ADMINISTERING ARTICULATION ASSESSMENTS ON THE IPAD®

by

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A THESIS

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ABSTRACT

The purpose of this study is to investigate the significance of technology as a time- and a resource-saver. Children between the ages of 2 years, 5 months and 5 years, 11 months had their speech sound abilities assessed using the *Goldman-Fristoe Test of Articulation* (GFTA-3; Goldman & Fristoe, 2015). The administration of the assessment took two forms: (a) the iPad® method, and (b) the hard copy method. Raw scores were compared between the two methods to determine reliability. In addition, time to administer and time to score each assessment was compared between the two methods. Finally, the influence of a child's experience with the iPad® was assessed with the frequency of redirections and imitations during the administration of the iPad®. Results showed that, when compared to the traditional hard copy version of assessment, the iPad® is a reliable instrument and will exhibit the same raw score. Results also showed that the time to administer each test did not differ, but the iPad® saves time because the scoring is fully automatic. Finally, results showed that a child's familiarity with an iPad® at home as measured in days per week and minutes per sitting was not related to an increased time in testing, but was related to more redirections required for the iPad® assessment. Overall, the iPad® is a reliable and valid assessment tool that can save the clinician time in scoring the assessment while still establishing articulation abilities of the child.

DEDICATION

This project is dedicated to the research subjects and their families who took their time to help make this project possible. In addition, it is dedicated to all of the wonderful individuals with communication disorders who inspire me each and every day to provide the best evidence-based practice to serve them.

LIST OF ABBREVIATIONS AND SYMBOLS

Arizona	*Arizona Articulation Proficiency Scale – 3rd Revision*
ASHA	American Speech-Language-Hearing Association
CAAP-2	*Clinical Assessment of Articulation and Phonology – 2nd Edition*
GFTA-3	*Goldman-Fristoe Test of Articulation – 3rd Edition*
p	Probability associated with the occurrence under the null hypothesis of a value as extreme as or more extreme than the observed value
SLP	Speech-Language Pathologist
SPAT-D	*Structured Photographic Articulation Test II featuring Dudsberry*
SSD	Speech Sound Disorder
t	Computed value of a t-test
<	Less than
=	Equal to

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CHAPTER 1

INTRODUCTION

Speech Sound Disorders

A speech disorder is defined as oral and verbal communication that is so deviant from the norm that it interferes with communication. Speech disorders can be divided into voice, fluency, or speech sound disorders (Bauman-Wangler, 2012). According to the American Speech-Language-Hearing Association (2015), speech sound disorders consist of problems with articulation (making sounds, such as substituting /p/ for /f/) and phonological processes (sound patterns, such as final consonant deletion). In the field of Speech-Language Pathology, preschoolers who have speech sound disorders (SSD) constitute about 75% of the population served by Speech-Language Pathologists (SLPs) in preschools and other settings (Mullen & Schooling, 2010). Furthermore, preschoolers with SSD are sometimes unintelligible to those other than family members, and may be at risk for further delays in literacy (Brumbaugh, 2013).

Assessment in Speech Pathology

Typically, standardized assessments are used to diagnose the presence of a disorder and it is a SLP who must accurately administer those assessments. Because a child's speech sound errors could be articulatory or phonological in nature, the presence of phonological patterns must be identified to properly diagnose a phonological disorder. Categorizing a speech sound disorder precisely and accurately can be justified because a correct diagnosis guides therapy. In other words, a problem must first be properly identified before it can be addressed. There are many different assessments to choose from when diagnosing a child with SSDs. Conducting a quick

and accurate assessment for a SSD is important for several reasons. First, articulation and phonological disorders constitute a relatively broad range of speech-language pathologies, and a variety of assessments are needed to reach a proper diagnosis. Second, articulation disorders can have an adverse effect on other aspects of language development. A child who feels embarrassed about communication might even choose to avoid social communication with peers. Third and finally, a SLP with a heavy caseload can benefit from a diagnostic instrument that is relatively quick while maintaining a standard of accuracy. Therefore, it is important that assessments be efficient as well as accurate, due to the limited time and resources of speech pathologists, specifically those in school settings (including preschool settings) who see articulation clients quite often.

Many SSD assessments measure production of single words in isolation in addition to sounds in continuous or connected speech, as part of either sentence repetition or storytelling tasks, for example a picture description task. Although testing the single-word production may not offer as in-depth of an analysis as connected speech does for a child's speech sound production (Andrews & Fey, 1986; Bernhardt & Holdgrafer, 2001), there are a few disadvantages to using connected speech sampling exclusively. For one, time is an imperative resource for a SLP, and transcription and analysis of a connected speech sample requires more time than may be available in most clinical settings (Bleile, 2002). In addition, a sufficient sample may be difficult to obtain because children may be reluctant to talk, and might choose to avoid what they perceive as more difficult words during conversation. Therefore, children likely will not provide an adequate inventory of speech sounds in a limited sample of conversational speech. Finally, although assessment of a child's connected speech can provide more in-depth

understanding of a child's SSD, for an initial diagnosis, a speech-language pathologist is more likely to focus on the production of single words in isolation.

A primary benefit of single-word assessments is that they provide norms for identifying SSD, which can be used to qualify children for therapy (Skahan, Watson, & Lof, 2007). Assessment norms allow a SLP to convert a raw score to a standard score, which in turn permits the SLP to compare the performance of a particular client to age- and gender-matched peers. Therefore, it is essential that SLPs have a variety of assessments at their fingertips for deciding what is most appropriate for a client. The SLP administers and scores each assessment in accordance with the procedures outlined by the assessment developer. Results can be integrated with other sources of information acquired during evaluation to arrive at an accurate assessment of the child's speech sound abilities (McCauley & Swisher, 1984).

Assessment measures. Most norm-referenced standardized assessment tools in the field of speech-language pathology have multiple measurements to compare the client to their same-age peers for reference. One measure is the raw score, which is the total number of errors the clinician counts during the assessment. The raw score can then be combined with the child's age and converted to a standard score, or a score based on a scale with a mean of 100, which allows the comparison across different tests and between peers (Jackson, 2015). In addition, these assessments can provide a percentile rank, which indicates the percentage of individuals in the normative group who performed at or below the client's level (Texas Speech Language Hearing Association, 2010).

Standardized Assessment of Articulation and Phonological Development

The assessments listed in Table 1 are the most commonly used assessments at the University of Alabama Speech and Hearing Center to analyze articulation and phonology

abilities in children, adolescents, and young adults. There are four well-known assessments for articulation and phonology that speech pathologists typically use: (a) The *Clinicial Assessment of Articulation and Phonology – 2nd Edition* (CAAP-2), (b) The *Goldman-Fristoe Test of Articulation – 3rd Edition* (GFTA-3), (c) The *Arizona Articulation Proficiency Scale – 3rd Revision* (Arizona), and (d) The *Structured Photographic Articulation Test II featuring Dudsberry* (SPAT-D). While each of these assessments is used to assess a child's speech sound inventory, each is different. In particular, the GFTA-3 and the CAAP-2 provide SLPs with the ability to analyze speech sounds to reveal phonological processes. In each of these assessments, the client is presented with a variety of pictures whose names consist of a variety of sounds (i.e., "duck" and "cage") to allow the SLP to accurately assess each phoneme across different positions within a syllable.

Table 1

Comparison of Articulation and Phonology Tests

	Test Measurements	Age Range able to be tested	Time to Administer	Estimated Time to Score (depending on total number of errors)	Methods of Assessment
CAAP-2	Articulation in words and in sentences, phonological processes	2 years, 6 months – 11 years, 11 months	15 – 30 minutes	10 – 25 minutes	iPad® and Manual Test Easel
GFTA-3	Sounds in Words, Sounds in Sentences, stimulability, phonological processes*	2 years – 21 years, 11 months	15 – 30 minutes	15 – 45 minutes (depending on KLPA-3 portion)	iPad®, Web-based on computer, and Manual Test Easel
Arizona	Articulation in words (with optional Language Screening)	1 year, 6 months – 18 years	5 – 15 minutes	5 - 15 minutes	Manual Test Easel
SPAT-D	Articulation in words and connected speech, stimulability, phonological processes	3 years – 9 years	10 – 25 minutes	15 – 30 minutes	Manual Test Easel

*Phonological Processes can be measured with the Khan-Lewis Phonological Analysis, Third Edition (KLPA-3)5

When choosing a specific assessment, it is also important to consider the client who is being assessed. The client's age, for example, is an important factor in the decision of which assessment a SLP might prefer to use. The Arizona provides black and white pictures, more suitable for older children. The SPAT-D includes pictures of a Golden Retriever puppy demonstrating several activities, which targets younger children. The CAAP-2 has more cartoon-like pictures, which also appeal to a younger client. The GFTA-3 provides two options for presenting picture plates: animation-like pictures for younger children up to age 6 years 11 months, and more photographic-type pictures for children over 7 years of age who may not be interested in pictures targeted for younger children.

The administration of each of these four assessments is fairly similar: an easel or iPad® faces the client with the picture plates, and directions for administration face the SLP. Directions are read aloud to the client before the assessment begins, and each assessment has similar instructions: "Tell me the picture that you see." The Arizona and SPAT-D, include instructions for the SLP to ask the child, such as "What is he doing?" or "What color is it?" to elicit responses other than simply the picture shown. If a picture is shown and the child does not know the specific word targeted, the SLP may provide a prompt, done in the CAAP-2. For example, if there is a picture of a duck and the client does not know that word, the SLP might prompt, "it says quack." Indirect models might also be used. For example, when the client is shown a picture of a watch, the SLP might direct "This is a watch. It tells time. What is it?" This direction gives the client the answer but prevents a direct imitation that may influence how a client articulates his or her response. Once a client produces the target word, it can be transcribed in the International Phonetic Alphabet, which is a phonetic system that uses a set of symbols to represent each sound that exists in spoken language (International Phonetic Alphabet, 2015).

Each of the identified four standardized assessments is norm-referenced, which provide the clinician the ability to compare the child's performance with the performance of a normative group. Each assessment also identifies speech sounds at both the initial and final positions of sounds in words, with the SPAT-D and GFTA-3 assessing the medial position as well. Each of these assessments, except for the Arizona, includes an inventory chart that reveals the sounds produced by a child regardless of correctness relative to the target, as well as providing the set of sounds available to the child for forming words (Eisenberg, 2010).

Considering the *Time to Administer* and estimated *Time to Score* of each assessment listed on Table 1, diagnosing either an articulation or phonological disorder in a child can be a lengthy process. For example, if the GFTA-3 is administered and the SLP chooses to fill out the Khan-Lewis Phonological Analysis, Third Edition (KLPA-3) portion to determine phonological processes, the total time spent determining and interpreting the assessment scores can be over an hour and a half. The KLPA-3 uses the client responses from the GFTA-3 to determine if a phonological process is present based on patterns of sound errors, so both are appropriate for one diagnosis. For SLPs with 50+ children on their caseload, this can negatively affect the time available for other clients. Fortunately, a SLP has options for administering an assessment, for example, the more common hard copy assessment easel or computer-based options such as the GFTA-3 for the iPad® applications.

The Use of Technology in Speech Therapy

The benefits and significance of multimedia technology in the learning environments such as convenience and ease of delivery has been well established in both the educational and clinical settings (Programme of International Student Assessment, 2005; Kozma, 2008). However, in addition to the use of technology in learning environments such as the iPad®,

families are also providing these technologies as a source of entertainment at home. The National Association for the Education of Young Children (2012) outlined the negative effects of technology overuse with young children, citing decreased academic performance, an impact on language development, behavior issues, and focus and attention problems. When students in Australia were asked what they liked about technology devices in the classroom, Lynch and Redpath (2012) noted that all students interviewed responded that they liked the 'games'. Thus, these children had to have designated tasks and application to apply structure within the classroom. However, while there have been many warnings against technology and its negative effects on children's learning, it is thought that the educational content is what matters—not necessarily the format in which it is presented (e.g., Wainwright & Linebarger 2006). Thus, with technology on the rise in homes, work settings, social settings, and even educational settings, it is important to consider the use of these tools for educational purposes. Such technologies are playing an increasingly important role in speech therapy. For example, new technologies can be used as a diagnostic or post-testing tool, and in some cases, they can be motivating for children undergoing assessment. One such technology is the use of the iPad® in standardized assessment.

Some important uses of the iPad® applications for both assessment and treatment are articulation drilling and story-telling. Interactive games, for example, allow a child to spin a wheel to land on a word, thus creating a story that the iPad® reads aloud, encouraging a child to imitate. The story produced by the child provides data for the SLP to collect to evaluate target sounds. Another use for iPad® applications can allow a child to direct a character to repeat what the child has already said, providing important feedback to the child regarding consistency with the adult form. Other iPad® applications encourage spontaneous storytelling as well. For

example, a child can drag certain pictures around on an iPad® screen, creating a series of images for a child to narrate.

Although computer-based technologies can be a valuable tool for speech therapy, there are drawbacks to consider. Robin (2008) emphasizes the importance of a SLP's knowledge and experience in effectively motivating and engaging clients, which are skills that do not come with new technologies but with base knowledge and experience. Additionally, young children who are familiar with the iPad® or other computer-based systems may respond inappropriately to the technology being used in therapy. For example, a child might associate the iPad® with gaming and playtime, which could diminish the efficacy of speech therapy intended by the SLP.

Although there are both positive and negative aspects of using technology during therapy, each client's abilities and experiences must always be considered when utilizing a new tool. Oud (2009) suggests that for the implementation of technology, supportive strategies include focusing content around clear goals, simplifying the content, presenting the content so that it is easy to understand and complete, and most importantly, directing attention to the most important points using visual and verbal cues. Focusing content around specific goals is important so that unnecessary work is not required of the child, which could cause the child to become tired or distracted. Simplifying the content is also important to prevent the child from becoming over stimulated by an overwhelming amount of content. Content that is too difficult for the child to understand could create conditions in which a child could give up easily or be less likely to stay on task.

Using the iPad® for Test Administration and Scoring

Administration on the hard copy assessment easel is different than administration on the iPad® in some important ways. For example, a SLP must have an assessment protocol and an

assessment easel while giving an assessment, whereas for the iPad® administration, only the iPad® itself is needed for the assessment (an assessment protocol is still required to record answers from the client for the CAAP-2). For hard copy administration, the SLP must turn pages and use questions and prompts to elicit the target word from the client, then transcribe the client's response onto the assessment protocol. For iPad® administration, a button or finger swipe can be used to bring about the next image. On the CAAP-2 application, an automated prompt from a voice on the iPad® may be used by tapping a picture, if needed. The GFTA-3 application for iPad® allows a SLP to tap on a specific sound in the word and to transcribe the word using a stylus.

Assessment scoring also differs between the hard copy and iPad® versions. For the hard copy, each word whose target sound was made in error by the client is counted, providing a raw score (i.e., a count of correctness) which can be converted to a standard score (i.e., a number scaled to the norm), percentile rank (i.e., the percentage of children the client score equal to or better than), and age equivalent (i.e., an estimated equivalent of the child's abilities based on the age norms), which are all found in the assessment hard copy. The SLP must calculate each of these scores by hand, for which there is a likelihood of error. The iPad® scoring, however, is more automatic and reduces some of the possibility for error. The GFTA-3 application automatically produces a score based on the phonemes entered during the administration, from which it calculates the raw score, standard score, percentile rank, and age equivalent. The CAAP-2 application requires the SLP to input errors from a list of the target words on the iPad®, which then generates the raw score, standard score, percentile rank, and age equivalent. The GFTA-3 application automatically converts the SLP's input during administration to a raw score,

standard score, percentile rank, and age equivalent. Overall, iPad® administration for the CAAP-2 as well as the GFTA-3 significantly lessens the assessment requirements of the SLP.

Finally, any direct benefits to the SLP are important to consider when giving an assessment on the iPad®. If the SLP is in control of the technological mode, the client will be unable to direct the assessment. Therefore, the assessment can be controlled and each picture stimulus will be seen. For example, the CAAP-2 iPad® version utilizes a two-finger swipe for navigating to the next picture, preventing a client from swiping to the next picture himself. Thus, an SLP has many selections when it comes to therapy and assessment tools. However, with the limited time and resources given to an SLP, these selections must be made carefully so that the SLP can maximize the efficiency of these tools. With the combination of technology and therapy, the SLP can save time and resources, and increase the overall quality of therapy.

CHAPTER 2

AIMS OF RESEARCH

I. The first aim is to compare the reliability of administration of the GFTA-3 on the iPad® versus the hard copy. It is predicted that overall assessment performance as measured by raw score will not differ statistically between these two methods.

II. The second aim is to compare the time required to administer the GFTA-3 on the iPad® versus the hard copy. It is predicted that time to administer the GFTA-3 will not differ between the iPad® and the hard copy.

III. The third aim is to compare the time required to score the GFTA-3 on the iPad® versus the hard copy. It is predicted that time to administer the GFTA-3 will be significantly less for the iPad® than the hard copy.

IV. The fourth aim of this study is to assess the impact of children's experience with the iPad® at home on assessment administration of the iPad® version of the GFTA-3. It is predicted that (a) the amount of time spent in one sitting on the iPad® and (b) how many days per week a child uses their own iPad® will both affect time required to administer the GFTA-3 on the iPad®.

CHAPTER 3

METHODS

Design

Children attending The University of Alabama Child Development Research Center (CDRC) and children scheduled for therapy at The University of Alabama Speech and Hearing Center were invited to participate in this research study, with 29 children participating in the final data collection period. Parents were informed that their child's speech sounds were to be evaluated on two occasions, seven days apart, to accurately assess the child's speech sound inventory with each method while avoiding the child becoming familiar with the picture plates. All parents or caregivers signed a consent form, in accordance with the Institutional Review Board at the University of Alabama. Children were also asked if they would like to participate in this study, and either the SLP research student or supervisor signed the assent form upon the child's verbal approval (see Appendix D).

On the first assessment visit, each participant was randomly assigned to an assessment measure: either the iPad® or the hard copy method for administration of the GFTA-3. On the second visit, the other method was administered. Each method is identical with some exceptions. Administration of pictures on the iPad® was achieved with two iPads®. The client had one iPad® that only showed the picture plates, and the SLP had another iPad® to use for transcription of the child's utterance. In between each transcription, the SLP pushed a button to navigate to the next picture. Transcription was completed by pressing the button of a specific phoneme within the target word, revealing a list of phonetic and diacritic symbols. The SLP

chose the target sound that was substituted, the symbol for omission, or the symbol for distortion to replace the target sound with the sound produced by the client.

To accomplish assessment administration for the hard copy method, the SLP turned through pictures on an assessment easel and transcribed the responses by hand on an assessment protocol. To score the iPad® method of assessment, the errors were entered into the iPad® during administration, and the procedure for generating raw and standard scores through this method was fully automatic upon completion of the assessment. The hard copy method required the SLP to convert the total errors into raw and standard scores using the tables in the examiner's manual of the assessment.

Procedures

First, two graduate students from the Speech and Hearing Center at the University of Alabama reviewed the hard copy and iPad® methods in addition to viewing an online training seminar from the publishers of the GFTA-3. The graduate students recruited participants in the lobby of the CDRC using an IRB-approved recruitment script, as children were picked up by their parents (Appendix A). Parents from the Speech and Hearing Center were asked if they would like to participate in the study upon visiting the Speech and Hearing Center using the same recruitment script (Appendix A). Parents were informed that choosing not to participate in the study would not adversely affect the quality of treatment received from the Speech and Hearing Center. If the parent consented, two appointments were made to assess the child's speech sound errors using the iPad® and hard copy versions of the GFTA-3, each administered within seven days of each other. If the child was recruited from the CDRC, the SLP obtained special permission to administer the assessments during the school day to prevent any inconvenience to the parent. Two trained graduate students earning a Master's of Science degree

in Speech-Language Pathology assessed the children using the GFTA-3 *Sounds in Words* to determine speech sound errors.

Process of Gaining Consent. If a parent indicated that he or she was interested in participating, a consent form was presented (see Appendix B). The examiner explained in detail the specific types of information that was used in the study, including the measures of speech sound disorders. The parent was informed that participation only required a maximum of two visits within a seven-day period. It was made clear to the parent that participation in the study is voluntary, and he or she may decide to stop participating at any time. Then, the parent or caregiver was asked if he or she has any questions about the study. Obtaining one signature on the consent form from a caregiver is most feasible due to the daytime work hours of the Speech and Hearing Center and CDRC, when only one caregiver may be available.

After signing the consent form, parents were asked to provide background information about their child, using the intake form (Appendix E). This included: (a) the child's birth date, (b) if and when they first noticed that their child may have a speech sound disorder, and (c) whether the child received treatment in the past year. Once parents have given consent, children were asked to provide assent. The assent form (see Appendix D) was read to the child, asking if he or she would like to look at pictures in a picture book. Children were told they could discontinue looking at the pictures at any time.

Process of Assessment Administration. Children were assessed in terms of their speech sound ability for the purposes of this study. The order of administration (iPad® or hard copy) was counterbalanced across participants. Once the order of administration was determined, the child was administered the GFTA-3 *Sounds in Words*, during which the administrator identified speech sound errors from transcribed productions of the child. Administration of each method

was audio-video recorded using a single camera. The assessment administrator used recordings for review of the assessment, to measure the duration of the assessment administration, and to note the number of times the administrator redirected the client (see Appendix C). Scoring of identified speech sound errors took place immediately after assessment administration. This included producing both 1) a raw score based on the number of speech sound errors and 2) converting the raw score into a standard score, percentile rank, and age equivalent. The SLP then reviewed the videotaped assessment and complete the *Client Response to Testing* rubric (Appendix F). This rubric includes a table for the clinician to measure the number of imitations and redirections as well as additional comments regarding that client. Imitations were defined as a direct imitation from the clinician following the client's unsuccessful attempt to independently identify the presented stimulus or identify the stimulus following an indirect model separated by a sentence including a semantic cue. Redirections were defined as any verbal or non-verbal attempt by the clinician to refocus the client on the assessment. The entire procedure was repeated seven days following the first administration using the other assessment method (iPad® or hard copy).

Measures

After each administration, the client's age, the client's gender, the assessment method, the achieved raw score, standard score, percentile rank, and age equivalent—as judged by the SLP based on the client's behavior during testing time—were all entered into an Excel database. Measures were also included from the iPad® familiarity form (see Appendix G). These measures included how many days per week the child spends playing on his or her personal iPad® at home, whether he or she uses instructional applications, game applications, or both, how much

time he or she spends on the iPad® in each sitting, and whether he or she has free or limited access to his or her personal iPad®.

Analysis

Within-subject comparisons were conducted with mixed model analyses using R statistical software (R Development Core Team, 2009) with the statistical package lme4 (Bates & Mächler, 2009). Degrees of freedom were calculated based on the Satterthwaite approximation using the statistical package lmerTest (Kuznetsova, Brockhoff, & Christensen, 2012). For each model, independent variables of interest were used in the base model to predict the dependent variable. These included Age, Sex, and Order of administration. Interactions were also considered and were kept in a model if significant.

First, raw scores from the *Sounds in Words* were compared between the iPad® and the hard copy methods to determine reliability between these two administration methods. Second, the time required to complete assessment administration was compared between the iPad® and hard copy methods. Third, the time required to count errors and convert to raw score, standard score, percentile rank, age equivalent, confidence interval, and growth scale values were compared between the iPad® and the hard copy methods. Finally, the data collected from the iPad® familiarity form (see Appendix G) was used to determine how the assessment administration was influenced by experience with an iPad® at home. Table 2 lists the means of performance by gender as well as other measures for this study.

Table 2

Participants

	Participants (*n*=29)	
	M	*SD*
Chronological Age (In Months)	46.28	8.84
Gender		
Female	12	--
Male	17	--
GFTA-3 (Raw Score)	27.02	18.14
Female	25.38	19.88
Male	28.18	17
Assessment Administered First	--	--
iPad®	15	--
Hard Copy	14	--
Imitations	3.97	5.03
iPad®	3.45	4.42
Hard Copy	4.48	5.60
Redirections	4.09	5.69
iPad®	4.69	6.37
Hard Copy	3.48	4.97
Days Spent on iPad® at Home	4.24	1.99
Minutes Spent on iPad® per Sitting	19.13	7.84
SSD Previously Identified	4	--

Reliability Measurement. Two graduate clinicians from the University of Alabama received the same training through a webinar from the Pearson website and three practice runs of the GFTA-3 on the iPad® and hard copy versions of administration. Following the analysis, reliability between two clinicians was measured using 20% of the completed GFTA-3 assessments, both hard copy and iPad®. The correlation coefficient was 0.99, or 99% reliable.

CHAPTER 4

RESULTS

Preliminary Analysis

A common method to evaluate whether two independent assessment procedures produce the same measure is the Bland-Altman method (Altman & Bland, 1983; Altman & Bland, 1987). For this method, the raw scores of each scoring procedure were plotted for each participant. The scatter of data within the resulting plot could then be visually inspected relative to a line of perfect fit (Figure 1). This plot depicts the strength of the relation between the two variables. In addition, a standard deviation was calculated from the differences between the raw scores of each procedure. The standard deviation calculated from the differences between the two procedures (hard copy and iPad) was 4.23. This value likely reflects the variance associated with different testing conditions for each of the child, not the variance associated with the testing procedures.

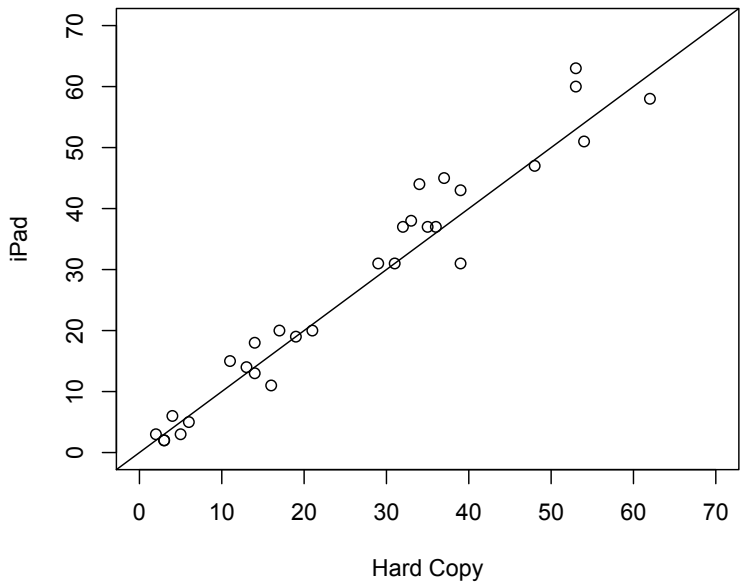

Figure 1. Raw scores of the iPad® plotted versus raw scores of the hard copy of the GFTA-3.

Aim I. It was predicted that overall assessment performance as measured by raw score would not differ statistically between the iPad® and hard copy methods.

There was no statistical difference in raw scores between the iPad® and paper versions of the GFTA-3, $b = 1.61$, $t(24) = 1.79$, $p = .086$. As expected, as children got older they achieved a lower raw score, $b = -0.66$, $t(35) = 3.03$, $p = .005$. There was a statistical significance of gender difference in raw score, $b = 11.69$, $t(29) = 2.80$, $p = .009$, with males having a higher mean raw score (M=28.18) versus females (M=25.38). Also, a higher raw score slightly correlated with a higher number of imitations, $b = 0.70$, $t(34) = 2.48$, $p = 0.02$. However, the number of redirections was not related to raw score, $b = ,0.43$ $t(36) = 1.93$, $p = .062$, but a correlation between number of redirections and raw score is approaching significance.

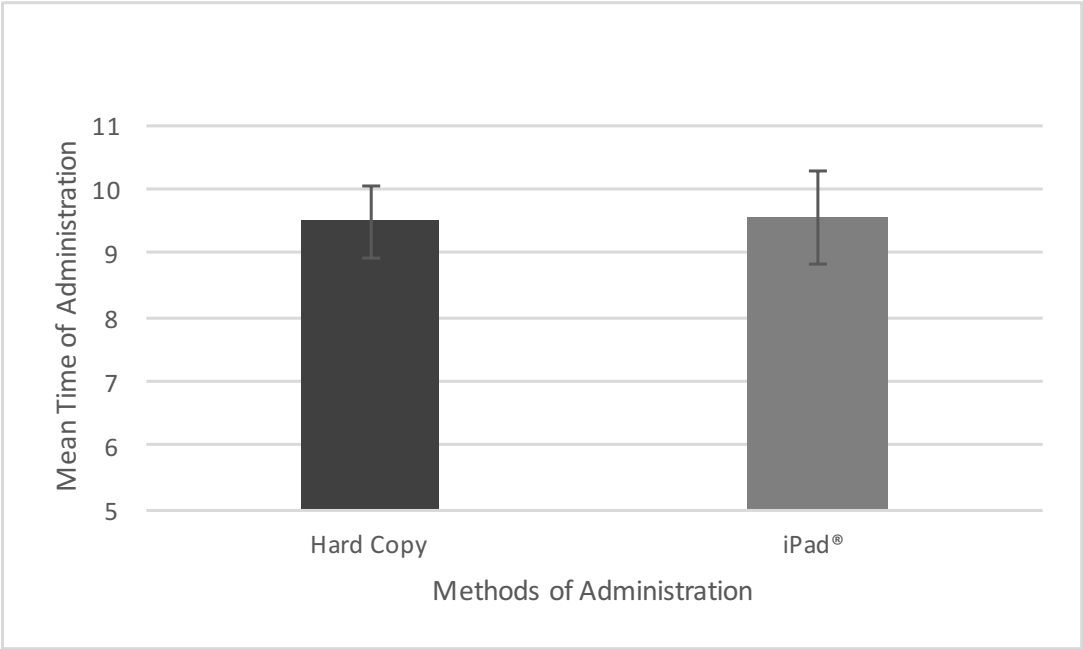

Figure 2. Mean raw scores of the hard copy (M=26.31) and iPad® (M = 27.72) methods.

Aim II. It is predicted that time to administer the GFTA-3 will not differ between the iPad® and the hard copy.

There was no difference between versions regarding time to administer the assessment, $b = -0.60$, $t(28) = .1.51$, $p = .141$ (Figure 2). However, testing time was related to more imitations, $b = 0.25$, $t(51) = 3.53$, $p < .001$, which was more apparent on the iPad® testing time, $b = 0.17$, $t(30) = 2.61$, $p = .014$. More redirections were also related to testing time, $b = 0.26$, $t(46.36) = 6.00$, $p < .001$. Finally, administration time decreased with increasing age of the child, $b = -0.09$, $t(47) = 2.32$, $p = .024$.

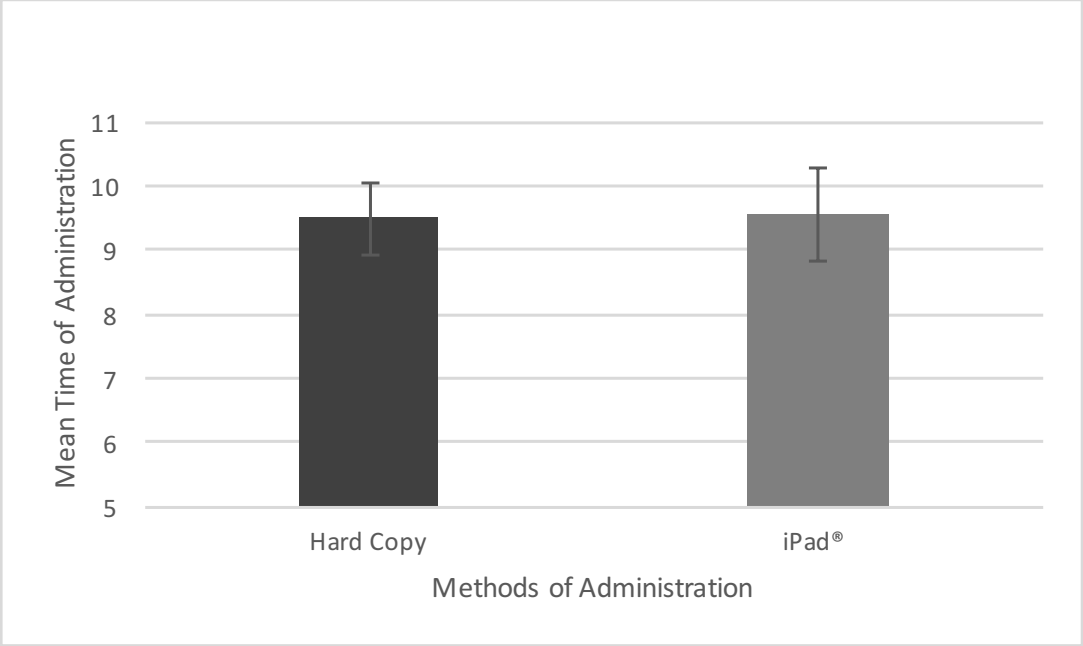

Figure 3. Mean testing time between the hard copy (M=9.48) and iPad® (M=9.53) methods.

Aim III. It is predicted that time to score the GFTA-3 will be significantly less for the iPad® than the hard copy.

Overall, the iPad® required less time to score compared to the hard copy version of the GFTA-3, $b = -3.20$, $t(54) = 16.28$, $p < .001$. In addition, the scoring time was greater as a child had a higher raw score, $b = 0.02$, $t(54) = 2.31$, $p = .025$,

Aim IV. It is predicted that (a) the amount of time spent in one sitting on the iPad® and (b) how many days per week a child uses their own iPad® will both affect time required to administer the GFTA-3 on the iPad®.

The child's familiarity with an iPad® measured in days per week he or she used it at home was not related to time it took to administer the assessment, $b = -0.63$, $t(49) = 1.90$, $p = .07$. Minutes spent on the iPad® per sitting at home also was not related to the testing time, $b = 1.50$, $t(52) = 1.30$, $p = .20$. However, the number of days a child uses an iPad® at home was highly significant with the number of redirections required throughout the assessment, $b = 0.21$, $t(45) = 3.82$, $p = 0.004$. Also, the number of minutes a child spent on the iPad® per sitting at home was slightly related to a lower number of redirections required during the assessment, $b = -0.39$, $t(45) = 2.13$, $p = 0.04$.

CHAPTER 5

DISCUSSION

The purpose of this study was to analyze the feasibility and possible challenges when using an electronic version of a gold-standard articulation assessment, the GFTA-3. Specifically, this study measured the reliability between the *Sounds in Words* subtest of both the traditional hard copy version and the newer iPad® version, the time it takes to both administer and score each version, and whether a child's interaction with an iPad® at home is related to the time it takes to administer the iPad® version of the assessment. These measures were collected from two clinicians administering each version seven days apart to 29 research participants. Each specific aim will be discussed next, followed by a discussion of clinical implications and potential future directions.

Aim I.

First, it was expected that there would be no statistical difference between the raw scores of the iPad® and hard copy versions of the *Sounds in Words* GFTA-3. Indeed, the mean raw score for the hard copy (M=26.31) did not differ from the mean of the iPad® (M=27.72). This indicates that no matter which version of the assessment is chosen for administration, each will yield similar results, thus rendering each version a valid assessment for articulation abilities. The interaction between age and raw score on the GFTA-3 indicated that as a child got older, they achieved a lower raw score. This is expected because older children have a more diverse sound inventory, thus resulting in fewer errors (and a lower raw score). The number of direct imitations a clinician needed to provide to elicit a response was greater with increases in raw score. While

this result is contradictory to Johnson's & Somers's (1978) findings that direct imitation results in less articulatory errors, this could be due to the child's hesitance to participate or that the child was already making articulation errors despite the direct imitation.

Aim II.

Second, the average time to administer the hard copy assessment was 9.48 minutes and the iPad® assessment was 9.53 minutes. There was no difference between these times as each assessment presents the same number of picture stimuli. Each research subject must produce all 60 picture stimuli for the clinician to calculate a raw score and other measures, therefore, it was expected that there would be no difference between the times it took to administer each version. However, there was an increase in testing time based on both imitations and redirections. This is likely due to the clinician encouraging the client to produce the stimuli and redirecting the client's attention back to the assessment, each of which can prolong the assessment. The effect of more imitations contributing to more time to administer was more apparent for the iPad®, which could suggest that a child's behavior on the iPad® version of the assessment required more clinician involvement. In addition, as expected, a child who is older required less time to administer the assessment overall, which is expected because older children make fewer articulation errors.

Aim III.

Third, it was expected that the iPad® would take less time to score, because the scoring for the iPad® is fully automatic. The clinician simply inputs the errors electronically during the assessment, and the iPad® generates the raw score and other measures automatically, leaving no burden of scoring on the clinician. A greater scoring time was related to a higher raw score, which was driven fully by the hard copy version of the assessment due to the iPad®'s

programmed scoring capabilities (regardless of the number of errors measured during the assessment). This was expected because it takes less time to count and convert a lower number of errors.

Aim IV.

Finally, the child's familiarity with the iPad® was expected to be correlated to the overall time it took to administer the iPad® version of the assessment, with the child's use of an iPad® measured using the parent report. Because the number of days and number of minutes per sitting playing on the child's personal iPad® at home did not affect testing time, it can be concluded that if a child is more familiar with the iPad®, there is no correlation with a longer testing time. However, evidence was found that more days using the iPad® at home was related to more redirections during the iPad® version of administration. This could be due to the child wanting to play games instead of look at pictures, pressing the "home" button, or being more familiar with the iPad® as a gaming or video device rather than a tool for therapy. Despite this outcome, it was found that the fewer minutes a child spends on the iPad® at home, the more redirections a child needed. While this might seem to contradict the notion familiarity with the iPad® was related to more redirections (such as the relation between days on the iPad® and redirections), one can speculate that a child is aware of the minute limitation when playing at home, and needs more redirections during the administration to use it as an assessment tool rather than a gaming tool. However, more evidence is needed to explore this further.

Clinical Implications

Table 3 identifies the differences in means for each measure between the neurotypical children and the children who were previously identified to have a SSD prior to this study.

Table 3

Neurotypical versus children with a previous SSD

	Neurotypical (*n*=25)		**Children with SSD (n=4)**		***p***
	M	*SD*	*M*	*SD*	
GFTA-3 (Raw Score)	24.12	17.82	40.00	9.01	<.001
Time to Administer	--	--	--	--	
Hard Copy	9.08	2.38	12.00	3.83	.161
iPad®	8.88	2.818	13.63	7.23	.060
Time to Score (Hard Copy Only)	2.88	0.73	5.00	1.41	.001
Imitations	--	--	--	--	
Hard Copy	3.8	5.01	8.75	8.00	<.001
iPad®	2.76	3.54	7.75	7.32	<.001
Redirections	--	--	--	--	
Hard Copy	2.68	3.57	8.5	9.47	.012
iPad®	3.80	4.38	10.25	13.33	.041
Days Spent on iPad® at Home	4.40	1.91	3.25	2.43	--
Minutes Spent on iPad® per Sitting	18.60	7.84	22.50	8.02	--

Table 3 identifies the means for raw score, time to administer each assessment, score the hard copy version (as the iPad® is fully automatic), imitations per administration method, redirections per administration method, and familiarity with the iPad® between neurotypical and children with SSD. Overall, the mean raw scores showed a higher mean for the children with SSD, which is to be expected due to the already identified speech sound disorder. In addition, the mean imitations and redirections for both methods were higher for children with SSD.

Based upon the equivalent raw scores between the iPad® and the hard copy versions of the GFTA-3, it can be concluded that providing an articulation assessment for the *Sounds in Words* subtest of the GFTA-3 is valid despite it being an electronic method of assessment. In addition, providing the assessment on the iPad® can save some time in regards to scoring, as the iPad® scores the assessment automatically based on clinician input. However, it is important to

note that while a child's familiarity with an iPad® at home may not necessarily increase testing time, it may be related to more redirections by the clinician to encourage the client to attend to the assessment. According to Fernandes (2011), 55.9% of school SLPs used an iPad® in therapy, and that number continues to grow. In addition, many participants in this survey (87%) use their iPad® for articulation therapy or assessment (Fernandes, 2011). As long as the SLP has the resources and availability to utilize an iPad® in therapy, it can be useful or even beneficial to use an iPad® in speech therapy. Because iPad® technology is becoming commonplace in therapy settings and reliability of scores is high no matter the assessment method, use of an iPad® for assessment is a resourceful tool for establishing articulation capabilities in children.

Limitations and Future Directions

Given the time restraints for this particular project and the nature of the assessment, a few limitations are worth mentioning. For one, this study was largely conducted on neurotypical children because of the availability of participants. Future studies should focus on both neurotypical and delayed populations in order to assess these results on the populations that SLPs typically see. In addition, with all assessments with human subject, particularly young children, uncontrollable environmental variables that come in to play can affect measures. The child may have been shy, tired, hungry, or experiencing something other than fully engaged with the assessment, which can affect performance and test administration. In addition, information regarding the family's socio-economic status (SES) was not collected, a factor that could have influences a child's experience with the iPad® technology. Thus, future studies investigating assessment methods should include a greater number of subjects, including children with both a speech sound disorder and neurotypical children. Also, future studies should take into account the SES of the family and test any relation with the child's iPad® experience.

CHAPTER 6

CONCLUSION

When choosing an assessment for establishing articulation abilities in a child, there are many options, such as the GFTA-3, CAAP-2, Arizona, and SPAT-D. However, an appropriate assessment must be chosen based on the client's needs and establishing norms for qualification of services. Recently, these options for assessment have been released electronically, providing SLPs the option to administer the assessment in a more convenient manner. Since iPad® technology is being used more in therapy (Prensky 2001), administering assessments on the iPad® is a valid way to establish a speech sound disorder in children. The reliability between the iPad® and hard copy versions of the GFTA-3, a gold-standard assessment, do not differ—therefore, the SLP can confidently administer the GFTA-3 with either version. In addition, the testing time between administrations does not differ because the assessment uses the same picture plates; however, scoring time for the iPad® is fully automatic, which saves the SLP time to score the assessment. For a SLP with a large caseload, this time-saving ability can be invaluable. Based on the results from this study, the SLP can also be confident that a child's familiarity with an iPad® at home will not cause the administration of the assessment to be prolonged. Overall, bearing the financial feasibility and availability in schools and clinics, the SLP can save time while also administering an accurate and reliable articulation assessment.

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Appendix A: Recruitment Script

The following script for the study "*Reliability of Administering the Goldman-Fristoe Test of Articulation-3rd Edition (GFTA-3) via iPad® versus Hard Copy*" will be presented to parents:

> "Would you consider taking part in a study about speech sound disorders assessment and analysis? We would like to use information about your child's speech sound disorder testing that includes the child's participation and speech error patterns. This information will be helpful in the analysis of a child's speech sound error patterns and in setting intervention goals. This would require two visits to the clinic that would take approximately 30 minutes each. We would like to use this information for research. This will help us better understand decision-making for testing procedures used in speech sound disorders and the development of intervention strategies. This will involve *audio and video* recording your child's speech. Would you be interested in taking part in this study?"

Appendix B: Consent Form

UNIVERSITY OF ALABAMA
HUMAN RESEARCH PROTECTION PROGRAM

Reliability of Administering the Goldman-Fristoe Test of Articulation, 3rd Edition (GFTA-3) via iPad® and Hard Copy

DeLaine Stricklin, M.S., CCC-SLP, Clinical Supervisor, Communicative Disorders
Anthony P. Buhr, PhD, Assistant Professor, Communicative Disorders

You (and your child, spouse, partner, etc.) are being asked to participate in a research study. You are being asked to give permission for your child, for whom you are a guardian, to take part in this research study. This study is called "*Reliability of Administering the* Goldman-Fristoe Test of Articulation-3rd Edition *(GFTA-3) via iPad® and Hard Copy*." The study is being conducting by DeLaine Stricklin, a SLP clinical supervisor, and Anthony P. Buhr, an assistant professor.

Is the researcher being paid for this study?
Dr. Buhr is not being paid for conducting this study.

Is this research developing a product that will be sold, and if so, will the investigator profit from it?
No product is being developed as part of this study.

Does the investigator have any conflict of interest in this study?
Neither investigator has a conflict of interest in conducting this study.

What is this study about? What is the investigator trying to learn?
This study is being conducted to learn more about assessment administration of the GFTA-3 in the preschool-age population. The study seeks to understand reliability and accuracy of speech sound error identification and analysis.

Why is this study important or useful?
This study is important because it will provide more information about the feasibility of using an iPad® to administer and score the *Goldman-Fristoe Test of Articulation-3rd Edition* (GFTA-3). Results of this study could provide speech-language pathologists with an alternative and more efficient means of assessing speech sound disorders in preschool-age children.

Why have I been asked to be in this study?
You have been asked to be in this study because you have come to the speech and hearing clinic at the University of Alabama. Your participation is voluntary, and if you do decide to participate, you are free to discontinue at any time.

How many people will be in this study?
Approximately 30 children and their parents or caregivers will participate in this study.

What will I be asked to do in this study?

If you agree to be in this study, you will be asked to do three things: 1) You will be asked to provide information about your child's speech sound development. 2) You will allow us to audio/video record your child's speech. 3) You will agree to bring your child to the clinic one more time within 7 days.

How much time will I spend being this study?
Overall, you will visit the clinic on two separate occasions within a 7 day period. Each session will require no more than 1 hour of your time.

Will being in this study cost me anything?
The only costs to you from this study is the time you take to visit the speech and hearing clinic at the University of Alabama and fill out the weekly questionnaire. Deciding not to participate will not affect the quality of treatment.

Will I be compensated for being in this study?
Your child will visit the treasure box after each session.

Can the investigator take me out of this study?
The investigator will not take you out of the study.

What are the risks (dangers or harms) to me if I am in this study?
There are not foreseeable risks in taking part in this study.

What are the benefits (good things) that may happen if I am in this study?
There are possibly no benefits for participating in this research study.

What are the benefits to science or society?
The benefit of this study to society is more efficient means of assessing speech sound disorders in preschool-age children.

How will my privacy be protected?
All personal information you choose to share about your child, including audio/video recordings, will be stored in a password-secured computer on hard drive in a room kept under lock and key. Only the primary investigator and graduate student will have access to this information. This information will be kept on hand for *no more than* 10 years after the conclusion of the study, *if rescoring needs to be conducted*, after which time it will be erased.

You will also be asked to give consent for health-related information to be maintained in the University of Alabama Speech and Hearing Clinic by signing a Health Insurance Privacy and Accountability Act (HIPAA) form. However, this information will not be used for this research study about developmental stuttering.

How will my confidentiality be protected?
Any personal information collected from you and your child will be stored in a database that is only identifiable by a number.

What are the alternatives to being in this study? Do I have other choices?
The alternative to being in this study is to decline to participate. Declining to participate in the study will not affect quality of treatment you receive at the Speech and Hearing Clinic.

What are my rights as a participant in this study?
Taking part in this study is voluntary. It is your free choice. You can refuse to be in it at all. If you start the study, you can stop at any time. There will be no effect on your relations with the University of Alabama.

The University of Alabama Institutional Review Board ("the IRB") is the committee that protects the rights of people in research studies. The IRB may review study records from time to time to be sure that people in research studies are being treated fairly and that the study is being carried out as planned.

Who do I call if I have questions or problems?
If you have questions, concerns, or complaints about the study right now, please ask them. If you have questions, concerns, or complaints about the study later on, please call the primary investigator (Dr. Anthony P. Buhr) at (205-348-1413).

If you have questions about your rights as a person in a research study, call Ms. Tanta Myles, the Research Compliance Officer of the University, at 205-348-8461 or toll-free at 1-877-820-3066.

You may also ask questions, make suggestions, or file complaints and concerns through the IRB Outreach website at http://osp.ua.edu/site/PRCO_Welcome.html or email the Research Compliance office at participantoutreach@bama.ua.edu.

After you participate, you are encouraged to complete the survey for research participants that is online at the outreach website, or you may ask the investigator for a copy of it and mail it to the University Office for Research Compliance, Box 870127, 358 Rose Administration Building, Tuscaloosa, AL 35487-0127.

I have read this consent form. I have had a chance to ask questions. I agree to take part in it. I will receive a copy of this consent form to keep.

_____

Signature of Research Participant Date

_____

Signature of Investigator Date

Appendix C: Audio/video Recording Consent

Audio/Video Recording Consent

As mentioned above, audio/video recordings of your child will be obtained for research purposes. These recordings provide an audio/video record of your child's speech, so that reliable information about your child's speech production skills can be obtained. These recordings will be stored on a secure hard drive, located in a locked room in the speech and hearing clinic, and only accessible to the primary investigator. These recordings may also prove to be valuable for future about developmental stuttering.

I understand that part of my participation in this research study will be audio/video recorded and I give my permission to the research team to record speech. I understand these recordings will be stored in a secure location.

☐ **Yes,** my participation in "*Reliability of Administering the Goldman-Fristoe Test of Articulation-3rd Edition (GFTA-3) via iPad® and Hard Copy*" can be audio/video recorded, and I give my permission to use these recordings for future research

☐ **Yes,** my participation in "*Reliability of Administering the Goldman-Fristoe Test of Articulation-3rd Edition (GFTA-3) via iPad® and Hard Copy*" can be audio/video recorded, but I prefer these recordings **not** be used for future research.

☐ **No,** I do not want my participation in "*Reliability of Administering the Goldman-Fristoe Test of Articulation-3rd Edition (GFTA-3) via iPad® and Hard Copy*" to be audio/video recorded.

Signing below constitutes your agreement to be audio/video recorded. You will be provided with a copy of this form.

_____ _____

Printed Name Date

_____

Signature

Appendix D: Assent form

The following assent script for the study *"Reliability of Administering the Goldman-Fristoe Test of Articulation-3rd Edition (GFTA-3) via iPad® versus Hard Copy"* will be presented to children who are between the ages of *2;6 and 5;11*.

"Hi __(child's name)__. My name is __(SLP's name)__. I am from the University of Alabama. I am trying to understand how kids say their words. You are ___age___ years old, and thought you might like to be in my study. All I want you to do is look at some pictures in a book and tell me what you see. I also want you to know that you can stop being in the study whenever you want. Do you have any questions for me?
If you don't have any more questions for me, would you like to be in my study?"

YES NO

_____ _____
Signature of Person Obtaining Assent Date

Appendix E. Intake Checklist

University of Alabama **Client ID: _____**
Intake Checklist **Date: _____**

"Reliability of Administering the Goldman-Fristoe Test of Articulation-3rd Edition (GFTA-3) via iPad® and Hard Copy"

Instructions: Please complete the following spaces below.

1. The current date: year_____ month _____ day_____
2. My child's birth date: year_____ month _____ day_____

   Chronological age: year_____ month _____ day_____
3. To the best of my knowledge, I first noticed my child's speech sound errors:

   year_____ month _____ day_____
4. To the best of my knowledge, my child's speech has previous been evaluated:

   Yes No
5. If your child has received treatment for a speech sound disorder in the past, please provide the dates corresponding to the beginning and end of treatment:

   From: year_____ month _____ day_____

   To: year_____ month _____ day_____
6. Other members of my immediate family who have exhibited a speech sound disorder:

   a. _____
   b. _____
   c. _____
   d. _____
   e. _____

Appendix F: GFTA-3 Client Response to Testing

GFTA-3 Client Response to Testing

Client: _____ DOB _____ CA _____ DOE _____

Coder: _____

Imitation:

- A direct model from the clinician of the presented test item following the client's unsuccessful attempt at producing the target word.

Redirection:

- Redirect or refocus a client's behavior, attention, or thought process to maintain task using a verbal or non-verbal (eye contact or gestural) direction
- Provide a clear and concise quick (no more that 1-2 sentences) reminder of what the child should be doing and/or where they should be in relationship to task.

Target:	**Number**	**Comments**
Direct imitations required for each picture plate		
Number of redirections required to complete the task		

Appendix G: Familiarity with iPad®

Client ID#: _____

Familiarity with the iPad®:

Is your child familiar with the use of an iPad®? Yes No

How many days per week does your child engage with the iPad®? _____

How many minutes does your child spend with the iPad® per sitting? 30 60 90 90+

Does your child have limited or free access to the iPad® during the day? Free Limited

Are the items your child engages in with the iPad® games, instructional, or both?
Games Instructional Both

Comments:

IRB Project #: 14_OR_300_ME -R2

UNIVERSITY OF ALABAMA
INSTITUTIONAL REVIEW BOARD FOR THE PROTECTION OF HUMAN SUBJECTS
REQUEST FOR APPROVAL OF RESEARCH INVOLVING HUMAN SUBJECTS

I. Identifying information

	Principal Investigator	Second Investigator	Third Investigator
Names:	DeLaine Stricklin	Anthony P. Buhr	
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University:	Alabama	Alabama	
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Title of Research Project: "Reliability of Administering the Clinical Assessment of Articulation and Phonology-Second Edition (CAAP-2) and Goldman Fristoe Test of Articulation, 2nd Edition (GFTA-2) via iPAD and Hard Copy Manual"

Date Submitted: 12 May 2014
Funding Source: NA

Type of Proposal	☐ New	☒ Revision	☒ Renewal Please attach a renewal application	☐ Completed	☐ Exempt
			Please attach a continuing review of studies form		
		Please enter the original IRB # at the top of the page			

UA faculty or staff member signature: _____

II. NOTIFICATION OF IRB ACTION (to be completed by IRB):
Type of Review: _____ Full board ___✓ Expedited

IRB Action:
___ Rejected Date: _____
___ Tabled Pending Revisions Date: _____
___ Approved Pending Revisions Date: _____
✓ Approved-this proposal complies with University and federal regulations for the protection of human subjects.
Approval is effective until the following date: 6-1-17 ss
Items approved: ___ Research protocol (dated_____)
___ Informed consent (dated_____)
___ Recruitment materials (dated_____)
___ Other (dated_____)

Approval signature [redacted] Date 6/2/2016