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Using Technology in the Treatment of Selective Mutism: The Incorporation of Mobile Applications

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USING TECHNOLOGY IN THE TREATMENT OF SELECTIVE MUTISM: THE INCORPORATION OF MOBILE APPLICATIONS

by

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ABSTRACT

Selective mutism (SM) is a diagnosis marked by withdrawal of speech in certain social situations. The treatment of SM is often a difficult and lengthy process and there are many barriers to successful intervention. Behavioral therapy is most effective in the treatment of SM and the addition of therapeutic activities such as games and mobile devices may provide distinct advantages to this treatment (i.e., decreased patient anxiety levels and more active engagement). The current investigation examined the utility of mobile applications during the behavioral treatment of SM as well as the effect of using mobile applications on child-reported and physiological indicators of anxious responding. Results indicated that children made remarkable treatment gains in just two treatment sessions (i.e., spoke to the clinician within 22 minutes of treatment and held five, five-minute conversations with additional adults during a second session) regardless of modality of delivery (using mobile applications, other activities, or reinforcement alone). Children shaped to speak with the inclusion of mobile applications reported less anxiety and exhibited decreased physiological anxious distress during treatment. The utility of mobile applications during the treatment of SM is discussed in addition to areas for future research (e.g., mobile-based treatment dissemination initiatives).

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LIST OF ACRONYMS

aBT	Behavior Therapy + Other Activities
ADIS-C/P	Anxiety Disorders Interview Schedule for DSM-IV: Child and Parent Versions
APA	American Psychiatric Association
BT	Behavior Therapy Alone Group
DSM-5	Diagnostic and Statistical Manual for Mental Disorders - Fifth Edition
EDA	Electrodermal Activity
GAD	Generalized Anxiety Disorder
HRV	Heart Rate Variability
iBT	Behavior Therapy + Mobile Application Group
PAND	Percentage of All Non-Overlapping Data
PC	Personal Computer
SAD	Social Anxiety Disorder
SepAnx	Separation Anxiety Disorder
SM	Selective Mutism
SPAI-C	Social Phobia and Anxiety Inventory for Children
SPAIC-PV	Social Phobia and Anxiety Inventory for Children – Parent Version

INTRODUCTION

Selective Mutism

Selective Mutism (SM) is a disorder marked by a consistent failure to speak in particular social situations during which speech is expected (e.g., at school), despite speaking in other situations (e.g., in the home). Functional impairment in academic or social achievement often occurs, and is required for the diagnosis according to the Diagnostic and Statistical Manual for Mental Disorders - Fifth Edition (DSM-5; American Psychiatric Association [APA], 2013). SM is a rare disorder with a prevalence of less than 1% of the general population (Bergman, Piacentini, & McCracken, 2002; Chavira, Stein, Bailey, & Stein, 2004; Elizur & Perednik, 2003; Steinhausen & Juzi, 1996; Viana, Beidel, & Rabian, 2009). SM is diagnosed typically in childhood and has an average age of onset ranging from 2.7 to 4.1 years (Cunningham, McHolm, Boyle, & Patel, 2004; Garcia, Freeman, Francis, Miller, & Leonard, 2004).

In the DSM-5, SM was moved from its original placement in the *Other Disorders of Childhood and Adolescence* diagnostic category to the *Anxiety Disorders* category. The rationale for placement in this category included the many empirical findings that, more often than not, SM co-occurs with other anxiety disorders (APA, 2013). Of particular interest to researchers has been the relationship between SM and social anxiety (see Viana et al. 2009, for a review). Due to the similar clinical presentations of SM and social anxiety disorder (SAD; a disorder characterized by intense fear and avoidance of social interactions; APA, 2013) it has been postulated that SM may represent a developmental variant of SAD (Anstendig, 1999; Bergman et al., 2002; Black & Uhde, 1992; Silveira, Jainer, & Bates, 2004). Some findings suggest that children with SM report being too afraid to speak in social situations and the lack of speech represents a behavioral avoidance mechanism (Black & Uhde, 1995; Dummit, Klein, Tancer, &

Asche, 1997; Sharp, Sherman, & Gross, 2007; Vecchio & Kearney 2005; Young, Bunnell, & Beidel, 2012). Further studies supporting the diagnostic overlap include data that approximately 80 to 97% of children with SM also meet diagnostic criteria for SAD (Black & Uhde, 1995; Young et al., 2012), and relatedly, children with SM report elevated levels of social anxiety and shyness (Carbone et al., 2010; Cunningham et al., 2004; Dummitt et al., 1997; Steinhausen & Juzi, 1996). Additional research indicates high familial loadings for anxiety disorders, particularly social anxiety disorder (Black & Uhde, 1995; Chavira, Shipon-Blum, & Stein, 2005; Kolvin & Fundudis, 1981; Kristensen & Torgersen, 2001). From an experimental/behavioral perspective, children with SM often benefit from treatments that reduce social anxiety, both pharmacological (Black & Uhde, 1994; Harvey & Milne, 1998; Lafferty & Constantino, 1998; Lehman, 2002; Maskey, 2001; Thomsen, Rasmussen, & Anderson, 1999) and cognitive/behavioral (see Anstendig, 1998; Cohan, Chavira, & Stein, 2006; Pionek Stone, Kratochwill, Sladezcek, & Serlin, 2002; Viana et al., 2009 for reviews).

Treatment of Selective Mutism

Treating SM is a difficult and often lengthy process, with some studies reporting intervention lengths up to six to eight months (e.g., Bergman, Gonzalez, Piacentini, & Keller, 2013; Nolan & Pence, 1970). Treatment barriers include positive and negative reinforcement for not speaking in certain environments (e.g., Mowrer's two factor theory; Mowrer, 1947), the child's resistance to treatment (Krysanski, 2003), and potentially the child's reputation or identity as "the kid who does not talk" (Bunnell & Beidel, 2013). Further, as proposed by Bunnell and Beidel (2013) "adult attention/pleas to speak often develop a paradoxical behavioral response from the child (i.e., as the adults plead with the child to speak, that attention may reinforce lack of speech)" (pp. 292). Difficulty with treatment also may be related to the sparse

literature examining the efficacy of treatments for the disorder. The overwhelming majority of the extant treatment literature in this population consists of case studies and single case designs whereas there have been only four studies providing group comparisons following treatment (i.e., Bergman, Gonzalez, Piacentini, & Keller, 2013; Manassis & Tannock, 2008; Oerbeck, Stein, Wentzel-Larsen, Langsrud, & Kristensen, 2014; Sluckin, Foreman, & Herbert, 1991), and only two of these investigations included a prospective, randomized control design (i.e., Bergman et al., 2013 and Oerbeck et al., 2014). The most recent meta-analysis examining treatment for SM was published over a decade ago, and supported the use of behavior therapy in the treatment of SM (Pionek Stone, Kratochwill, Sladezcek, & Serlin, 2002).

The most commonly used interventions for SM include contingency management and shaping (Amari, Keith, Arlene, Schenick, & Kane, 1999; Bunnell & Beidel, 2013; Facon, Sahiri, & Riviere, 2008; Marino Fernandez, 1986; Guna-Dumitrescu & Pelletier, 1996; Masten, Stacks, Caldwell-Colbert, & Jackson, 1996; Nolan & Pence, 1970; Oerbeck, Johansen, Lundahl, & Kristensen, 2011; Porjes, 1992), stimulus fading (Beare, Torgerson, & Creviston, 2008; Kehle, Madaus, Baratta, & Bray 1998; Masten, Stacks, Caldwell-Colbert, & Jackson, 1996; Nolan & Pence, 1970; Oerbeck et al., 2011; Watson & Kramer, 1992), systematic desensitization/exposure (Bunnell & Beidel, 2013; Kee, Fung, & Ang, 2001; Rasbury, 1974; Rye & Ullman, 1999; Vecchio & Kearney, 2007; Vecchio & Kearney, 2009), self-modeling (Kehle et al., 1998), and social skills training (Bunnell & Beidel, 2013; Fisak, Oliveros, & Ehrenreich, 2006; Reuther, Davis, Moree, & Matson, 2011). Contingency management is often the first step in the treatment process. Rewards are contingent on compliance with directions from the therapist and parents, such as to produce verbalizations. Over time, rewards become contingent upon reaching treatment goals of increased difficulty (e.g., speaking at louder volumes or

verbalizing words rather than sounds), which may be likened to the rewarding of successive approximations of speech (i.e., shaping, although in this case "speaking to unfamiliar people" is the new behavior being learned). Stimulus fading involves the progressive introduction of additional stimuli (e.g., persons or settings) as the child speaks to someone with whom he or she is comfortable speaking. Systematic desensitization/exposure therapy is useful particularly when SM co-occurs with social anxiety. Systematic desensitization involves the presentation of a mood state (relaxation/enjoyment) incompatible with anxiety when the individual is in the presence of the anxiety-producing event or situation. Although some efficacy has been demonstrated when using these interventions separately, increased clinical efficacy may result when shaping, stimulus fading and exposure are combined.

Comprehensive Intervention for SM and the Use of Activities in Treatment

Many investigations have used a combination of behavioral methods in treating SM. Often referred to as "modular cognitive-behavioral treatments" or "multidisciplinary interventions" (e.g., Christon et al., 2012; Giddan, Ross, Sechler, & Becker, 1997), these interventions have resulted in decreased social anxiety and decreased functional impairment associated with SM, as well as increased speech production across settings. These multidisciplinary interventions have varied in delivery, but appear to include common behavioral methods. Specifically, some success has been noted when using behavioral methods such as psychoeducation, contingency management, shaping, self-modeling, cognitive restructuring, relaxation, exposure, systematic desensitization, stimulus generalization/fading, social skills, and parent training (Bergman et al., 2013; Bunnell & Beidel, 2013; Christon et al., 2012; Giddan et al., 1997; Guna-Dumitrescu & Pelletier, 1996; Kehle et al., 1998; Mitchell & Kratochwill, 2013; Powell & Dalley, 1995; Vecchio & Kearney, 2007; Vecchio & Kearney, 2009; Watson &

Kramer, 1992).

Careful review of these investigations reveals that an important component of successful SM intervention may involve the use of devices that prompt vocalization or listening to previously recorded vocalizations during therapy. Most common among these devices appears to be the use of audio recorders with which the children record their voices and play it for others to hear, thus following a desensitization/exposure paradigm (Blum et al., 1998; Kee et al., 2001; Oerbeck et al., 2011; Oon, 2010). An extension of this paradigm has included the children using audio devices with pre-recorded responses to answer questions that may be asked by others (e.g., "Yes," "No," "Thank you," and "Goodbye"; Kee et al., 2001). Additionally, and following the desensitization paradigm, the use of games (e.g., chutes and ladders, passing a ball back and forth, blowing up balloons, and melting ice pops) have been utilized to promote speaking behaviors during behavior therapy (Mitchell & Kratochwill, 2013; Oon, 2010; Reuther et al., 2011; Sharkey, McNicholas, Barry, Begley, & Ahern, 2008). Other tools included internet delivered cognitive behavioral therapy (Fung, Manassis, Kenny, & Fiksenbaum, 2002), index cards indicating which words to vocalize (Giddan et al., 1997), edited and dubbed video recordings to simulate the children speaking to others (Kehle et al., 1998), and a car radio where sound was increased in volume to require the child to speak at increased voice volumes (Nolan & Pence, 1970). The use of activities in behavioral intervention for SM has provided an interesting treatment paradigm that, when coupled with today's technology, may provide an important advancement in the treatment of SM. One of these activities may include the use of mobile applications.

Using Mobile Applications to Treat Selective Mutism

Mobile devices such as tablet PCs and smartphones provide numerous free-to-use and

inexpensive applications, which are downloadable to the device. By having a virtually unlimited number of activities (e.g., games requiring verbalization, sound and video recorders, flash cards decibel meters, recording devices) in one compact electronic device, mobile devices may serve as an invaluable tool during the initial stages of treating SM. Further, many youth are familiar with and readily use mobile devices on a daily basis (Lenhart, 2015; Madden, Lenhart, Duggan, Cotesi, & Gasser, 2013). Thus, the use of mobile devices may promote both more engagement and a willingness to participate in treatment in addition to providing a range of electronic activities in one compact device.

Thus far, mobile applications have been used in one study (i.e., Bunnell & Beidel, 2013). This investigation resulted in the successful treatment of a 17-year-old female with SM who was previously unresponsive to pharmacological and standard behavioral intervention. Following limited treatment gains using traditional exposure therapy alone, the authors used mobile applications while rewarding successive approximations of speech. Using mobile applications and a shaping hierarchy, the patient was speaking in a conversational tone and using complete sentences at the end of the first treatment session. These results required replication. In Study 1 we used a single case design strategy to replicate and validate the use of mobile applications as an adjunct to behavior therapy.

STUDY 1: REPLICATION AND EXTENSION

The primary goal of Study 1 was to replicate and extend the initial treatment success (Bunnell & Beidel, 2013) using a single-case design strategy. Specifically, the primary dependent variable in Study 1 was the time until audible speech occurred. The hypotheses for Study 1 were as follows: following initiation of treatment using mobile applications, children will a) speak audibly during the initial treatment session to at least one unfamiliar adult (i.e., the clinician) and b) speak audibly to the clinician and at least one other unfamiliar adult during the second treatment session.

METHOD

Procedure

Following informed consent, children were assessed via a clinician administered diagnostic interview in addition to child- and parent-report measures to affirm the diagnosis of SM. Children and their parents were informed that the purpose of the study would be to evaluate the usefulness of mobile applications during the treatment of SM, and that they would play games on a tablet PC (i.e., an Apple iPad) with the goal of helping them to feel more comfortable speaking around other people. In addition to one treatment planning session, children completed two, 55-minute sessions conducted in the same week. This investigation focused solely on the ability of the mobile applications to quickly shape speaking behavior. All assessment and treatment sessions were administered by a senior doctoral student in clinical psychology.

Design

Study 1 used a single-case (A-B) design strategy, the results of which are interpreted graphically. This design compares baseline data to data collected following the implementation of treatment to determine a treatment effect via the demonstration of a clear change from baseline. In Study 1, the treatment planning session served as a baseline for the assessment of speech to unfamiliar adults. In addition, subjective anxiety was assessed during baseline as well as the treatment sessions.

Participants

Participants were four children who met DSM-5 (APA, 2013) criteria for SM. Children ranged in age from 6- to 10-years. Children 1 and 2 were Latina female sisters (ages 9 and 10-years, respectively) who had not spoken to non-family members since 5-years of age. Both children refused speech to peers and staff at school, and reported elevated levels of social anxiety

as the reason for their withdrawal of speech. Child 3 was a 7-year old Latino male who refused speech to non-family members since 4-years of age, with the exception of whispers to one teacher and one peer approximately twice per week. Although his mother perceived him as experiencing elevated levels of social anxiety, Child 3 did not report significant elevations in anxiety as the reason for his speech withdrawal. Child 4 was a 7-year old Caucasian female who refused speech to non-family members since 3-years of age, with the exception of whispers to one peer at school approximately once per day. All children refused speech to extended family members within and outside of their home. Exclusionary criteria included potential comorbid severe psychopathology (i.e., bi-polar disorder, schizophrenia) and/or suicidal ideation. Children with other co-morbid diagnoses were not excluded and none of the children were taking anti-depressant medications during the time of the study. See Table 1 for participant demographics and child- and parent-reported assessment results.

Table 1 Participant Demographic and Assessment Data

Child	Age	Sex	Race	SPAI-C	SPAIC-PV
1	9	F	Latino	37	33
2	10	F	Latino	35	31
3	7	M	Latino	2	24
4	7	F	Caucasian	23	26

Note. SPAI-C = Social Phobia and Anxiety Inventory for Children; SPAIC-PV = Social Phobia and Anxiety Inventory for Children – Parent Version; Scores ≥ 18 on the SPAI-C and SPAIC-PV reflect clinically elevated levels of social anxiety.

Assessment

Diagnostic interview. The Anxiety Disorders Interview Schedule for DSM-IV: Child and Parent Versions (ADIS-C/P; Silverman and Albano, 1996) are semi-structured interviews used for the diagnosis of anxiety and related disorders in youth. The ADIS-C/P provides a diagnosis based on both child- and parent-report, although the assessment of child functioning relied mostly on parent-report in the current study. If children responded to questions during the

interview, it was by nodding their head.

Child social anxiety. Children and their parents completed the Social Phobia and Anxiety Inventory for Children (SPAI-C; Beidel, Turner, & Morris, 1995) and the SPAI-C Parent Version (SPAIC-PV; Beidel, Turner, & Morris, 2004). The SPAI-C and SPAIC-PV consist of 26 items that assess the frequency of anxiety symptoms during particular social situations. Participants rate each item using three ordered responses: 0 = Never, or Hardly Ever, 1 = Sometimes, and 2 = Most of the Time or Always. The SPAI-C and SPAIC-PV have demonstrated adequate reliability and validity (Beidel et al., 1995; Beidel, Turner, Hamlin, & Morris, 2000; Higa, Fernandez, & Nakamura, 2006)

Behavioral Assessment. Children's within-session speaking behaviors and anxiety were recorded digitally by the clinician. The number of persons to whom the children spoke during each session as well as the children's latency to speak to the clinician and additional adults was recorded digitally and counted. Children were prompted to rate their current anxiety level on a 5-point Likert-scale (0 = No Anxiety; 1 = Mild Anxiety; 2 = Moderate Anxiety; 3 = Severe Anxiety; 4 = Extreme Anxiety) every ten minutes during baseline and both treatment sessions.

Treatment

Following assessment, children and their parents participated in a treatment planning session during which the treatment rationale was presented, and a contingency management plan to increase speaking behaviors was established. Specifically, children were told that they would earn $10 of monopoly money to spend on prizes for each compliant response during sessions. Further, children would receive rewards from their parents (e.g., extra dessert, staying up 30-minutes past bedtime) following each treatment session during which they complied with clinician requests.

Children then completed two, 55-minute sessions administered within the same week. During session 1, children were rewarded for successive approximations of speech while using mobile applications. During the second session children were rewarded for approaching and speaking to multiple other unknown adults around the University campus, which consisted mostly of asking open-ended questions. All children followed the same shaping hierarchy, including the same mobile applications at each step in treatment, with some minor variation during the second session (see Table 2 for the specific shaping hierarchy).

Table 2 Mobile Applications Used During Each Session

Session	Step	Mobile Application	Behavior to Emit	Treatment Goal
1	1	Free Candle	Blow out candle once	Emit audible sound
	2	Free Candle	Blow out candle with increased pressure	Emit audible sound at increased volume
	3	Free Candle	Blow out candle at increased frequency (≤5)	Emit multiple audible sounds at increased volume
	4	Blowing Game	Blow ants off of a virtual picnic table loudly	Emit multiple audible sounds at increased volume
	5	Yes/No Fun Deck	Blow in response to close-ended questions	Emit audible sounds while responding to questions
	6	Talking Gina	Blow "O" sounds	Begin to emit audible verbalizations
	7	Talking Gina	Blow "U" sounds	Continue to emit audible verbalizations
	8	Talking Gina	Blow vowel sounds	Increase the number of audible verbalizations
	9	Meet the Vowels	Whisper vowels	Continue to practice emitting audible verbalizations
	10	Meet the Letters	Whisper letters including consonants	Increase the number of audible verbalizations
	11	Meet the Words	Whisper words	Begin to verbalize words
	12	Meet the Words	Speak words with increased volume	Increase the volume of verbalized words
	13	Camstar	Say the names of items photographed	Generalize speaking to items rather than written words
	14	Yes/No Fun Deck	Say yes or no to questions asked	Respond verbally to close-ended questions
	15	Monsters	Record and play responses to open ended questions	Respond verbally to open-ended questions
	16	Monsters	Record and play open ended questions asked by the child directed toward therapist	Verbalize questions for others to answer
2	1	Monsters*	Record and play open ended questions asked by the child directed toward others in the room	Verbalize questions for others to answer
	--	SPLDecibel Meter	Ask open ended questions while maintaining a designated volume	Verbalize questions for others to answer at increased volume

Note. * = Possible substitution of SPLDecibel Meter application depending on the child's progress.

RESULTS

Behavioral Assessment

Within-session speaking. Figure 1 displays the number of adults to whom each child spoke during each session. All children withheld speech during the treatment planning session. All children spoke to the clinician during the first session, and child 3 spoke to six adults in addition to the clinician during the first session. As displayed in Figure 1, children spoke to a range of 7 to 19 adults during the second session (M = 13). This number depended on the availability of adults with whom children could speak as well as the time allotted for each session, but of note is that children approached and spoke with all adults with whom they were instructed to initiate conversation.

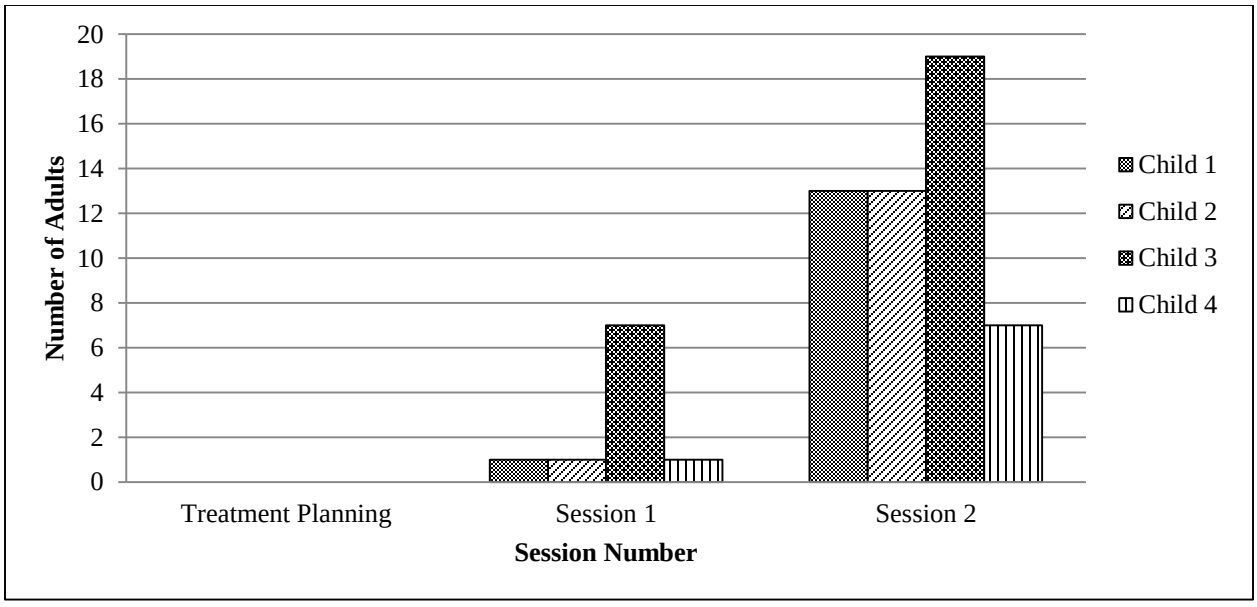

Figure 1 Number of Adults Spoken to During Each Session

Within-session latency to speak. As demonstrated in Table 3, all children whispered to the clinician within 31 minutes of the first session and all children spoke in a conversational tone within 40 minutes of the first session. Further, all children spoke to an adult other than the clinician within 14 minutes of the second session.

Table 3 Within-Session Latency to Speak

Child	Session 1		Session 2
	Time to Whisper to Clinician	*Time to Speak Audibly to Clinician*	*Time to Speak to an Additional Adult*
Child 1	30.00	40.06	13.44
Child 2	31.20	39.38	12.53
Child 3	19.29	27.39	*
Child 4	19.97	32.30	5.00

Note. * = Child 3 spoke to an additional unfamiliar adult within 50 minutes of the first session; time is measured in minutes.

Within-session anxiety. As demonstrated in Figure 2, all children reported mild to moderate levels of anxiety during the first two sessions, with the exception of child 3 who reported ratings of 0 for both sessions.

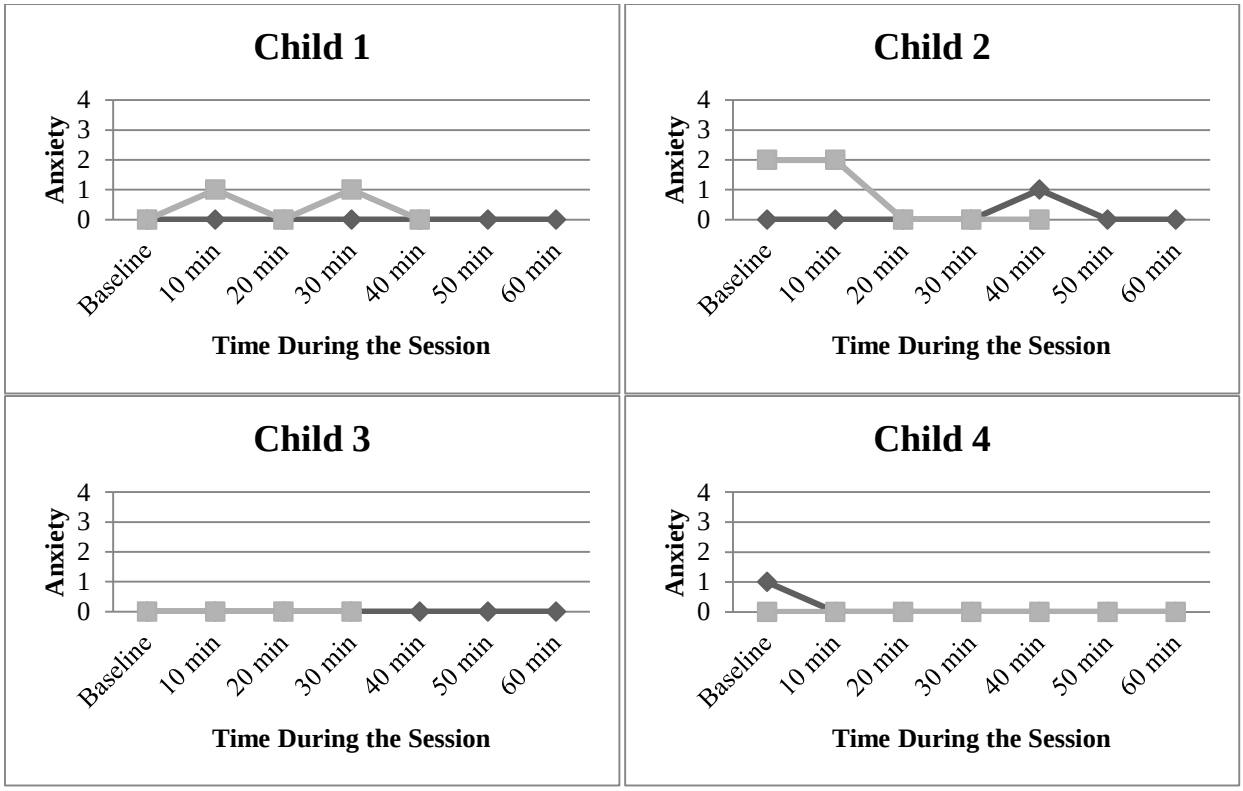

Figure 2 Within-Session Anxiety Ratings
♦ = Session 1; ■ = Session 2

DISCUSSION

The goal of Study 1 was to determine whether the use of mobile applications during the shaping of verbal behaviors could enhance verbal responding in children with SM. When compared to the extant literature and clinical experience, the results of Study 1 suggest that, when used in conjunction with rewarding successive approximations of speech, the use of mobile applications may decrease the time and clinical effort necessary to achieve a significant milestone in the treatment of children with SM, that is, to achieve the goal of speaking to a non-family member in a public setting. All children spoke to an unfamiliar adult (i.e., the clinician) during the first treatment session. All children spoke to the clinician audibly within 40 minutes of the first treatment session. All children also spoke audibly to the clinician and at least one other unfamiliar adult during the second treatment session (children spoke to an average of 13 adults during this session) and did so within the first 14 minutes of the second treatment session. These rapid treatment gains are highly encouraging given that children in this study had not spoken to unfamiliar adults or peers before beginning treatment.

There are limitations of Study 1; predominantly a lack of comparison to children treated using the identical shaping protocol but without the use of mobile applications. Another limitation not addressed in Study 1, but which might be addressed in an additional investigation is a lack of understanding of the exact mechanisms by which the changes occurred. More specifically, it is unknown why such rapid treatment gains were made during this study. It is possible that the engagement of the mobile device served to decrease the child's anxiety allowing them to more fully engage in the shaping process (Bunnell & Beidel, 2013). The authors suggested that "using tasks that require vocalization but engage children in reinforcing game-like activities may shift direct focus away from speaking, which in turn could decrease social anxiety

and thereby allow speech to occur" (pp. 292). In other words, it is possible that reciprocal inhibition, the process that underlies desensitization (Wolpe, 1954, 1958, 1961; Wolpe & Lazarus, 1966), may allow for faster treatment gains in children with SM. This explanation seems likely given the minimal anxiety reported by the children during these initial sessions. Anecdotally, when asked why they were not anxious, all children reported, "because I was having fun". It may be possible to test this hypothesis by examining children's physiological anxious arousal during treatment using mobile applications, while comparing this reactivity to children who are treated using the same method but without the inclusion of mobile applications.

STUDY 2: MECHANISMS OF CHANGE DURING TREATMENT: INTRODUCTION

Systematic Desensitization

Systematic desensitization was one of the earliest behavioral interventions for anxiety disorders, particularly specific phobias (Wolpe, 1954, 1958, 1961; Wolpe & Lazarus, 1966). According to Wolpe, systematic desensitization involves the use of a competing response that interferes with a response pattern which is considered "unadaptive". Theoretically, unadaptive responses (e.g., anxiety) are eliminated through use of the counter conditioning paradigm (Jones, 1924), which postulates that a conditioned stimulus' ability to elicit a conditioned response is lost if the conditioned stimulus is paired with a new stimulus that elicits a response *incompatible* with the original conditioned response. For this process to occur, the incompatible response must be "stronger" than the original conditioned response (Wolpe, 1968). The pairing of this incompatible response is believed to inhibit the original conditioned response, which is weakened over time. Because of the bi-directionality of each stimulus' ability to inhibit the other, Wolpe termed this process "conditioned inhibition based upon reciprocal inhibition" (Wolpe, 1968). Based on these laboratory findings Wolpe introduced the intervention known as systematic desensitization, which involves the gradual exposure to feared stimuli while simultaneously conditioning a response that is incompatible with fear (e.g., typically relaxation or feelings of happiness). This differs from other types of exposure therapy, which are based on an extinction model and involve the use of exposure to feared stimuli without the use of a competing response. Systematic desensitization is used widely in the treatment of anxiety disorders.

In theory, a systematic desensitization/reciprocal inhibition paradigm might explain the rapid treatment gains observed when using the mobile applications. Pairing an emotion

incompatible with anxiety during a distressful situation (i.e., interaction with a stranger) will eliminate fearful responses in those settings, which in turn should allow speech to occur. Based on the minimal levels of child-reported anxiety observed in these two studies, this seems likely, but confounds arise when using solely child-reported anxiety (e.g.,). Adding the direct assessment of anxious arousal during treatment using measures such as heart rate variability (HRV; i.e., inter-beat interval) and electrodermal activity (EDA; also known as galvanic skin conductance) would help to clarify the mechanism by which mobile applications seem to exert their effect, particularly by comparing autonomic arousal to that of children treated with behavior therapy (i.e., without the use of mobile applications).

HRV is the variation between heart beats (i.e., the inter-beat-interval), and is an indicator of autonomic regulation or flexibility (i.e., the interplay between sympathetic and parasympathetic activation; Billman, 2011). Increases in HRV occur when individuals are in a calm or relaxed state, which is indicative of increased parasympathetic activity. Conversely, decreases in HRV are observed when an individual is experiencing high levels of distress such that parasympathetic activity is inhibited (e.g., a "fight or flight" response). These trends have been noted particularly as individuals attempt to regulate their emotions during stressful social interactions (Porges, 2007). Similarly, EDA is a direct measure of sympathetic activation and elevations in EDA are observed in youths with elevated social anxiety during socially-distressing interactions (e.g., Mesa, Beidel, & Bunnell, 2014).

Thus, the goal of Study 2 is to examine children's physiological arousal during shaping procedures, with and without the use of mobile applications. The hypotheses of Study 2 were that, when compared to children shaped with reinforcement alone and children shaped using other therapeutic activities, children shaped with the use of mobile applications would a)

complete the shaping hierarchy earlier in the session, b) speak earlier in the session, c) report lower levels of anxiety during treatment, and d) exhibit lower levels of physiological anxious arousal (as measured by HRV and EDA).

METHOD

Procedure

Following informed consent and assent, children and their parents participated in a diagnostic assessment and completed questionnaires assessing child- and parent-report of social anxiety. Children were informed that the purpose of the study would be to help them to feel more comfortable speaking around other people. Children and their parents were also educated on the use of physiological monitoring equipment, the rationale behind the procedure, and contingency management procedures which included rewards of $10 of monopoly money for each compliant response during sessions to be spent on prizes at the end of the session in addition to rewards from parents between sessions. Children were then assigned randomly to one of three behavioral therapy groups: children shaped to emit audible speech including the use of mobile (i.e., Apple iPad) applications (iBT), children shaped using other similar activities (aBT), or children shaped with reinforcement alone (BT). A Microsoft Excel formula for random number generation was use to assign children to their respective groups. Following assessment and randomization, children participated in two sessions, conducted within the same week. Physiological arousal was assessed during these sessions. Outcome data included children's time to completion of the shaping hierarchy, latency to speak to the clinician and an additional adult, self-reported anxiety, and physiological measures of anxious arousal (as measured by HRV and EDA). Assessment and treatment sessions were administered by two senior doctoral students in clinical psychology, and sessions were video and audio-recorded.

Design

Study 2 used a single case (A-B) design with comparisons of child speaking behaviors, self-reported anxiety, and physiological anxious arousal among the iBT, aBT and BT groups.

Children were asked to sit quietly for five minutes at the beginning of each session to establish a baseline level of anxious arousal during both treatment sessions. Following this baseline phase, the treatment phase began and data collection continued.

Participants

Participants included 15 (n = 5 per group) children who met DSM-5 (APA, 2013) criteria for SM. Participants ranged in age from 5 to 17 years. Exclusionary criteria included children with severe psychopathology (i.e., bi-polar disorder, schizophrenia) and/or suicidal ideation. Participants with other co-morbid diagnoses were not excluded. Participants taking anti-depressant medications during the time of the study were included as long as they had been on a stable dose for at least one month prior to beginning treatment. It should be noted that Child 5 in the BT group presented with a unique case of SM and SAD such that her withdrawal of speech and social fears were specific to speaking to adults, particularly while in the presence of her parents, thus her scores on the SPAI-C and SPAIC-PV both fell below the cutoff for a probable diagnosis of SAD. Despite this, the child and her parents insisted that social anxiety was the driving factor behind her withdrawal of speech. Similarly, Child 2 in the iBT group reported low levels of social anxiety on the SPAI-C, although his parents felt that his lack of speech was largely associated with social anxiety, as demonstrated by his elevated SPAIC-PV score. Participant demographic, diagnostic, and social anxiety severity data are presented in Table 4.

Table 4 Participant Demographic, Diagnostic, and Social Anxiety Severity Data

	Age	Sex	Race	Diagnoses	SPAI-C	SPAIC-PV
				iBT Group		
Child 1	9	M	White	SM, SAD	23	14
Child 2	16	M	White	SM, SAD, SepAnx	9	40
Child 3	13	F	White	SM, SAD	41	33
Child 4	9	F	White	SM, SAD, GAD	38	43
Child 5	6	F	Latina	SM, SAD	16	16
				aBT Group		
Child 1	10	F	White	SM, SAD	41	38
Child 2	5	M	Latino	SM, SAD	46	46
Child 3	16	F	Latina	SM, SAD	28	43
Child 4	11	F	White	SM, SAD	39	42
Child 5	5	F	Latina	SM, SAD, Enuresis	38	36
				BT Group		
Child 1	15	F	Latina	SM, SAD	44	45
Child 2	5	M	Black	SM, SAD, SepAnx	36	40
Child 3	8	M	White	SM, SAD, Enuresis	30	28
Child 4	7	F	White	SM, SAD	30	41
Child 5	9	F	White	SM, SAD	13	14

Note. SM = Selective Mutism; SAD = Social Anxiety Disorder; SepAnx = Separation Anxiety Disorder; GAD = Generalized Anxiety Disorder; iBT = group shaped using mobile applications; aBT = group shaped using other therapeutic activities; BT = groups shaped using no activities; SPAI-C = Social Phobia and Anxiety Inventory for Children; SPAIC-PV = Social Phobia and Anxiety Inventory for Children – Parent Version; Scores ≥ 18 on the SPAI-C and SPAIC-PV reflect clinically elevated levels of social anxiety.

Assessment

Diagnostic interview. The ADIS-C/P was administered to children and their parents simultaneously. Children were not asked to speak during this interview although they were asked to nod their heads (yes or no) to indicate whether they agreed with their parents' response to particular questions. If disagreements took place, children would whisper to their parent and child and parent would compromise on an appropriate response. Children did not speak to the clinician during the assessment session.

Child and parent report of social anxiety. Children and their parents completed the SPAI-C and SPAIC-PV. For younger children who experienced difficulty with reading, parents assisted in reading SPAI-C questions.

Behavioral assessment. Each child's latency to complete the shaping hierarchy during the first session, and latency to speak to the clinician and an additional unfamiliar adult (during the second session) was recorded and coded using the Noldus Behavioral Observation System XT (Noldus Information Technology, 2015) and comparisons were made amongst groups. Children reported their current level of anxiety using a 5-point Likert scale following the baseline period and every five minutes during sessions.

Physiological assessment of anxious arousal. Physiological anxious arousal (i.e., HRV and EDA) was measured using the Mindware BioLab Acquisition Software and Ambulatory System (Mindware Technologies, LTD, 2009). This ambulatory equipment allows for the simultaneous collection of data continuously (i.e., approximately 500 samples per second) via a small ambulatory unit, which transmits data wirelessly to be stored digitally for subsequent analysis. These data are then examined juxtaposed to a synced video recording of the treatment sessions using the Noldus Behavioral Observation System XT (Noldus Information Technology, 2015). Anxious arousal relative to baseline levels was then calculated and compared amongst groups.

Treatment

All children were shaped using the hierarchy described in Table 5 with the iBT group including the use of mobile applications (see column 3), the aBT group including the use of other activities which were similar to each step's respective mobile application (e.g., bubbles, pinwheels, flash cards, sound recorders; see column 4), and the BT group following the

hierarchy without the inclusion of activities or devices (see column 5). Children remained in the session until completion of the hierarchy. In two cases (i.e., iBT Child 3 and aBT Child 2) this was not possible due to variable consistency in the children's level of response to requests from the clinician, and the eventual withdrawal of compliant responses. Thus, data from these two children were not analyzed. Children were rewarded with $10 of monopoly money for each compliant response during sessions. This monopoly money was added at the end of the session and spent on prizes (e.g., small toys and stickers) at the clinic, and also counted toward a reward from the child's parent following the session (e.g., money towards a game or toy). They were rewarded for successive approximations of speech during the first session, and were required to complete each step of the hierarchy successfully a minimum of five times to advance to the next step. The protocol for the second session included five, five-minute conversations with unfamiliar adults during which children were rewarded each time they spoke to the adult. During this process, children asked the adult an open-ended question, which the adult answered, and then asked the same question to the child. This process continued, alternating between the adult and the child initiating the initial questions for a total of five minutes. During session 2, children in the iBT and aBT groups began with the use of the mobile device or voice recorder (see Table 5), but were allowed to continue conversations without the use of the device if they felt comfortable doing so.

Table 5 Shaping Hierarchy for Study 2

Session	Step	Mobile Application	Other Tool	Behavior to Emit	Treatment Goal
1	1	Free Candle	Blow Bubbles	Blow once	Emit audible sound
	2	Free Candle	Blow Bubbles	Blow with increased pressure	Emit audible sound at increased volume
	3	Free Candle	Blow Bubbles	Blow at increased frequency (≤5)	Emit multiple audible sounds at increased volume
	4	Blowing Game	Pinwheel	Blow loudly and repeatedly	Emit multiple audible sounds at increased volume
	5	Yes/No Fun Deck	Yes/No Flashcards	Blow in response to close-ended questions	Emit audible sounds while responding to questions
	6	Talking Gina	Voice Recorder	Blow "O" sounds	Begin to emit audible verbalizations
	7	Talking Gina	Voice Recorder	Blow "U" sounds	Continue to emit audible verbalizations
	8	Talking Gina	Voice Recorder	Blow vowel sounds	Increase the number of audible verbalizations
	9	Meet the Vowels	Flash Cards	Whisper vowels	Continue to practice emitting audible verbalizations
	10	Meet the Letters	Flash Cards	Whisper letters including consonants	Increase the number of audible verbalizations
	11	Meet the Words	Flash Cards	Whisper words	Begin to verbalize words
	12	Meet the Words	Flash Cards	Verbalize words with increased volume	Increase the volume of verbalized words
	13	Camstar	Disposable Camera	Say the names of items photographed	Generalize speaking to items rather than written words
	14	Yes/No Fun Deck	Yes/No Flashcards	Say yes or no to questions asked	Respond verbally to close-ended questions
	15	Monsters	Voice Recorder	Respond to open ended questions	Respond verbally to open-ended questions
	16	Monsters	Voice Recorder	Ask and respond to open ended questions	Verbalize questions for others to answer
2	1	Monsters	Voice Recorder	Ask and respond to open ended questions with additional adults	Verbalize questions for others to answer

Note. Children were required to complete each step of the hierarchy a minimum of 5 times before moving to the next step.

RESULTS

Data Analysis

Session recordings and physiological data were imported into Noldus Observer XT observation software (Noldus Information Technology, 2015). Baseline and treatment phases were coded as well as time until completion of the shaping hierarchy, children's latency to speak to the clinician (operationalized as either whispering or saying a complete word), and latency to speak to an additional unfamiliar adult. These data were then compared descriptively among groups. Children's self-reported anxiety was recorded in-session by the clinician and change scores were calculated by averaging scores across the treatment phase and subtracting this average from baseline ratings. Children's anxiety ratings at the time of first speech to the clinician were also recorded and compared among groups. HRV (i.e., inter-beat interval) and EDA (i.e., skin conductance level in microsiemens) were averaged for each minute of each session.

Small n Statistics software (Gilroy, 2015) was used to compare baseline and treatment HRV and EDA data for each participant using the following evidence-based metrics for single case research. The Percentage of All Non-Overlapping Data statistic (PAND; Parker, Hagan-Burke, & Vannest, 2007) measures the percentage of all data points that do not overlap between baseline and treatment. Hedge's g* (Hedges, 1981) is an effect size measure with additional adjustment for the upward bias of smaller sample sizes (i.e., does not assume equal variances). Pearson's r^2 represents the variance accounted for by the relation between baseline and treatment phase scores.

Behavioral Assessment

Hierarchy completion and speaking behavior. Thirteen of 15 children (86.67%) completed the shaping hierarchy during the first session. Children's latency to complete the hierarchy ranged from 14 to 54 minutes (M = 31.21, *SD* = 12.62). The average latency to complete the hierarchy for children in the iBT group (M = 27.69, *SD* = 6.84) was approximately 3 to 7 minutes shorter in comparison to those in the aBT (M = 35.65, *SD* = 9.23) and BT (M = 31.79, *SD* = 17.82) groups, respectively.

All children, regardless of group spoke to the clinician within 22 minutes of the first session. The average latency to speak to the clinician for all groups fell between 10.56 and 13.68 minutes, a range of approximately three minutes. This latency was slightly higher for children in the iBT group. All children spoke to an additional unfamiliar adult within 97.76 seconds of being prompted to do so during the second session. The average latency for each group ranged from 23.43 to 36.09 seconds. All children participated in the planned five, five-minute conversations with unfamiliar adults (see Table 6).

Table 6 Behavioral Assessment of Hierarchy Completion and Speaking Behavior

	Latency to Hierarchy Completion (in minutes)	**Latency to Speak to the Clinician (in minutes)**	**Latency to Speak to Additional Adult During Second Session (in seconds)**
		iBT Group	
Child 1	37.81	22.05	11. 80
Child 2	25.86	13.48	14.54
Child 3	-	-	-
Child 4	23.55	5.04	20.29
Child 5	23.53	14.15	97.76
M (*SD*)	**27.69 (6.84)**	**13.68 (6.98)**	**36.09 (46.48)**
		aBT Group	
Child 1	37.36	11.23	18.35
Child 2	-	-	-
Child 3	22.32	8.18	44.05
Child 4	39.52	11.00	73.47
Child 5	43.40	16.05	3.77
M (*SD*)	**35.65 (9.23)**	**11.61 (3.27)**	**34.91 (30.63)**
		BT Group	
Child 1	54.19	10.80	13.75
Child 2	47.35	20.08	29.59
Child 3	19.02	6.95	25.06
Child 4	23.99	8.83	23.86
Child 5	14.41	6.17	24.89
M (*SD*)	**31.79 (17.82)**	**10.56 (5.61)**	**23.43 (5.84)**

Note. M = Mean; SD = Standard Deviation.

Child-reported anxiety. With respect to self-reported levels of anxiety, children in the iBT group tended to report lower and less varied ratings of anxiety for both sessions. The average rating during the first session for children in this group was 1.57 (*SD* = 0.74), compared to 2.67 (*SD* = 0.89) and 2.20 (*SD* = 1.22) for the aBT and BT groups, respectively. The average rating during the second session for children in the iBT group was 1.46 (*SD* = 0.60), compared to 2.54 (*SD* = 1.30) and 1.64 (*SD* = 1.12) for the aBT and BT groups, respectively. All children in the iBT group reported moderate and below moderate levels of anxiety (≤ 3), whereas children in the aBT and BT groups reported maximum ratings between 4 and 5.

With respect to individual ratings of anxiety, four children (two in the aBT group and two in the BT group) reported anxiety ratings above baseline levels during the first session. Children in the iBT group did not report ratings above their initial baseline anxiety ratings during this session, suggesting no increase in anxiety as a result of treatment demands to begin speaking. During session 2, a similar pattern was observed with the exception that one child in the iBT group reported ratings above baseline, although it should be noted that the child from this group was the only child to return back to baseline levels by the end of the session.

Children's anxiety ratings during each session were averaged and subtracted from baseline anxiety ratings, with positive and negative values indicating average increases and decrease from baseline, respectively. One child in the aBT group and one child in the BT group exhibited average increases in anxiety from baseline during session 1. In contrast, all other children exhibited either average decreases or no average change in anxiety from baseline. On average, each group exhibited mean decreases in anxiety from baseline, with the iBT group demonstrating the largest decrease, and the aBT and BT groups following in suit. Group differences were *minor* but followed the hypothesized pattern of anxious responding (see Figure 3).

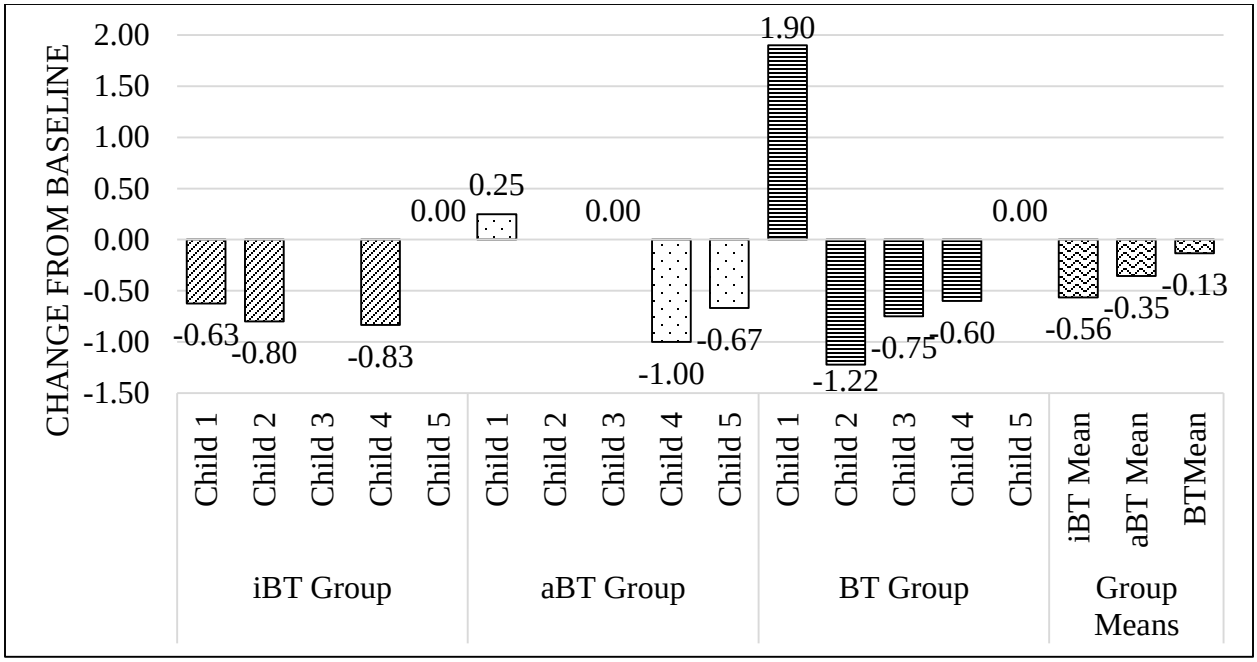

Figure 3 Average Self-Reported Anxiety Ratings in Relation to Baseline Ratings for Session 1

In contrast to session 1, average decreases in anxiety from baseline were not observed for session 2. Only one child in the iBT group exhibited an average increase from baseline, whereas two children from the aBt and BT groups exhibited increases. On average, each group exhibited mean increases in anxiety from baseline. A similar pattern to session 1 was observed such that the iBT group demonstrated the smallest average increase with the aBT and BT groups following in suit. Group differences were more pronounced for this session and once again followed the hypothesized pattern of anxious responding (see Figure 4).

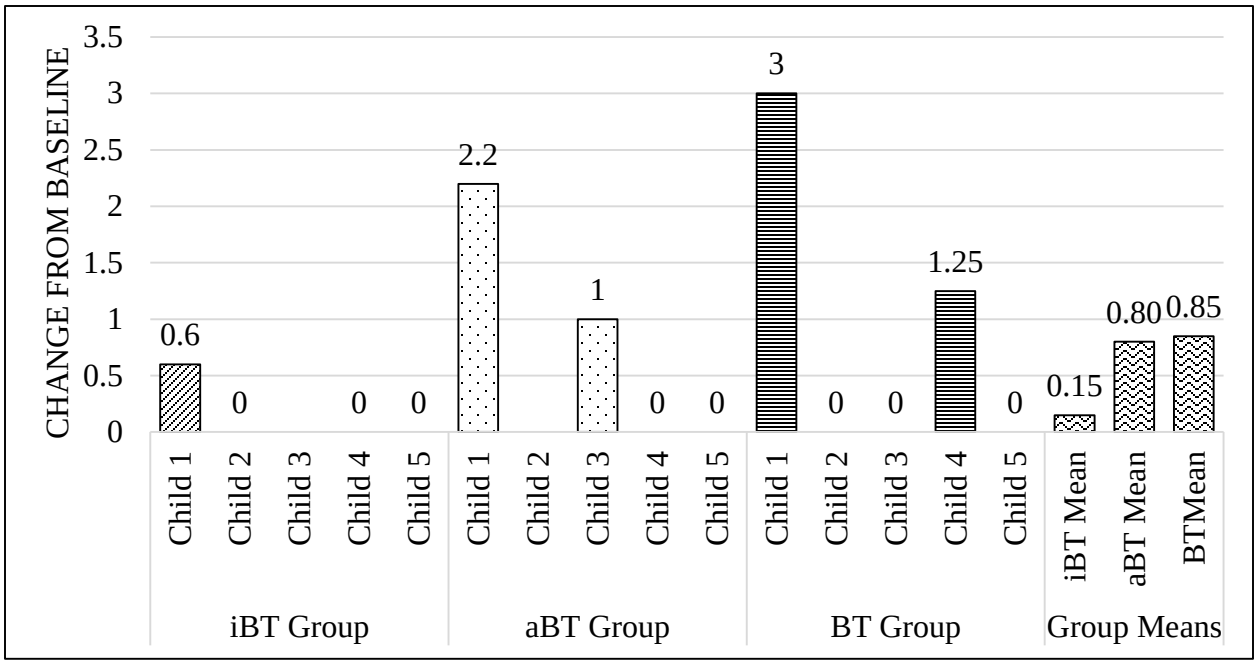

Figure 4 Average Self-Reported Anxiety Ratings in Relation to Baseline Ratings for Session 2

Anxiety ratings were recorded at the time of each child's first audible word to the clinician during the first session. As demonstrated in Figure 5, following initial speech to the clinician, children in the iBT group reported the lowest ratings of anxiety (M = 1.5, *SD* = 0.58) in comparison to the aBT (M = 2.5, *SD* = 0.58) and BT (M = 2.2, *SD* = 1.30) groups.

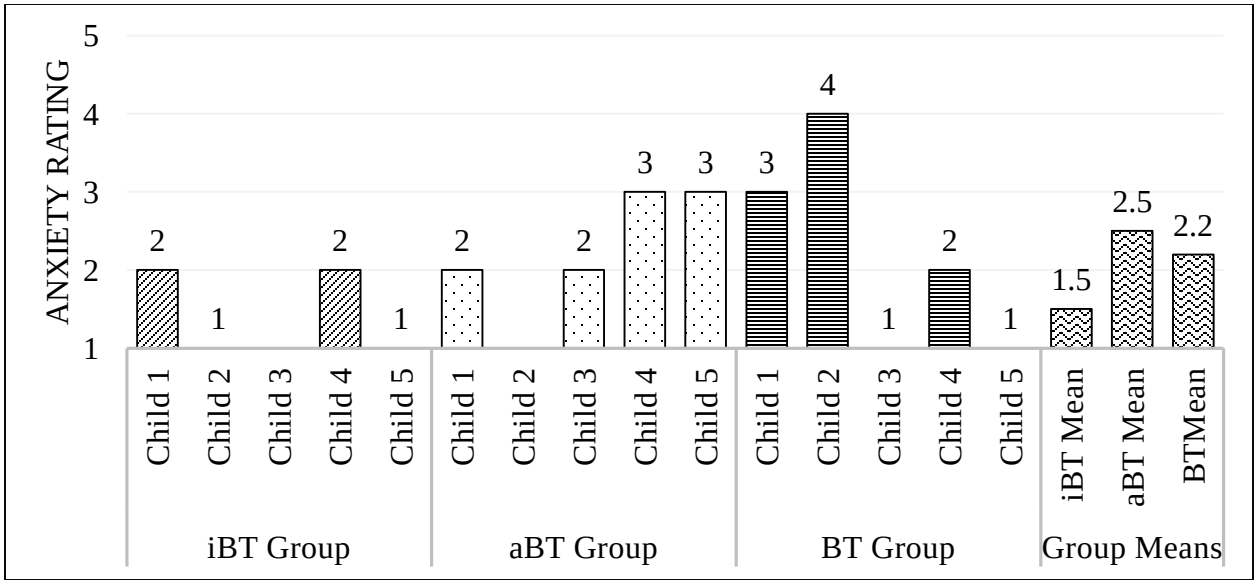

Figure 5 Self-Reported Anxiety Following Initial Speech

Physiological assessment of anxious arousal. Comparisons of HRV among children in the three treatment groups followed similar patterns to self-report of anxiety, yet comparisons of EDA and did not yield consistent results for groups across sessions.

HRV Session 1. Results of analyses of HRV concurred with self-reported anxiety. Specifically, children in the iBT group tended to exhibit fewer changes in HRV from baseline. From baseline measures, mean HRV decreased by 0.51 and 0.92 standard deviations for children in the aBT and BT groups, respectively, indicating increased sympathetic (i.e., "fight or flight") responding. Conversely, children in the iBT group showed average 0.05 standard deviation increase in HRV from baseline, indicating parasympathetic activation (e.g., recovery after a "fight or flight" response). Non-overlap effect size indices concurred with these results with children in the iBT group demonstrating the least non-overlap in HRV between baseline and treatment phases (i.e., 66.10% vs. 83.80% and 72.65% for the aBT and BT groups, respectively). The iBT group's change in HRV from baseline also accounted for a smaller proportion of the variance (i.e., less 8% to 11% compared to the other groups; see Table 7).

Table 7 Comparisons in HRV among Participants for Session 1

	M (*SD*)$_{Baseline}$	**M (*SD*)$_{Treatment}$**	**Hedge's g***	**PAND**	**r^2**
		iBT Group			
Child 1	759.22 (21.17)	744.24 (46.76)	-0.30	56.25	0.03
Child 2	1193.64 (69.59)	1068.21 (115.70)	-1.02	87.88	0.25
Child 3	-	-	-	-	-
Child 4	703.14 (45.46)	728.16 (84.89)	0.28	37.50	0.02
Child 5	618.70 (24.72)	658.81 (30.22)	1.23	82.76	0.33
Mean	**818.68 (40.23)**	**799.86 (69.39)**	**0.05**	**66.10**	**0.16**
		aBT Group			
Child 1	677.24 (17.80)	645.32 (26.86)	-1.10	85.18	0.28
Child 2	-	-	-	-	-
Child 3	684.01 (21.08)	706.30 (38.22)	0.55	75.86	0.09
Child 4	925.97 (17.04)	851.31 (32.37)	-2.15	95.74	0.60
Child 5	611.28 (10.67)	629.26 (24.84)	0.67	78.43	0.13
Mean	**724.63 (16.65)**	**708.05 (30.57)**	**-0.51**	**83.80**	**0.27**
		BT Group			
Child 1	836.44 (31.94)	794.18 (45.10)	-0.86	60.00	0.19
Child 2	702.64 (17.17)	717.53 (32.10)	0.43	67.27	0.05
Child 3	674.08 (10.84)	658.76 (18.00)	-0.81	74.07	0.18
Child 4	576.14 (14.32)	515.90 (18.06)	-3.09	100.00	0.76
Child 5	671.98 (17.99)	663.31 (29.90)	-0.28	61.90	0.02
Mean	**692.26 (18.45)**	**669.94 (28.65)**	**-0.92**	**72.65**	**0.24**

Note. PAND = percentage of all non-overlapping data.

HRV Session 2. Children in the iBT group demonstrated the least non-overlap in HRV between baseline and treatment phases (i.e., 59.35% vs. 70.00% and 81.83% for the aBT and BT groups, respectively), suggesting the least change from baseline for this group during session 2. However, the results of the Hedge's g* effect size estimates suggested that the aBT group exhibited the smallest decrease in HRV (Hedge's g* = -0.29), followed by the iBT (Hedge's g* = -0.78), and BT (Hedge's g* = -1.05) groups. Little difference was noted for the variance accounted for changes in HRV from baseline between the iBT and aBT groups (r^2s = 0.17 and 0.19, respectively), although the BT group's change from baseline accounted for a large portion of the variance (r^2 = 0.44; see Table 8).

Table 8 Comparisons in HRV among Participants for Session 2

	M (*SD*)$_{Baseline}$	**M (*SD*)$_{Treatment}$**	**Hedge's g***	**PAND**	**r^2**
		iBT Group			
Child 1	815.53 (24.43)	777.05 (36.14)	-0.99	63.89	0.24
Child 2	1011.93 (66.49)	980.17 (43.61)	-0.61	47.06	0.11
Child 3	-	-	-	-	-
Child 4	725.54 (40.36)	685.97 (28.37)	-1.18	70.59	0.31
Child 5	700.69 (6.86)	691.66 (24.92)	-0.35	55.88	0.04
Mean	**813.42 (34.53)**	**783.71 (33.26)**	**-0.78**	**59.35**	**0.17**
		aBT Group			
Child 1	678.74 (9.07)	661.94 (10.34)	-1.49	79.41	0.42
Child 2	-	-	-	-	-
Child 3	698.09 (21.64)	685.18 (22.19)	-0.53	73.68	0.08
Child 4	827.52 (22.28)	820.76 (32.90)	-0.19	57.50	0.01
Child 5	584.36 (9.34)	598.02 (12.00)	1.05	69.44	0.26
Mean	**697.18 (15.58)**	**691.47 (19.36)**	**-0.29**	**70.00**	**0.19**
		BT Group			
Child 1	953.50 (13.81)	892.02 (22.98)	-2.50	97.56	0.67
Child 2	676.86 (24.60)	715.32 (33.48)	1.07	75.00	0.27
Child 3	697.68 (31.51)	660.70 (16.63)	-1.80	88.89	0.51
Child 4	583.71 (25.37)	553.41 (11.59)	-1.91	94.77	0.54
Child 5	738.74 (25.05)	719.70 (15.79)	-0.10	52.94	0.24
Mean	**730.10 (24.07)**	**708.23 (20.09)**	**-1.05**	**81.83**	**0.44**

Note. PAND = percentage of all non-overlapping data.

EDA Session 1. Results of analyses of EDA for session 1 were mixed. Children in the iBT group demonstrated the least non-overlap in EDA between baseline and treatment phases (i.e., 86.46% vs. 91.10% and 99.26% for the aBT and BT groups, respectively), suggesting the smallest increase from baseline for this group. The results of the Hedge's g* effect size estimates suggested that the aBT group exhibited the smallest increase in EDA (Hedge's g* = 2.96), followed by the iBT (Hedge's g* = 3.25), and BT (Hedge's g* = 4.11) groups. The variance accounted for in changes in EDA from baseline followed a similar pattern (see Table 9). Overall, the iBT and aBT groups appeared most similar in response with respect to EDA, with the BT group consistently exhibiting the highest level of physiological response.

Table 9 Comparisons in EDA among Participants for Session 1

	M (*SD*)$_{Baseline}$	**M (*SD*)$_{Treatment}$**	**Hedge's g***	**PAND**	**r^2**
		iBT Group			
Child 1	17.91 (1.40)	19.40 (1.06)	1.23	45.83	0.32
Child 2	4.02 (0.13)	6.51 (0.42)	5.66	100.00	0.91
Child 3	-	-	-	-	-
Child 4	2.67 (0.14)	6.39 (0.95)	3.75	100.00	0.82
Child 5	5.60 (0.82)	9.58 (1.59)	2.36	100.00	0.64
Mean	**7.55 (0.62)**	**10.47 (1.00)**	**3.25**	**86.46**	**0.67**
		aBT Group			
Child 1	4.80 (0.74)	6.60 (1.15)	1.45	87.04	0.40
Child 2	-	-	-	-	-
Child 3	5.45 (0.53)	6.37 (0.95)	1.73	79.31	0.22
Child 4	8.04 (3.27)	17.5 (1.14)	5.85	100.00	0.91
Child 5	9.90 (0.60)	12.64 (0.89)	2.83	98.04	0.72
Mean	**7.05 (1.28)**	**10.78 (1.03)**	**2.96**	**91.10**	**0.56**
		BT Group			
Child 1	6.70 (1.19)	14.44 (1.32)	5.30	100.00	0.90
Child 2	7.17 (0.65)	11.90 (1.61)	2.73	100.00	0.92
Child 3	11.43 (1.30)	14.57 (0.77)	3.23	96.29	0.77
Child 4	13.42 (0.55)	15.96 (0.58)	3.98	100.00	0.84
Child 5	12.73 (0.36)	15.05 (0.40)	5.31	100.00	0.90
Mean	**10.29 (.81)**	**14.38 (0.93)**	**4.11**	**99.26**	**0.86**

Note. PAND = percentage of all non-overlapping data.

EDA Session 2. Changes in EDA for the second session were inconclusive with all children exhibiting elevated levels of physiological responding. No overlap in levels of EDA between baseline and treatment phases were observed. An opposite pattern from previous analyses was observed such that children in the iBT group exhibited the largest increase in EDA, followed by the aBT and BT groups in sequentially decreasing order. These results contrasted results from HRV analyses as well as child-report of anxious responding (see Table 10).

Table 10 Comparisons in EDA among Participants for Session 2

	M (*SD*)$_{Baseline}$	**M (*SD*)$_{Treatment}$**	**Hedge's g***	**PAND**	**r^2**
		iBT Group			
Child 1	8.80 (0.88)	13.99 (0.35)	10.41	100.00	0.97
Child 2	6.15 (0.13)	7.910 (0.27)	6.16	100.00	0.92
Child 3	-	-	-	-	-
Child 4	7.97 (2.10)	20.31 (1.58)	6.73	100.00	0.94
Child 5	5.60 (0.82)	9.58 (1.59)	2.36	100.00	0.64
Mean	**7.13 (0.98)**	**12.94 (0.95)**	**6.41**	**100.00**	**0.87**
		aBT Group			
Child 1	5.21 (0.40)	8.10 (0.45)	5.89	100.00	0.92
Child 2	-	-	-	-	-
Child 3	4.28 (0.67)	6.92 (0.61)	3.86	100.00	0.83
Child 4	9.79 (1.00)	19.95 (0.93)	7.85	100.00	0.95
Child 5	12.39 (1.67)	19.20 (0.79)	6.54	100.00	0.93
Mean	**7.92 (0.93)**	**13.54 (0.69)**	**6.03**	**100.00**	**0.90**
		BT Group			
Child 1	4.90 (1.14)	12.81 (2.62)	2.84	100.00	0.72
Child 2	11.4 (0.51)	20.14 (1.80)	4.63	100.00	0.87
Child 3	12.73 (0.64)	16.93 (0.38)	9.11	100.00	0.96
Child 4	7.99 (1.06)	11.72 (1.03)	3.24	100.00	0.77
Child 5	7.82 (0.62)	11.25 (1.13)	2.85	100.00	0.72
Mean	**8.97 (0.79)**	**14.57 (1.39)**	**4.53**	**100.00**	**0.81**

Note. PAND = percentage of all non-overlapping data.

DISCUSSION

Traditionally, the treatment of SM has been a difficult and lengthy process. This may, in part, be due to the many barriers to treatment commonly observed within this population (e.g., reinforcement for not speaking in certain environments and children's resistance to treatment). Behavioral intervention for SM, including contingency management, shaping, systematic desensitization and exposure, has evidenced the most empirical support based on meta-analytic review (Pionek Stone et al., 2002). Data suggest that the addition of therapeutic activities (e.g., games, sound recorders) also may provide some advantages to the behavioral treatment of SM, particularly when coupled with today's technological advances (e.g., mobile devices such as tablet PCs and smartphones; Bunnell & Beidel, 2013; Bunnell, Procci, Beidel, & Bowers, in press). Particularly, mobile devices allow access to a wide variety of mobile applications (e.g., games requiring verbalization, sound and video recorders, flash cards decibel meters, recording devices) that may provide therapeutic value for the treatment of SM in one small, convenient location. In addition to convenience and applicability, the use of mobile devices may promote both more engagement and a willingness to participate in treatment, perhaps through systematic desensitization/reciprocal inhibition (Wolpe, 1968); specifically, the pairing of enjoyment or pleasure, rather than anxiety or fear, when speaking with a stranger.

The results of Study 2 largely supported the hypotheses. With respect to hierarchy completion of speaking behaviors during treatment, the results of Study 1 were replicated. Children in the iBT group completed the hierarchy earlier that children in the aBT and BT groups, although this difference was minor (i.e., their latency to complete the hierarchy was 3 to 7 minutes longer in length). All children, regardless of group, spoke to the clinician within 22 minutes of treatment. Examination of group differences revealed that the BT group demonstrated

the shortest latency to speak to the clinician, followed sequentially by the aBT and iBT groups, respectively. Perusal of session recordings revealed that this minor difference in latency was likely due to time spent switching between and setting up mobile applications/therapeutic activities as well as time spent providing instructions for each application/activity. For example, the average time spent instructing children in the first step in the hierarchy was 14.46 seconds for the BT group, whereas instruction time was 41.56 and 46.96 seconds for the aBT and iBT groups, respectively. Hypothetically, multiplying this instruction time for each of the nine changes in mobile applications/therapeutic activities would result in approximately 6 and 9 minutes of additional instruction time throughout the protocol for the aBT and iBT groups, respectively. Regardless of possible group differences, it is important to note that these differences are not likely to have clinical significance, especially given that the largest mean difference between groups for speaking to the clinician was approximately 3 minutes. All children also completed five, five-minute conversations with additional unfamiliar adults during the second treatment session. After being prompted to do so, all children began speaking initially to an unfamiliar adult within approximately 1.5 minutes. The average latency to speak to an additional adult was similar between groups.

To our knowledge, no other study has reported the elicitation of speech within the first session of the treatment of SM for multiple children, particularly across such a wide age range. Moreover, this is the first investigation to report speech to multiple unfamiliar adults during the second session of treatment. Although requiring replication with a larger sample, perhaps if used initially in combination with other recent interventions for SM (e.g., Bergman et al. 2013, and Oerbeck et al. 2014), more rapid treatment progress might occur, allowing ultimately for a shorter length of treatment and higher cost-effectiveness. These data support the prior literature

(e.g., Cohan et al., 2006; Pionek Stone et al., 2002) suggesting that behavioral strategies are most effective in the treatment of SM, and demonstrate specifically that the use of a structured shaping hierarchy and specific contingency management protocol may result in early verbalization. This may, perhaps, occur regardless of the activities with which they are administered, although understanding the specific mechanisms of change during treatment is of great importance (Kazdin & Nock, 2003).

The outcome of this investigation supported the second hypothesis. In particular, children in the iBT group consistently *reported* lower and less variable levels of anxiety during each session when compared to children in the other groups. Their maximum rating of anxiety fell within the moderate range (≤ 3), whereas some children in the other two groups reported ratings in the severe and extreme ranges. Consistent patterns also were observed for children's average anxiety ratings in relation to baseline ratings such that children in the iBT group indicated smaller changes in distress in both sessions when compared to children in the other groups. This pattern also held true when examining children's report of anxiety following initial speech to the clinician (i.e., children in the iBT group reported lower levels of distress after speaking to the clinician for the first time). These data were consistent with those observed in Study 1, and suggest that children's subjective experience of anxious responding during treatment is decreased when mobile applications are used, as opposed to other therapeutic activities and reinforcement alone.

Given SM's recent reclassification as an anxiety disorder in the DSM-5 (APA, 2013), and literature suggesting that SM may be a developmental variant of SAD (e.g., Anstendig, 1999; Bergman et al., 2002; Black & Uhde, 1992; Silveira et al., 2004), finding ways to engage these children in therapy using a treatment modality that promotes speech while eliciting limited

subjective anxious distress is of great importance. Granted, not all children with SM meet criteria for SAD, some might be better classified as anxious-communication delayed or anxious-mildly oppositional (Cohan, Chavira, Shipon-Blum, Hitchcock, Roesch, & Stein, 2008), and others might simply be exhibiting oppositional behaviors (although these findings are mixed; Viana et al., 2009). Despite debate over etiology and co-morbidity of the disorder, it is plausible that a structured and outlined shaping hierarchy and specific contingency management protocol that makes use of tools that cause *little to no distress* in these children may be of particular use as treatments for SM are further refined.

The final hypothesis was that children in the iBT group would exhibit lower levels of physiological anxious arousal in comparison to children in other groups. The data from the first session supported this hypothesis as children in the iBT group demonstrated an average standard deviation *increase* in HRV from baseline and the least non-overlap in HRV between baseline and treatment phases, whereas standard deviation *decreases* and higher non-overlap in HRV were noted in the aBT and BT groups. These data suggest greater regulation of anxious arousal in children in the iBT group when compared to children in the other groups. These results were partially supported by the finding that children in the iBT group once again demonstrated the least non-overlap between baseline and treatment phases in EDA, although effect size changes between baseline and treatment phases suggested some variation in responding.

Physiological data for the second session provided varied results, which presented some difficulty in interpretation. Specifically, children in the iBT group demonstrated the least non-overlap between baseline and treatment phases for levels of HRV, but no variation in non-overlap between phases was observed for EDA among children, regardless of group. Effect size indices did not concur with these findings and varied depending on the physiological measure

used (i.e., HRV vs. EDA). For example, effect size results suggested that children in the aBT group exhibited the smallest decrease in HRV relative to baseline, whereas other results suggested that children in the BT group exhibited the smallest increase in EDA during session 2.

Despite somewhat mixed results, particularly in the case of EDA data, collectively the data suggest decreased anxious responding in the iBT group. A number of factors might explain some of the more ambiguous findings in this study. One factor might have been that children had the option of continued use of mobile applications or voice recorders during session 2 based on their preference, which might have led to changes in physiological anxious arousal. More saliently, EDA is associated with numerous emotional response patterns. These include negative emotions such as fear, anxiety and embarrassment, but also include positive emotions such as amusement, happiness, and pleasure (Kreibig, 2010). Given this confound, it may be difficult to differentiate between anxious and pleasurable responding (i.e., either due to enjoyment from activity or positively reinforcing stimuli) in these children based solely on EDA response. To illustrate, children using mobile applications might have experienced pleasure, resulting in elevated EDA levels, whereas children shaped with reinforcement alone might have experienced higher levels of anxious distress, also resulting in elevated levels of EDA. Despite this confound, self-reported anxious distress and HRV data suggested that children experience less anxious distress when mobile applications are included, at least during initial administration of the shaping hierarchy.

The examination of HRV in addition to child-reported anxiety in this study is a particular strength as it allows for a more specific analysis of anxious responding, particularly in relation to social anxiety or distress (Porges, 2007). Specifically, the average effect size increase in HRV during shaping of speech for the iBT group suggests increased parasympathetic activity, or

plainly put, a recovery after a "fight or flight" response. These data provide initial support for the postulation that shaping of speech with the inclusion of mobile applications can be an effective strategy in working with children with SM, and that the likely mechanism of change in this process is counter conditioning. Moreover, although the results of this study suggest that children with SM respond similarly with respect to hierarchy completion and speaking behavior regardless of modality of delivery, there may be benefits for the clinician to use mobile applications in this process. For instance, having numerous therapeutic activities in one small, compact device might be particularly advantageous, especially as "digital technologies play an important role in young children's lives, and they generally embraced them with enthusiasm and pleasure" (Chaudron, 2015; pp. 24). Further, mobile devices are likely to be readily available to clinicians across a wide range of settings (i.e., recent data suggest that approximately 78% of college graduates own smartphones; Smith, 2015). Perhaps the most clinically significant finding relates to rapid treatment gains observed as a result of using this particular shaping hierarchy, and data suggesting the experience of less distress while including the use of mobile applications. Given the commonly reported lengthy treatment requirements for SM, having an established procedure for reinforcing speech early in the treatment process will be of great value, especially during the beginning stages of treatment.

This study has several limitations that provide opportunities for future work in this area. First, this study made use of a single case design strategy with a randomized assignment to treatment groups. Although this design was appropriate for the question at hand, a larger randomized controlled trial would allow for more powerful statistical comparisons. The small sample included in this study limited the ability to test group differences statistically. Difficulty with recruitment in this population is well noted with published investigations examining the

treatment of SM traditionally having included small samples (e.g., N = 21 and 24 for Bergman et al. 2013 and Oerbeck et al. 2014, respectively). Difficulty with recruiting this population is likely due to the low prevalence of the disorder (i.e., ≤ 1%). A second limitation which might have affected data from the second session was that children had the option to continue use of mobile applications or voice recorders based on their preference. While some children chose to continue using these devices, others did not, which limited consistency for this session. Third, it should be clearly noted that the protocol presented in this study is not intended as a comprehensive treatment for SM. The shaping hierarchy provided should be viewed as a useful tool during the initial stages of the treatment of SM; to promote speech early in treatment in hopes of decreasing the time needed to begin to make initial therapeutic gains. Further intervention is needed past these two sessions, as speaking to a clinician is unlikely to result in spontaneous speech in the child's natural environment. As noted by Beidel and Turner (2007), after children with SM and SAD are able to consistently produce speech following behavioral shaping of verbalizations, they may then go on to successfully participate in continued evidence-based intervention for SAD (e.g., Social Effectiveness Therapy; Turner, Beidel, Cooley, Woody, & Messer, 1994) which aims to decrease social anxiety and increase the frequency and effectiveness of socialization. Fourth, no follow-up data were collected, thus it is unclear if the rapid initiation of speech was maintained weeks later.

In summary, rewarding successive approximations of speech using this shaping hierarchy is likely to lead to early speech production for children with SM, regardless of the modality in which it is delivered. Children's experience of anxiety may be lessened with the use of therapeutic activities such as mobile applications and other fun games, as evidenced by children's report of anxious distress and physiological data in concordance with this report. It is

evident that mobile applications provide some utility during the treatment of SM. Further, it is possible that mobile devices will demonstrate incremental utility as efforts are made to increase the reach and accessibility of evidence-based procedures for encouraging speech in these children. This reach is not likely to be limited to providers, as protocols such as the one described in this investigation might be used by parents and teachers, following adequate training, to promote generalization of speaking behaviors to the child's natural environment. Future research efforts in the area of technology and the treatment of SM might focus on this initiative as the potential reach will be widened significantly. In truth, we are only beginning to understand the utility and potential of today's technological advances to increase the quality of mental health care, and future research in this area is likely to lead to surprising advances in this effort.

APPENDIX A: IRB APPROVAL LETTER

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: **UCF Institutional Review Board #1**
FWA00000351,
IRB00001138

To: **Brian E Bunnell** and Co-PIs: **Deborah Casamassa Beidel, Franklin Mesa**

Date: **November 20, 2014**

Dear Researcher:
On 11/20/2014 the IRB approved the following human participant research until 11/19/2015 inclusive: Type of Review: IRB Continuing Review Application Form Expedited Review

Project Title:	Using technology in the treatment of selective mutism
Investigator:	Brian E Bunnell
IRB Number:	SBE-13-09469
Funding Agency:	
Grant Title:	
Research ID:	N/A

The scientific merit of the research was considered during the IRB review. The Continuing Review Application must be submitted 30days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at https://iris.research.ucf.edu .

If continuing review approval is not granted before the expiration date of 11/19/2015, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

All data, including signed consent forms if applicable, must be retained and secured per protocol for a minimum of five years (six if HIPAA applies) past the completion of this research. Any links to the identification of

participants should be maintained and secured per protocol. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed as key study personnel.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual. On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Patria Davis on 11/20/2014 12:55:47 PM EST IRB Coordinator

APPENDIX B: HEART RATE DATA

Table 11 Comparisons in HR among Participants for Session 1

	M (*SD*)$_{Baseline}$	**M (*SD*)$_{Treatment}$**	**Hedge's g***	**PAND**	**r^2**
		iBT Group			
Child 1	79.07 (2.19)	80.96 (5.59)	0.31	56.25	0.03
Child 2	50.40 (3.04)	56.95 (7.68)	0.81	87.88	0.18
Child 3	-	-	-	-	-
Child 4	85.62 (5.58)	83.32 (8.30)	-0.26	37.5	0.02
Child 5	97.10 (4.02)	91.25 (4.18)	-1.27	82.76	0.35
Mean	**78.05 (3.71)**	**78.12 (6.44)**	**-0.10**	**66.10**	**0.14**
		aBT Group			
Child 1	88.64 (2.31)	93.13 (3.76)	1.1	85.18	0.28
Child 2	-	-	-	-	-
Child 3	87.78 (2.72)	85.21 (5.02)	-0.49	75.86	0.07
Child 4	64.81 (1.20)	70.58 (2.72)	1.99	95.74	0.56
Child 5	98.18 (1.71)	95.50 (3.98)	-0.63	78.43	0.11
Mean	**84.85 (1.98)**	**86.10 (3.87)**	**0.49**	**83.80**	**0.25**
		BT Group			
Child 1	71.81 (2.71)	78.80 (4.50)	0.82	60	0.17
Child 2	85.43 (2.12)	83.79 (3.86)	-0.39	67.27	0.05
Child 3	89.03 (1.42)	91.14 (2.51)	0.81	74.07	0.18
Child 4	104.19 (2.55)	116.44 (4.16)	2.79	100	0.72
Child 5	89.34 (2.44)	90.63 (4.07)	0.31	61.9	0.03
Mean	**87.96 (2.45)**	**92.16 (3.82)**	**0.87**	**72.65**	**0.23**

Note. PAND = percentage of all non-overlapping data.

Table 12 Comparisons in HR among Participants for Session 2

	M (*SD*)Baseline	**M (*SD*)Treatment**	**Hedge's g***	**PAND**	***r*²**
		iBT Group			
Child 1	73.62 (2.21)	77.38 (3.75)	0.94	63.89	0.22
Child 2	59.50 (3.91)	61.33 (2.86)	0.55	47.06	0.09
Child 3	-	-	-	-	-
Child 4	82.90 (4.56)	87.61 (3.55)	1.15	70.59	0.3
Child 5	85.63 (0.83)	86.85 (3.11)	0.37	55.88	0.04
Mean	**75.41 (2.88)**	**78.29 (3.32)**	**0.75**	**59.35**	**0.16**
		aBT Group			
Child 1	88.41 (1.17)	90.66 (1.42)	1.46	79.41	0.41
Child 2	-	-	-	-	-
Child 3	86.01 (2.77)	87.66 (2.87)	0.55	75.86	0.09
Child 4	72.55 (1.93)	73.22 (2.93)	0.21	57.5	0.01
Child 5	102.70 (1.64)	100.37 (1.99)	-1.07	69.44	0.27
Mean	**87.42 (1.88)**	**87.98 (2.31)**	**0.29**	**70.55**	**0.19**
		BT Group			
Child 1	62.93 (0.92)	67.30 (1.75)	2.34	97.56	0.64
Child 2	88.74 (3.18)	84.06 (4.12)	-1.05	75	0.26
Child 3	86.14 (3.95)	90.87 (2.27)	1.72	88.89	0.49
Child 4	102.94 (4.29)	108.46 (2.30)	1.87	94.77	0.53
Child 5	81.29 (2.72)	83.41 (1.84)	0.96	52.94	0.23
Mean	**84.41 (3.01)**	**86.82 (2.45)**	**1.17**	**81.83**	**0.43**

Note. PAND = percentage of all non-overlapping data.

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