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An Assessment Protocol for Tolerating Medical Procedures: Evaluating Operant and Physiological Behaviors

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Evaluating Operant and Physiological Behaviors

by

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Abstract

Title: An Assessment Protocol for Tolerating Medical Procedures: Evaluating Operant and Physiological Behaviors

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All individuals, regardless of age, race, gender, or diagnosis, must learn to tolerate and/or participate in routine medical procedures (e.g., wellness exams, dental cleaning, blood draws). For some individuals, tolerating medical procedures can be a particularly onerous task. Specifically, individuals with intellectual disabilities (ID) experience more frequent difficulties with treatment adherence. With this population, a variety of techniques have been empirically demonstrated to increase cooperation with medical routines. However, no studies have reported changes in physiological behavior throughout training, and only a few studies have reported data on problem behavior. Several studies used graduated exposure or a hierarchy of the medical procedure with a series of steps; participants learned to tolerate the sequence of steps (i.e., the hierarchy), one by one, over time. However, the extent to which this step-by-step approach is needed is unclear. In the current study, we evaluated the hierarchy across dental cleaning, dental x-ray, and needle tolerance procedures, and collected data on physiological behavior and problem behavior throughout. We conducted assessment probes after training the first three steps in each medical procedure and after every second step thereafter; probes were

terminated at the onset of problem behavior and training resumed at that step number. Results showed that participates were able to skip as many as 48 steps in dental cleaning. Results show that the assessment protocol increased efficiency by eliminating unnecessary steps across all three procedures. All participants learned to tolerate all three procedures and experienced less problem behavior and stress, as measured by physiological indices, throughout treatment.

Keywords: medical tolerance, graduated guidance, hierarchy, assessment tool, physiological measures, dental, blood draw, needle

Table of Contents

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Dedication

This labor of love is dedicated to the three important people in my life who are largely responsible for the person I have become. Having their collective strength behind me is a constant force in my continuing journey as a behavior analyst and, specifically, in this research.

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An Assessment Protocol for Tolerating Medical Procedures: Evaluating Operant and Physiological Behaviors

Introduction

The Center for Disease Control and Prevention (CDC) strongly recommends regular health and dental exams. These exams can detect medical problems before they arise or discover problems early enough to make treatment more successful (CDC, 2020). For example, research suggests that poor oral health is linked with other chronic diseases, such as diabetes, heart disease, stroke (Seymour et al., 2007), or respiratory disease (Azarpazhooh & Leake, 2006). Thus, regular dental exams can help mitigate other potential health risks. It is also likely that regular physical exams and testing reduce the risk of problems, such as heart disease and strokes, which are responsible for nearly 1 in 3 deaths in the United States each year (CDC, 2020). Given that heart disease and strokes are correlated with high blood pressure, high cholesterol, diabetes, obesity, lack of exercise, and poor diet, physicians must conduct regular physical exams that involve blood pressure tests and blood draws, among many others, to monitor the health of their patients. Likewise, to do their part in maintaining good health, individuals of all ages, races, and genders must learn to tolerate routine medical procedures (e.g., wellness exams, dental cleaning, blood draws). For some individuals, tolerating medical procedures can be a particularly onerous task. For these people, the stimuli associated with the procedures function as negative reinforcers. As a result,

escape/avoidance behaviors are evoked and maintained by the termination of said stimuli during medical and dental visits. Indeed, unpleasant stimuli can cause people to avoid medical visits altogether. Specifically, individuals with intellectual disabilities (ID) experience more frequent difficulties with tolerating routine medical procedures and treatment adherence. Therefore, adverse health outcomes can be at least partially attributed to inadequate preventive care, due to the avoidance of and noncompliance with medical procedural demands (Allen & Kupzyk, 2016; Lewis et al., 2002), particularly in the intellectually disabled population.

In addition to escape/avoidance behavior, particular respondent behavior (e.g., increased heart rate, sweating) may also occur and be problematic during medical procedures. Therefore, both respondent or classical conditioning, as well as operant conditioning, are relevant to understanding how an individual might learn to tolerate an unpleasant medical procedure. In operant conditioning, learning occurs as a result of the strengthening or weakening of particular consequences. For instance, an individual might emit inappropriate behaviors during a medical exam, and, if these behaviors result in the termination of the exam, the individual is likely to engage in similar behaviors in future medical exams. Respondent conditioning, on the other hand, involves the repeated pairing of behaviors that are elicited automatically (i.e., reflexes) or behaviors essential to an organism's survival (e.g., increased heart rate, perspiration) with a neutral stimulus. For example, for some

individuals, the pain from a needle injection might elicit an increase in heart rate. After several pairings of the painful stimulation from the needle and the sight of the doctor, the sight of the doctor alone may elicit an increase in heart rate.

Skinner (1953) espoused that emotions, such as fear or anxiety, could be defined with two classes of behavior: a strengthening of particular classes of operant behavior and a change in respondent behavior. Since Skinner, other researchers (Allen & Kupzyk, 2016; Friman et al., 1998; Friman & Piazza, 2011; Jennett & Hagopian, 2008) have discussed fear or anxiety during medical procedures using this same model. Thus, in the case of fear or anxiety, escape/avoidance behavior (i.e., operant behavior) is likely to occur, and there is also an increase in the typical respondent behavior, such as an elevation of heart rate and gastric secretions. Similarly, in the clinical psychology literature, where the two classes are often intertwined, anxiety or fear has been defined as a multi-component construct "including *affective* states (e.g., subjective fear), *cognitions* (e.g., thoughts, beliefs), *behavioral* patterns (i.e., avoidance), and associated *physiological arousal* (e.g., increased heart rate)" (Moskowitz et al., 2017). Moreover, clinical psychologists can diagnosis someone with general anxiety (e.g., generalized anxiety disorder) or specific anxiety (e.g., related to spiders, medical procedures, social settings, or elevators).

The aforementioned classes of anxiety-related behavior are often seen in individuals diagnosed with intellectual disabilities (ID) or autism spectrum disorder

(ASD). Indeed, compliance with medical procedures is particularly problematic to individuals with an ID, and this might well be linked to health problems. To wit, this population tends to have poorer health outcomes (i.e., diabetes, obesity, heart failures, psychiatric issues) than the general population (Allen & Kupzyk, 2016; Diament, 2014; Janicki et al., 1999). Because of the presence of behavioral difficulties, providing medical care to these individuals has been a source of difficulty (cf. Erfanian & Miltenberger, 1990). For example, individuals diagnosed with ASD have higher rates of medical fears than their typically developing peers (Gillis et al., 2009). Furthermore, over a third of this population actively avoids or is entirely non-compliant with even the simplest of medical procedures (Gillis et al., 1999). For these individuals stimuli associated with medical procedures are often highly unpleasant, increasing the value of avoidance or escape from the stimuli (Allen & Kupzyk, 2016; Friman & Piazza, 2011; Jennett & Hagopian, 2008). The outcome is often the same for many other non-intellectually impaired individuals with anxiety or issues with medical compliance. That is, the individual exhibits problematic behavior (e.g., eloping, hitting, kicking, crying) because of a history of avoidance and/or escape from the medical procedure(s).

The Respondent-Operant Distinction in Tolerating Medical Procedures

In addition to operant behaviors, respondent behaviors (e.g., increased blood pressure, perspiration, increased heart rate) often increase as a result of an individual's medical fears or anxiety. Fear and anxiety responses are often directly measured using physiological metrics (heart rate, blood pressure, galvanic skin response), all of which can be conceptualized as respondents or respondent events (cf. Jennett & Hagopian, 2008; Rosen, Connell, & Kerns, 2016). A detailed explanation of respondent conditioning follows: In respondent conditioning, an unconditioned stimulus (US) (e.g., a painful stimulus) elicits an unconditioned response (UR) (e.g., heart rate increase). After multiple pairing trials between the US and a neutral stimulus (NS) (e.g., mask, white coat), the NS becomes a conditioned stimulus (CS) that elicits a conditioned response (CR). For example, a health care provider wearing a white coat or mask administers a shot or a needle stick (US) to a child that, in turn, elicits an increase in heart rate (UR). After repeated trips to the doctor that result in painful stimulation, the sight of the doctor, the white coat, or the mask (e.g., once a NS) becomes a CS that elicits a CR, which was similar to the UR (e.g., increased heart rate). Now, the child experiences an increase in heart rate at the sight of the doctor, white coat, or mask. CSs prepare organisms to deal with evolutionary relevant USs and increase the likelihood of survival/reproduction; as such, they are useful for evolutionary purposes but not necessarily in modern society (Domjan, 2005). Note that there are different

methods of arranging the NS and US. The most effective procedure is the delayed conditioning procedure, in which the NS occurs and, during its presentation, the US occurs, and both terminate at the same time (Lattal, 2013).

Interestingly, a CS can condition other neutral stimuli in a process termed higher order conditioning (Fisher, Piazza, & Roane, 2011). Using the previous example, the sight of the receptionist (NS) might be paired with the sight of the doctor (CS). As a result, the sight of the receptionist (CS_1) elicits a heart rate increase. This process might well explain the development of respondent behavior to a wide variety of stimuli (e.g., a building in a section of town) associated with a medical procedure. Moreover, respondent conditioning has been implicated in other phenomena such as conditioned seizures (Krafft & Poling, 1982), immunosuppression (Ader, & Cohen,1975), chemotherapy-related nausea (Stockhurst, Enck, & Klosterhalfen, 2007), heroin overdose (Siegal, Hinson, Krank, & McCully, 1982), and taste aversion (Garcia, Kimeldorf, & Koelling, 1955). Therefore, when teaching individuals to tolerate unpleasant medical procedures, researchers should account for both operant and respondent behavior.

In one of the few medical studies that utilized respondent conditioning, Whitehead, Lurie, and Blackwell (1976) determined whether a delayed conditioning procedure could decrease systolic blood pressure. The control group consisted of six nonhypertensive participants, and the experimental group comprised seven hypertensive participants. The researchers paired a soft noise and

the sound of a tilt-table motor (CS) with tilting the participant's head forward 15º (US). The experimental group was exposed to 30 trials: 15 trials of CS only and 15 trials of CS+US. The control group was exposed to a randomized presentation of the CS only for 15 s and the US only for 15. During the conditioning trials, the CS was presented for 30 s after which the participant's head was tilted forward 15º. The results showed that systolic blood pressure decreased after the CS condition for both individuals with and without hypertension.

In addition to conditioning blood pressure, researchers have also examined the effects of conditioning blood glucose (BG) levels in 33 healthy-adult males between 20-30 years of age (Stockhorst, Steingrüber, & Scherbaum, 2000). Researchers used the detection of insulin by the brain as the US and insulin secretion as the UR. The CS was a combination of peppermint oil and rosewood oil. Participants were divided into two different groups. Group 1 (CS-INS) received an intravenous insulin injection (0.05 iU/kg body weight); Group 2, the placebo group, (CS-SAL) received injections of saline paired with the CS. The researchers conducted pairing sessions across four consecutive days followed by the test or acquisition day. Results showed that Group 1 experienced a decrease in blood glucose levels in the presence of the CS; however, the participants in Group 2 did not experience a decrease in BG levels in the presence of the CS. In Experiment 2, the participants were assigned to either the CS with insulin injections (CS-INS) or the Group in which the CS was paired with glucose (CS-GLUC). These results

showed that the participants in the CS-INS group had a decrease in BG levels; however, the participants in the CS-GLUC group did not experience a significant change in BG levels. These findings are influential in ascertaining how individuals with diabetes detect or fail to detect hypoglycemia. Researchers suggest that the neutral stimuli that are paired with insulin injections might induce "anticipatory symptoms, and thus impede the detection of the later hypoglycemia-induced symptoms" (p. 156).

There is a paucity of research dedicated to behavioral interventions focusing on reducing anxiety-related behaviors (i.e., respondent behavior), despite a call for behavior analysts to study anxiety (Friman, Hayes, & Wilson, 1998). In a recent literature review, Rosen, Connell, and Kerns (2016) investigated all behavior-analytic interventions that addressed anxiety using within-subjects experimental design with individuals with lower-functioning autism (LFA). Studies were included if the primary or secondary goal addressed anxiety and "… the intervention addressed avoidance or escape behavior (e.g., crying, screaming, running away) in the presence of aversive stimuli that was attributed to symptoms of anxiety (e.g., worry, fear, phobia, stress)" (p. 123). Results yielded only seven studies that met their stringent within-subject designs criteria. Of those seven studies, only three studies addressed medical phobias related to medical procedures and treatment (i.e., Luscre & Center, 1996; Shabani & Fisher, 2006; Wolff & Symons, 2013). The other studies addressed anxiety related to loud sounds

(Koegel, Openden, Koegel, 2004), water (Love, Matson, & West, 1990; Rapp, Vollmer, Hovanetz, 2005), and activities or activity rooms (Schmidt, Luiselli, Rue, & Whalley, 2013). However, all three of these medical studies defined anxiety solely as the presence of operant behaviors, neglecting respondent behaviors. While all seven studies effectively employed behavior analytic interventions to reduce anxiety-related behavior, this review did not focus on studies that directly measured respondent behavior. Nevertheless, these researchers recommended including some form of physiological measurement in future studies.

Prior to Rosen et al. (2016), two previous substantive literature reviews addressed avoidance behaviors during a variety of activities. First, Jennett and Hagopian (2008) critically reviewed research published between 1970 – 2007 for individuals with intellectual disabilities. The review examined 12 single case research studies, all of which used sound experimental designs and procedures that addressed the phobic avoidance behaviors of a variety of activities and stimuli, such as the sight of dogs, riding escalators, medical procedures, and dental exams. Effective treatment comprised the use of at least one of these seven treatment components: in-vivo exposure, a hierarchy of steps, contingent reinforcement, prompting, modeling, extinction/blocking, and distracting stimuli (p. 156). All 12 studies included in vivo exposures and a form of reinforcement for appropriate behaviors, and eight studies included the use of a hierarchy of steps. Jennett and Hagopian (2008) defined a hierarchy as the gradual exposure to the unpleasant or

feared stimulus (p. 156). That is, the feared or unpleasant tasks were broken down into small steps, similar to what is done during a task analysis (TA). Response requirements increased or decreased based on the participant's performance. All 12 studies included reinforcement for appropriate behaviors. Across the various studies, gradual exposure was described using different terms (i.e., shaping, stimulus fading, contact desensitization). The authors recommended that gradual exposure and reinforcement should be included in any intervention package. Although this review was not limited to medical procedures, it did include two medical studies that investigated avoidance of needles during blood draws (Hagopian, Crockett, & Keeney, 2001; Shabani & Fisher, 2006) and three dental studies that investigated avoidance of dental exams and related stimuli (Conyers et al., 2004; Luscre & Center, 1996; Maguire, Lange, Scherling, & Grow, 1996). Of these five medical and dental procedure studies, none included a functional analysis of problem behavior. Moreover, none reported any assessment procedure that might allow clinicians to skip steps of the hierarchy. Finally, none of these studies included any measures of respondent behavior.

More recently, Allen and Kupzyk (2016) expanded Jennett and Hagopian's (2008) review by addressing specific avoidance responses during medical routines in individuals with ID. The search yielded 27 studies of individuals with ID ranging in age from 22 months to 41 years. Studies included a diverse sampling of medical procedures; these procedures included "dental exams and cleaning, pill swallowing,

physical exams, nebulizer treatments, needle sticks, central line care, and wearing of positive airway pressure masks" (p. 26). Of these aforementioned procedures, dental exams and needle sticks were the most common. Graduated exposure and contingent reinforcement were the most common treatment components to address phobic avoidance and noncompliance, which was consistent with Jennett and Hagopian's (2008) findings. In fact, 23 of the 27 studies included some form of graduated exposure to the unpleasant stimuli. Graduated exposure was typically done in one of two ways: first, stimuli were presented in the order in which they appeared in the medical procedure – in a task analysis fashion. In the second approach, researchers rank ordered the steps by the intensity of the fear response to the stimuli so that the least feared stimuli were presented first and the most feared were presented last. In either technique, the gradual exposure to the unpleasant stimuli was reportedly altered based on various dimensions such as duration, size, and distance (Beck, Cataldo, Slifer, Pulbrook, & Guhman, 2005; Reimers et al., 1988; Shabani & Fisher, 2006).

It is interesting to note that Jennett and Hagopian (2008) entitled their review "Identifying empirically supported treatments for phobic avoidance in individuals with intellectual disabilities." Moreover, throughout the review, the authors referred to the target behaviors as phobic avoidance. This term was used, according to the authors, because the avoidance behavior reported in the various studies occurred along with other behaviors indicative of fear and/or anxiety

(p.151). Previous studies used only the term "phobia," "anxiety," or "fear" when referring to the target behaviors, thus not explicitly connecting the operants at work. Interestingly, the Diagnostic and Manual 5th Edition (DSM-5) provides a variety of criteria for a specific phobia that include avoidance behavior, concomitant fear and/or anxiety, and impairment in areas of functioning. In addition, the reaction is "out of proportion to the actual danger posed…" (p. 197). The DSM-5 further reports that in children, there may be "crying, tantrums, freezing, or clinging" (p.197). Thus, the target behaviors reported by Jennett and Hagopian (2008) may indeed fit the definition of a phobia. In the case of individuals with ID, it has long been reported that such individuals exhibit escape/avoidance behaviors that are severe, disruptive, and in a sense, out of proportion. The occurrence of these escape/avoidance behaviors can be attributed to an individual's history of reinforcement (Skinner, 1953). Therefore, the term "phobic avoidance" is somewhat redundant (i.e., phobias involve avoidance behavior); the remainder of this paper will instead simply refer to the specific behaviors targeted in each study, such as avoidance behavior, failure to comply, and other problem behaviors (e.g., tantrums, aggression, self-injury).

Numerous studies (see Allen & Kupzyk, 2016) have documented compliance issues across various medical procedures which vary in intensity or invasiveness. For example, research has addressed physical or wellness exams (Gillis et al., 2009), immunizations (i.e., Wolff & Symons, 2012), blood draws

(Grinder et al., 2012), nebulizer treatments (Reimers et al., 1998), cleaning of central lines (McComas et al., 1998), electroencephalogram (EEG) evaluation (DeMore et al., 2009), blood transfusions (Gorski & Westbrook, 2011), and catheterizations (Gorski et al., 2004). Medical treatment compliance research has employed multiple treatment components that have yielded efficacious results. The most frequently used treatment components are described in greater detail below.

Common Intervention Components in Research on Tolerating Medical Procedures

Contingent Reinforcement

The first treatment component that has been widely used is contingent reinforcement. This is the delivery of a preferred item, presumably that has been empirically shown to increase a specific behavior in the past, contingent on approach responses or tolerance of a particular step in the TA (Allen & Kupzyk, 2016; Hagopian &Jannett, 2008). As a result, some measure of compliant behavior was shown to increase. The majority of medical tolerance studies incorporate some type of potential positive reinforcers (e.g., praise, tokens, toys, tangibles). Although not mentioned in previous studies, negative reinforcement, in the form of brief escape from the procedure, is often used contingent on compliance to a particular response requirement. Potential reinforcers were identified in several ways: interviews with parents or caregivers, verbal reports, direct observation, or preference assessments using a selection-based response (e.g., paired stimulus,

multiple stimulus preference assessment with and without replacement). Although the other methods can be effective (see Hagopian et al., 2001 for review), a reinforcer assessment is a superior process for identifying reinforcers.

Graduated Exposure or the Escape-avoidance Hierarchy

Contingent reinforcement is used to increase compliance during the escape/avoidance hierarchy training. As previously mentioned, many studies used a gradual introduction of the steps to train compliance. This type of procedure was called by a variety of names, such as desensitization, operant procedures, reinforced practice, stimulus fading, graduated exposure, in-vivo desensitization, contact desensitization, in-vivo graduated exposure, fading, escape and avoidant behavior, or hierarchy (Allen & Kupzyk, 2016; Hagopian & Jannett, 2008). A similar procedure has been used in the feeding literature, which was termed distance fading or a hierarchy (Bachmeyer, Gulotta, & Piazza, 2013; Rivas, Piazza, Patel, & Bachmeyer, 2010; Sasaki and Fryling, 2013). For the remainder of this proposal, the term escape-avoidance hierarchy, or merely the hierarchy, was used. This term more succinctly describes the underlying behavioral processes that occur. That is, when an individual is presented with a highly unpleasant stimulus, he or she will likely refuse to move toward that stimulus (avoidance) or will engage in behaviors to escape from the stimulus or situation. The term hierarchy is appropriate to depict the gradual arrangement of steps in a specific task. Indeed, in the most recent literature review (Allen & Kupzyk, 2016), the escape-avoidance hierarchy was

described as “exposure sequenced according to a task analysis, time exposed to the stimuli, size of the stimulus, and distance from the stimulus” (p. 31). The kinds of hierarchies that have been reported are discussed below.

Some studies have developed a detailed task analysis in which response requirements are gradually and systematically increased within a given medical procedure. That is, researchers developed a standard hierarchy with all required steps to test compliance. In baseline, participants typically are exposed to each step in the hierarchy until they engage in escape behavior or until they refuse to comply with the task demand. Then, in treatment the researchers start at the step in which escape or refusal occurred, and gradually introduce the remaining steps. After compliance with a particular step, the experimenter moves to the next step and so on, until the task is completed (Allen & Kupzyk, 2016; Jennett & Hagopian, 2008). It should be noted that in some studies (Grinder et al., 2012), the experimenter adjusted the pre-determined sequence of steps as the study progressed to establish compliance.

The escape-avoidance hierarchy can involve merely varying some stimulus dimension, such as time. For example, Reimers et al. (1988) gradually increased the duration of wearing a nebulizer mask from 3 s to the required duration of 20 min for a 2.7-year-old boy with ID and chronic lung disease. After baseline, two interventions followed. In treatment 1, appropriate mask wearing resulted in ice cream and praise and inappropriate behaviors were ignored. This treatment was

effective in decreasing the overall attempts at mask removal or avoidance behavior (i.e., head turns); however, this treatment was ineffective in increasing the total duration of wearing the mask. Conversely, treatment 2 used escape extinction, a procedure that prevents the individual from getting out of the task, or in this case prevented mask removal. Results showed a near-zero rate of inappropriate behaviors. Moreover, the duration of mask wearing was successfully increased. Initially, sessions were increased in 20 s intervals until the participant tolerated 2 min of the mask, at which time the duration was increased using 1-min increments. At 6 min, the duration increased in 5-min intervals until the terminal duration was achieved.

The stimulus size has also been varied. For example, Beck et al. (2005) gradually increased the size of a pill, along with the use of contingent reinforcement, modeling, shaping, and negative reinforcement in a treatment package. The study included eight children using an AB design. The incremental increase in pill size was not quantified. In general, a mock medication was placed on the back of the participant's tongue. If the participant swallowed the pill, praise and a preferred item were delivered. If the pill was not swallowed, the same pill size was presented on the next trial. Pill size increased after two consecutive trials with compliance and no disruptive behavior. Results showed that all eight participants learned to swallow a full-sized pill. For six of the eight participants, the effects of training generalized to their caregivers in other settings.

In a similar study by Ghuman, Cataldo, Beck, and Slifer (2004), pill size was also increased during treatment. There were four participants, who ranged in age between 4-6.5 years. A treatment package was used that included positive reinforcement, verbal instruction, modeling, and physical prompts. Pill size increased from the size of a small, sprinkle candy to a full-sized pill. Results showed increases in pill swallowing for all four participants, although only two learned to swallow a full-sized pill.

In addition to manipulating the number of steps, amount of time, or size of a stimulus, researchers have also gradually altered the distance to the unpleasant stimulus. For example, Shabani and Fisher (2006) manipulated the distance of a needle to the participant's arm with an eighteen-year-old male who weighed 280 pounds. The participant was diagnosed with Type 2 diabetes and an ID. The participant had not tolerated blood draws in over two years due to a significant amount of self-injury and physical aggression. An ABAB withdrawal design was used to evaluate the effects of the treatment on the percentage of correct trials. Treatment consisted of stimulus fading plus a 10 s differential reinforcement of other behavior (DRO) schedule contingent on the nonoccurrence of arm movement. Sessions were conducted in an outpatient therapy center with generalization probes carried out in the nurse's office. In each session, the participant was prompted to place his arm on a pre-outlined board at the onset of a 10 s interval. Correct trials were scored if his hand moved less than 3 cm on the outline board, and correct

trials resulted in access to preferred edibles. Failure to meet the requirements resulted in no edible and staff turning away from the participant for 10 s. During these 10 s trials, a lancet from the participant's blood glucose monitoring device was systematically faded closer to the participant's index finger. Ultimately, the lancet was used to draw blood for the glucose test. Results showed an increase in the percentage of correct trials across steps, which ultimately yielded adequate blood glucose testing. The two-month follow-up data showed 100% correct trials.

It should be noted that as the participant moved through the initial steps, the experimenters implemented a probe wherein they attempted a blood draw, which was unsuccessful. Fading in the lancet resumed with continued success until the actual blood draw was required. Interestingly, the stimuli associated with this step are likely the most unpleasant, and therefore would be expected to evoke problem behavior.

Similarly, Wolff and Symons (2012) conducted another needle avoidance study that manipulated the distance of the needle from the participant's arm. Here, the participant was a 41-year-old male with ASD who resided in a group home. All sessions occurred in the participant's group home, and generalization probes were conducted in the physician's office. Procedures were adopted and slightly modified from the two previous studies (Hagopian et al., 2001; Shabani & Fisher, 2006). This study employed a changing criterion design to evaluate treatment effects. The mock needle, a dull finishing nail taped to a syringe, was gradually moved closer to

the participant's arm in a 16-step task analysis. In Baseline, the participant was instructed to keep 'arm on table' as the experimenter moved closer to the participant across trials. The participant's arm had to remain on the table for 10 to 15 s. Once the participant removed his arm from the table, baseline sessions were terminated and treatment was initiated at that distance. Treatment included stimulus fading plus differential reinforcement of alternative (DRA) behaviors. Correct trials resulted in access to edibles, and incorrect responses produced no programmed consequence. A timer was introduced at various points in the study, and the DRA was also terminated and re-introduced. These procedural changes, in addition to the decrease in the proximity of the needle, may have constituted contextual changes that contributed to the re-appearance of problem behavior through the sessions.

A unique hierarchy application includes gradually manipulating the level of restraints used when individuals engage in dangerous behaviors. For example, Hagopian, Crockett, and Keeney (2001) investigated variations in restraint level that involved both distance and duration. In this study, the experimenters implemented a collection of procedures to teach compliance to a blood draw procedure with a 19-year-old male diagnosed with ID, intermittent explosive disorder, and cerebral palsy. Historically, the participant had engaged in high-magnitude aggressive behaviors that destroyed the waiting and exam rooms. Hagopian et al. (2001) evaluated the effects of a treatment package that included pre-session anxiolytic medication, modeling, non-contingent access to distracting

stimuli, and differential reinforcement of alternative behavior (DRA). To ensure safety, a papoose, or thick material that wraps around the individual and is secured with Velcro and straps, was used to restrict movement and prevent problem behavior. To accomplish this, the experimenters used a sequence of steps to fade in the proximity of the papoose culminating in the straps only loosely applied. Later in the study, the straps were tightened for increasing durations until they remained tight for 60 s. After blood draws were implemented, the papoose was faded out, but the participant grasped a strap with one hand during blood draws. Results showed that the participant's compliance increased from 0% in baseline to 100% at the end of treatment over the course of six weeks.

Finally, Szalwinski et al. (2019) investigated inter-session interval (ISI) in teaching compliance in mock dental exams. The intervention involved gradual exposure, escape extinction (EE), guided compliance, and reinforcement for compliance. In one intervention condition, massed treatment, 15-min sessions were presented three to five times each week for two participants; the third participant required additional treatment sessions (range = 12 to 18) per week. In the spaced treatment condition, sessions were presented one time each week. Results showed that, in general, compliance and problem behavior observed in the spaced treatment condition were improved by implementing the massed treatment condition.

High Probability Instructional Sequence

The high probability (high-p) instructional or command sequence is an antecedent-based intervention used to increase compliance to a low-probability (low-p) request (Mace et al., 1988). The high-p sequence involves the delivery of 3-5 high-probability instructions before the delivery of the low-p, or target request. Research has shown that compliance to the low-p request is more likely when potential reinforcers are delivered after compliance to each high-p request (Pitts & Dymonds, 2012; Zuluaga & Normand, 2008). A notable benefit of using the high-p sequence to increase compliance is that it does not require physical guidance (Lipschultz & Wilder, 2017). Given these benefits, it is not surprising that medical tolerance studies have examined its effectiveness. Currently, the high-p sequence has been effective in increasing compliance with a few medical procedures: central-venous line and specific routine procedures (i.e., ear and throat exams, cutting toenails).

McComas, Wacker, and Cooper (1998) examined the effects of a high-p command sequence on compliance to an 11- step medical procedure. The participant was a 22-month-old male diagnosed with ID and short bowel syndrome. The medical procedure involved tolerating a central-venous line (C-line). The sessions were conducted in a hospital setting with the participant's mother implementing all procedures. Session duration ranged from 5-12 min. The treatment package included DRA, escape extinction (ESC EXT), and the high-p

sequence (HIGH-P) to increase compliance to the low-p request of "hold still." Compliance was scored if the participant remained on his back and kept his torso and legs completely still for 5 s. A multielement design was used to evaluate two different multi-component treatment packages with complex procedures and contingencies: DRA/ESC EXT and HIGH-P/DRA/ESC EXT. In the DRA procedure, compliance was followed by the opportunity to play with the mother for 5 s. In the ESC EXT procedure, if the participant failed to comply, the experimenter held him down for the remainder of the 30 s session. In the high-p procedure, the experimenter presented 3-high-p requests (e.g., touch head, blow kiss) followed by the low-p request of "hold still." Compliance to the high-p requests resulted in praise, and failure to comply led to issuing the next request. Compliance to the low-p request resulted in the termination of the task and attention from the mother. Results showed that the percentage of compliance was 78% in the HIGH-P/DRA/ESC EXT procedure, and 44% in the DRA/ESC EXT procedure. Thus, the high-p sequence produced higher levels of compliance to this procedure. Interestingly, in the DRA/ESC EXT condition, the data showed an initial increase to 100%, followed by a decrease to 0%, finally stabilizing between 20-25%. As treatment progressed, it is possible that the alternation of the two procedures, one with a higher rate of reinforcement (i.e., HIGH-P/DRA/ESC EXT) and the other treatment with the lower rate of reinforcement (i.e., DRA/ESC EXT), might have contributed to the occurrence of inappropriate behavior in the latter.

The second study that incorporated the high-p sequence was conducted by Riviere, Becquet, Peltret, Falcon, and Darcheville (2011). This study used the high-p command sequence to increase medical compliance with standard medical procedures. The effects of the high-p sequence were examined using an ABABCB reversal design with three different medical procedures; examining throat (Set 1), looking in ears (Set 2), and cutting toenails (Set 3). In the A condition, compliance with the low probability (low-p) response, randomly selected from three target sets, was recorded. Compliance to the low-p command was correct if the participant completed the response within 10 s of the instruction given by his mother or medical professional. Correct responses produced praise and access to preferred items, whereas non-compliance resulted in both the mother and medical staff turning away from the participant, which then initiated a 45 s inter-trial interval. In the B condition, all procedures were identical to the A condition except the participant's mother issued high-p commands prior to the low-p command. Compliance to each high-p command within 5 s was followed by praise. Compliance to three consecutive high-p commands was followed by the low-p command. Condition C was identical to condition B, except that the medical professional implemented all treatment procedures. The B condition was identical to the B condition except that the participant's mother only provided praise after three consecutive high-p commands were completed. Overall, results showed the high-p procedure increased compliance to the low-p requests across all conditions.

However, compliance in the C condition, after the second B condition, markedly decreased.

In both of these studies, the high-p sequence increased compliance to the low-p request. Both the McComas et al. (1998) and the Riviere et al. (2011) studies used praise as a potential reinforcer for compliance to high-p requests. However, neither study included a reinforcer assessment or preference assessment. Parents identified all preferred items; this, in itself, is a limitation.

Modeling

Generalized imitation is a critical skill in childhood development (Dawson & Adams, 1984); imitation allows individuals to learn by observing a model perform a behavior or chain of behaviors and then imitating, or copying, the model's behavior. Although typically developing children imitate readily, many children with ID must be taught to imitate. Several types of modeling techniques have been used to teach individuals with ID to imitate a variety of skills (See Gardner and Wolf, 2013 for a review). Two main types of modeling are video modeling and in-vivo modeling (live demonstrations).

Video modeling is an instructional technique that uses recorded videos to demonstrate skills, as opposed to live demonstrations of the target behavior. This procedure allows individuals to watch the video and then imitate a simple behavior (e.g., clapping hands, raising hand) or complex behavior chains (e.g., brushing

teeth, dental cleaning). Video modeling has also been used to increase compliance with medical procedures.

In both video and in-vivo modeling, the participant observes a model who is demonstrating a target behavior; he or she then has an opportunity to imitate the modeled behavior. In both, the models can be peers or adults (McCoy & Hermansen, 2007; Wang & Koyama, 2014). Peer models are in the same age range as the participant; with regard to children, adult models are older than the participant, and involve individuals such as teachers, parents, or therapists. Models can also involve individuals who are familiar or unfamiliar to the participant.

Video modeling. Video modeling has been employed to teach a variety of skills (e.g., social, functional, play) to individuals with (Delano, 2007) and without disabilities (Dowrick, 1999; Hitchcock, Dowrick, & Prater, 2003). Some researchers hypothesize that individuals with ASD and other intellectual disabilities may have an affinity for videos and movies (Charlop-Christy, Le, & Freeman, 2000; Corbette & Abdullah, 2005; Dowrick, 1999), and are therefore especially responsive to video modeling interventions.

Video modeling has been incorporated in several medical compliance studies, mostly dental procedures (Isong et al., 2014) and physical exams (Cuvo et al., 2010a, 2010b). For example, Cuvo et al. (2010a) used a 9-minute DVD showing a typically-developing peer cooperating with a routine physical exam. In this study, six children diagnosed with ASD ranging in age from 3-6 years old

served as participants. Treatment comprised several components, such as differential reinforcement, shaping, fading, and escape extinction, as well as the 9-min DVD. Parents were instructed to show their child the DVD during the treatment condition and record data on the frequency of watching the video, as well as the child's interest in the video using a Likert scale (1-5) with 1 (did not watch video) to 5 (watched all). Results showed that compliance with the medical exam increased for all participants, and compliance was established to each step of the exam. However, due to the six-component treatment package, the effects of video modeling alone cannot be ascertained. Moreover, no IOA data were recorded. In regards to the video modeling data, parents reported that participants watched the video from three times during the study to one to two times each day of the study. The Likert scores varied, on average, from 2.5 to 5 across participants. These data suggest that most of the participants did not consistently attend to the video.

Cuvo et al. (2010b) used the same treatment package to train five children to tolerate dental exams. The only minor difference in the video modeling component was how the parents scored the Likert scales. Rather than using the 5-point Likert scale, parents were asked to use a 3-point Likert scale to indicate the degree to which their child attended to the video, with 1 meaning no interest and 3 indicating attending to the entire duration of the video. Results of the training showed an increase in compliance to the dental exam for all participants. As in the aforementioned study, the effectiveness of the video model alone is unclear. A

component analysis should be conducted to tease out the effects of the video modeling; or perhaps video modeling might be tested alone, and the full package only implemented if compliance is not increased. According to parent report data, three of the participants watched videos from 5 to 50 times; there were no data for the other two. The Likert data ranged from 2 to 3, although most watched approximately half the time, according to parent reports. In both of the aforementioned studies, participants were exposed to the video at home, so the time between watching the video and the procedure is unknown. Thus, it is possible that hours or days elapsed between viewing the procedure and actually tolerating the procedure.

To control the time between viewing and the actual procedure, Isong et al. (2014) required participants diagnosed with ASD to watch the video in the dental waiting room 15 min before the procedure. Using a between-subject design, the participants were randomly assigned to one of four different groups: (A) control, (B) video peer modeling, (C) video goggles (displayed 2D and 3D movies as distractor stimuli during the procedure) and (D) video peer modeling plus video goggles. Results showed lower anxiety and problem behavior scores in group D wherein individuals watched the peer video modeling and had access to distracting stimuli (i.e., video goggles). There were no effects noted in other treatment groups.

Luscre and Center (1996) examined the effects of a treatment package including prompts, video peer modeling, and reinforcement on dental compliance.

A multiple baseline design across participants was used. Participants included three boys diagnosed with ASD with four typically developing boys as video models. All sessions were conducted in the school setting with the exception of weekly generalization probes and the final dental exam held in the dentist's office. Baseline procedures consisted of in-vivo dental probes; however, due to aggression, sessions were terminated, and remaining baseline sessions were conducted in the participants' school. In all treatment stages, each participant had access to distracting stimuli (i.e., country music, handheld mirror, fruit, Play-Doh™). A peer dental video model displayed the current and next step in the dental hierarchy. The latter was intended to increase compliance to the future steps. Compliance with each step resulted in preferred activities. Results showed all three participants completed the hierarchy in the school setting. However, only participant 1 successfully tolerated dental cleaning in the dentist's office. That participants 2 and 3 were not successful suggests that perhaps the change in the context from the school to the office was responsible for the re-occurrence of problem behavior in the latter; more specifically, the contextual stimuli controlling the appropriate behavior in the analog setting at school were not present in dental office sessions.

Conyers et al. (2004) compared the effects of video modeling with those of in vivo desensitization using an 18-step dental procedure for six adults diagnosed with ID. Three participants were assigned to each treatment. In the video modeling component, a well-known staff member modeled each step of the dental procedure,

which lasted approximately 15 min. In the video, the model received verbal praise after each step. Participants watched the video on two separate occasions, after which a probe session was conducted. Here, the experimenters presented the dental procedure, step-by-step, until the participant refused to continue. In the in vivo desensitization procedure, the experimenters delivered praise for compliance with the first step, as well as prompting as needed. Each succeeding step was added when the participant appeared calm. The same sequence, two treatment sessions followed by a probe session, was used for the in vivo desensitization group. Results showed that in vivo desensitization increased compliance for all three participants, and the improvements were maintained at a follow-up visit. For the video modeling group, only one participant showed an increase in compliance. The other two participants were switched to the in vivo desensitization procedure; this treatment increased compliance for both participants. It should be noted that sessions were conducted at the participants' adult day training (ADT) facility and not in the dental office. However, there were reports that three of the participants received actual dental care one month after treatment ended, and were reported to be more cooperative (p. 237).

It should be noted that the use of the term "desensitization" is perhaps problematic. Desensitization is a procedure first developed in the field of behavior therapy by Joseph Wolpe (1958) that involves three steps. In step 1, a hierarchy of feared stimuli is constructed starting with a stimulus that is either not aversive, or

only minimally so, and ending in a stimulus that is highly aversive. In the second step, the participant learns relaxation skills. Third, the participant is exposed to the hierarchy while practicing the relaxation skills, and only progresses through the hierarchy when he/she is able to stay relaxed when presented with a given step. Thus, in the Conyers et al. (2004) study, a hierarchy was used, and participants worked their way through it. But, at no time did they learn relaxation skills. Thus, this procedure may not be an accurate example of desensitization.

In vivo modeling. In vivo modeling, or live modeling, differs slightly from video modeling, in that the model demonstrates the target behavior in real time, rather than in a prerecorded video. Altabet (2002) used a between-subjects design to compare the performance during dental cleanings for 35 participants diagnosed with ID who were receiving dental care interventions. Another 28 individuals were in a no-treatment control group. Data were collected on the number of steps completed in the procedure, as well as the number of restraints and sedations required throughout treatment. The treatment consisted of a hierarchy of 34 steps, modeling, shaping, paired relaxation, and reinforcement. Sessions were conducted twice a week for approximately three months in an analog session with a minimum of two sessions conducted in the dentist's office. Overall, results showed that the treatment group's performance was superior to the non-treatment group. No significant difference was reported between the two groups concerning the number

of restraints or use of sedatives. It should be noted that the effects of modeling alone are unknown in this study, as it was combined with many other procedures.

Orellana, Martinez-Sanchis, and Silvestre (2014) reported a procedure they termed "Tell-Show-Feel-Do." Seventy-two individuals, diagnosed with ASD, served as participants. A pre- and post-treatment assessment was conducted. In the pre-treatment assessment, participants were exposed to a sequence of steps in a dental exam. The participants' behavior was scored using the Frankl Scale, which is a measure of compliance for pre- and post-tests (Frankl, Shiere, & Fogels, 1962). There were five sessions of treatment wherein participants first received explanations regarding what was to transpire. The explanation was provided by a person, or through the use of a puppet or stuffed animal, depending on the age of the participant. Then, the experimenter demonstrated what was to happen using the same delivery method. Subsequently, participants could touch, or "feel," any device or equipment that was being shown. Video modeling, as well as photographs, were also used. Finally, the actual procedure was implemented with the participant. Results showed increases in steps completed in the post-treatment compared to the pre-treatment assessment. It must be noted that there were many procedures used in this study, and the relative effects of in vivo modeling, or any other component, are therefore unknown.

DeMore, Cataldo, Tierney, and Slifer (2009) investigated using modeling of specific steps. Seventeen children, diagnosed with a Smith-Lemli-Opitz syndrome

(SLOS), served as participants; children with SLOS are at risk for congenital malformations, ID, and ASD. In this study, a stuffed animal served as the model in an EEG procedure to demonstrate the placement of the electrodes. Treatment also comprised differential reinforcement, escape extinction, and a sequence of steps. Results showed that all participants complied with at least 75% of the steps; note that these data were collected in mock sessions. During the actual EEG, all but two participants tolerated the placement of all 21 electrodes, and the other two tolerated the placement of nine electrodes. Notwithstanding the positive results, it is unclear if the modeling per se had any effect.

In addition to the research mentioned above, two additional studies included in vivo modeling as a part of a complex treatment package. Cavalari et al. (2013) investigated the effects of a treatment package using in vivo modeling, social stories, a hierarchy, and positive reinforcement, on compliance with a medical exam; note that a nurse modeled each step in the hierarchy before implementation. Results showed an increase in compliance over 56 sessions. Gillis et al. (2009) implemented a treatment package including graduated exposure, reinforcement, and in vivo modeling to increase compliance with a medical exam. However, the authors did not describe how modeling was done. Nonetheless, results showed 15 of the 18 participants learned to comply with the medical exam.

Thus, although both video and in vivo modeling have been used in several studies, they have been combined with many other procedures, and therefore, the

effects of these procedures in isolation are unclear. Only one study, Conyers et al. (2004), reported the singular effects of modeling, and the results were not uniformly positive. Therefore, additional research is needed to evaluate the effects of modeling as a contributing factor in treatment packages, and as a stand-alone procedure.

Distracting stimuli. Several studies have used distractor stimuli during various medical procedures. For example, Maguire, Lange, Scherling, and Grow (1996) investigated four adults diagnosed with ID who were learning dental exam compliance. To help facilitate compliance, participants were given coin purses or water bottles to hold during treatment implementation. This procedure was combined with verbal explanation and description of the procedure, contingent reinforcement (i.e., praise, money), and graduated exposure. Results showed the level of resistance decreased during treatment and was maintained at a follow-up appointment. Note that resistance was not objectively quantified, but instead was scored using a rating scale (0-3). Moreover, the singular effects of the distracting stimuli, apart from those of the package, are unknown. A similar procedure (i.e., holding a teddy bear) was used by Hagopian et al. (2001) during a blood draw.

Access to ongoing visually distracting stimuli (e.g., movies, bubbles) has also been investigated. For example, Grinder et al. (2012), previously reviewed herein, used access to movies as the distracting stimulus during dental exams. The movie was presented both 30 s before, during, and 30 s after each session. A

similar procedure was used by Isong et al. (2014). Here, participants watched a 2D or 3D movie, using eyewear, during a dental procedure. Finally, bubbles were used in Slifer et al. (2007) as an element of a treatment package.

As with modeling, the singular effects of distracting stimuli are unknown. This procedure has always been used as a component of a multi-component treatment package. Some researchers have hypothesized that distracting stimuli do have important effects. For example, Allen and Kupzyk (2016) suggest that distractor stimuli evoke responses that are incompatible with both the respondent and operant behavior in anxiety or fear. Thus, these stimuli might evoke "relaxation" responses that are incompatible with, for example, heart rate increases, and they might also evoke positive operant behavior that is incompatible with inappropriate escape behavior. Additional research is necessary to ascertain the effects of non-contingent access to distracting stimuli during medical procedures.

Escape extinction. An escape extinction (EE) procedure requires withholding reinforcement for behaviors that have previously contacted reinforcement (Cooper, Heron, & Heward, 2007). For behaviors maintained by negative reinforcement, stimuli that would have been terminated after inappropriate behaviors in the past, would instead be unchanged after such behavior. For example, a child's tantrums occur because, in the past, tantrums were followed by the termination of a medical procedure. In escape extinction, tantrums would not produce termination of the procedure.

Ten of the 34 medical and dental studies use EE as one of the treatment package components. EE was used during dental exams (Cuvo et al., 2010a; Szalwinski et al., 2019), physical exams (Cuvo et al., 2010b), electroencephalography (EEG) (DeMore et al., 2009; Slifer et al., 2008), central-venous line care (McComas et al. 1998), nebulizer treatments (Reimers et al., 1988), wearing of positive airway mask (Slifer et al., 2007), and needle sticks (Slifer et al., 2011). EE is a robust procedure, so it is not surprising that it was effective in increasing compliance in all of the aforementioned studies.

Escape extinction was one of the treatment procedures in the Cuvo, Reagan, Ackerlund, Huckfeldt, and Kelly (2009) study that involved a 10-component physical examination. Six individuals diagnosed with ASD served as participants. The two dependent variables were the number of steps completed during the exam components and the percentage of 10 s partial interval bins with problem behavior. A multiple probe design across exam components was used to evaluate the effectiveness of the treatment package, which included EE, as well as distracting stimuli, gradual exposure, reinforcement, and video modeling. Before the intervention, parents identified six preferred items for their child, and the experimenters conducted a paired stimulus preference assessment with the reported items. These preferred items were used as distracting stimuli during the procedure and as rewards for compliance with the exam components. Escape extinction was implemented upon the occurrence of problem behaviors; when the participants

emitted inappropriate escape or avoidance behaviors in the presence of some unpleasant or aversive stimulus, the stimulus remained present. The stimulus was only terminated, and preferred items were made available, when the participant tolerated the sight or touch of the stimulus for an entire 10 s interval. Results showed an increase in compliance for all participants during intervention, although, for some participants, compliance with some untreated components increased without intervention. Interestingly, problem behaviors were hypothesized to be maintained by escape from aversive stimuli, but a functional analysis was not conducted. In fact, escape and avoidance behaviors were "inferred from emotional and physical responses (e.g., crying, whining, attempting to leave the room, pushing away medical instruments) that appeared to be members of a functional response class whose members were reinforced by removing or preventing contact with aversive stimuli" (p. 173).

Some aspects of the EE component in the above study raise questions. As previously mentioned, the stimulus was to remain until problem behavior ceased for an entire 10 s interval. However, the participant was allowed to escape the demand in some steps that required physical movement. For example, in one of the steps, the participant was instructed to sit on the exam table, but if the participant ultimately refused to do so, after several procedures were attempted then they were allowed to sit on the floor for the remainder of the exam. It is unclear why EE was not done in this case. In another example, one of the steps required the participant

to open her mouth. The data showed that she ultimately cooperated, but the authors failed to precisely report what happened when she initially refused to open her mouth. Therefore, the lack of EE procedural details limits replication or a more refined analysis.

In the previously reported study by McComas et al. (1998), EE was part of two different treatment packages: DRA/ESC EXT and HIGH-P/DRA/ESC EXT. In both treatment packages, failure to comply with the low-p request resulted in the use of physical restraint until the step was completed. Thus, this involves two procedures. One is the withholding of escape after refusals; the other is the application of the restraint. The relative contribution of each procedure is unknown. Also, it should be noted that a functional analysis was not conducted to determine if the behavior was maintained by escape from task demand.

Similar to the McComas et al. (1998) study, Reimers et al. (1998) reported the effects of two different treatments, one with EE and one without EE, on compliance to wearing a mask during nebulized respiratory treatments. In the first treatment, the participant received squirts of soft ice cream from a syringe for tolerating the mask for progressively increasing durations. If inappropriate behavior occurred before the interval elapsed, the mask was removed and all inappropriate behaviors were ignored. The purpose of this condition was to pair stimuli associated with a highly preferred food with those associated with wearing the mask. The experimenters increased the magnitude of ice cream deliveries with the

duration of wearing the mask. In the second treatment, the experimenters used EE, which required the participant to wear the mask for the entire interval. Turning the head away from the mask resulted in physically guiding it back to the midline. If the participant attempted to remove the mask, the experimenter blocked all attempts and prompted hands down to the side. During the course of the experiment, the researchers increased the required duration of wearing the mask. Results showed that for the first treatment, without EE, the average duration of mask wearing was 5.59 s and the percentage of intervals with either head turns or blocks was 31 and 5 percent, respectively (p. 607). Conversely, in the second treatment, with EE, the average duration of mask wearing increased to 20 min, with head turns and blocks at near-zero levels. Thus, the addition of EE produced sizable increases in mask wearing and a substantial decrease in problem behavior.

In a similar study, four preschool children were taught to tolerate wearing positive airway masks (PAP) during sleeping hours using a treatment package including EE (Beck et al., 2005; Slifer et al., 2008). Researchers employed a 16-step PAP task analysis. Participants were taught to wear the mask for increasing durations, starting with 5 s and ending at 15 m. Sessions were first conducted during the daytime to train the parents and nurses to implement the procedures. Escape extinction consisted of the experimenters, parents, or nurses physically blocking all attempts to remove the PAP, ignoring inappropriate behaviors (i.e., crying, screaming, head turns), and redirecting the participant to another activity.

Following training in the daytime, the procedures were replicated at home during nap and overnight sleep times. Results showed an increase in mask wearing from 0 s to approximately 14 hr at night. However, this study did not report the number of attempts to remove the PAP or successful removals. These data are valuable, as frequent attempts to remove the PAP would make the intervention labor intensive.

Two studies have used EE during EEG procedures. In the first study, EE was used in a case study as part of a treatment package to train 17 children with ID to comply with an overnight EEG procedure (DeMore et al., 2009). In the EE procedure, when participants attempted to remove the electrodes from their head, the experimenter delivered a verbal command to engage in the incompatible behavior “hands down;” if that was ineffective, physical blocking was implemented. Results showed that 15 participants tolerated the application of all 21 EEG electrodes, and 2 participants tolerated 9 electrodes. However, the authors did not report some important data and information. First, the number of verbal instructions or physical blocks required for each participant is unknown. These data would be helpful in evaluating the extent to which behavior was resistant to the extinction used. Second, it is unclear if the two participants who failed to comply with the application of all electrodes had more difficult problem behaviors. The inclusion of the severity of the problem behavior would assist future researchers in determining if EE is a reasonable intervention. A functional analysis would have been useful to verify whether or not problem behavior was maintained by a history

of escape from the EEG procedure. Moreover, the experimenters could have implemented a preference or reinforcer assessment. These data could be used to examine the relation between reinforcer value and treatment outcomes.

In the second EEG compliance study, seven children with DD ages 2-10 years were trained to tolerate electrodes during an EEG without restraint, anesthesia, or sedation (Slifer et al., 2008). This study employed an AB design to evaluate the effects of a treatment package that involved EE in addition to distracting items, gradual exposure, and reinforcement. During the EE component, all attempts to remove the electrodes were physically blocked, and the participants were redirected to engage in an incompatible behavior; distracting stimuli were also provided. More specifically, if the participants attempted to remove or touch an electrode, the examiner said “hold your toy” or “clap your hands” as the participant’s favorite song was being played (p. 192). Results showed that the percentage of steps completed increased to 100%, and the percentage of steps with problem behavior decreased, for all participants. It should be noted that the EE procedure involved three components: withholding escape, presentation of the request, and presentation of music. Future research should investigate their respective effects. Finally, the current study produced rapid compliance and decreases in problem behavior for all participants, and these effects were obtained over an average of four sessions for a total of two hours. In the DeMore et al. (2009) study, only 53% of the participants complied with the application of all

electrodes; but in this study, there was only a single one-hour session. Thus, it is possible that a few more sessions might have yielded superior results.

Perhaps the most likely time to employ EE is when teaching individuals to tolerate blood draws involving needle sticks. Holding the arm (i.e., withholding escape) may well be necessary to ensure the needle is applied correctly and safely. Eight children ages 4 to 16 years learned to tolerate a needle stick using EE, as well as task analysis, topical analgesic, verbal prompts, and redirection to other activities (Slifer et al., 2011). The dependent variables included the percentage of steps completed/tolerated and the percentage of steps in which "behavioral distress" occurred. Behavioral distress was defined as a combination of negative vocalizations (e.g., screaming, yelling, crying) and any overt behavior that attempted to evade the procedures (e.g., turning away, pushing away items). The EE procedure involved interrupting or preventing the escape behavior by verbal prompting, redirection to a specific activity or task, and if necessary, physical blocking, while prompting the participant to remain in the general location. Results showed that behavioral distress decreased from 80-100% of the sessions in baseline to less than 20% of the sessions in treatment; moreover, compliance increased from 0-60% in baseline to 100% in treatment.

These aforementioned EE studies typically used physical blocking to prevent the participants from escaping the unpleasant stimulus. None of the authors mentioned the degree to which they employed EE. For example, they removed the

PAP mask, but the mask was still in sight; the sight of the mask could still be unpleasant but not as unpleasant as wearing the mask.

Assessment

Assessments typically precede treatment; they are the gold standard for ascertaining pertinent clinical information, such as identifying individual preference (Fisher et al., 1982), determining reinforcer effectiveness (DeLeon & Iwata, 1996; Durand, Crimmins, Caulfield, & Taylor, 1989; Fisher et al., 1992) discovering optimal discrete trial interventions (Carroll, Owsiany, Cheatham, 2018), pinpointing employee performance problems (Austin, 2000; Carr, Wilder, Majdalany, Mathisen, & Strain, 2013), or verifying the cause of inappropriate behaviors and replacement behaviors (Carr & Durand, 1985; Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994; Querim, Iwata, Roscoe, Schlichenmeyer, Ortega, & Hurl, 2013). More recently, research has focused on creating assessment tools that aim to individualize communication training (Valentino, LeBlanc, Veazey, Weaver & Raetz, 2018), error-correction procedures (Iwata & Rodgers, 1991; McGhan & Lerman, 2013), and employee performance (Carr et al, 2013). In fact, Carroll, Owsiany, and Cheatham (2018), claimed that conducting assessments, even brief assessments, could save "valuable intervention time" (p. 498). However, few assessment-based studies can be found in the the medical tolerance literature.

Although there have been decades of research on teaching individuals to tolerate medical and dental procedures, the lack of assessment in the literature is

noteworthy. Indeed, this near absence of assessment in the medical tolerance literature challenges researchers who advocate that assessment driven interventions are superior to non-assessment indicated treatments. Central to this study is the lack of assessment as it relates to medical tolerance training. Research that conducted any form of assessment is highlighted below. The current study will utilize multiple assessments as an integral part of pre-intervention procedures and treatment evaluation.

Preference assessment. In skill acquisition programs, it is essential to identify effective reinforcers for all participants. A preference assessment is one way to ascertain potential reinforcers. The literature is replete with studies that have successfully demonstrated ways to determine individual preference and potential reinforcers (Fisher et al., 1992; Pace, Ivancic, Edwards, Iwata, & Page, 1985). Despite this research, some studies rely solely on the caregiver's or teacher's opinion, which is less effective than more rigorous assessment methods (Green et al., 1988). Consideration must also be given to the length of a research study or the amount of time it takes for an individual to master a program or skill. During this time, individual preference can change, rendering the once preferred item ineffective. Moreover, research has demonstrated that the potency of the reinforcer can diminish with the task requirement (DeLeon & Iwata, 1996).

In the medical tolerance literature, seven studies based their participants' preferred items exclusively on parent, caregiver, or teacher report (DeMore et al.,

2009; Gillis et al., 2009 and 2004; Slifer et al., 2008; Slifer et al., 2007; Slifer et al., 2011; Wolff & Symons, 2012). Only four studies conducted a formal preference assessment, employing a paired stimulus preference assessment (Cavalari et al., 2013; Cuvo 2010a, b; Stuesser et al., 2020), multiple stimulus without replacement (Shabani & Fisher, 2006), and vocal reports (Hagopian et al., 2001). Perhaps even more concerning is several of these studies failed to obtain information on potential reinforcer preference in any form (Beck at al., 2005; Conyers et al., 2004; Davit et al., 2011; DeMore et al., 2009; Gorski et al., 2005; Gorski & Slifer, 2004; Grinder et al., 2012; Isong et al., 2014; Maguire et al., 1996; McComas et al., 1998; Riviere et al., 2011). Finally, only a few studies omitted any type of indirect or direct preference assessment, and instead provided brief escape from the procedure as a potential reinforcer (Altabet, 2002; Boj & Davila 1989; Lunskey et al., 2003; Orellana et al., 2014; Reimers et al., 1988; Szalwinski et al., 2019). Although negative reinforcement in the form of escape from the medical procedure can be highly effective, it fails to reduce the unpleasantness of the procedure. That is, if the participant only receives negative reinforcement for complying with the task, the task itself is only paired with escape and not any preferred items or activities. For escape to be valuable, the task itself has to remain demanding or unpleasant; thus, using EE as a potential reinforcer does not allow the unpleasantness of the task to diminish, an essential feature of toleration.

Functional Analysis. Although it is highly plausible that problem behavior is maintained by escape from the medical procedure, a brief FA could confirm this hypothesis. Yet, only one study included an FA. Stuesser & Roscoe (2020) conducted the first medical tolerance study that employed a FA, adapting procedures from Iwata et al. (1990). The FA comprised three conditions: a task demand condition, a medical demand condition, and a control condition. In the non-medical task demand condition, the experimenter presented demands similar to those used in the typical daytime routines. A three-step prompting procedure was used to initiate and maintain task engagement. Contingent on problem behavior, the experimenter provided a 30 s break from the task; the experimenter also delivered praise contingent on compliance. In the medical demand condition, the experimenter presented the first step of the targeted medical procedure. Problem behavior resulted in a 30 s break from the medical procedure, and compliance produced a praise statement and the next step in the medical procedure. Noncompliance resulted in the initiation of the same three-step prompting procedure used in the non-medical task demand condition. In the control condition, the experimenter informed the participant that she needed to work and was unavailable; there was no interaction with the participant, and no programmed consequences for problem behavior. It is unclear if there were any activities or items available in this condition. Results showed that all three participants' behavior was sensitive to escape from the medical task demand, but not to the non-

medical task demand. Following the FA, treatment was initiated that involved differential reinforcement without EE. For 3 of the 4 participants, stimulus fading was added to the aforementioned procedures, a necessary component for reducing their problem behavior. Three individuals learned to tolerate a mock blood draw and one individual learned to tolerate well-check procedures.

Assessment Tools. A study by Cavalari et al. (2013) represents the first attempt to create an assessment tool to empirically determine the next treatment step. These researchers trained a 16-year-old female with ASD and an intellectual disability to tolerate a 12-step physical exam using graduated exposure and positive reinforcement. The step-forward probes were designed to assess compliance to the untrained steps in the escape-avoidance hierarchy. That is, after compliance to a trained step, a new step was presented without positive reinforcement for compliance; negative reinforcement was provided in the form of escape for inappropriate target behaviors. But, the step-forward probes did not guide treatment until after step 6, and there were few procedural details as to how this was done. For example, after step 4, the step-forward probe yielded compliance through step 10, but the next sessions initiated at step 5 of the task analysis. Overall, the participant did comply with the full exam after 56 sessions. However, this study is not without limitations. First, as previously noted, the step-forward probes were limited to steps 6-12, suggesting that probes conducted on steps 1-5 did not evaluate how to proceed with the exam. Second, a visual inspection of problem

behaviors associated with each step was not presented. Third, no data were collected on physiological measures. Fourth, this study did not conduct any maintenance or generalization probes, limiting the external validity of the study. Finally, although the authors of this study claimed they employed a changing criterion design, it was not, in fact, a changing criterion design. Rather, the graph depicts the next step and does not include goal lines or a criterion reversal phase. These limitations provide an opportunity to expand and strengthen the medical compliance research literature.

More recently, Szalwinski et al. (2019) reported an assessment procedure used during gradual exposure to a mock dental cleaning for three participants and a mock well exam for one participant. The primary purpose of this investigation was to examine the effects of varying inter-session intervals (ISI). Additionally, the authors reported the use of terminal probes wherein during treatment, participants were exposed to the entire targeted medical procedure sequence. Compliance resulted in the initiation of maintenance sessions; if noncompliance or problem behavior occurred, then the experimenter resumed the gradual exposure procedure. Terminal probes were implemented after two consecutive steps were completed with high levels of compliance and low levels of problem behavior. These levels were defined as four consecutive sessions of 80% or more of the targeted steps completed, and 20% or less of disruptive behavior compared to baseline. Data show that the probes were implemented relatively infrequently. For example, one

participant, John, received one probe and then transitioned to maintenance. However, the first terminal probe occurred after the second treatment (i.e., massed treatment phase) at approximately session 26, or 36 weeks. Another participant, Nick, received two probes before moving to maintenance. The third participant, Beth, received several probes, as treatment gains required many sessions and procedural variations. Thus, terminal probes provided more efficient treatment by skipping unneeded steps. Note, however, that the criteria to attempt a terminal probe were somewhat stringent (see above), as were the criteria to add a step. Thus, the probes were relatively infrequent. It is unknown whether more frequent probes could further increase treatment efficiency. It is also unclear if the procedures produced treatment effects that would generalize to a real-life dental exam, as the study just involved simulations in a clinic.

Szalwinski et al. (2019) noted the concerns regarding the extensive time requirements when using gradual exposure to achieve treatment outcomes. Assessments such as those described herein should reduce the amount of time required. However, as noted above, each study had limitations concerning the use of the assessments. Thus, a set of procedures guided by frequent assessments is needed to produce the most effective, efficient treatment for medical adherence. Moreover, factors for developing an assessment tool are based on limitations of escape-avoidance hierarchies discussed in the previously described studies, especially those noted in Calvalari et al. (2013).

Purpose of current study

The medical tolerance literature yields promising results for individuals who actively avoid or engage in inappropriate behaviors during medical procedures. However, no studies have thoroughly evaluated both physiological and operant behavior during medical procedure tolerance training. Moreover, many of the hierarchies reported in the literature involve numerous steps; to proceed step-by-step might well involve an inordinate amount of time. Practitioners need a way to move through a hierarchy as quickly as possible. Thus, the purpose of this study is multifaceted and will require two different experiments. First, this study is the first to develop an assessment protocol that identifies what step, or steps, in the escape/avoidance hierarchy procedure are necessary. Indeed, the assessment is a tool whereby experimenters can skip steps or repeat steps in a hierarchy as needed. Second, this study is the first to incorporate measurement of both operant and physiological behavior for all participants and procedures. Given that operant behavior is affected by treatment procedures, researchers need to determine if there are concomitant changes in physiological responses that are reasonable measures of stress. Moreover, physiological indices can provide important information about individuals who have limited vocal repertoires. Finally, this study is only the second investigation that incorporates a functional analysis to verify that inappropriate behavior is maintained by escape from the medical procedure, and the first to use a trial-based functional analysis to do so. Experiment 1 examines the

effects of assessment tool and intervention during dental cleanings and dental x-rays, whereas, Experiment 2 replicates Experiment 1 with needle tolerance.

Experiment 1

Method

Participants

The dental cleaning and x-ray portion of the study included five young males, ages 4 to 9 years, all with an intellectual disability (ID) and a history of dental treatment nonadherence. All participants received applied behavior analysis (ABA) services at an early intervention clinic, and attended the same pediatric dental practice. All parents expressed concerns regarding dental hygiene and dental nonadherence to the Board Certified Behavior Analyst (BCBA) at the clinic.

Leo, a five-year-old boy, spoke in three-to-four-word sentences and could follow two and three-step instructions, and his inappropriate behaviors included screaming, crying, and hitting. He previously required mechanical restraint in the form of a papoose to comply with a dental cleaning.

Harlow was an eight-year-old boy, and spoke in six-to-eight-word sentences, and followed at least 10 three-step instructions. Harlow engaged in a variety of inappropriate behaviors, including screaming, crying, hitting himself or hitting others. His mother refused to take him to the dentist due to compliance difficulties with tooth brushing at home and her fear that the experience would be "traumatizing."

Davis, five years of age, vocally communicated using two-word sentences and followed multiple one and two-step instructions. His inappropriate behaviors included screaming, crying, and hitting others. He previously required general sedation and intubation to clean, extract, and cap multiple teeth.

Gavin, a four-year-old boy, communicated using sign language and could independently request three items and follow two one-step instructions (i.e., come here, sit down). His inappropriate behaviors included crying, eloping, and hitting others. Similar to Harlow's mother, Gavin's mother also avoided a dentist visit due to overall general compliance issues and lack of communication, both speaking and ability to follow instructions. At the time of the study, Gavin only chewed on a toothbrush and would not tolerate his parents brushing all of his teeth.

Jose, eight years of age, communicated using three-to-four-word sentences, and followed multiple two-step instructions. Jose's inappropriate behaviors consisted of screaming and hitting. Jose had a prior history of complying with dental cleanings until his last visit during which he failed to tolerate a Novocain shot, which ultimately resulted in two unfilled cavities. When Jose's mother asked him if he wanted to go to the dentist, he replied: "No, that hurts."

Settings and Materials

The first author conducted all sessions, except for the in vivo probes, in a local clinic exam room, which was approximately 4.5m x 6.5m, and attended all in vivo probes at the local pediatric dental office. The in-vivo probes occurred in a private exam and treatment room in the office. The dentist provided the first author with a bite guard to prevent the patients from closing their mouth and eight x-ray bites, and modeled the steps in the dental cleaning procedure. In addition, she prioritized the top three necessary procedures as tolerating scraping teeth, blowing air on the teeth, and taking x-rays.

The treatment room contained a reclining chair with a swivel tray that held all the dental supplies (i.e., dental scraper, mirror, green mask, gloves, sunglasses, bite guard, dental floss, and gauze pads). A tall floor lamp provided additional lighting, similar to the dentist's office. The Duff Air Brush Machine™ blew air comparable to the dentist's air blower. During the x-ray simulation, the experimenter wrapped a large weighted blanket around the participant's torso and neck and held a clear cylinder near the participant's face to mimic a lead protective apron and camera, respectively.

Additional materials included an iPad™ for recording all sessions, an iPhone™ used to stream data from the Empatica Wristband™, the participant's preferred item identified in the preference assessment, (primarily an iPad™), a treatment session summary sheet in a plastic sheet protector with dry erase marker,

a clipboard with datasheets, and timers. The experimenter conducted sessions wearing scrubs.

The dental cleaning task analysis comprised a 55-step procedure that required participants to tolerate shining a bright light on their faces, scraping teeth, blowing air on teeth, examining mouth with a mirror, brushing all teeth, flossing, applying fluoride treatment to each tooth, and touching teeth with fingers and a gauze pad. The complete task analysis can be found in Appendix A.

Dependent Variable and Data Collection

The primary dependent variable was the step number completed in the dental procedure (i.e., dental cleaning, dental x-ray, and mask tolerance) during each trial. Compliance was defined as tolerating the specific step without inappropriate behavior. Trials both with and without inappropriate behavior were recorded. Inappropriate behaviors prevented medical staff and the experimenter from completing their standard treatment protocols.

The Empatica E4 Wristband™, approved for research by the U.S federal food and drug administration (FDA), captured the physiological measures, which constituted the secondary dependent variable; the wristband recorded stress levels using electrodermal activity (EDA), or skin conductance (SC) response level, measured in microSiemens (uS). EDA is used to detect stress levels through the changes in electrical current passing through the sweat glands. The two electrodes on the wristband measure subtle changes in electrical current passing through the

skin on the inside of the individual's wrist. The Empatica E4 Wristband™ also recorded heart rate, blood volume, temperature, and activity level; however, we will only report the EDA measures, as this is the most sensitive measure.

Interobserver Agreement and Treatment Integrity

A trained observer scored interobserver agreement (IOA) data, either from video recordings or during the procedure, on 100% of assessment probes, FA trials, and baseline trials for all participants. During treatment, a second observer independently collected data on 66% of Leo's trials, 75% of Davis' trials, 76% of Harlow's trials, 79% of Gavin's trials, and 75% of Jose's trials. IOA for steps completed involved a trial-by-trial computation; specifically, the number of trials that the two observers agreed that the step was completed, divided by the total number of trials, and multiplied by 100 (Larking, Hawkins, & Collins, 2016). A similar IOA procedure was used for trials with inappropriate behavior. IOA was 100% for both step number completed and problem behavior across all FA trials, assessment probes, and baseline trials for all participants. IOA for treatment trials ranged from 94.5% to 100%. The only disagreement occurred with problem behavior in Leo's treatment between trials 9-13.

To assess treatment integrity on assessment trials, observers scored whether the experimenter administered the probes on the correct trial and required the participant to comply with one step in the hierarchy. Treatment integrity was calculated by dividing the number of times the assessment probe was administered

divided by the number of times the assessment probe should have been conducted for each procedure multiplied by 100, and converting to a percentage. Results show that assessment probe accuracy was 100% across all participants and procedures.

Independent Variable

The escape-avoidance hierarchy treatment for each medical task analysis served as the primary independent variable. The first author consulted the participants' pediatric dentist for all necessary steps in the dental cleaning and x-ray procedures, and the pediatric anesthesiologist provided a detailed description for in-clinic sedation procedures.

Pre-Treatment Procedures

Parent interview. The experimenter interviewed each participant's parent to gather information regarding dental cleaning history, behavioral concerns, and preferred items or activities. Each participant's primary care physician provided medical clearance before the onset of the study. Finally, all parents answered questions regarding stress associated with watching their child during dental cleanings.

Preference assessment. Parents, participants, and participants' BCBA interviews, as well as direct observation, informed the preference assessments. The experimenter conducted a variety of preference assessments to identify the highest preferred item(s) before each trial including a multiple stimulus without replacement (MSWO) preference assessment (DeLeon & Iwata, 1996) followed by

a paired stimulus preference assessment (Fisher et al., 1992) with the top two items from the MSWO. Due to inappropriate behavior and elevated EDA levels, the experimenter conduced a free operant preference assessment for three participants. Regardless of the type of assessment, the experimenter identified the top two items and then selected the highest preferred item of the two. Interestingly, some participants engaged in more problem behavior under the paired stimulus and MSWO preference assessments than in a free operant assessment, and their physiological measures were heightened during this time. It seemed that some of the participants wanted to watch specific portions of a show or watch a show in a particular way. After evaluating their EDA measures, the experimenter conducted a free operant assessment with the iPad™. This adjustment mitigated the occurrence of problem behavior and yielded high preference items. During the free operant preference assessments, the experimenter capped the sessions after 2 min of interaction. At the end of the 2 min, the experimenter said, "Okay you can pick another song or movie." If the participant selected a different item, the experimenter started the 2-min timer and recorded the name of the item and start time. This process was repeated up to three times in order to identify a hierarchy of preferred items. If the participant said he did not want to select another item, then the experimenter confirmed the participant's preference by asking, "Okay, do you want to listen to (name of song) or watch (name of movie) while (stated the medical procedure)." If the participant said yes, the experimenter escorted him to

the treatment room. During the dental cleanings, participants were able to watch videos on an iPad™ or listen to music, as the dental office provided this same arrangement. However, during the dental x-ray procedure, participants were not permitted to hold any electronic devices; instead, the experimenter was allowed to stand within 8 feet and hold the iPad™ during the x-ray procedures.

Functional analysis. A brief trial-based FA was conducted to verify that participants' inappropriate behavior was sensitive to escape from the medical-task demand or escape from the sight of unpleasant stimuli (Bloom, Iwata, Fritz Roscoe, & Carreau, 2011). Each session consisted of a 2-minute control segment followed by a 2-minute test segment. During the control segment, no demands were placed, and the participants had access to preferred items in the exam room. If problem behavior occurred during the control segment, data were recorded, but no programmed consequences were delivered. After 2 min elapsed, the test segment commenced. Here, the experimenter stood approximately 6 feet outside of the exam room threshold and said, "(Participant's name) it is time to do (specific medical procedure)." The experimenter escorted the participant into the exam room. All pertinent medical exam materials were visible as if the procedure would occur. For example, all dental tools were displayed on the arm of the dental chair, the floor light was on, and the air blower was activated. Then, the experimenter presented each step in the dental cleaning or x-ray sequence, one by one, until problem behavior occurred or the 2-minute segment ended. Contingent on problem

behavior, the dental task was terminated. Each participant was exposed to three sessions of control-test pairs with approximately 10 min between sessions (McDonald, Moore, & Anderson, 2012). Results showed that all participants exhibited problem behavior during 0% of the control segments and 100% of the test segments. However, we eliminated two participants from the study due to compliance with all steps in the procedure, even though their parents had reported dental nonadherence. Data from these two participants are excluded from the study.

Physiological Measures. The purpose of including a physiological measure was to evaluate how the participants' stress levels, as quantified by these measures, changed over time across different settings. The Empatica E4 Wristband™, referred to as the Wristband™ henceforth, captured all physiological measures. Three participants required training to tolerate the Wristband™. The experimenter instructed the participant to wear the "watch" until the timer went off, as signaled by an audible beep. Then, the experimenter placed the device on the participant's left arm and started the timer. Participants were allowed to engage in any activity during this time. Compliance resulted in the removal of the wristband, delivery of a preferred item, and a 1-min break. If the participant attempted to remove the wristband during the interval, the experimenter blocked the attempt, reset the timer, and redirected the participant to an ongoing activity. The time intervals were initially brief (e.g., 3 to 5 s) and then increased to 30 min over several trials. Note that when the time interval was greater than 10 min,

participants' attempts to remove the wristband were only blocked; there was no reset of the timer. Device tolerance data included the date, start and end times, wrist placement (i.e., left or right), total duration, problem behavior occurrence, room number in which the session occurred, and any additional notes. The number of training trials varied from 3-10. Once the participants tolerated the device for 30 min without problem behavior, they were admitted to the study. During treatment sessions, the experimenter or parent blocked any attempts to remove the device and redirected the participant.

During all trials of the study, the Wristband™ was placed on the participant's left wrist with the silver electrodes aligned between the ring finger and middle finger at least 5 min prior to the trial; the wristband remained on until 5 min after the trial ended. These steps helped to determine participant baseline measures and their recovery time. Typically, preference assessments were run in the 5-min interval before the procedure and the participant accessed preferred items in the 5 min post procedure. No task demands were placed during these intervals. Empatica™, the company that manufactures the Wristband™ and other FDA-approved devices, stored all physiological measures on their secure web-based platform and provided an application for live data streaming.

Experimental Design

We employed a concurrent multiple probe design across participants to evaluate the effects of the escape-avoidance hierarchy. Trials were conducted up to four days per week with a maximum session duration of one hour. To ensure insurance coverage, in-vivo dental visits were separated by at least six months.

Procedure

Baseline

Five minutes before each baseline trial, the experimenter placed the E4 Wristband™ on the participant's left wrist (see above). Figure 3 depicts the baseline and treatment flow chart. At the beginning of each baseline trial, the experimenter stood approximately 3 feet outside the exam room and instructed the participant, "(Name of the participant), it is time to go to the dentist." The experimenter then initiated the hierarchy of steps beginning with the participant walking into the exam room, sitting down, and tolerating the remaining steps listed in Appendix 1. Note that each participant had the option of sitting on the caregiver's or therapist's lap. Compliance with each step in the hierarchy resulted in the presentation of subsequent steps until the participant either engaged in inappropriate behavior, or refused to comply with the step requirements within 10 s. At that point, the trial was terminated and all procedures ended. At the end of each trial, the experimenter recorded the step number that terminated the trial, and

set the 5-min timer for the wristband. The participant rejoined the scheduled activity in the clinic. The experimenter removed the wristband from the participant's wrist after the 5 min elapsed, and took a picture of the participant's wrist; pictures were used to record treatment integrity measures related to the position of the wristband device and sensors. Baseline procedures were identical for all participants, and trials were conducted across multiple days. The total number of trials on a given day did not exceed one hour.

Baseline and Post-Treatment In-Vivo Probes

During baseline and post treatment, one in-vivo probe was conducted for each of the participants. The procedures were identical to baseline, except that the trial was conducted at the dentist's office; here, the dentist attempted to conduct a routine cleaning. In baseline, some participants refused to enter the exam room; therefore, the dentist conducted the trial in an observation room, where the dentist attempted to recline the participant on the caregiver's lap and look inside the participant's mouth. The first author was present for all in-vivo visits and recorded the visit on an iPad™. Data were recorded on the step number completed, the occurrence of problem behavior, and physiological measures.

Escape-Avoidance Hierarchy Treatment

Trials were conducted in the same way as in baseline with the following exceptions: The experimenter presented step 1 of the dental exam hierarchy (55 steps in the dental cleaning and 14 steps in dental x-ray). Compliance with the step 1 requirements (i.e., walk in exam room with examiner wearing gloves and a mask) resulted in access to the highest preferred item from the preference assessment and a 30 s break. If step 1 requirement was not met (i.e., refusal to complete a step and/or inappropriate behavior), then the preferred item was withheld, although the 10 s break was presented. The target step was re-presented until compliance occurred or a maximum of 10 trials were conducted; however, we never reached the maximum number of trials as all participants complied with the step in under 10 trials. Two consecutive successful trials resulted in access to the preferred item and a 2-min break in the exam room. After the 2-min break, the experimenter trained step 2 (i.e., sits in reclining chair with feet elevated) and step 3 (i.e., reclines in chair for 10 s) of the hierarchy in the same way. The first three steps of each procedure were always trained before conducting an assessment probe (see Figure 3).

Assessment Probe. After step 3 was mastered, an assessment probe was conducted (see Figure 4). Assessment probes were similar to baseline sessions in that the experimenter presented each step of the procedure until the participant refused to comply within 10 s, engaged in problem behavior, or the procedure was completed. For example, if the participant completed step 4 requirements, and emitted no inappropriate behavior, then step 5 was presented, and so on. If, at any point, the participant emitted inappropriate behavior or refused to comply within 10 s, the experimenter provided a brief 10 s break and recorded the last successful step, after which the experimenter presented the instruction "You only need to do (name any step in the task analysis that would likely be successful, based on the experimenter's judgement), and then you can earn a break." Then, the experimenter presented this step. Compliance resulted in termination of the trial. The experimenter presented prompts contingent on noncompliance until the participant complied with the step, at which point the trial was terminated. The purpose of returning to a previously mastered step within the procedure was to minimize reinforcing escape-maintained inappropriate behaviors during the probes.

After completion of the initial assessment probe, training re-commenced as described above. Moreover, assessment probes were conducted thereafter following successful training every two steps in the task analysis. For example, if the assessment started at step 4 and problem behavior occurred at step 13, then the experimenter trained step 13 in the next trial, as described above, followed by step

14. Following successful training of steps 13 and 14, another assessment probe was implemented. In summary, the assessment probes were administered at step 4 and then again after the participant successfully tolerated two consecutive steps; this continued until the completion of dental cleaning hierarchy (55 steps) and dental x-ray hierarchy (14 steps).

Maintenance probes. Maintenance probes were conducted in the original training site after approximately one month and two months, post intervention. The experimenter conducted all maintenance probes in a manner identical to that in treatment, but omitted assessment probes (see Figure 3).

Treatment integrity. To assess treatment integrity, data were collected by a second observer on the occurrence of correct procedural implementation of the escape/avoidance hierarchy, assessment probe procedures, and the Wristband^{TM}. The correct implementation steps are in Appendix 1 (dental cleaning) & 2 (dental x-ray). Treatment integrity data were calculated by dividing the number of steps correctly implemented by the total number of steps, and multiplying by 100. Treatment integrity was assessed during all assessment probes for all participants and over 50% of treatment and baseline session. The Wristband^{TM} treatment integrity data included correct placement and duration. The device was to be worn for at least 5 min pre and post treatment on the left wrist with the electrodes aligned between the ring and middle fingers. The experimenter took pictures of the participant's wrist after each trial to confirm correct placement; note that the

electrodes caused slight indentations on the wrist so observers could detect the actual placement of the electrodes. Results showed 100% treatment integrity across all trials for all procedures.

Social validity. Upon completion of the final maintenance probe, the experimenter administered a social validity questionnaire and a parental stress index questionnaire (see Appendix 3 and 4, respectively). The social validity questionnaire comprised eight questions using a five-point Likert scale (i.e., 1 = Strongly Disagree to 5 = Strongly Agree). These questions inquired about the acceptability of the procedures, the likelihood to recommend similar treatment in the future, if this treatment was easier to observe than previous treatments, and if the goal of the treatment was important to their child's overall health. The parental stress index questionnaire gathered information regarding the extent to which medical procedures are stressful for parents. This survey used the same Likert scale for 7 questions, including the degree to which parents find it stressful to watch their child undergo medical procedures, whether they thought the procedure was more stressful for them than their child, their tendency to avoid medical procedures, and the value of physiological data.

Results and Discussion

First, the trial-based FA data for all five participants were concordant, demonstrating that escape from medical procedures(i.e., dental cleaning maintained inappropriate behavior (see Figures 1 and 2). In the control segments, there were 0 inappropriate behaviors; in test segments, participants engaged in inappropriate behavior in 100% of the segments. Thus, all participants' behavior was sensitive to escape from the medical procedures used.

Second, Figure 5 shows the hierarchy treatment results for dental cleaning. In baseline, the data show all participants completed approximately 5% of the steps, except Jose who completed 20% of the steps. In treatment, all participants completed the entire hierarchy, and required between 19-38 trials. Furthermore, all participants completed 100% of the steps in the post-treatment in vivo probe, and in the 1 and 2 month maintenance probes, with the exception of Leo in the 2 month maintenance probe. Leo required retraining on a single step in the hierarchy, after which 100% compliance was observed.

Figure 7 shows results for dental x-rays tolerance. In baseline, none of the participants exceeded step number 3. In treatment, all participants completed the entire hierarchy, and effects were maintained in all in vivo and maintenance probes. Jose required the fewest treatment trials (7), whereas Gavin needed 17 trials to reach mastery. Leo, Harlow, and Davis reached mastery criteria in 15, 8, and 16 trials, respectively.

Concerning the occurrence of inappropriate behavior, all five participants showed an overall decrease in the number of trials with inappropriate behavior (See Figures 5 & 7). In baseline, inappropriate behavior occurred during each trial for all five participants. However, in treatment trials, problem behavior (range = 5% to 29%) occurred for only 29%, 23%, 10%, 11%, and 5% of the trials for Leo, Davis, Harlow, Gavin, Jose, respectively. For baseline in vivo probes, problem behavior occurred in all trials with each participant. In post-treatment in vivo probes, problem behavior did not occur for any participant. Similar data were obtained with the maintenance probes with the following exception: At the two-month maintenance probe, Leo failed to tolerate the air blower; he screamed "NO," forcibly hit the examiners hand, and covered his mouth. Therefore, the experimenter used a countdown procedure to gain compliance and complete the cleaning.

During the x-rays, participants exhibited less problem behavior overall compared to the dental procedure (See Figure 7). In baseline, all participants engaged in problem behavior and nonadherence across all trials. In treatment, the percentage of trials with problem behavior (range = 0% to 31%) decreased to 20%, 0%, 11%, 12%, and 0% for Leo, Harlow, Gavin, Davis, and Jose, respectively. In treatment, step number 3 (i.e., open mouth) produced the most inappropriate behavior for all participants. In addition, step number 8 evoked problem for Leo and Davis. Problem behavior occurred in all baseline in vivo probes but did not

occur in the post-treatment in vivo except for Gavin. Due to work obligations, Gavin's mother did not participate in any treatment sessions.

Three participants (i.e., Leo, Davis, Gavin) required specific training to open and close their mouths upon command, a prerequisite for x-ray bite placement. To teach this, the experimenter said "open" or "ahh" plus physically pushed on their chin to prompt an open mouth. Conversely, the experimenter taught the participants to close their mouth by saying, "close" or "mmm" with a simultaneous physical prompt, in the form of a light touch under the chin. After several teaching trials, all participants complied with either a positional prompt or vocal prompt.

Assessment probes yielded positive results for all participants. Indeed, the assessment probes allowed the experimenter to skip steps in the hierarchy for all participants. The total number of dental cleaning treatment steps eliminated was 43, 46, 44, 48, and 35 for Leo, Davis, Harlow, Gavin, and Jose, respectively. The assessment probes were also effective in the 11-step dental x-rays procedure. The number of steps skipped in the x-ray hierarchy for the participants were: 11 for Jose, 9 for Leo, Harlow, and Davis, 7 for Gavin.

Figure 6 depicts EDA data for dental cleaning baseline, treatment, and maintenance probes, as these trials were conducted in the ABA clinic. Note that the data show the maximum EDA measure for the trial. These data show a decrease in EDA from baseline to treatment and maintenance. The most sizable reduction is

demonstrated in Harlow's data, which shows a decrease in his EDA measure from 5.80 to 0.34 μS in treatment trials. However, note that there was a small increase in EDA from the end of treatment to maintenance probes. This result suggests that practice sessions between maintenance probes might be required to maintain decreases in EDA. Figures 6 also show EDA data for the baseline and post treatment in vivo probes, as these data were collected in the dentist's office. These data show that for 4 of the 5 participants, EDA data decreased from baseline to post-treatment in vivo probes. Gavin showed an increase in EDA data that could be attributed to the mother's presence in the post treatment in vivo probes.

Participants experienced similar EDA reductions during dental x-rays (See Figure 8). All participants demonstrated a reduction in EDA from across all treatment phases. EDA levels reduce by 3.89 μS, 1.24 μS, 0.14 μS, 0.83 μS, and 2.39 μS, for Leo, Harlow, Gavin, Davis, and Jose, respectively. The most significant reduction in demonstrated in Leo's data, which shows a decrease from 4.60 μS to 0.71 μS; moreover, Leo experienced a considerable reduction (5.37 μS) in EDA levels from the baseline in vivo probe to post-treatment. Unfortunately, Leo was the only participant who attempted x-rays in baseline. Thus, we cannot compare the relative changes from baseline and post-treatment in vivo probes for the other participants.

Finally, the parental social validity questionnaire, which involved acceptability of the goals, treatment procedures, and outcomes, showed that parents

strongly agreed to the acceptability and value of the above. One potential factor in this result is that escape extinction was not used, so problem behavior during such a procedure was avoided. Another factor could have been the use of the assessment probes, which reduced the number of required trials to complete the hierarchy. Interestingly, parents also reported that our intervention was more successful than previous attempts. The parent stress questionnaire showed that medical exams are stressful, and most parents reported that they would sometimes avoid medical procedures. The results did show, however, that they would continue with medical procedures because of their child's progress. Moreover, they all found value in the physiological measures that were used, but all estimated that they (the parent) were more stressed about the procedures at certain points than their child was.

The social validity data are significant. Over one third of individuals with ID fail to comply with basic medical procedures (Gillis et al., 2009). This can be attributed to not only the stress of undergoing the procedure, but also the anxiety of the caregivers watching, or providing support, during the procedure. As the parent questionnaires indicated, all caregivers avoid necessary medical and dental attention for their children because of the anticipated stress of seeing their child upset or engage in problem behavior. Developing procedures that are acceptable to caregivers and effective in promoting their child's compliance are likely to reduce the stress levels of all parties and, thus, lead to essential medical care that has been avoided. Although dental cleanings and x-rays can be difficult for individuals with

ID, other medical procedures can also evoke problem behavior and anxiety in this population. Once such procedure is receiving exposure to a needle or needle injection.

Experiment 2

Introduction

In Experiment 2, we replicated the procedures conducted in Experiment 1 using a different medical hierarchy (i.e., needle tolerance). We also tested the generality of the assessment tool and procedures. Needle tolerance, either for intravenous therapy (IV), blood draws, or shots, is required for many individuals during their lifetime. Unfortunately, the majority of children are "afraid" of needles and approximately 20-30% of adolescents exhibit the same distress (McLenon & Rogers, 2019). Inappropriate behaviors may become exacerbated by prolonged medical avoidance. Existing research has largely exposed individuals to mock needle exams (Wolff & Symons, 2012) and has neglected to incorporate the terminal needle-related procedures. Therefore, Experiment 2 examined the effects of our procedures in Experiment 1 while collaborating with medical professionals to conduct blood draws for two participants and an IV for another participant.

Method

Participants

Three males, 8 to 9 years of age, receiving services from the same ABA clinic as in Experiment 1, participated. All parents reported their child was averse to tolerating needles. Harlow and Jose, who participated in Experiment 1, also particpanted in Experiment 2. During Harlow's dental exam, the dentist found

multiple cavities and a cracked tooth, which required local sedation or general anesthesia and intubation. Harlow's mother opted for local sedation that required tolerating a needle for IV administration of medication. Jose had a prior history of physical restraints during blood draws. His mother reported his most recent blood draw was at age four and required two adults to restrain him. His mother said this was a very traumatic experience for her. Jose's physician ordered lab work to monitor his lipid levels, glucose, and A1C, so acquiring tolerance to blood draws was important.

Andy, eight years of age, vocally communicated using three-to-five-word sentences and followed multiple one- and two-step instructions. His pediatrician recently categorized him as failure to thrive due to inability to gain weight and ordered bloodwork to rule out multiple medical factors that might be contributing to low weight. Similar to Jose, the previous attempt to draw blood required two adults to physically restrain him. His inappropriate behaviors included screaming, crying, hitting, and biting others.

Settings and Materials

As in Experiment 1, the first author conducted all sessions in the same location, except for the in vivo probes. The treatment room contained a reclining chair with a swivel tray that held all the blood draw or needle tolerance supplies (i.e., tunicate, alcohol wipe, gloves, 3-mm needle, stress ball). The in-vivo probes occurred at either a chain laboratory (Andy), a hospital-based laboratory (Jose), or a

pediatric dental office (Harlow). The needle tolerance task analysis, found in Appendix 5, comprised 13 steps.

Dependent Variable and Data Collection

Similar to Experiment 1, the primary dependent variable was the step number completed in the needle tolerance hierarchy (i.e., blood draw, intravenous injection) during each trial. The experimenter scored stress levels (i.e., EDA), compliance, and inappropriate behaviors identical to those in Experiment 1.

Experimental Design

Again, we employed a concurrent multiple probe design across participants to evaluate the effects of the escape-avoidance hierarchy. Trials were conducted up to three days per week with a maximum session duration of thirty minutes.

Procedure

All pre-treatment and treatment procedures were identical to Experiment 1 with three minor exceptions. First, the needle tolerance procedure included 13 steps. The steps in the task analysis included the location (i.e., arm or ankle) to accommodate both the blood draw procedure for OP and Jose and the IV sedation for Harlow. Second, this experiment excluded baseline in vivo probes and only included one post-treatment in vivo probe. All of the participants' parents requested that we exclude the baseline vivo probes; they all knew experience that their

children could not tolerate needles. Thus, parents felt this step was unnecessary, would create undue stress, and delay treatment. The first author attended all in vivo probes and the various locations. Third, maintenance probes were conducted one month after treatment ended.

Interobserver Agreement and Treatment Integrity

IOA data were collected and calculated in the same manner as Experiment 1. IOA data were recorded on 100% of assessment probes, FA trials, and baseline trials for all participants. During treatment, a second observer independently collected data on 66% of Andy's trials, 76% of Harlow's trials, and 75% of Jose's trials. IOA was 100% for both step number completed and problem behavior across all FA trials, assessment probes, and baseline trials for all participants. IOA for treatment trials ranged from 94.5% to 100%.

Treatment integrity was calculated in the manner identical to that in Experiment 1. Results show that treatment integrity data were 100% in all trials for which they were collected.

Social validity. The experimenter administered the same social validity questionnaire and a parental stress index questionnaire as in Experiment 1 following the final maintenance probe (See Appendix 3 & 4).

Results and Discussion

Overall, our findings in Experiment 2 are consistent with those from Experiment 1. The trial-based FA demonstrated that inappropriate behavior was sensitive to escape from medical procedures for all three participants (see Figure 9). Data show 0% of segments and 100% of segments with inappropriate behavior during control and test conditions, respectively.

Second, Figure 8 depicts the hierarchy treatment results for needle tolerance. In baseline, none of the participants completed any of the steps. On the other hand, the treatment data that reflect all participants completed the maximum number of steps average number of treatment trials ranging from (12-18). Furthermore, all participants completed the procedure (i.e., blood from
draw or IV) in the post-treatment in vivo probe without any inappropriate behavior. Similarly, treatment effects continued for one month after treatment.

Concerning the occurrence of inappropriate behavior, all three participants showed an overall decrease in the frequency of inappropriate behavior (see Figure 10). All participants exhibited inappropriate behavior during all baseline trials; however, inappropriate behavior attenuated in treatment trials (range = 17% to 27%). Specifically, inappropriate behavior occurred during 17% of trials for Andy and Jose and 27% of trials for Harlow.

Assessment probes effectively eliminated steps (range = 6 to 9) for all participants. The number of total needle tolerance treatment steps eliminated was 6 for Andy, and 8 for Harlow and Jose.

Figure 11 shows EDA data for baseline, treatment, and maintenance probes, as these trials were conducted in the ABA clinic. Recall that the EDA is the maximum value treatment phase. EDA data decreased from baseline to treatment and maintenance for all three participants. The most sizable reduction is demonstrated in Jose's data in which his EDA measure decreased from 5.30 μS in baseline to 0.28 μS by the end of treatment. However, as in Experiment 1, two of the three participants showed a slight increase in EDA levels from the end of treatment to the maintenance probe. However, maintenance EDA levels remained lower than those in baseline and in the initial treatment phase. Results for the EDA data for the in vivo probe are displayed in the bottom panel of Figure 1. These data show that EDA measures remained relatively low for two participants and further decreased in the third. Compared to baseline EDA levels, participants experienced a reduction in EDA or stress levels that ranged from 2.88 μS to 4.91 μS. Harlow experienced the largest reduction (4.91 μS), followed by Jose (4.77 μS), and Andy (0.40 μS).

Finally, parental social validity questionnaire data were similar to those in Experiment 1. Specifically, all parents strongly agreed (all 5s) to the acceptability and value of the goals, procedures, and outcomes of the study. Moreover, the

parents reported similar stress levels when observing their child undergo the procedure, and all parents strongly agreed that they avoided needle-related medical procedures. They also reported that as a result of seeing their child progress during the study, they would continue to schedule medical exams for their child. One parent admitted she delayed scheduling the blood draw because she is terrified of needles.

General Discussion

Overall, these results are promising and replicate prior research in several ways. First, a plethora of studies have successfully employed escape-avoidance hierarchies (e.g., Calvalari et al., 2013; Grider et al., 2012; Reimers et al., 1998), and the current study used hierarchies in both experiments. Thus, the use of hierarchies, and the gradual exposure to each step of the hierarchy, has been a component of effective procedures to treat medical noncompliance. However, it is unknown if the use of hierarchies is a necessary element of effective procedures. Future research could compare the use of hierarchies with procedures that instead present exposure to the entire medical exam with all of the steps. Given the fact that individuals diagnosed with ID exhibit problem behavior when presented with medical procedures, and such behavior can be disruptive, or even dangerous (Jennett & Hagopian, 2008), management of problem behavior without the use of hierarchies might well be difficult.

The current study omitted EE, which replicates the results of previous studies that did not use EE (Conyers et al., 2004; Gorski et al., 2004; Maguire et al., 1996). This replication is a clinically relevant outcome, as previous research has shown that the use of EE is associated with extinction bursts (Lerman et al., 1999) and other problem behavior, such as aggression (Lerman & Iwata, 1995). Given the negative side effects of EE, research that investigates alternatives to EE is important (e.g., Athens & Volmer, 2010). In the current study, the only

programmed consequence for noncompliance was the omission of the preferred activity and a 30 s break in the exam room. At no time was noncompliance or other forms of problem behavior followed by guided compliance. Excluding EE might have resulted in the relatively low levels of problem behavior during treatment and probes, but it is unknown if these levels were lower than those that would have been observed if EE were used. However, future research should examine the procedures in the current study. Although the participants were not guided to comply, the 30-s breaks were in the exam room where task-related stimuli were still visible. Thus, it is possible that, in effect, noncompliance and/or problem behavior did not produce escape from task-related stimuli, and therefore underwent extinction. Furthermore, previous research has shown that interrupting the completion of a task can decrease problem behavior and increase compliance (Ward et al., 2017). In addition, the 30 s breaks produced a signaled delay to accessing preferred items/activities, such that noncompliance and/or problem behavior were punished. Future research should further investigate the specific procedures involved when EE is not used, paying particular attention to the role of task-related stimuli.

To date, only a few previous studies in the medical tolerance literature (Cavalari et al., 2013; Cuvo et al., 2010a, b; Shabani & Fisher, 2006;) used preference assessments to identify preferred items. Unfortunately, 67% of the medical tolerance studies omitted such assessments entirely and another 16% of the

studies used only informal assessments. In fact, in the most recent medical literature review, Allen and Kupzyk (2016) recommended that future medical tolerance studies incorporate formal preference assessments. The current study incorporated these into the procedure by implementing a preference assessment prior to each trial. Frequent preference assessment are important to ensure researchers identified highly preferred items, as participant preferences can readily change and caregiver reporting is often inaccurate (Green et al., 1999; Piazza et al., 2011).

In the current study, we discovered that both the PS and MSWO preference assessments evoked problem behavior for multiple participants. Conversely, zero problem behaviors occurred in the free operant assessments. These findings are consistent with previous preference assessment research in which the PS and the MSWO preference assessments produced higher rates of problem behavior than free operant assessment for individuals with problem behavior maintained by access to tangibles (Kang et al., 2010; Tung, Donaldson, & Kang, 2017). Thus, researchers and clinicians alike should consider free operant preference assessments if participants' problem behavior is maintained by access to tangibles, as the procedure might well mitigate problem behavior (Verriden, & Roscoe, 2016). Moreover, our abbreviated 2-min free operant assessment produced similar results as the Tung et al. (2017) study and was therefore more efficient than the typical assessments that last 5 min or longer (Rapp et al., 2010; Roane et al., 1998).

Future researchers should investigate if the free operant assessment will effectively identify potential reinforcers for other individuals with escape-maintained problem behavior and if a 2-min duration is sufficient. Researchers might also consider assessing factors that influence selecting a preference assessment, such as an individual's language ability, preoccupations, and problem behavior.

Finally, previous studies (Grider et al., 2012; Slifer et al., 2007) used a combination of preferred items/activities and escape from the hierarchy contingent on compliance. The current study did so as well in both experiments. However, we eliminated some procedures that have been used in other studies. For example, the treatment package used in this study excluded modeling, video modeling, escape extinction, the high probability command sequence, and social stories. However, the current study included a hierarchy of steps with preferred items/activities, escape from the procedure for compliance, and distractors, such as music and iPad™. These items were used because pediatric dental offices typically provide similar distractors. Nonetheless, the relative contribution of each of the components used in the current study are unknown. Future research could disentangle their relative contribution to treatment effects.

The current study also extended previous research. To date, only one other medical tolerance study incorporated an FA of problem behavior (Stuesser & Roscoe, 2020). This study used FAs that involved a variety of medical and nonmedical-related conditions; note that the duration of the FA sessions were

relatively long, given the testing of several different variables. The current study addressed this issue by eliminating the non-medical demand conditions and employing a trial-based FA with three trials. We found that the brief trial-based FA provided convincing data that problem behavior was, indeed, sensitive to escape from medical procedures. In addition, the trial-based FA limited the frequency and duration that participants were exposed to unpleasant conditions. The FA results were generally consistent with parent reports of problem behavior (both intensity and duration) associated with medical and dental exams. Interestingly, for two potential participants, the FA contradicted parent reports that their child did not comply and also exhibited problem behavior during dental exams; the FA data showed that these two children quickly moved through the dental hierarchy without problem behavior or noncompliance. Thus, the FA helped to identify those potential participants who needed treatment versus those who did not. Future studies could also implement a brief trial-based FA using specific task-related stimuli (e.g., tooth scraper, air blower, needle) that evoke problem behavior, so the intervention can be more specifically tailored to address the actual problem.

The current study also extended the literature by investigating frequent assessment probes. Only two studies reported assessment probes (Cavalari et al., 2013; Szalwinski et al., 2019). However, the Calvalari et al. (2013) study probe data were not used to guide treatment and the Szalwinski et al. (2020) conducted relatively infrequent probes, which did not serve the same function. The primary

purpose of their probes was not to guide and expedite treatment. In the current study, frequent assessment probes were used to identify the step at which noncompliance and/or problem behavior occurred. Treatment then commenced at the prior step. Data from both experiments show that participants skipped as many as 48 steps, saving untold amounts of time. Unexpectedly, the lowest functioning participant, Gavin, skipped the most steps. It appears that, for him, the most aversive steps were those that involved the experimenter initially touching his teeth with her fingers versus other instruments. Once he could tolerate these steps, the stimuli in the remainder of the task were less aversive, and therefore completion of the hierarchy of steps quickly occurred. The probes decreased treatment time in all three hierarchies tested across the two experiments, suggesting the technique has generality.

It is unclear how many initial steps should be trained before commencing the assessment probes. The current study trained three steps, but it is unclear when Szalwinski et al. (2020) administered the first assessment probe. It is possible that fewer steps could be trained with the same outcome of the assessment probes, thus, further reducing the number of training trials that are required. Also, the assessment probes were implemented after two consecutive steps were mastered. The efficiency of the procedures if more or fewer steps were required is unknown, and could be studied in future research. Finally, when a participant emitted problem behavior or noncompliance at a step during the assessment probe, the experimenter

required compliance to a previously mastered step to minimize reinforcing problem behavior. Whether this component was essential is unknown. Future research could answer this question.

Previous hierarchies involved rapid thinning of the schedule of reinforcement. For example, in the Shabani and Fisher (2006) study, the steps were added across every phase of the experiment. This resulted in a relatively rapid decrease in the rate of reinforcement over the course of two weeks and a temporary decrease in compliance. Thus, the occurrence of inappropriate behaviors may have been caused by increasing the response requirement, which decreased the rate of reinforcement (Nevin & Shahan, 2011; Shahan & Sweeney, 2011). Therefore, when working with a hierarchy, additional reinforcers might be programmed when adding steps, or higher reinforcer magnitudes might be implemented. Additionally, with hierarchies, some steps are relatively simple and involve small requirements; other steps involve several sub-steps or extended time requirements. For example, in the current study, Leo showed much more resistance to the air blower during dental cleaning. It is possible that using a quantitative relationship between the step size and reinforcer magnitude might yield better results than was achieved in previous studies. For example, if a step involves one element, then one reinforcer might be programmed. If, however, the step involves four elements, then four reinforcers might be arranged. This quantitative relationship would also help when researchers must gradually thin the schedule of reinforcement.

Previous research (see Allen, & Kupzyk, 2016) recommended conducting frequent in-vivo probes to facilitate compliance. The current study achieved compliance during treatment and in the vivo probes, suggesting multiple exposures to the testing context were unnecessary. Basic research and translational research models further support these findings and would caution clinicians against repeated in-vivo probes with potentially painful procedures as these conditions are optimal for treatment relapse (See Bouton & Todd, 2014; Nevin & Wacker, 2013). Treatment relapse is the recurrence of problem behavior after it has been previously eliminated due to intervention (Podlesnik & Kelley, 2015). Clinicians should consider these relapse laboratory models to mitigate treatment relapse.

One such context renewal model helps explain Gavin's elevated EDA levels during the in-vivo probes compared to treatment. The increased EDA levels could be attributed to the presence of his mother, who was present during in-vivo probes and absent during the treatment sessions. The change in this one variable produced a context change (i.e., ABA renewal) that could account for the increase in EDA levels and the presence of some inappropriate behaviors. That is, Gavin's mother was historically present during initial doctor's visits in which problem behavior occurred; however, she was absent during the treatment context in which we gained dental treatment adherence (i.e., context B). Finally, Gavin's mother was present during the dental in-vivo probe (context A), and Gavin's problem behavior reemerged and EDA levels increased. This seemingly minor change to some

clinicians was likely sufficient enough to produce treatment relapse. Thus, basic research can provide models and recommendations to mitigate deleterious effects on health outcomes. Moreover, the similarity of the training context and the test context (i.e., medical offices) can also impact treatment relapse. It is important to note that the training environment was as similar as possible to the testing condition. In fact, identical medical instruments were used across settings, and the experimenter wore scrubs as well. Thus, future researchers can evaluate the extent to which the similarity between training context and testing context promote generalization (see Podlesnik & Miranda-Dukoski, 2015).

This study was the first to incorporate continuous physiological measures using the Empatica Wristband™ across multiple medical procedures. These physiological data provide a framework for future researchers to assess and treat physiological measures. Moreover, an important outcome of the current study is that treatment of operant behavior was accompanied by decreases in physiological measures of arousal. All participants experienced reduced EDA measures throughout the treatment condition. Continuous physiological measure pinpointed specific steps in a medical procedure that were likely most aversive, as noted by the increase in EDA levels. This measure is far more sensitive than heart rate or blood pressure measures, which only capture data at one point in time. Moreover, in the current study, the heart rate measure did not detect differences in emotional behavior. That is, elevated heart rates occurred both when participants were excited by positive

developments in the session, such as marked by a positive affect and occurrence of stereotypy, and when participants were stressed or upset, such as noted by the occurrence of inappropriate behavior and negative affect. EDA measures, on the other hand, remained low and stable for all participants when they were excited and exhibiting vocal and motor stereotypy; conversely, EDA measures increased when presented with unpleasant demands. For example, during Harlow's preference assessment before his dental treatment session, his heart rate ranged from 69.82BPM to 191.99BPM while his EDA levels remained low and stable (range, 0.11 uS to 0.15 uS). However, during the most aversive part of the dental cleaning, Harlow experienced an EDA level of 2.00 uS and his heart rate was 135 BPM. His highest heart rate, therefore, was not correlated with the most aversive part of the procedure. These data indicate EDA measures are more closely aligned with emotional conditions that would be considered stressful. This measure might provide greater insight for individuals with ID who cannot vocally communicate distress. As such, researchers could use elevated EDA levels to prompt participants to request a break or alternative step before engaging in inappropriate operant behavior.

For individuals who can vocally communicate their discomfort, the EDA measures can guide the clinician when moment-to-moment adjustments might be needed. For example, during in-vivo dental cleaning, Harlow's EDA measures increased, as the dentist was scraping his teeth. As she scraped the next tooth, he

manded for an alternative activity in the form of the air blower. The dentist honored his request and briefly switched to the blower, which produced an immediate reduction in EDA levels. Similar spikes in the EDA measure isolated the most difficult step and easiest step in each procedure for all participants. For example, the most elevated EDA measures during dental tolerance was tolerating the blower for Leo and Davis, scraping or touching the two front teeth for Jose. Similarly, Gavin experienced highest EDA levels early in the procedure when keep mouth open and touching his teeth with finger or scraper.

In addition, EDA data from the preference assessments and treatment conditions provide promising findings for further analysis. During the MSWO and PS preference assessments, some participants' data showed an increase in EDA levels, as well as increases in problem behavior. Previous research demonstrated that MWSO and PS preference assessments evoked more problem behavior, yet excluded physiological measures. The current study found that an increase in inappropriate behavior had concomitant elevated EAD measures during these assessment tools, compared to a free operant preference assessment. The free operant preference assessment did not produce increased EDA levels, suggesting this assessment tool was less stressful for multiple participants. Increased EDA levels could corroborate these earlier findings of increased operant behavior during MSWO and PS preference assessment (Kang et al., 2010; Tung, Donaldson, &

Kang, 2017). Monitoring and intervening on EDA levels could mitigate the occurrence of problem behavior.

An additional benefit from the study is that it programed for generalization within the TA and across people implementing the procedure. Direct observation and an interview with the pediatric dentist confirmed that including a step variation was a necessary component. The dentist said she frequently has to go back and examine or clean a specific tooth or teeth. Therefore, the TA included the recommendation, which no other studies have done. By incorporating this step, participants were prepared for stimuli that might occur unexpectedly during the in vivo dental cleaning. Doing so could have facilitated the maintenance or persistence of treatment effects, especially despite changes in context. Therefore, it is reasonable to train a few variations of the targeted medical procedure hierarchy over time. Stokes and Baer (1977) offered a similar recommendation for programming generalization, as they suggested “multiple exemplars” and “train loosely.” Finally, given the importance of treatment context, future researchers should consult the basic research for guidance on the use of contextual stimuli as related to the treatment setting and variable that contribute to treatment relapse, especially if training cannot occur in the doctor’s office.

Finally, this study is the first to train compliance with dental x-rays and dental sedation. The American Dental Association (ADA) recommends x-rays every six months; x-rays can detect damage and disease that otherwise would go undetected

in routine cleaning. Therefore, we must teach children to tolerate this procedure. If surgery is required to repair the teeth, tolerating local anesthesia is far less risky than undergoing general anesthesia, which requires intubation. We are pleased that this study offers future researchers a way to address these issues.

Limitations

These studies are not without limitations. First, due to the timing of the FA, we were unable to provide physiological measures. Therefore, it is unclear how stressful the FA trials were for each participant as compared to baseline and treatment conditions.

Next, because the Empatica Wristband™ provided multiple physiological measures, further analysis is required to determine the significance between heart rate and EDA levels under various conditions. Based on informal inspection as presented in the Empatica graphing software, we concluded that heart rate failed to correlate with the most stressful portion of the medical procedure. Previous researcher (Allen & Stokes, 1987) also reported that heart rate measures during medical procedures lacks the sensitivity to detect overall stress level throughout medical procedures.

Despite conducting 2-month maintenance probes, it is unknown the extent to which participants would tolerate additional follow-up dental cleaning or blood draws. Due to the pandemic, the second dental cleanings were all cancelled. Thus,

future researchers should consider assessing treatment effects and EDA levels for at least two consecutive dental cleanings. It is still unknown how often participants need maintenance checks during dental cleanings and dental x-rays.

Finally, analyzing the physiological data was more time consuming than conducting the session. This was, in part, because no other study had incorporated these measures or used this device. To track the physiological data, the first author recorded the time that each trial was initiated and terminated for all participants, the procedure step number, and the date of each trial. The time associated with these measures could be viewed as barrier for future researchers.

To conclude, the present studies found that the procedures used, including the escape avoidance hierarchy, produced positive treatment effects across all medical procedures and participants. These treatment effects also maintained throughout the 1-month and 2-month maintenance probes. The generality of the assessment probes suggests that the probes can be used in clinical applications to increase efficiency. Moreover, changes in operant behavior were accompanied by changes in physiological measures; this is interesting and clinically relevant. Clinicians can treat problem behavior in these situations with a reasonable expectation that physiological measures of stress will improve; furthermore, clinicians can use physiological measures to help guide treatment and possibly prevent problem behavior. Finally, our procedures demonstrated improvements in physiological measures, as well as operant behavior, that positively affect treatment compliance.

If clinicians can recommend these procedures to families and medical professionals, and suggest that the person will learn compliance to the medical procedure, and experience decreasing levels of stress during the process, consumers might well be more likely to enter and complete treatment.

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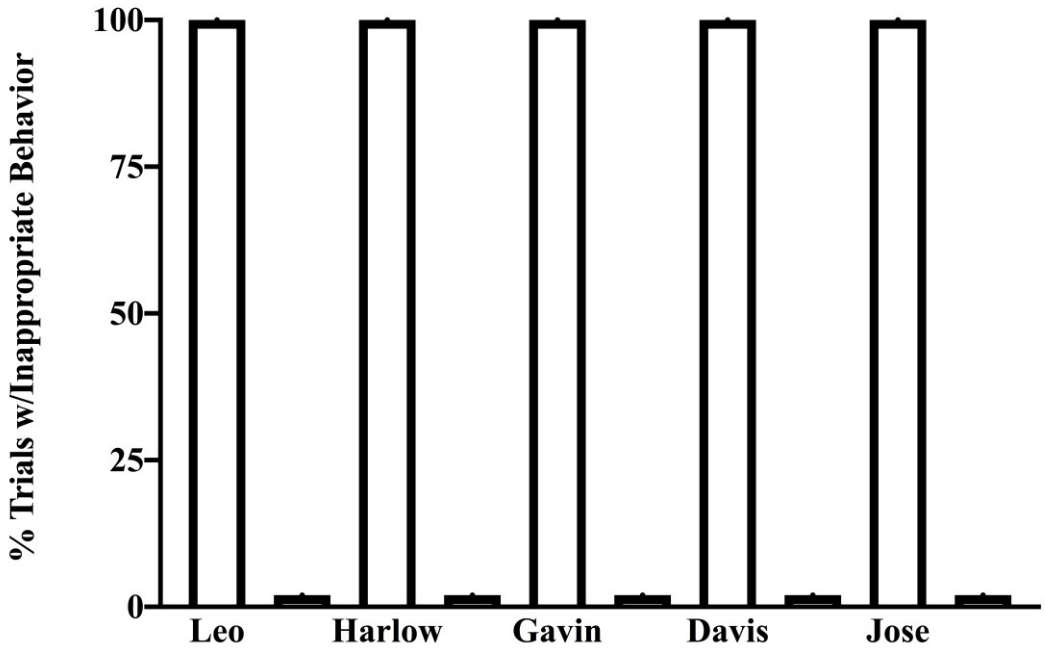
***Figure* 1**

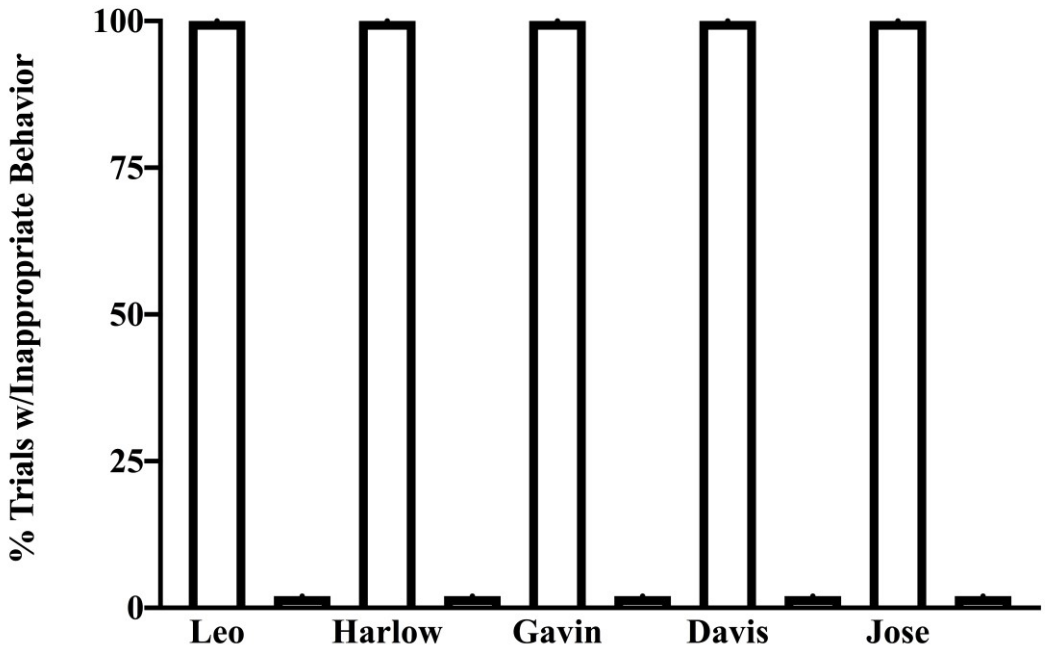
Trial-based Functional Analysis Results for Dental Cleaning Procedures.



Note. The open bars indicate the test segment results whereas the dark bars depict the control segment results across three trials.

Figure 2

Trial-Based FA Results for Dental X-Ray



Note. The open bars indicate the test segment results whereas the dark bars depict the control segment results across three trials.

Figure 3

Treatment Procedure Flow Chart

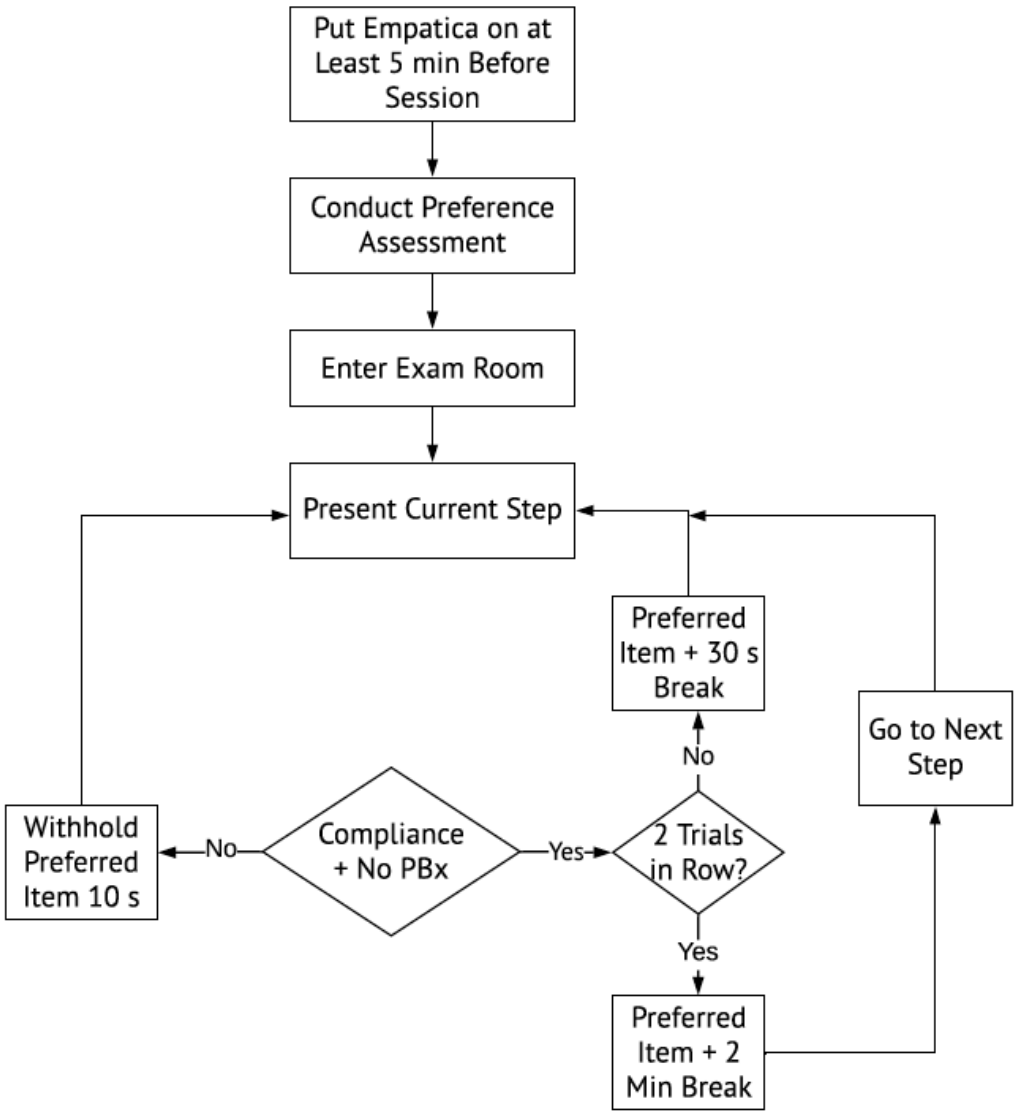
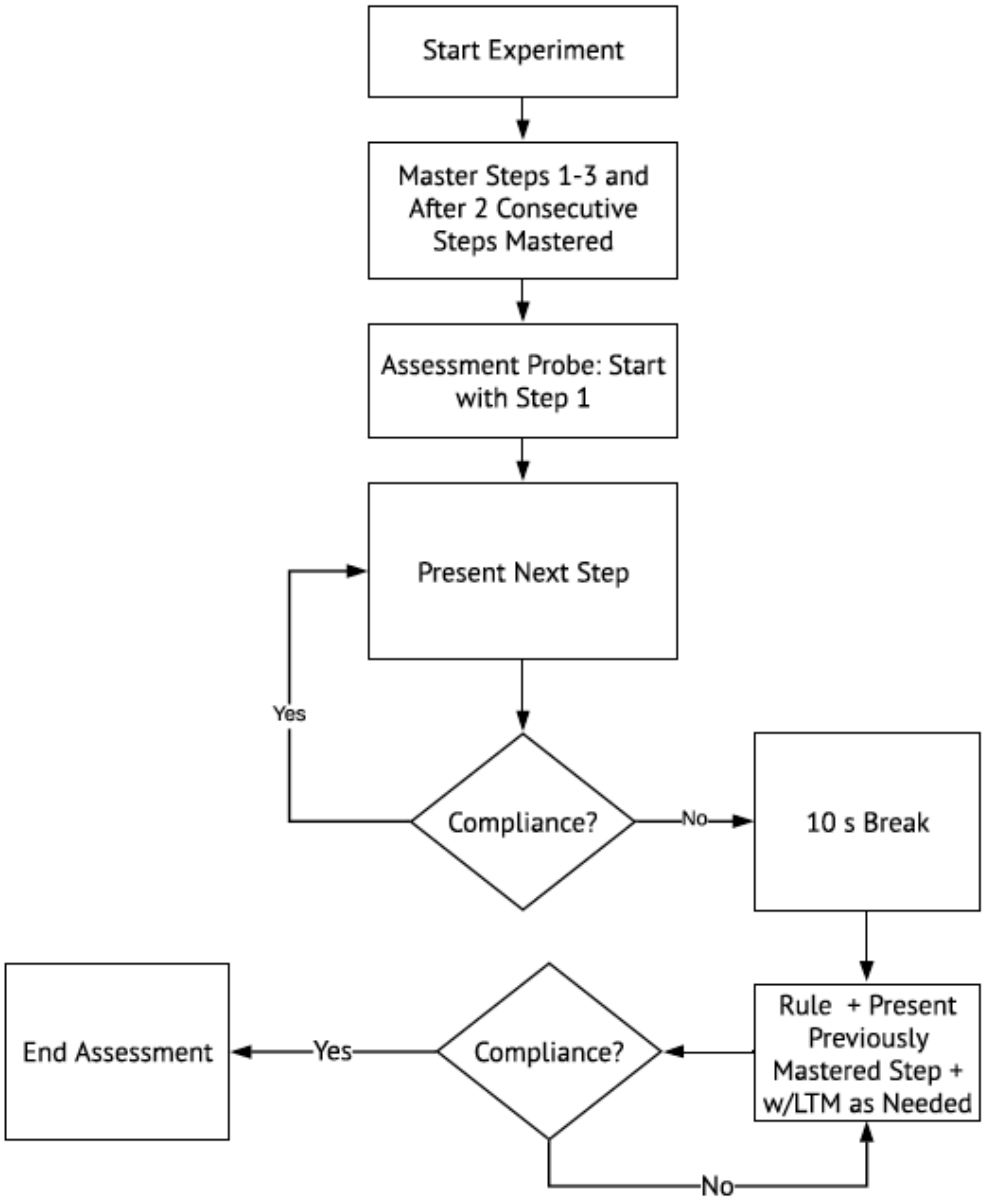


Figure 4

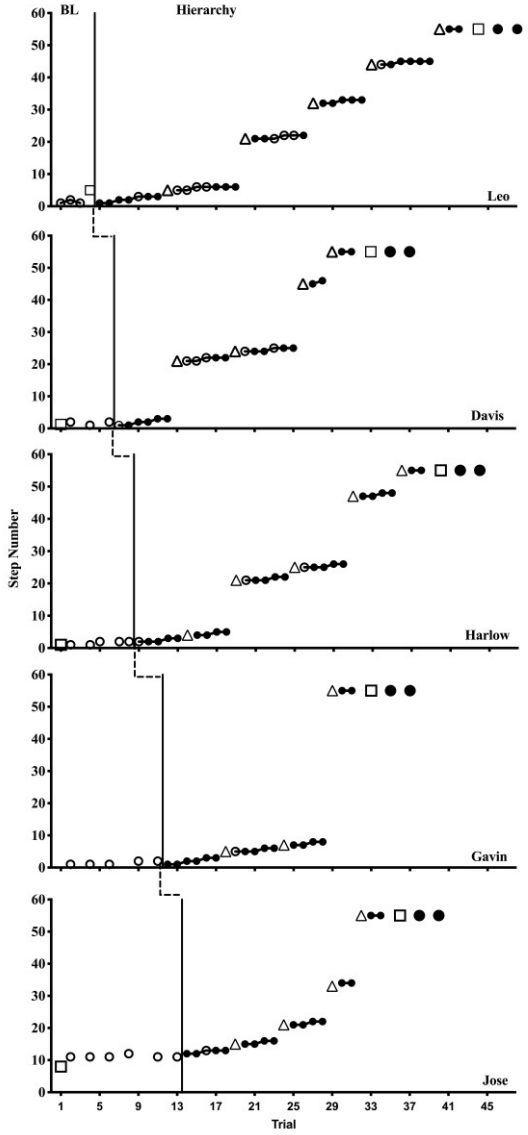
Assessment Probe Flow Chart



Note. Most-to-least prompting (MTL) required the most intrusive prompt to ensure a correct response and fade accordingly.

Figure 5

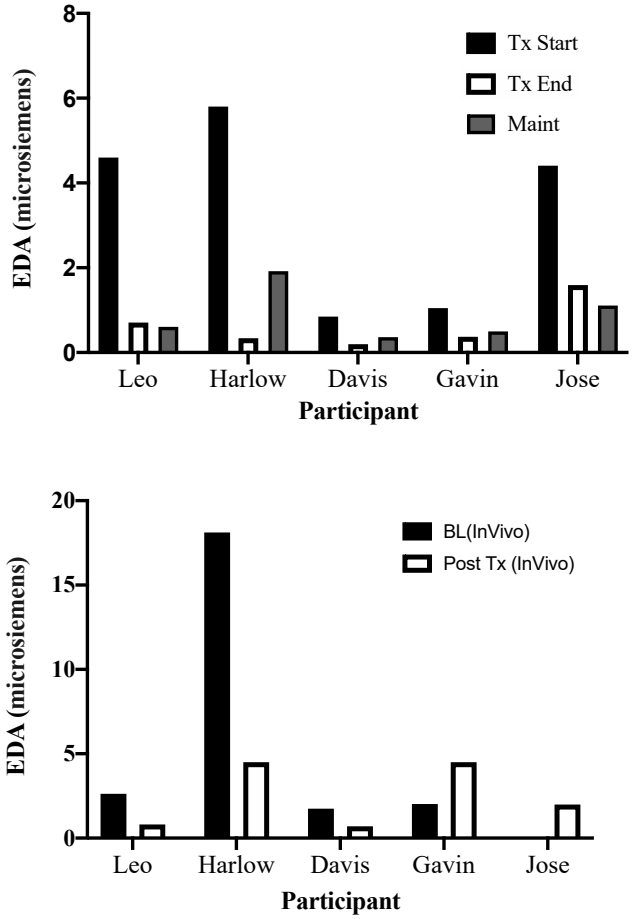
Dental Cleaning Results



Note. Closed circles depict trials with compliance and open circles indicate trials with problem behavior, open triangles depict assessment probes, open squares reflect in vivo probes**.**

Figure 6

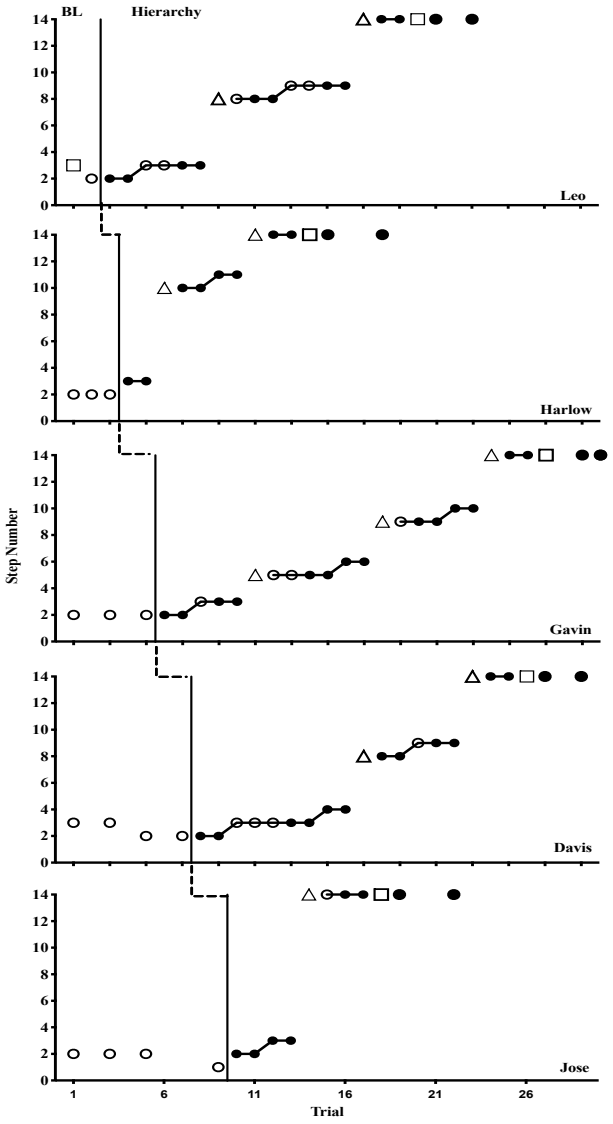
Dental Cleaning Physiological (EDA)Results



Note. The upper panel represents EDA data during clinic-based treatment sessions. The highest EDA measure during the first five trials was used for the start of treatment. Treatment end included the last two trials with all steps, and maintenance probes. The lower panel represents the physiological measures for the baseline and treatment in vivo probes.

Figure 7

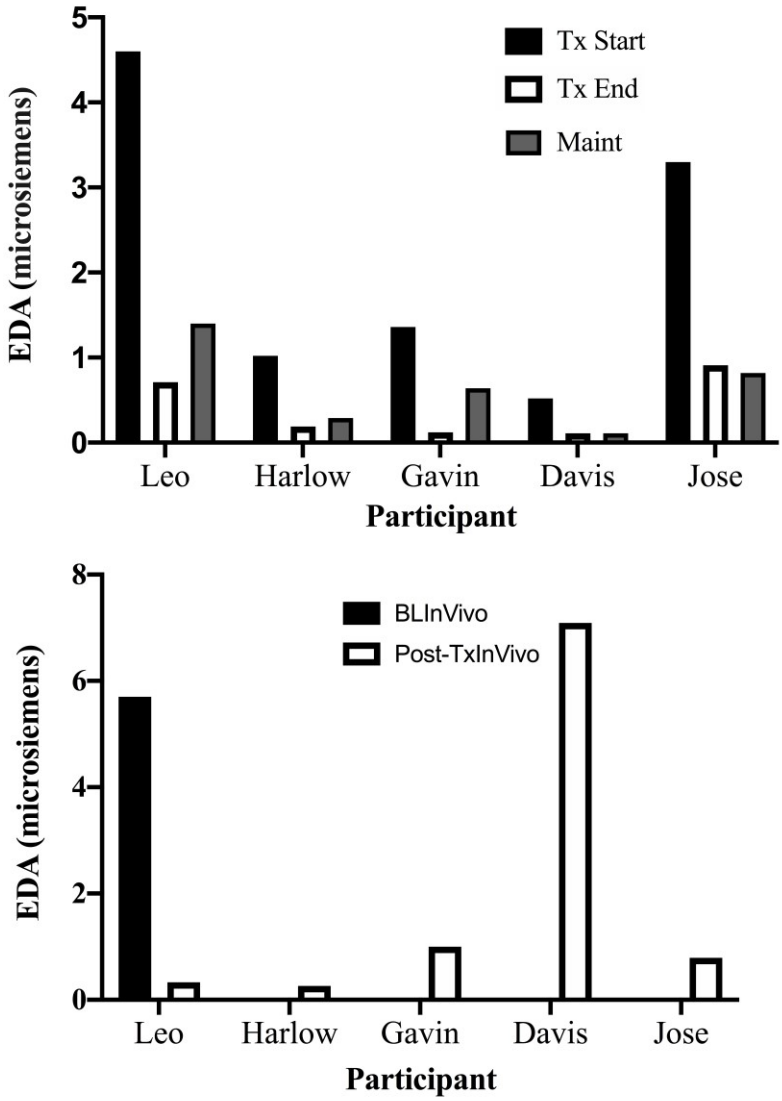
Dental X-Ray Hierarchy Results



Note. Closed circles depict trials with compliance and open circles indicate trials with problem behavior, open triangles depict assessment probes, open squares reflect in vivo probes.

Figure 8

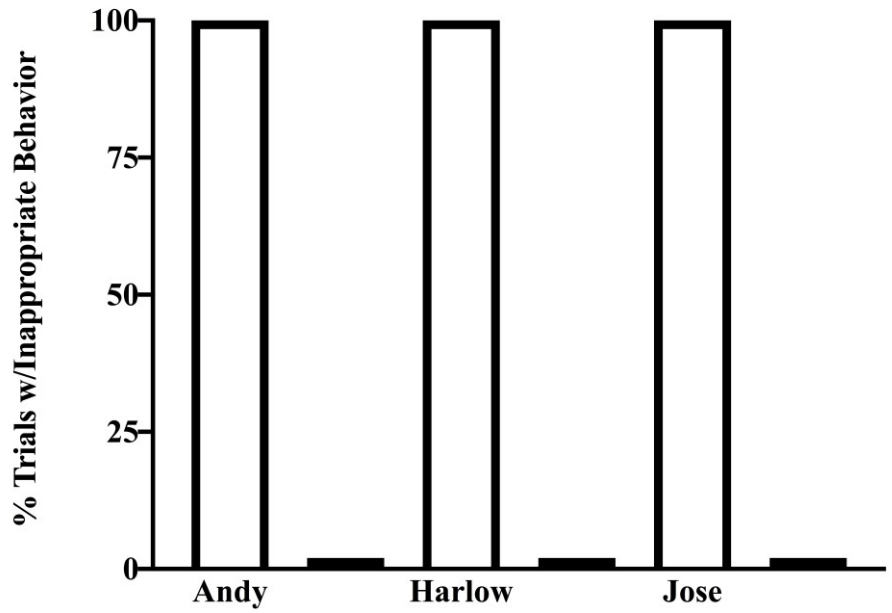
Dental X-Ray Physiological (EDA) Results



Note. The upper panel represents EDA data during clinic-based treatment sessions.. The lower panel represents the EDA measures for the baseline and treatment in vivo probes

Figure 9

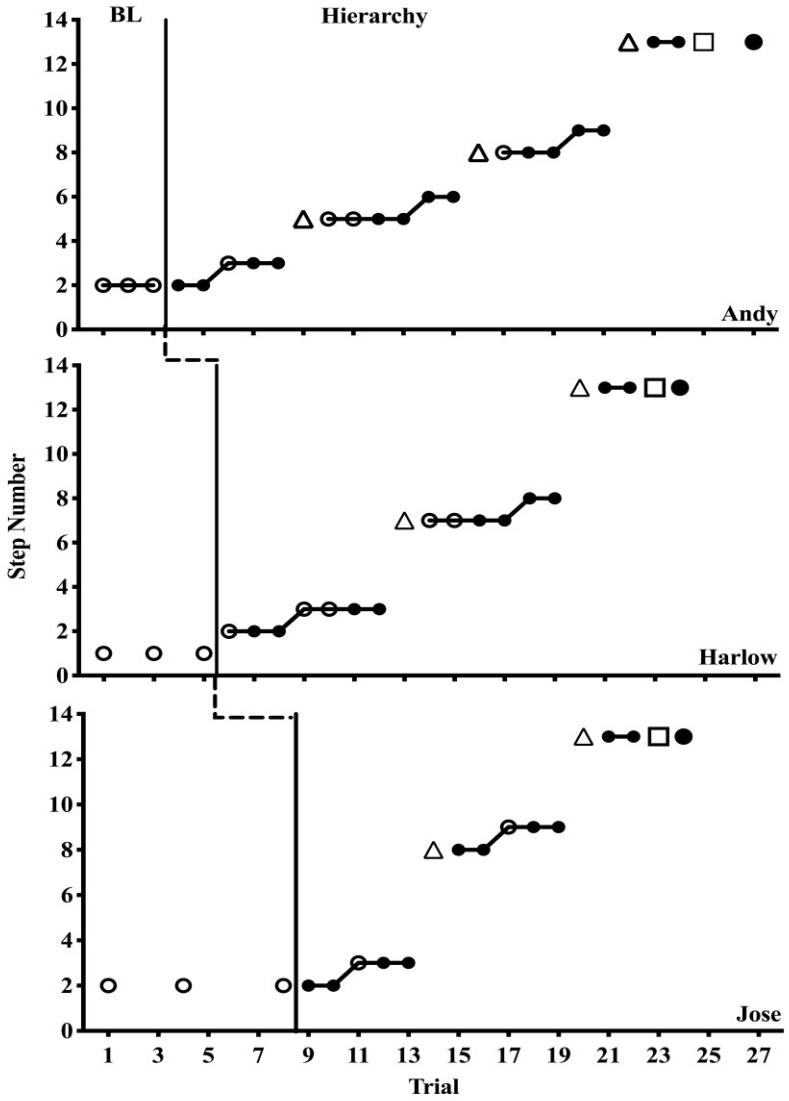
Trial-Based FA Needle Tolerance Results



Note. The open bars indicate the test segment results whereas the dark bars depict the control segment results across three trials.

Figure 10

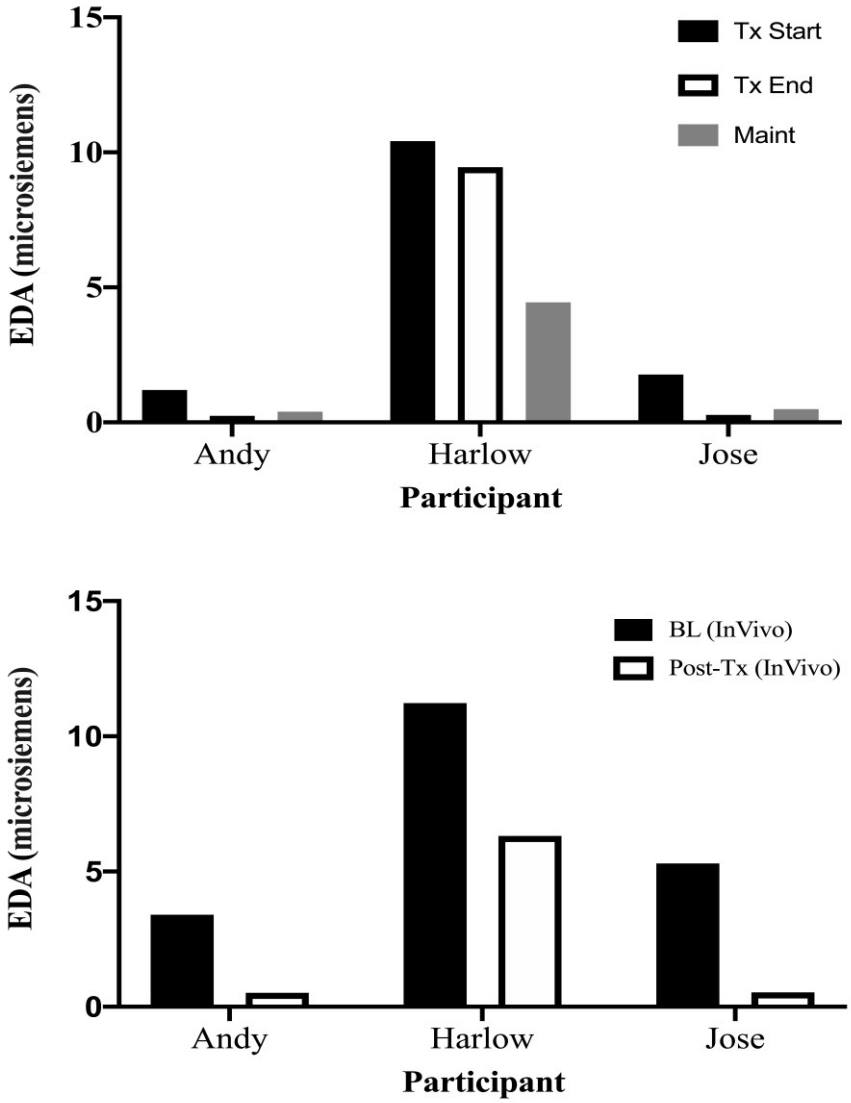
Needle Tolerance Treatment Hierarchy



Note. Needle tolerance results for medical compliance (closed circle), inappropriate behavior (open circles), assessment probes (open triangles), and in vivo probes (open squares).

Figure 11

Needle Tolerance Physiological Measures (EDA)



Note. The upper panel represents EDA data during clinic-based treatment sessions. The lower panel represents the EDA measures for the baseline and treatment in vivo probes.

Appendix 1

Task Analysis for Dental Cleaning

Step #	Step Description	Step #	Step Description
1	Walk in room therapist wearing gloves and mask	28	Using toothbrush, touch bottom middle quadrant (outside) 3s
2	Sits in chair and props feet up	29	Using toothbrush, touch bottom middle quadrant (inside) 3s
3	Recline chair 10"	30	Using toothbrush, touch bottom left quadrant (outside) 3s
4	Recline chair 10" with light on (glasses optional)	31	Using toothbrush, touch bottom left quadrant (inside) 3s
5	Using finger w/glove, examine bottom right side 3"	32	Using toothbrush, touch top R quadrant (outside) 3s
6	Using finger w/glove, examine bottom left side 3"	33	Using toothbrush, touch top R quadrant (inside) 3s
7	Using finger w/glove, examine top right side 3"	34	Using electric polisher, touch top middle quadrant (outside)
8	Using finger w/glove, examine top left side 3"	35	Using electric polisher, touch top middle quadrant (inside)
9	Using mirror and metal scraper pick, touch bottom R side 3" . Use bite blocker if necessary	36	Using electric polisher, touch top left quadrant (outside)
10	Using mirror and metal scraper pick, touch bottom L side 3"	37	Using electric polisher, touch top left quadrant (inside) 3s
11	Using mirror and metal scraper pick, touch top R side 3"	38	Wipe all teeth with gauze pad
12	Using mirror and metal scraper pick, touch top L side 3"	39	Say cheese and look at all teeth
13	Using mirror and metal scraper pick, scrape all teeth bottom R quadrant 10"	40	Program Variation go back to inspect a tooth and scrape or blow a tooth

14	Using mirror and metal scraper pick, scrape all teeth bottom middle quadrant 10"	41	Floss teeth in bottom, back right quadrant
15	Using mirror and metal scraper pick, scrape all teeth bottom L quadrant 10"	42	Floss teeth in the bottom middle quadrant
16	Using mirror and metal scraper pick, scrape all teeth top R quadrant 10"	43	Floss teeth in the bottom left quadrant
17	Using mirror and metal scraper pick, scrape all teeth top middle quadrant 10"	44	Floss teeth in the top, right quadrant
18	Using mirror and metal scraper pick, scrape all teeth top L quadrant 10"	45	Floss teeth in the top, middle quadrant
19	Tolerates air blower on hand	46	Floss teeth in the top, left quadrant
20	Air blow bottom R quadrant 10"	47	Wipe all teeth with gaze pad
21	Air blow bottom middle quadrant 10"	48	Say cheese and look at teeth and touch 2
22	Air blow bottom L quadrant 10"	49	Apply fluoride treatment to top right quadrant
23	Air blow top R quadrant 10"	50	Apply fluoride treatment to top middle quadrant
24	Air blow top middle quadrant 10"	51	Apply fluoride treatment/paste to top left quadrant
25	Air blow top L quadrant 10"	52	Apply fluoride treatment/paste to bottom left quadrant
26	Using electric polisher, touch bottom R quadrant (outside) 3 s	53	Apply fluoride treatment/paste to bottom middle quadrant
27	Using electric polisher, touch bottom R quadrant (inside) 3 s	54	Apply fluoride treatment/paste to bottom right quadrant
		55	Put chair upright and exit room

Appendix 2

Task Analysis for Dental X-Ray

Step	Step Description
1	Walks into room and sits on chair
2	Tolerates weighted blanket over torso and neck
3	Opens mouth
4	Tolerates X-Ray placed Left Side of mouth
5	Bites down
6	Keep mouth closed for 10 seconds
7	Tolerates plastic tube touching cheek with mouth closed no movement
8	Opens mouth to Remove X-Ray bite
9	Open Mouth
10	Insert X-Ray placed on Right side of mouth
11	Bites down
12	Keep mouth closed for 10 seconds
13	Tolerates plastic tube touching cheek for 10 seconds no movement
14	Open mouth and remove x-ray

Appendix 3

Parental Social Validity Questionnaire

Question	***Strongly Disagree***	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***
The researcher explained the goal of the study	1	2	3	4	5
The goal of the intervention is important to my child's overall health	1	2	3	4	5
I am satisfied with the treatment procedures	1	2	3	4	5
This intervention was effective for my child	1	2	3	4	5
This intervention was easier to observe than previous attempts	1	2	3	4	5
I am satisfied with the treatment outcomes	1	2	3	4	5
I found the physiological data useful	1	2	3	4	5
This intervention was easier to observe than previous attempts	1	2	3	4	5
I am likely to recommend this intervention to others	1	2	3	4	5
Total					

Appendix 4

Parental Stress Index Questionnaire

Question	***Strongly Disagree***	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***
Watching my child undergo medical treatment is often times stressful, despite being necessary	1	2	3	4	5
Knowing my child's stress and current state of distress is important to me	1	2	3	4	5
Before this treatment, I would avoid some medical procedures because I was afraid it would be difficult or stressful for my child.	1	2	3	4	5
After treatment, I am more likely to continue working on the medical procedure because of seeing my child's progress	1	2	3	4	5
I think the procedure was more stressful for me than for my child at certain points.	1	2	3	4	5
This treatment would be helpful for other parents who are stressed about their child's ability to complete routine medical exams	1	2	3	4	5
I found the physiological data useful or important	1	2	3	4	5
Total					

Appendix 5

Task Analysis for Needle Tolerance

Step	Step Description
1	Walk in room and sits in chair
2	Extends arm on rest or body part all materials displayed on arm trey. Needle in sight on trey
3	Place tourniquet around extended arm bicep or ankle for 5 second
4	Place tourniquet around extended arm bicep or ankle for 10 second
5	Tap on veins at crease of arm or on foot for 10 s
6	Apply alcohol wipe
7	Place needed flat against skills
8	Needle against skin pinch skin between fingernails for 5 s
9	Needle against skin pinch skin between fingernails for 20 s
10	Needle against skin pinch skin between fingernails for 40 s
11	Needle against skin pinch skin between fingernails for 60 s
12	Remove tourniquet
13	Remove needle