vowel subtests were correlated with measures the sound matching first and sound matching last variables described in the assessments section. The results are shown in Table 4.

As seen in Table 4, there was a mixed pattern of significant correlations between the four

subtests of the DAAP and SM-First. Specifically, SM-First was not significantly associated with onset, $r = .34$, or coda, $r = .38$, yet it was significantly associated with rime, $r = .75$, bootstrapped 95% CI from .55 to .99, and vowel, $r = .87$, bootstrapped 95% CI from .71 to 1. The results were similar for SM-Last. SM-Last was not significantly correlated with onset, $r = .54$ or coda, $r = .66$, but was with rime, $r = .76$, $p = .047$, and vowel, $r = .89$, $p = .044$, although the bootstrapped 95% CIs for both of these indicated these values may not be significant. This inconsistency was likely due to the very small sample size, relatively high variability for these measures, and the fact that chance for these measures was actually 33% correct.

To account for this, one additional analysis was conducted with a new binary variable, SM-Chance. SM-Chance recoded the SM-First variable to indicate which children did not exceed chance (i.e., less than or equal to 33%) and which ones did exceed chance (i.e., greater than 33%). As seen in Table 1, four children scored less than chance, three children scored greater than chance. The results were much more consistent for this new variable. SM-Chance was significantly correlated with onset, $r = .76$, rime, $r = .91$, coda, $r = .75$, and vowel, $r = .89$, as indicated by conventional significance values and bootstrapped 95% confidence intervals (see Table 4). These results indicate that children who scored better than chance on the SM-First variable scored significantly higher on all four subtests of the DAAP.

Correlations between DAAP and Early Reading

Similarly, bivariate Pearson correlations were calculated between the subtests of the DAAP and LSK to determine the association between the DAAP and a measure of early reading skill. As seen in Table 4, scores on LSK was not significantly associated with onset, $r = .65$, but was significantly associated with rime, $r = .64$, bootstrapped 95% CI from .24 to .98, coda, $r = .64$, bootstrapped 95% CI from .13 to .99, and vowel, $r = 81$, bootstrapped 95% CI from .72 to 1.

Chapter Four:

Discussion

Very few standard phonological awareness assessments are available for children with CCN that use AAC. Often, standard assessments of phonological awareness (e.g. CTOPP and WRMT-R) are modified to fit children with CCN's needs. Assessments of phonological awareness are needed to determine a children's pre-literacy ability and thus provide the individual with the appropriate instruction. It is especially important that children with CCN master minimal literacy skills, so they can create their own messages via AAC devices.

An ideal assessment of phonemic awareness for individuals with CCN include the four features described in the introduction section of this literature review. The Dynamic Assessment of Phonemic Awareness via Alphabetic Principle (DAPA-AP) and the newer version, the Dynamic Assessment of the Alphabetic Principle (DAAP), developed by Barker, Bridges, and Saunders, represents a formal attempt to satisfy all four features of an ideal assessment for individuals with CCN. This study represents another step in establishing the reliability of the DAAP which assesses phonemic awareness via alphabetic principle without using speech responses. Furthermore, this study looked at correlations between the DAAP and other standard measures of phonemic and phonological awareness. Results provided that the DAAP may have strong reliability and thus may be an appropriate assessment for individuals with CCN.

Reliability is referred to as the degree in which an assessment tool produces a stable and consistent result (Phelan & Wren, 2005). The DAAP demonstrated excellent reliability as indicated by a high internal consistency of items overall, $\alpha = .96$. Furthermore, reliability of the

items within each subscale ranged from .96 to .99. These values indicate that performance on particular items, across children, was generally consistent. In other words, children with the same ability level tended to get the same items correct or incorrect. As a final indicator of reliability, bivariate correlations were calculated between each subscale score. The values of bivariate correlations ranged from .82 to .99 and were all significant according to bootstrapped 95% confidence intervals. This information indicated that children who scored high on one subtest tended to score high on other subtests, and vice versa. Taken together, these results indicate that the DAAP is a reliable assessment.

The four subscales of the DAAP compared to SM-First, SM-Last, and SM-Chance, and LSK yielded interesting results. In evaluating the concurrent validity of the DAAP, SM-First variable was found to be significantly related to both the rime and vowel subscales of the DAAP, but not the onset and coda subscales of the DAAP. These results were surprising because SM-First and the onset subtest both measure awareness of first sounds of words. Likewise, the SM-Last variable was found to be significantly related to the vowel subscale of the DAAP, but interestingly was not related to the coda subscale of the DAAP. Again, this is surprising because the coda subtest and SM-Last presumably measured the same aspect of phonemic awareness (i.e., awareness of final sounds).

Although these results do not provide compelling evidence of convergent validity, it is likely that these confusing outcomes are due to the nature of the SM-First and SM-Last variables. Because these are forced-choice tasks where each item has three choices, there is a 33% chance of correct responding for each item, introducing a large amount of measurement error into the outcomes. For example, a participant who scores 30% on one of these tasks actually hasn't demonstrated any knowledge of first or final phonemes, they have only responded as well as

someone would who was guessing. Moreover, the small sample did not provide sufficient power for the analyses to overcome this measurement error. Consequently, SM-Last was recoded into a binary variable, SM-Chance, that differentiated those who performed at 33% or less (i.e., chance) from those who scored greater than 33% (i.e., better than chance). A subsequent correlation analysis with SM-Chance provided strong evidence for concurrent validity, as all subtests were significantly correlated with this new variable. These results are consistent with those reported by Barker et al., 2014.

The LSK measure was used evaluate question 3, which asked about the convergent validity of the DAAP. The LSK variable was found to be significantly related to rime, coda, and vowel of the DAAP, but not significant to onset of the DAAP. This is qualified by the fact that the association between onset and LSK was .65, which was actually slightly larger than the .64 for rime and coda. In other words, all of the correlations estimated were quite large in magnitude, and the lack of significance between onset and LSK was likely due to the small sample size of the study. Consequently, this study provides evidence for the convergent validity of the DAAP consistent with the results of Barker et al., 2014.

Limitations and Future Directions

The results of this study may have been affected by several limitations. First, as described previously, participants were given different assessments phonological awareness. Specifically, five participants were given sound matching from the CTOPP-2 (Wagner, Torgesen, Reshotte & Pearson, 2013) and two participants were given initial sound matching and final sound matching from the PPA (Williams, 2014). These measures were similar in that they both used pictures for children to respond, provided a spoken target word, and asked children to choose the picture of the word that started or ended with the same sound as the target. Unfortunately, the items were

different, the number of questions were different, and the ceiling rules were different. Analyzing the percent correct was the best way to make outcomes on these measures equivalent. This notwithstanding, the fact that two different measures of sound matching were used could explain, at least in part, the inconsistent outcomes for the initial analyses. Consequently, caution should be used when interpreting this result.

Clearly, the small sample size also was a limitation of this study. Because of this, bootstrapped 95% confidence intervals were used around the correlation estimates to help interpret results. Indeed, many of the results reported here did not reach conventional levels of statistical significance and only showed significance when inspecting the 95% confidence intervals. This would be expected in an underpowered design. With a larger sample size, the correlations would more likely reach conventional levels of statistical significance.

Third, this study did not include a measure of receptive language. Receptive language refers to the ability of listening and understanding expressive language (ASHA, n.d.). Research reports that effective literacy includes all language capacities (Burns & Smith, 2011). A receptive language assessment, such as the Peabody Picture Vocabulary Test – 4th edition (PPVT-4; Dunn and Dunn, 2007), would have been ideal to include in this study. The variable of receptive language, letter sound knowledge, and subscales from the DAAP may have been found to be strongly correlated and would have provided an additional indicator of convergent validity.

Lastly, the DAAP may be too long for children with limited attention spans. Each subtest of the DAAP includes between 6 and 18 blocks of 6 trials. This means that for a single administration of a single subtest, participants may complete 36 to 108 trials depending on how many answers are correct or incorrect. Importantly, because of the dynamic nature of the DAAP, participants who need more support, and thus have more difficulty with the assessment, often

take more time and have to respond to more stimuli. This may lead to frustration and ultimately withdrawal from the assessment. Future versions of the DAAP could include the option of no response. For example, if the participant does not answer the question in 10 seconds, the no response button could be pressed by the administrator. A ceiling rule could also be in place to ensure the assessment is completed in a timely matter.

Conclusion

Nonverbal assessments of phonological and phonemic awareness for individuals with complex communication needs are limited. Valid and reliable phonological and phonemic assessments are especially needed in this population to identify appropriate intervention approaches. The DAAP was created exactly for this purpose. Minimal literacy skills such as letter sound knowledge can give children with CCN the opportunity to communicate and generate their own messages, instead of being reliant on vocabulary provided by others. The findings of this study are consistent with those found in previous studies (Barker, et al., 2014). Although this study found evidence that the DAAP was reliable and valid for children with CCN, future studies should aim to include a receptive language task and shorter assessment duration.

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Table 1

Participant Characteristics and Scores

Child	Sex	Age (Years)	Diagnosis	Race	DAAP				SM-First	SM-Last	LSK	SM-Chance
					Onset	Rime	Coda	Vowel				
1	Female	9.8	Epilepsy; Developmental Delay	Not Reported	2.5	1.8	3.0	1.2	38%	15%	25	> Chance
2	Female	9.7	Mosaic Down Syndrome	Not Reported	1.5	1.3	0.5	N/A	54%	0%	20	> Chance
3	Male	4.4	Apraxia; Expressive Language Delay	Caucasian or White	0.0	0.0	0.0	0.0	23%	0%	8	≤ Chance
4	Female	4.6	Apraxia; Chromosomal Anomaly	Caucasian or White	2.0	0.0	1.0	0.0	0%	0%	17	≤ Chance
5	Male	6.1	Down Syndrome	Other/Multi-Racial	0.0	0.0	0.0	N/A	31%	0%	25	≤ Chance
6	Female	10.6	Down Syndrome; Apraxia of Speech; Autism	Caucasian or White	0.0	0.0	0.0	0.0	20%	20%	5	≤ Chance
7	Male	12.1	Autism	Caucasian or White	3.0	3.0	2.8	2.7	50%	50%	26	> Chance

Table 2

Syllable Pairs for Each DAAP Subtest

Onset	Rime	Coda	Vowel
mat/sat	kog/kib	mot/mog	kog/kag
mib/sib	sog/sib	sot/sog	sog/sag
mob/sob	nog/nib	rot/rog	nog/nag
mup/sup	tog/tib	tep/tek	tog/tag
min/sin	mog/mib	nep/nek	mog/mag
med/sed	pog/pib	fep/fek	pog/pag

Table 3

Item and Subscale Reliability

	Onset	Rime	Coda	Vowel[a]
Onset	.97	.90	.95	.87
Rime	.82 (.32 – 1)	.98	.92	.99
Coda	.91 (.80 – 1)	.85 (.13 – 1)	.96	.90
Vowel	.78 (.56 – 1)	.99 (.98 – 1)	.84 (.69 – 1)	.99

Note. Values on the diagonal are the alpha for the items within the subtest. Values above the diagonal are alphas between the subtests. Values below the diagonal are bivariate correlations between the subtests. Values in parentheses are bootstrapped 95% confidence intervals; those that do not contain 0 are statistically significant.

[a] Based on $n = 5$

Table 4

Associations between DAAP Subtests and other Measures

	SM-First	SM-Last	SM-Chance	LSK
		Onset		
r	.34	.54	.76	.65
p	.46	.21	.05	.12
Lower 95% CI	-.51	-.54	.24	-.10
Upper 95% CI	.97	.93	1.00	.99
		Rime		
r	.75	.76	.91	.64
p	.05	.05	.00	.12
Lower 95% CI	.55	-.26	.79	.24
Upper 95% CI	.99	1.00	1.00	.98
		Coda		
r	.38	.66	.75	.64
p	.40	.11	.05	.12
Lower 95% CI	-.61	-.45	.13	.13
Upper 95% CI	.95	.98	1.00	.99
		Vowel[a]		
r	.87	.89	.89	.81
p	.06	.04	.04	.10
Lower 95% CI	.71	.11	.75	.72
Upper 95% CI	1.00	1.00	1.00	1.00

[a] Based on *n* = 5
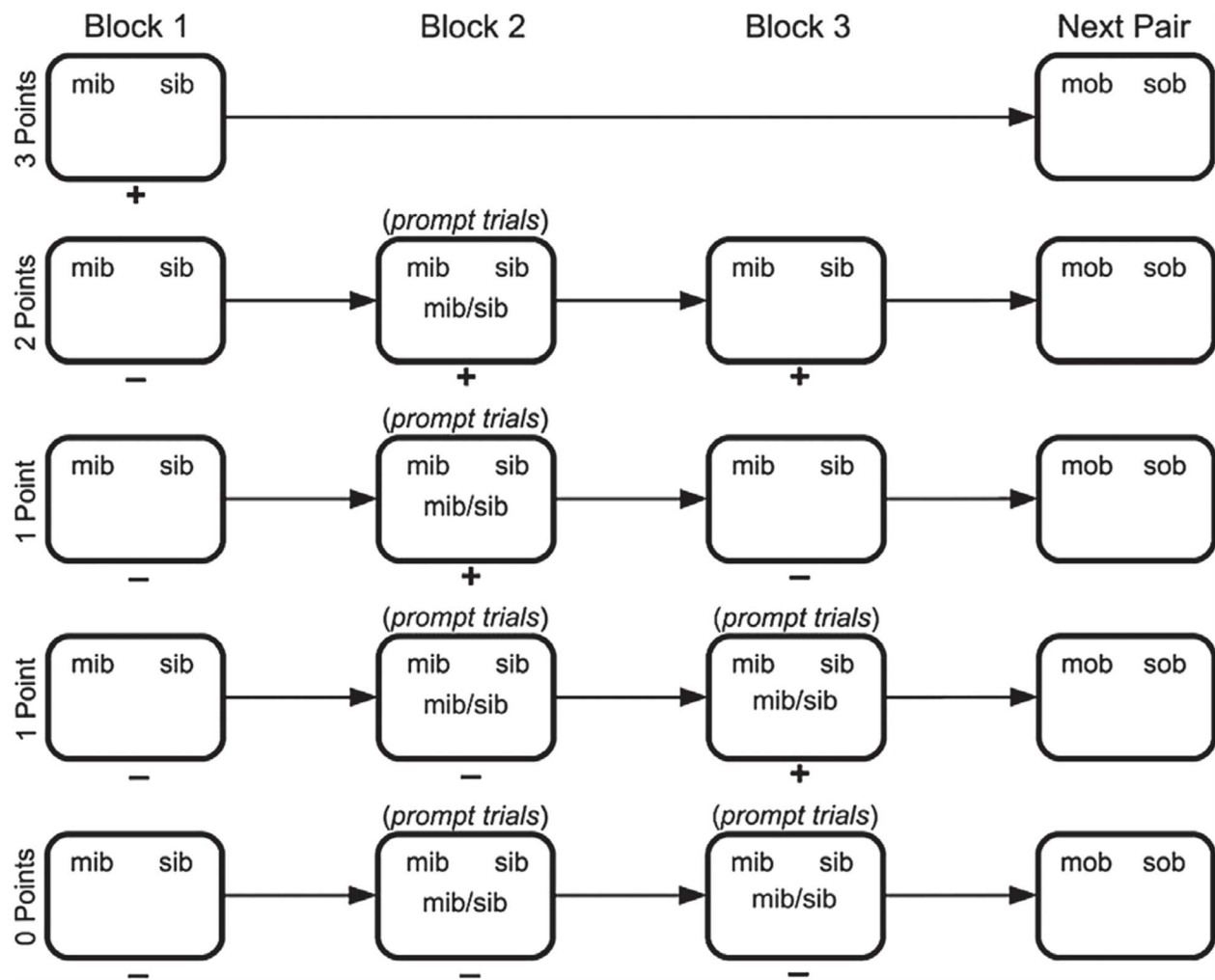
Figure 1 depicts scoring as a function of each possible pathway through the blocks for the syllable pair, mib/sib.

Appendix: IRB Approval

USF
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RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 ● Tampa, FL 33612-4799
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11/18/2016

Robert Barker, Ph.D.
Communication Sciences and Disorders
4202 E Fowler Ave, PCD 1017
Tampa, FL 33620

RE: **Expedited Approval for Continuing Review**
IRB#: CR3_Pro00014854
Title: Validity of a Non-speech Computerized Assessment of Phonemic Awareness across
        Children with Different Language Profiles

Study Approval Period: 11/27/2016 to 11/27/2017

   Dear Dr. Barker:
   On 11/18/2016, the Institutional Review Board (IRB) reviewed and
APPROVED the above application and all documents contained within including
those outlined below.

**Approved
Item(s): Protocol
Document(s):**
     Comp PA Assessment protocol 2014-04-22 V#2 Clean.docx

Consent/Assent Document(s)*:

Informed Consent CAPA Validity Clinic 2014-04-22 V#2 Clean.docx.pdf
Informed Consent CAPA Validity Schools (HOST) 2014-04-22.docx.pdf
Informed Consent CAPA Validity Schools 2014-04-22 V#2 Clean.docx.pdf

   *Please use only the official IRB stamped informed consent/assent document(s) found
under the "Attachments" tab on the main study's workspace. Please note, these consent/assent

document(s) are only valid during the approval period indicated at the top of the form(s) and replace the previously approved versions.

The IRB determined that your study qualified for expedited review based on federal expedited category number(s):

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Per CFR 45 Part 46, Subpart D, this research involving children was approved under the minimal risk category 45 CFR 46.404: Research not involving greater than minimal risk.

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with USF HRPP policies and procedures and as approved by the USF IRB. Any changes to the approved research must be submitted to the IRB for review and approval by an amendment. Additionally, all unanticipated problems must be reported to the USF IRB within five (5) calendar days.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

John Schinka, Ph.D.,
Chairperson USF Institutional
Review Board