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Function-Based Approach to the Treatment of Audible Diurnal Bruxism

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by

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Abstract

Bruxism is defined as the grinding of one's upper and lower teeth such that physical damage is caused. To date, behavioral interventions that examine environmental relations with respect to diurnal bruxism have outperformed medical and psychological treatments. However, the behavioral interventions have relied on punitive measures to eliminate the behavior. This study evaluated a function-based antecedent intervention for bruxism with a 4-year-old girl. The function was determined to be maintained by automatic reinforcement following a four condition (i.e., attention, escape, play, and ignore) functional analysis. A further assessment of the sensory stimulations associated with bruxism (i.e., external pressure on the jaw, internal pressure on the teeth, and auditory stimulation) determined it was more specifically maintained by the vibration sensation produced when the teeth grinded together. The study used the function and evaluated non-contingent delivery of matched stimulation (i.e., treatment that matches the function of the participant's bruxism) as a treatment of bruxism. While it was an effective method to reduce bruxism, the speed of the reduction was not rapid enough and the stimulation was unable to be thinned, concluding that it was not an effective form of treatment.

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Introduction and Literature Review

An individual's oral health affects his or her diet and nutrition, sleep, social interactions, education, and work (US Department of Health and Human Services, 2000). Poor oral health may lead to tooth loss, diminished salivary functions, periodontal diseases, oral-facial pain, and increased medical and dental expenses (Lang et al., 2009). Much of oral health is mediated through an individual's behavior, and can consist of acts such as brushing, flossing, and attending regular dental exams. While many behaviors serve to maintain good oral health, some behaviors can be more destructive to oral health than others, such as bruxism.

Bruxism is a class of behavior which serves to impair good oral hygiene. First recognized by Marie and Pietkiewkz (1907), bruxism, then termed bruxomania, was defined as the habit of teeth grinding (Cash, 1988). Frohman replaced the term bruxomania in the dental literature with bruxism in 1931 (Cash, 1988). With improved understanding of bruxism came refined definitional changes. An accepted current definition defines bruxism as "…a repetitive jaw-muscle activity characterized by clenching or grinding of the teeth and/or by bracing or thrusting of the mandible" (Lobbezoo et al., 2013, p. 3, cf. Koyano, Tsukiyama, Ichiki, & Kuwata, 2008; Lobbezoo, Van Der Zaag, Van Selms, Hamburger, & Naeije, 2008).

The American Academy of Orofacial Pain (1996) considers bruxism to be one of the most detrimental conditions among the parafunctional activities of the stomatognathic system, citing it responsible for tooth wear, periodontal tissue lesions, and articular and/or muscular damage. Additional problems include, but are not limited to, abnormal wear on the teeth, impacted bone and gum structure, fractured teeth, headaches, oral-facial pain, tooth sensitivity, difficulty in eating, TMJ disturbances, decreased jaw range, articular and/or musculature damage, and potential teeth mobility (Cash, 1988; Glaros & Melamed, 1992; Glaros & Rao, 1977; Lobbezoo et al., 2008; Nadler, 1966; Pavone, 1985; Thompson, Blount, & Krumholz, 1994). Glaros and Melamed (1992) noted that bruxism is commonly an antecedent to these problems and other temporomandibular disorders, recommending that early intervention for bruxism occur in an effort to prevent or delay further development of temporomandibular disorders.

Lobbezoo et al. (2013) suggested a grading system for operationalizing bruxism. First, bruxism can either be audible (i.e., grinding teeth) or inaudible (i.e., clenching teeth; Koyano et al., 2008; Lang et al., 2009; Lobbezoo et al., 2013). Second, bruxism can occur when the individual is awake (i.e., diurnal) or when the individual is asleep (i.e., nocturnal; Cash, 1988). With respect to this paper, attention will be paid only to audible diurnal bruxism unless otherwise specified.

Diagnosing Bruxism

Bruxism's etiology differs across professions, and a consensus has yet to be forthcoming. The medical field views bruxism as pain attenuation (e.g., dental discomfort), the psychology field views it as coping, and the behavior analytic field views bruxism as operant behavior. Prior to assessing and treating bruxism, one should consult with a medical doctor to rule out any possible medical etiology (Professional and Ethical Compliance Code for Behavior Analysts, 2014). Lang et al. (2009) noted that bruxism may start as a medical problem, but ultimately can come to be maintained by reinforcement contingencies (e.g., attention).

Diagnosing bruxism can be a difficult task for medical and behavioral personnel alike, as it may be difficult to identify if the tooth damage is the cause or result of bruxism (Koyano et al., 2008). Additional concerns regarding the individual's awareness of grinding are correlated with nocturnal and inaudible subtypes (Cash, 1988; Glaros & Melamed, 1992; Glaros & Rao, 1977; Koyano et al., 2008; Lobbezoo, Van Der Zaag, & Naeije, 2006; Lobbezoo et al., 2008; Nadler, 1966; Singh, Satish, Singh, & Singh, 2014).

A variety of methods to diagnose bruxism have been devised to assist in its identification, particularly given that some bruxism may go unnoticed (e.g., nocturnal, inaudible). These diagnostic methods include questionnaires, clinical observation, wearing an intra-oral appliance, electromyography (EMG) recording of the masticatory muscles, and polysomnography (Koyano et al., 2008). However, regarding audible nocturnal or diurnal bruxism, individuals, or someone present in daily immediate environment, generally report the bruxism and a clinical observation verifies the diagnosis.

In a clinical observation of bruxism, medical personnel are looking for any of the following indicators: tooth wear within the normal range of jaw movements, masseter muscle hypertrophy on voluntary contraction, complaint of discomfort, fatigue, or stiffness of masticatory muscles, teeth are hypersensitive to cold air or liquid, temporomandibular joint is clicking or locking, and an indentation of the tongue on the cheek (Koyano et al., 2008). When atypical wear on teeth is observed teeth grinding is deduced whereas clenching is assumed when pain in the temporomandibular joint, facial musculature, neck, shoulders, or in the teeth is reported (Glaros & Melamed, 1992).

Bruxism Treatment

Thompson et al. (1994) stated that, "while the symptoms of bruxism in adults can be treated, the condition usually cannot be cured" (p. 1620). To date, these claims have largely held true. The following review of the literature outlines treatment methods across four treatment modalities: (1) medical, (2) psychological, (3) non-function-based behavioral, and (4) function-based behavioral.

Medical treatments. Prior to selecting a treatment method, a dentist reviews the manner in which the individual's upper and lower teeth fit together during biting (i.e., occlusion; Occlusion, 2008). Following assessment, dentists will select a medical treatment for the following reasons: (a) they believe that the tooth wear will instigate bruxism, (b) the etiology is believed to be dental discomfort, and/or (c) ideal occlusion (upper and lower teeth fit together) is no longer present (Glaros & Melamed, 1992).

When a particular medical treatment is selected, the topography of bruxism is not necessarily considered (i.e., bruxism can be audible or inaudible, diurnal or nocturnal); rather the intensity of bruxism (i.e., how forceful the grinding or clenching is) serves as the basis for treatment decisions. For example, occlusal appliances may not be the prescribed medical treatment if bruxism intensity is extremely forceful as such treatment could result in bone loss around the appliance (Lobbezoo et al., 2006). The medical treatments used to date involve occlusal and pharmacological interventions.

Occlusal. There are two types of occlusal treatments used to treat bruxism in the medical field; occlusal appliances and occlusal interventions. Both treatment methods are prescribed as a means to prevent future wear on the teeth.

Occlusal appliances (i.e., splints) are structures that are formed to the shape of one's mouth, similar to a mouth guard (Cash, 1988; Glaros & Melamed, 1992; Glaros & Rao, 1977; Lobbezoo et al., 2008; Singh et al., 2014). Although splints are primarily used to treat nocturnal bruxism, they are one of the most widely used medical treatments for bruxism (Glaros & Rao, 1977; Lobbezoo et al., 2008). Pavone (1985) suggested the splints counteract the damaging effects of either the clenching or grinding by training the patient how to maneuver the mandibular muscles. However, splints have been found to be an effective method to prevent further wear on one's teeth, but when removed or not worn, bruxism returns (Cash, 1988; Glaros & Melamed, 1992; Lobbezoo et al., 2008).

Occlusal interventions are permanent restorative procedures intended to restore ideal occlusion (Glaros and Rao, 1977). In other words, occlusal interventions are dental surgeries that make the upper and lower teeth fit together correctly. An example of an occlusal intervention procedure is occlusal equilibrium. Occlusal equilibrium is a procedure that wears down the teeth that are inhibiting ideal occlusion. This is done via the use of a grinding instrument, and if often described as 'spot grinding' (Glaros & Melamed, 1992). Other occlusal interventions include occlusal rehabilitation and orthodontic treatments (Lobbezoo et al., 2008).

Ahlgren, Omnell, Sonesson, and Toremalm (1969) commented that bruxism patients have a high degree of muscle tone making the proper occlusion difficult. Turner (1984) suggested that great care be considered with occlusal interventions, as bruxism may continue following the restoration. Considerations prior to using this method of treatment must be made, as it is irreversible, difficult to achieve, and has not been deemed an effective method of treatment (Cash, 1988; Glaros & Melamed, 1992; Glaros & Rao, 1977; Lobbezoo et al., 2008).

The long-lasting effects of occlusal appliances and interventions as a means to treat bruxism has found little to no evidence of success (Cash, 1988; Glaros & Melamed, 1992; Glaros

& Rao, 1977; Lobbezoo et al., 2008). Use of such procedures should be carefully observed by a dentist.

Pharmacological. Lobbezoo et al. (2008) found that, since mid-1990, pharmacological treatments have begun to overtake occlusal (i.e., dental) and behavioral treatments of bruxism in terms of preferred treatment options. Pharmacological treatments used to manage bruxism include muscle relaxants (e.g., Saletu et al., 2005), antidepressants (e.g., Bostwick & Jaffee, 1999; Brown & Hong, 1999; Ranjan, Chandra, & Prabhu, 2006), and botox injections (e.g., Monroy & da Fonseca, 2006; Tan & Jankovic, 2000; Van Zandijcke & Marchau, 1990).

Medication, as a form of treatment, is only effective so long as it is being consumed. With injections, however, Monroy and da Fonseca (2006) found that the medicinal effects lasted 60 days following application, at which point bruxism returned. Therefore, pharmacological treatments work more so as a paralyzing or numbing agent to assist in bruxism management than treating bruxism.

It should be noted that there are risks accompanying the use of the medications to alleviate bruxism. Such risks include potential dependency, adverse reaction, or may even exacerbate bruxism (Lobbezoo et al., 2008; Winocur, Gavish, Voikovitch, Emodi-Perlman, & Eli, 2003). Signh et al. (2014) recommended that pharmacological management of diurnal bruxism be avoided for most patients. However, Singh et al. (2014) and Lobbezoo et al. (2008) also noted that for those with patients with substantial degrees of pain (who also have not responded to other treatments) might receive temporary pain relief due to bruxism from prescription medication.

Therefore, the treatments provided by the medical field have primarily found momentary alleviation of bruxism. However, long-lasting, safe, and effective medical, occlusal and/or pharmacological treatments have yet to be found.

Table 1

Summary of Medical Treatments

Authors	Treatment	Results		
		Baseline	**Intervention**	**Follow-up**
Van Zandijcke & Marchau, 1990	Injection of botulinum toxin	Not collected	The 5th day after injection, bruxism reduced significantly	8 weeks following injection, bruxism resumed at high levels.
Bostwick & Jaffee, 1999	Antidepressants	Self-reported, not collected	Self-reported as much lower levels[1234]	Same dose, still low[123] Taper Rx, no reoccurrence[4]
Brown & Hong, 1999	Reduced Antidepressants	Not collected	Self-reported elimination after 2 days	3 months Self-reported elimination with same dose[1]
Tan & Jankovic, 2000	Injection of botulinum toxin	Not collected	Self-reported at one month after injection bruxism ceased	1.5 years bruxism did not return, and no further injections were given
Saletu et al., 2005	Muscle Relaxants-Sleep Bruxism	6.3 hours of sleep per night	9.3 hours of sleep per night	Not collected
Ranjan et al., 2006	Reduction of Antidepressants	Not collected[1,2]	Self-reported reduction after 2 weeks[1] and after 3 days[2]	1 month Self-reported elimination with same dose[1,2]
Monroy & da Fonseca, 2006	Injection of botulinum toxin-a	Parent report high frequency, no baseline data collected	Immediate decrease and cessation on the 10th day. Cessation lasted 60 days.	At 60th day, bruxism resumed at high levels.

Psychological treatments. Another etiology of bruxism relates to the individual's lifestyle and their ability to cope with stress (Cash, 1988; Glaros & Melamed, 1992; Thompson et al., 1994). Psychological treatment methods to reduce bruxism have included relaxation and meditation (e.g., Restrepo, Alvarez, Jaramillo, Velez, & Valencia, 2001), hypnosis (e.g. Goldberg, 1973), and music therapy (Ford, 1999). However, none of these procedures have proven to be effective in the treatment of bruxism (Cash, 1988; Glaros & Melamed, 1992; Lobbezoo et al., 2008; Thompson et al., 1994).

To date, psychological treatments have resulted in little to no contribution to the treatment of bruxism. Behavioral treatments, on the other hand, have had made significant contributions.

Table 2

Summary of Psychological Treatments

Study	Treatment	Results		
		Baseline	**Intervention**	**Follow-up**
Goldberg, 1973	Hypnosis	Not collected[1,2,3]	Self-reported reductions[1,2], After 5 visits and 5 sessions bruxism had decreased	Self-reported eliminations[1,2], Not collected, however self- reported that bruxism returned after sessions[3]
Caron et al., 1996	Music Therapy	Waiting on ILL		
Ford, 1999	Music Therapy	Passive music: 52% of time Interactive music: unknown % of time	Passive music: 21% of time Interactive music: increased 57% of time	Not collected
Restrepo et al., 2001	Relaxation & Meditation	100% of participant engaged in bruxism	About 32% of the participant's bruxism was eliminated	Not collected

Behavioral treatments. Behavioral treatments are often selected when bruxism is maintained by operant contingencies and/or when an individual's bruxism was initially due to medical reasons but over time has come to be maintained by operant contingencies (Lang et al., 2009). To date, there are two variations of behavioral treatments used with bruxism; non-function-based (NFB) and function-based (FB). NFB behavioral treatments consist of treatments based on considerations other than functional relations (e.g., time, effort, difficulty of the intervention). FB behavioral treatment capitalizes on the functional relations identified during functional assessment. Both treatment categories have proven successful, though evidence points to FB interventions having a greater likelihood of long-term success.

Non-function-based. NFB behavioral treatments are based on the principles of punishment and reinforcement as their change agent. Such NFB behavioral treatments include biofeedback (Cannistraci, 1976; Kardachi, Bailey, & Ash, 1978; Lund & Widmer, 1989; Manns, Miralles, & Adrian, 1981; Mealiea & McGlynn, 1987; Rubeling, 1979; Shulman, 2001; Solberg & Rugh, 1975; Treacy, 1999), massed practice (Ayer, 1976; Ayer & Gale, 1969; Ayer & Levin, 1973; Ayer & Levin, 1975), aversive conditioning (Blount, Drabman, Wilson, & Stewart, 1982; Jenkins & Peterson, 1978; Kramer, 1981; Rudrud & Halasyzn, 1981), habit training/awareness (Bebko & Lennox, 1988; Blake, Thomas, & Thompson, 2011; Rosen, 1981; Rosenbaum & Ayllon, 1981), and differential reinforcement of other behaviors with contingent consequence (Gross & Isaac, 1982).

Aversive conditioning. Aversive conditioning includes correlating a previously neutral or reinforcing behavior with an aversive consequence. The theory behind aversive conditioning is that the behavior will decrease as it takes on aversive properties through respondent learning. Such conditioning takes place through contingent consequences or massed practice.

In a contingent-consequence procedure, the delivery of the consequence (i.e., aversive stimulus) is contingent upon the occurrence of the aberrant behavior. Rudrud and Halasyzn (1981) used contingent massage as the contingent consequence. Initially the contingent massage was not intended to be aversive. But following the study, the authors commented that the massage may have become aversive to the client as bruxism decreased as a result of its contingent application. Blount et al. (1982) briefly applied ice contingent upon bruxism, however the ice was suspected to be aversive prior to introduction. These two studies found that bruxism reduced by 50.20% and 94.5% with contingent massage and contingent icing, respectively.

Jenkins and Peterson (1978) used contingent consequence in the form of squirting lemon juice in the oral cavity with a 60-year old male psychiatric patient when he would begin bruxing. Differing from Rudrud and Hazalzyn (1981) and Blount et al. (1982), the consequence was self-monitored and self-administered. Upon implementation of the treatment, bruxism levels decreased significantly and continued to decrease until it was completely eliminated. Two-year follow up data found that zero levels of bruxism maintained.

Another form of aversive conditioning is massed practice. Massed practice is an antecedent procedure where the individual practices bruxing outside of their typical bruxing. In other words, the individual brux in a repetitive manner, numerous times a day until the masticatory muscles fatigue and/or pain is elicited (Glaros & Rao, 1977).

Ayer and Gale (1969) reported the first successful application of this treatment method for bruxism. Ayer and Levin (1973; 1975) successfully reproduced this finding by eliminating bruxism with 11 out of 14 participants (1973), and 25 out of 33 participants (1975). This method has been noted to be cost-effective and time efficient (Thompson et al., 1994); however, Glaros and Rao (1977) recommended this treatment be used with caution as it may cause structural damage and should include the use of mouth guard.

Collectively, aversive conditioning treatment methods have provided effective treatment methods for the reduction of bruxism. It is also worth commenting that aversive conditioning has also been a successful method of treatment for nocturnal bruxism (e.g., Heller & Strang, 1973; Moss, 1982).

Biofeedback. Biofeedback (i.e., EMG) has primarily been used for diurnal inaudible bruxism and nocturnal bruxism, as it monitors the slightest pressure. With biofeedback, when the individual bruxes, a form of feedback is provided. The feedback that is produced when the individual bruxes is usually a tone that would arouse the person enough to disrupt their bruxing (Mealiea & McGlynn, 1987). While reductions of bruxism were observed when feedback was provided, bruxism returned once treatment was removed (Glaros & Melamed, 1992).

Habit reversal/awareness. Habit reversal/awareness is a procedure that trains the person to detect the precursors that precede their bruxism (Cooper, Heron, & Heward, 2007). When the client bruxes they are to engage in a competing activity that uses the same muscles as bruxism. For example, the client opens their mouth when they brux. The opening of their mouth is a competing, incompatible response. Azrin and Nunn (1973) developed the habit reversal procedure which (1) brings about awareness of the behavior, (2) interrupts the chain of behaviors as early as possible, (3) teaches a competing response, and (4) eliminates any potential social contingencies maintaining the habit.

Rosenbaum and Ayllon (1981) used Azrin and Nunn's (1973) procedure and taught an individual to detect when his teeth connected and his jaw started to move either to the right or left. When he bruxed, or had started to brux, he was told to close his mouth, bite his teeth together, and not move them for 2 minutes. The individual's bruxism decreased from 85 instances per day during baseline to five instances per day at the conclusion of the treatment period. Low levels maintained during 6-month follow up. Bebko and Lennox (1988), Rosen (1981), and Blake et al. (2011) achieved similar results following Azrin and Nunn's (1973) habit reversal procedure. Overall, habit reversal/awareness as a form of treatment for bruxism has been very effective.

Combined reinforcement and punishment. Gross and Isaac (1981) evaluated a reinforcement procedure combined with a contingent consequence procedure to treat bruxism. They used differential reinforcement of other behavior (DRO) and a contingent effort procedure. DRO consisted of providing social rewards (e.g., praise, hugs, and pats) every 10 seconds the client abstained from bruxing; with every brux the client was led through repeated forced arm exercises. Results showed that the procedures were effective and eliminated the client's bruxism, and maintained at 3-month follow-up.

Overall, the behavioral treatments for bruxism have proven largely successful in the reduction, and in some cases elimination, of bruxism. It should be noted that many of the studies that attempted to treat diurnal bruxism did not demonstrate high levels of experimental control and most are case reports. However, the overall success found suggests that behavioral treatments are a viable and essential treatment method for bruxism.

Table 3

Summary of Non-Function-Based Behavioral Treatment

Study	Treatment	Results		
		Baseline	Intervention	Follow-up
Ayer & Gale, 1969	Massed Practice	Not reported	Reported to have ceased on 10th night	6-month: Zero reported instances of bruxism
Ayer & Levin, 1973	Massed Practice	Not reported	Mean number of days until bruxism ceased for 11 participants: 10 days. 3 participants bruxism did not cease	2-week: Zero reported instances of bruxism
Heller & Strang, 1973	Aversive Conditioning	Mean rate of 1.75 instances of bruxism per minute. Return to baseline rate of 1.2 instances per minute.	First conditioning: Mean rate of 0.65 instances per minute. Second conditioning mean rate of 0.5 instances of bruxism per minute.	Not collected
Ayer, 1976	Massed Practice	All 33 participants bruxed often	Mean number of days until bruxism ceased: 10 days	1 year: 75.5% of participants no longer bruxed
Jenkins & Peterson, 1978	Aversive Conditioning	Rate of 30.5 instances of bruxism/minute	Self-monitoring alone: rate of 16.1 instances/minute Self-monitoring plus aversive stimulation: rate of 0.40 instances/minute	2 years: zero instances of bruxism
Gross & Isaac, 1981	DRO plus Aversive Conditioning	Participant 1: 75% Participant 2: 85%	Participant 1: 16% Participant 2: 8%	3-month: Participant 1: 0% Participant 2: 0%
Kramer, 1981	Aversive Conditioning	18 instances of bruxism	10 instances of bruxism	3-week: 0-3 instances of bruxism per day
Rosenbaum & Allyon, 1981	Habit Reversal	75 instances/ day	8.5 instances/day	6-month: 5 instances/day
Rosen, 1981	Habit Reversal	Not collected	1st day of treatment 25 instances of bruxism. On the 4th day of treatment bruxism ceased	6-month: Zero instances of bruxism
Rudrud & Halaszyn, 1981	Aversive Conditioning	78.9%	28.7%	Not collected

Blount et al., 1982	Aversive Conditioning	Participant 1: 63% Participant 2: 60.6%	Participant 1: 8.4% Participant 2: 11.4%	Not collection, yet reports of generalization to other times of day where treatment was not conducted.
Bebko & Lennox, 1988	Aversive Conditioning	Participant 1: 86.6% Participant 2: 62.8%	Participant 1: 22.7% Participant 2: 27.9%	6-month: Participant 1: 40% Participant 2: 0%
Barnoy et al., 2009	Contingent Combined Cue of physical and vocal cue	Not collected	Combined cue: approx. mean rate of 1.83 instances per minute	3-week: Combined cue mean rate of .01 instances per minute
Blake et al., 2011	Habit Reversal	Bruxing 8-12 hours per day	Decreased and virtually disappeared	Not collected
Armstrong et al., 2014	Contingent Vocal Reprimand	Baseline: approx. mean 63% of intervals	Vocal Reprimand: approx. mean 25% of intervals Physical Prompt: approx. mean 30% of intervals Combined: approx. mean 28% of intervals	2-week: Vocal reprimand: approx. mean 19% of intervals

Function-based. Skinner (1957) explained a functional analysis (FA) as the cause-and-effect relations between one's environmental variables and their behavior. Iwata, Dorsey, Slifer, Bauman, and Richman developed a procedure to help evaluate a behavior's function (see Beavers, Iwata, & Lerman, 2013; Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994). Although not the only method of evaluating function, the FA used in Iwata et al. (1982/1994) is highly cited as being an effective method for evaluating problem behavior (e.g., Broussard & Northup, 1997; Goh et al., 2013; Rapp, Miltenberger, Galensky, Ellingson, & Long, 2013) as well as assisting in the selection of treatment (e.g., Mevers, Fisher, Kelley, & Fredrick, 2014; Vollmer, Iwata, Zarcone, Smith, & Masaleski, 1993; Vollmer, Marcus, & Ringdahl, 1995)

In an FA, the experimenter/clinician manipulates antecedent and consequential variables relative to behavior to demonstrate a functional relation between the environment and behavior. While recognized as an effective tool in the assessment of problem behavior in the behavioral and medical fields (e.g., Hall, Hustyi, Chui, & Hammond, 2014; Piazza, Hanley, & Fisher, 1996; Woods, Luiselli, & Tomassone, 2013), little attention has been paid to the use of FAs in the assessment and treatment of bruxism.

The procedures used in Iwata et al. (1982/1994) are often referred to today as the gold standard for determining the function of problem behavior (Schlinger & Normand, 2013). Beavers, Iwata, and Lerman (2013) commented that since Iwata et al. (1982/1994) presented their data on the functional characteristics of self-injurious behavior, the procedures have been replicated, extended, or discussed in over 2,000 articles and book chapters. FA methodology has been used with hundreds of individuals, various populations, in a number of settings, and with many types of problem and non-problem behaviors.

The methods used in Iwata et al. (1982/1994) included four standard conditions: social-positive reinforcement (e.g., access to attention), social-negative reinforcement (e.g., escape from demands), automatic reinforcement (e.g., self-stimulatory), as well as a control condition (i.e., play). A possible fifth condition is another social-positive reinforcement in the form of tangibles; however, this condition is only recommended when the experimenters suspect the behavior is maintained by tangible items. This is a consideration one must made to avoid developing a maintaining function as the individual would receive tangible reinforcement for each instance of bruxism (Rooker, Iwata, Harper, Fahmie, & Camp, 2011). To observe the effects of the conditions, they are alternated using a multielement design. The multielement design allows the experimenter to observe the target behavior in each of the conditions separately and to make a comparison between the conditions.

To determine the behavior's function, antecedent and consequence manipulations are contrived to evoke the target behavior. The condition in which problem behavior is most frequent, as compared to the control condition, is said to be of the same function as what maintains the behavior in the natural environment.

To assess if a behavior is maintained by attention (i.e., socially-mediated positive reinforcement), the experimenter conducting the session removes all attention in the absence of the target behavior as the antecedent manipulation. However, when the target behavior is emitted, attention (praise or reprimand) would be provided. In other words, attention would only be given contingent upon the occurrence of the target behavior. If the target behavior occurred at high levels during this condition (and only this condition), the conclusion that the behavior is maintained by attention could be made.

To assess if the behavior is maintained by escape (i.e., socially-mediated negative reinforcement), the experimenter conducting the session places demands as the antecedent manipulation. However, when the target behavior is emitted, demands are temporarily removed. That is, demands are only removed contingent upon the occurrence of the target behavior. If the target behavior occurred at high levels during this condition (and only this condition), the conclusion that the behavior is maintained by escape could be made.

To assess if the behavior is maintained by automatic reinforcement (e.g., self-stimulatory or pain attenuation behavior), the experimenter conducting the session would not be interacting with the individual. Their lack of interaction would then serve as the antecedent manipulation—

except during those occasions when the target behavior would be harmful to the individual, in which case the experimenter would interact to avoid potential harm. No socially-mediated contingencies are produced as the individual is continually ignored. If the target behavior occurred at high levels during this condition, the conclusion that the behavior is maintained by automatic reinforcement could be made. However, one can also conclude that the behavior is maintained by automatic reinforcement if high levels of the target behavior occur across all conditions, indicating an insensitivity to social-mediation of the reinforcement.

The last condition in a standard FA is the play condition, often referred to as an enriched environment condition. This condition is used as the control condition. In this condition the individual is surrounded by a variety of preferred items and receives intermittent attention from the experimenter. There are no contingent consequences for the occurrence or non-occurrence of the target behavior. This is the condition in which the other conditions are compared to. If high levels of the target behavior occur in this condition one can conclude that the behavior is maintained by automatic reinforcement.

Although functional analyses have been used for a variety of self-injurious behaviors, to date, there are only three studies that have functionally assessed bruxism (i.e., Armstrong, Knapp, & McAdam, 2014; Barnoy, Najdowski, Tarbox, Wilke, & Nollet, 2009; Lang, Davenport, Britt, Ninci, Garner, & Moore, 2013). And of the three, only one used the function as the deciding factor for treatment (i.e., Lang et al., 2013).

Barnoy et al. (2009) was the first study to evaluate bruxism's function. The authors interviewed the participant's staff about the client's bruxism as their functional assessment. The results of the interview found that their participant's bruxism was maintained by automatic reinforcement. Following this conclusion, the analysis of the function was discontinued and a punishment procedure (i.e., touching the chin down to open mouth and say ‘ah’, p. 846) was selected as treatment. Armstrong et al. (2014) replicated Barnoy’s punishment procedures when it was concluded that their participant’s bruxism was, too, maintained by automatic reinforcement. Therefore, although both studies determined the function of their participant’s bruxism, they did not demonstrate the functional relation of the bruxism. Rather, they discontinued their analysis and selected a punishment procedure. The procedures selected were physical cue (i.e., touching the chin down to open mouth) with a verbal reprimand (Barnoy et al., 2009) and verbal reprimand alone (Armstrong et al., 2014). Both procedures were effective at reducing bruxism to near-zero levels (Armstrong et al., 2014; Barnoy et al., 2009).

Lang et al. (2013) is the only study to date that used the results of the FA to select a treatment for bruxism. The FA found that their participant’s bruxism was maintained by attention. When considering the functional relation of attention and bruxing, the authors elected to use functional communication training (FCT) as their treatment. During the intervention, when the participant bruxed, the therapist would instruct the participant to say the therapist’s name (e.g., “say, ‘Courtney’”; p. 324). Following the prompt, the therapist ignored all subsequent occurrences of bruxism, and would only interact with the participant when he appropriately manded for her attention. Results were that, as the appropriate manding for attention rose, bruxism decreased to near zero levels. Three-week follow-up data were that bruxism was nearly eliminated (i.e., 0.05% of intervals), while manding remained at high levels.

Although the literature regarding assessment of function for bruxism is limited, and function-based treatment is even more limited, collectively the research is suggestive of an effective method to treat bruxism. However, the current research on functional accounts of bruxism resort to punishment-based interventions when confronted with automatically maintained bruxism. Research has yet to further evaluate the maintaining variables of the automatically maintained bruxism. Further assessments of sensory stimulation is necessary to determine the maintaining variables of this aberrant behavior in efforts to eliminate the behavior without the necessity of a punishment-based approach.

Table 4

Summary of Function-Based Behavioral Treatments

Study	**Treatment**	**Function**	**Results**		
			Baseline	Intervention	Follow-up
Lang et al., 2013	Functional Communication Training (FCT)	Attention	Bruxism: 16.5% of intervals FCT: 0% of opportunities	Bruxism: 2% of intervals FCT: 36.5% of opportunities	Maintenance phase: Bruxism: .05% of intervals FCT: 73.5% of opportunities

Further Assessments of Sensory Stimulation

To reiterate, behavior that is maintained by automatic reinforcement persists in the absence of socially-mediated contingencies. Meaning, engagement in the behavior is not contingent upon the presence of other people. Such functional maintenance proves difficult for those intervening on the behavior. Therefore, further considerations as to how to treat aberrant behaviors maintained by automatic reinforcement must be addressed.

Vollmer (1994) emphasized the importance of antecedent assessments as a means to identify specific sensory sources that might maintain automatically reinforced behavior. When incorporating antecedent assessments with sensory stimuli, one is able to evaluate and determine which sensory stimuli are correlated with target behaviors (Patel, Carr, Kim, Robles, & Eastridge, 2000). However, prior to determining the influence specific sensory stimulation may have, one must define the aberrant behavior and determine the potential sensory stimulations the behavior produces.

Following the breakdown of stimulations, an assessment of which stimulation matches the sensory consequences of the aberrant behavior must occur. Similar to an FA, the assessment uses a multielement design rotating the presumed sensory stimulations. The stimulation that provides the same or similar consequences as the aberrant behavior will decrease the frequency of the aberrant behavior.

As an example of antecedent analyses of automatically maintained behavior, Patel et al. (2000) conducted a follow-up analysis (i.e., antecedent assessment of sensory stimulation) for an individual who would rapidly move his tongue up and down in his mouth. Patel et al. determined three potential sensory stimulations that may provide reinforcement for the client’s rapid tongue movements: (a) auditory stimulation produced by the movement of the tongue, (b) vibratory stimulation produced by the physical up-and-down movement of the tongue, and (c) moisture produced to alleviate dry lips. To assess the auditory stimulation, the authors prepared an audio recording of the sound produced by the tongue’s movement. To assess the vibratory stimulation, the authors provided a vibrating tooth brush and a vibrating candy holder. And lastly, to assess moisture-based stimulation, the authors applied lip balm on the individual’s lips. Results found that the individual's behavior was maintained by auditory stimulation. The intervention selected was differential reinforcement of other behavior (DRO) with audible toys (e.g., musical Elmo, drum, musical bear). Results of the intervention were near zero levels (i.e., *M* = 3.3% of intervals), a 53.6% decrease from baseline.

Once the specific, or multiple, sensory stimulations that provide similar reinforcement as the aberrant behavior are determined, interventions may be developed based upon this sensory delivery mode. Such interventions include antecedent, consequence, and component analyses.

Non-contingent presentations of putative sensory-based reinforcement (NCR[1]) of the matched stimulation is a widely used antecedent intervention (Rapp, 2007). In this intervention, the matched stimulation is provided on a fixed time schedule without concern for the occurrence or non-occurrence of the aberrant behavior. NCR for automatically maintained behavior has been effective for the reduction of aberrant behavior with a variety of behaviors (e.g., Piazza, Adelinis, Hanley, Goh, & Delia, 2000; Rapp, 2007).

Component analyses have investigated using NCR in combination with consequent procedures. Such consequent procedures analyzed include DRO (e.g., Lanovaz & Argumedes, 2010) and response interruption and redirection (RIRD; e.g., Love, Miguel, Fernand, & LaBrie, 2012). When comparing the success of the intervention methods, NCR of matched stimulation as an antecedent intervention has been found to provide superior results (e.g., Vollmer et al., 1993).

Antecedent assessments of sensory stimulation have provided therapists and experimenters the opportunity to further evaluate the maintaining variables of automatically

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[1] Although technically contingent and not technically reinforcement, the literature tends to refer to this procedure as NCR. In an effort to remain consistent, I adopt the same, albeit incorrect, term here

maintained behavior. To date, assessments of sensory stimulation have yet to be used when functional analyses determine bruxism is maintained by automatic reinforcement. However, this procedure is evidence that the function of bruxism can be further determined when it is found to be automatically maintained. Further evaluation of sensory stimulation provides the opportunity to determine the particular type of stimulation that maintains the behavior; therefore, allowing clinicians and experimenters to better select a method of treatment for their clients.

Statement of Purpose

Medical approaches to treatment for bruxism have taken rise over the behavioral treatments (Lobbezoo et al., 2008). However, the treatments that are being used do not result in permanent cessation of bruxing. The behavior returns when either the medication is no longer being consumed, the injection wears off, or you take out the occlusal splint (e.g., Goldberg, 1973; Monroy & da Fonseca, 2006; Van Zandijcke & Marchau, 1990).

Addressing bruxism as a behavior rather than a condition provides one the ability to analyze its function. And by further evaluating the etiology of the behavior, one is able to determine its true function. Further studies must be conducted using function-based behavioral treatments to assist in the delivery of effective treatment research for those impacted by bruxism.

The purpose of this study is to provide the field of dentistry and behavior analysis some insight as to the effects of a function-based approach to the treatment of bruxism. To accomplish this, the present study will (a) evaluate the function of a child’s bruxism through a functional analysis, (b) if the function is found to be maintained by automatic reinforcement, extend previous research through an assessment of sensory stimulation, and (c) evaluate a treatment based on the results of the functional relation.

Method

Participant, Setting, and Materials

The participant, August, was a 4-year old girl diagnosed with autism who engaged in audible diurnal bruxism since she was 2 years old. August would brux from the time she woke up until she fell asleep. It was not reported by her parents that she would brux in her sleep. August received one-on-one behavior analytic treatment at an autism treatment center from 8am to 4pm, Monday through Friday. All phases of the study were conducted during her typical therapy hours at the center.

The study was conducted in two 10 x 10 rooms, an art room and a teaching room. The rooms contained a table, chairs, various toys, and instructional materials. The rooms also contained a handheld video camera that was placed on a stand.

Response Measurement and Interobserver Agreement

Bruxism was defined as the audible grinding of the participant's upper and lower teeth. Previously trained data collectors reviewed the video of each session. During all phases of the study, partial interval data on the occurrence or non-occurrence of bruxism were collected as well as the latency to brux during baseline and intervention phases. Partial interval data were converted to a percentage by dividing the intervals in which bruxism occurred by the total intervals, and then multiplying by 100.

Data on interobserver agreement (IOA) were collected across all phases, analyses and results are depicted in Table 5. IOA was calculated using the exact count formula, (i.e., exact occurrence divided by the total occurrences or non-occurrences).

Table 5

Interobserver Agreement

Phase	Sessions analyzed	IOA Results	Standard Deviation	Range
Functional Analysis	100%	100%	0.00%	100%
Assessment of Sensory Stimulation	100%	100%	0.00%	100%
Baseline 15-Second PI Intervals	69%	91.36%	5.04%	82.5%-100%
Baseline 1-Sec. PI Intervals	50%	93%	5.05%	85% - 100%
Treatment 15-Second PI Intervals	42%	91.04%	4.67%	80% - 100%
Treatment 1-Sec. PI Intervals	63%	96%	4.14%	85% - 100%

Note. Mean IOA was 95% (SD=4%)

Procedures

Observer training. Observers were center employees with a minimum of one year experience implementing treatment and recording treatment data. Training consisted of the first author meeting with the observers in a group setting once, and then one-on-one with each observer on two additional occasions. The initial meeting with the group of potential observers was an informational meeting about the study (e.g., definitions, training process, time commitments). Once all questions were answered, the individual training went as follows: (1) review the materials, (2) role playing data collection, (3) role playing treatment delivery, and (4) oral and written test. A task analysis was used to document the training process (refer to Appendix C).

Explanation of definitions. Following the training materials task list (refer to Appendix C), the author explained bruxism's definition, including occurrences and non-occurrences, how to use the recording equipment, definition of matched stimulation, defined the role of the deliverer and the role of the data collector, and the data collection components (e.g., recording method, length of interval, duration, "+", "-"). The author provided the observers with a list of all definitions for their reference and copies of the data collection sheets. The author allowed time for clarification and questions.

Observer role play-data collection. The author reviewed the materials explained in the group meeting, and allowed time for clarification and questions prior to role playing. Following the review, the observer was provided with a pen, a blank data sheet, and a timer. Prior to beginning the video, the author told the observer to act as if they were collecting the data. When there were no further questions, the author started the pre-recorded video clip of the participant bruxing.

After the data were collected, the author reviewed the collected data and compared it with a data sheet the author had previously completed. To be able to continue on with the next phase of training, IOA needed to be at least 90%. IOA was collected using exact count (i.e., agreements divided by the agreements and disagreements and multiplying by 100). Observers who failed to meet the 90% IOA criterion, were given one additional attempt to pass this phase. If the observer did not reach mastery (i.e., scores below 90%) by the second attempt, they were no longer permitted to be an observer in the study.

Observer role play treatment delivery. The author reviewed the materials explained in the group meeting and allowed time for clarification and questions prior to role playing. The author gave specific instructions for when to deliver treatment and for how long. Following the review, the author provided the observer a pre-set timer and the stimulation to deliver. Prior to beginning the video, the author told the observer to act as if they were delivering treatment. The act included extending his or her arm out with the stimulation in hand for the entire time they were delivering the treatment and retracting it when they were not delivering it. The author was behind the observer and marked down when the RA-in-training delivered treatment and for how long it was delivered.

To be able to continue on with the next phase of training, IOA must have been at least 90%. Observers who failed to meet the 90% IOA criterion were given one additional attempt to pass this phase. If the observer did not reach mastery (i.e., scores below 90%) by the second attempt, they were no longer able to be an observer in the study.

Oral and written test. The final phase of training included a written and oral test. For the written test, the author provided the observer a blank version of the task list he or she previously received, and instructed him or her to fill it out. Following the written exam, the author began the oral exam. The oral exam included five questions from the task list. The observers had to achieve at least 90% accuracy, in both the written and oral test. Observers who failed to meet the criterion in either of the tests, were given one additional attempt. If following the second attempt they did not receive 90%, they were no longer involved in the study. However, if they achieve at least 90% on either the first or second attempt, they were considered trained and able to act as an observer.

Initial functional analysis. Ignore, attention, demand, and play conditions were conducted in a similar manner as those described by Iwata et al. (1982/1994). Conditions were presented using a multielement design, with each condition lasting 5 minutes. The first author, as well as a Board Certified Behavior Analyst, were responsible for facilitating this analysis.

During the ignore condition, the observer said, “Play by yourself, I have work to do,” and then reverted her attention to an activity (e.g., writing on a clipboard). If the participant bruxed, the observer continued to work on her activity and did not respond to the participant. The observer only interacted with the participant if she engaged in a behavior that was dangerous (e.g., climbing on the table).

During the attention condition, the observer said “I am going to read my book, if you want my attention, just brux,” and then reverted her attention to an activity (e.g., reading a book). If the participant bruxed, the observer provided brief attention (e.g., “Hey there,” “Don’t grind your teeth,” looked at the participant) and then returned to her previous activity.

During the demand condition, the observer said, “If you do not want to work, just brux,” and then presented previously mastered demands every 2 seconds. When the participant did not comply with the demand within 3 seconds, a least-to-most prompting sequence was used (i.e., gestural, partial physical, full physical). If the participant complied with the demand, following 2 seconds, another demand was placed. If the participant bruxed, the observer removed the stimuli that accompanied the demand (e.g., cards) and turned away for 15 seconds. After 15 seconds the observer presented another demand.

During the play condition, the observer said, “Let’s play” and brought out various toys and activities. The observer interacted with the participant and the toys giving brief attention about every 10 seconds. If the participant bruxed, there were no programmed consequences.

Assessment of matched sensory stimulation. An assessment of possible sensory stimulations was implemented after the functional analysis was completed. The sensory stimulations assessed included internal pressure on the teeth, external pressure on the jaw, and auditory stimulation. Conditions were presented using a multielement design, with each condition lasting 3 minutes. The first author and a MA-level Board Certified Behavior Analyst were responsible for facilitating this assessment.

To reproduce the external pressure on the jaw, vibrating devices were placed on the external jaw area of the face. Internal pressure was reproduced using chewy tubes that were placed inside of the oral cavity. And, the auditory stimulation was reproduced using headphones that played a compilation of pre-recorded audio clips of the participant bruxing. The audio clips were selected from the functional analysis videos. The control condition was similar to the play condition in the FA with no stimulations available or presented.

In each stimulation condition, access to the stimulation was positioned so that August's response effort was not a factor. Meaning, August did not have to pick up the vibrating devices or chewies, and she could continue to play. Therefore, in the external pressure conditions, the author lightly placed the vibrating devices on her jaw area. In the internal pressure conditions, the chewy was held at the plane of her lips. And in the auditory condition, the headphones were placed in her ears at a medium volume. When August would move away from any of the stimulations (e.g., reaching for a toy), the stimulation was repositioned to continue access. If August emitted any behavior that suggested she did not like the stimulation (e.g., cry, push the stimulation away), that session was terminated. August pushed away the stimulation in the auditory condition once.

During the assessment, eight variations of the three potential sensory stimulations were evaluated, along with a control condition. For internal pressure, the following stimulations were assessed: non-vibrating chewy (I[2]), chewy with a pulse vibration (IPV), and chewy with a continuous vibration (ICV). For external pressure, a pulse vibration (EPV) and a continuous vibration (ECV) were assessed. For auditory, the pre-recorded audio clip was used (A). Two combined stimulations were assessed; chewy and external vibration (I/V) and external vibration and auditory (V/A). In these combined conditions, both stimulations were available.

Baseline. Baseline was the same as the play/control conditions in the functional analyses. The sessions were 10 minutes, and the participant had access to a variety of toys and activities with intermittent observer attention (e.g., vocal, eye contact, participating with toy play). There were no programmed consequences for bruxing.

Intervention. Based on the results of the sensory functional analysis, an intervention was developed. The design was a multiple baseline across settings with an embedded multi-element design with a constant series control. Sessions, control and treatment, were 10 minutes. In the control condition, the contingences were identical to the baseline condition. The treatment was non-contingent delivery of the matched stimulation found in the sensory assessment.

During the matched stimulation sessions, the stimulation was delivered on a fixed time (FT) schedule with a FT access. The schedule of reinforcement was selected from the average inter-response-time between teeth grinds collected during baseline (e.g., Patel et al., 2009). The duration of access was adjusted to control for the rate of reinforcement given extended time requirements to contact reinforcement. In other words, requirements to earn reinforcement

[2] “I” refers to internal pressure, whereas “E” refers to external pressure

increased as access time decreased, thus keeping the maximum rate of reinforcement constant across all sessions. Upon introduction of the intervention, the control and matched stimulation sessions were conducted in separate rooms. After visual inspection of the data indicated that bruxism rates had steadied, treatment was introduced in the same room as the control.

Access to the matched stimulation was thinned as the occurrences of bruxism decreased to two or less grinds across one session. Reducing bruxism to two or fewer grinds per session would result in a 10% increase in the FT schedule of reinforcement. Meaning, when the participant bruxed for less than two intervals in one session, in the subsequent session her access to the stimulation decreased to 9 seconds, and her FT schedule increased to 6 seconds.

An intervention termination criterion was developed that stated if the number of intervals bruxism occurred was not decreasing by at least 25% by the end of the 15th day of treatment, the treatment would be discontinued and an alternative procedure would be implemented. The alternative procedure[s] were left to the discretion of her treatment center's Board Certified Behavior Analyst. The true criterion for mastery was complete elimination of bruxism. However, for this study, the functional relation criteria for mastery was defined as when accessing the matched stimulation, August does not brux for at least 90% of intervals across 8 consecutive sessions with the FT schedule of 14 seconds.

Results

Six center employees were selected for training. All trainees passed the role-playing phases without requiring remediation. One observer failed to meet the 90% criterion in the written test. Following a remediated attempt, she met the criterion and completed her observer training. Throughout the course of the study, four of the six trainees were used as observers.

Figure 1 displays the functional analysis results for August. Throughout all conditions, including the play (control) condition, bruxism persisted. Bruxism levels were relatively undifferentiated across all conditions despite the presence/absence of programmed consequences (mean percentage intervals: ignore, 27.2%, demand, 25.5%, attention, 32.7%, and play, 39.4%), suggesting an automatic function.

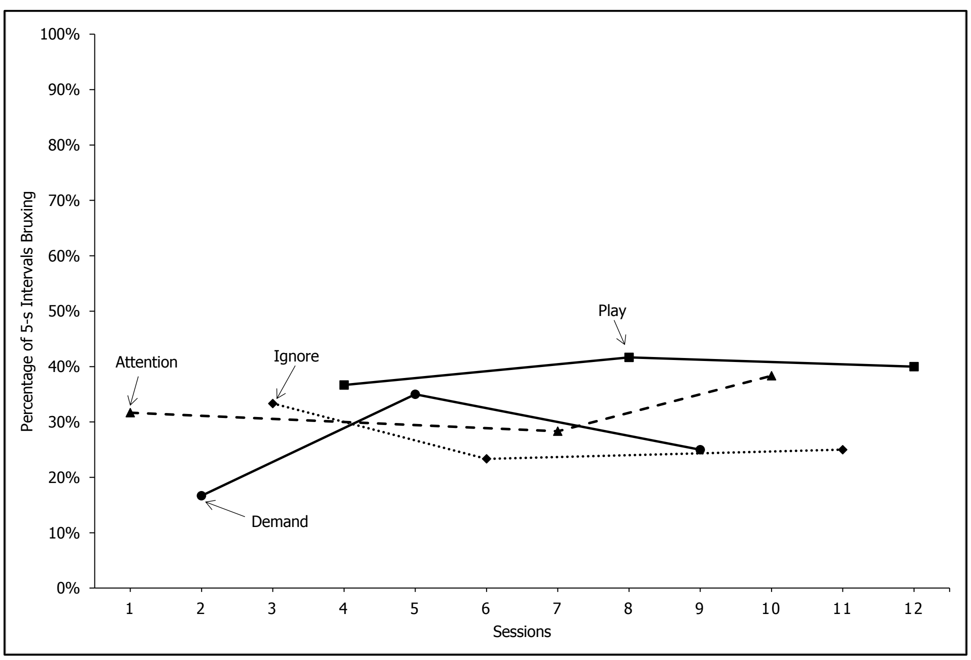

Figure 1. Functional Analysis. Percentage of 5-s intervals in which bruxism occurred during the functional analysis.

To further assess the sensory stimulations correlated with the automatic function of her bruxing, a sensory stimulation assessment was implemented. Figure 2 depicts the stimulations assessed during the sensory analysis. Throughout all of the conditions assessed, bruxism persisted; however, the stimulation conditions demonstrated differentiated results and variability following repeated exposure. The control test condition produced results that were consistent with the data found in the original functional analysis (i.e., mean percentage: 47% of intervals).

August's bruxism persisted most in condition I, ICV, and V/A with a mean occurrence of approximately 51%, 34%, and 33% of intervals, respectively. August bruxed less frequently in condition I/V, EPV, ECV, and A, with a mean occurrence of approximately 25%, 31%, 32%, and 28% of intervals, respectively. The stimulation condition where the bruxism persisted the least was non-contingent access to the IPV stimulation, with a mean occurrence of approximately 16% of intervals. Therefore, the hypothesized matched stimulation selected for treatment was a chewy with a pulse vibration.

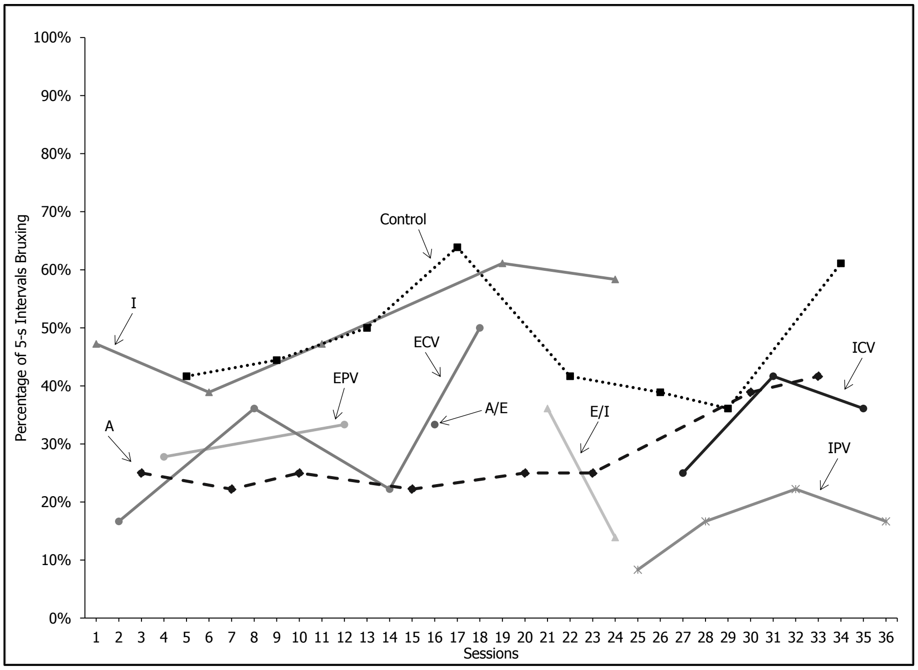

Figure 2. Assessment of Sensory Stimulations. Percentage of 5-s intervals in which bruxism occurred during the assessment of sensory stimluations. *(I= Chewy; A= Auditory; EPV= External Pulse Vibration; ECV= External Continuous Vibration; A/E=Auditory and External Vibration; E/I= External Vibration and Chewy; ICV= Chewy Continuous Vibration; IPV= Chewy Pulse Vibration).*

Figure 3 portrays the baseline and treatment results of the non-contingent delivery of matched stimulation using a 15-second partial interval recording method. Baseline data were collected for 32 sessions, across 19 days. And, across those sessions, the percentage of intervals of bruxism increased from approximately 68% of intervals during the first three sessions, to approximately 91% of intervals during the last three sessions of baseline. The mean occurrence of bruxism was approximately 74% of intervals (range 55% to 97.5% of intervals).

Treatment data were collected for 57 sessions across 21 days, 67% of the sessions were matched stimulation (i.e., treatment condition) and the remaining 33% of sessions were control. Overall, the mean occurrence of bruxism decreased across treatment sessions while the control condition remained similar to baseline levels. During treatment sessions, August's bruxing decreased from an average of 70% of intervals during the first three sessions to an average of approximately 14% of intervals in the last three sessions. This is approximately an 80% decrease in the mean occurrence of intervals from the introduction of treatment.

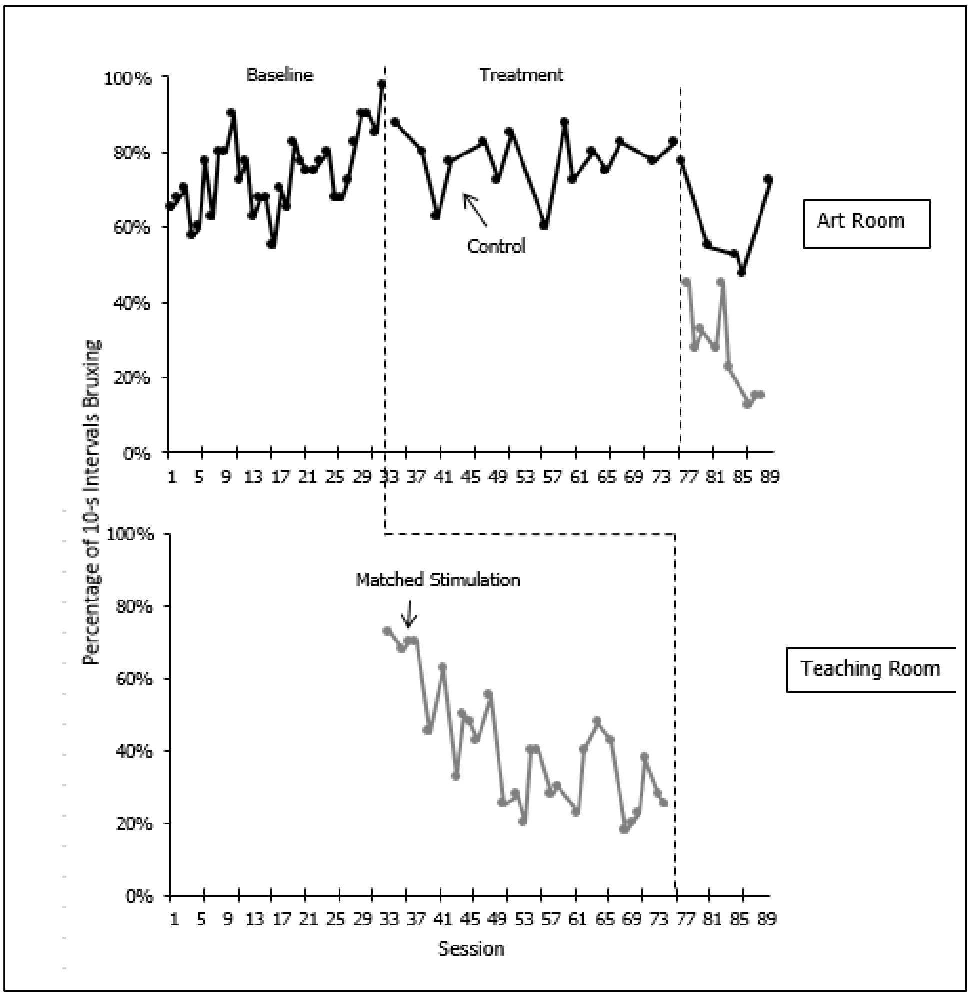

Figure 3.Intervention across Sessions. Percentage of 15-s intervals in which bruxism occurred across settings during baseline, control, and matched stimulation conditions.

Figure 4 depicts the baseline and treatment results of using a 1-second partial interval recording of the first minute (i.e., 00:00-1:00) and last minute of the session (i.e., 9:00-10:00) for every third session (contact the author for complete data set). These data were collected to evaluate within session effects. Results indicated that August's bruxing within session did not demonstrate much variability, and that, although she was bruxing less from session to session, she was bruxing at a similar rate within session. August's bruxing decreased in the matched stimulation condition while it remained similar to baseline levels in the control condition.

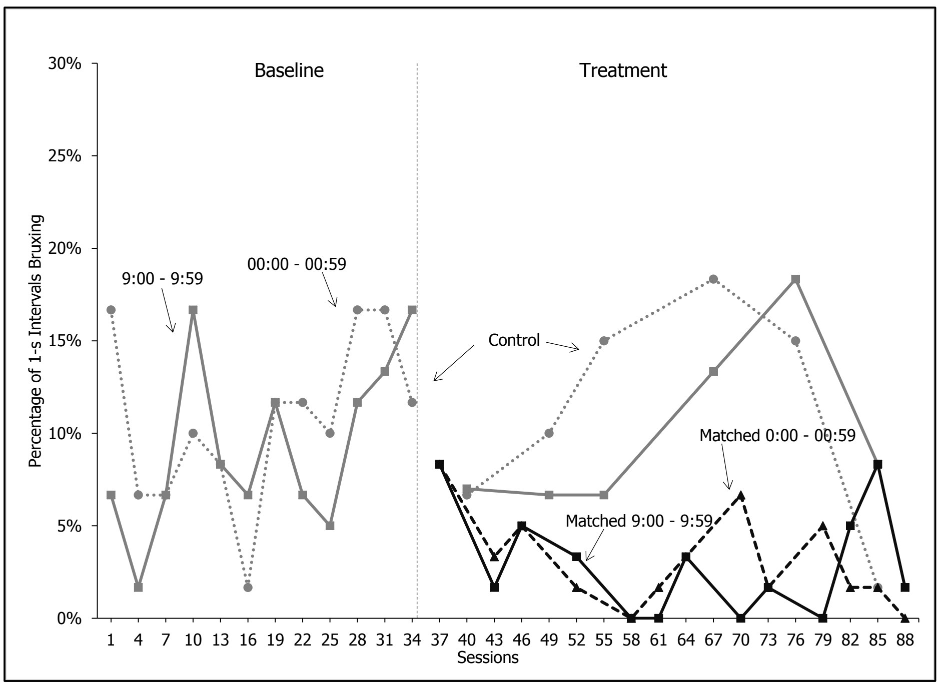

Figure 4. Intervention within Session. Percentage of 1-s intervals in which bruxism occurred within session (i.e., the first minute, 00:00 – 00:59, and the last minute, 9:00 – 9:59) during baseline, control, and matched stimulation conditions. Figure displays every third session.

After the 89th session, August's parents requested that the function-based intervention be terminated and that a punishment-based procedure be attempted. Parents reported a slower-than-anticipated reduction as the rationale for treatment termination. Thus, although the function is an important component to consider with treatment, if the function-based treatment is not producing rapid enough results with such a destructive behavior, a change in treatment might be needed. Responsibility has been transferred to August's treatment environment with the understanding that they will select another treatment (i.e., punishment procedure).

Discussion

The current study replicated previous research by conducting a functional analysis of bruxism (e.g., Armstrong et al., 2014; Lang et al., 2013). The persistence of bruxism across the conditions of the functional analysis confirmed that August's bruxism was maintained by automatic reinforcement. Historically, when bruxism was found to be maintained by automatic reinforcement, punitive measures were the selected treatment with no further analysis of the sensory conditions that maintained it (i.e., Armstrong et al., 2014; Barnoy et al., 2009).

Being that bruxism is a behavior that occurs within the body (i.e., inside of the oral cavity) and that it does not involve any other environmental stimulus (e.g., hands, toys, objects), its difficulty in determining the function and treating increases. Much of the literature that has evaluated and treated automatically maintained aberrant behaviors with matched simulation have treated behaviors that involve another environmental stimulus (e.g., saliva play, Piazza et al., 2000; nail biting, Zawoyski, Bosch, Vollmer, & Walker, 2014). However, the research conducted regarding behaviors that occur within the body are lacking. To date, there have not been any studies that have further analyzed within body behaviors when the behavior is determined to be maintained by automatic reinforcement. The matched stimulation treatments for within body behaviors such as automatically maintained rumination (e.g., Wilder, Register, Register, Bajagic, & Neidert, 2009) and vocal stereotypy (e.g., Rapp et al., 2013), have used a hypothesized stimulation formulated from a functional analysis and/or a preference assessment. No formal assessment of the stimulations of the behaviors were conducted.

This study is the first attempt at assessing the sensory stimulations associated with automatically maintained diurnal bruxism, as well as the first study to evaluate a function-based intervention to treat automatically maintained diurnal bruxism. To further analyze the automatic function of August's bruxism, an assessment of sensory stimulation was conducted followed by an evaluation of matched stimulation as an intervention. While this study succeeded in identifying a functional relation between sensory stimulation and August's bruxism, the process in demonstrating a functional relation requires further discussion.

First, a discussion about the development of the stimulations assessed in the sensory assessment is required. When the sensory assessment was introduced, three stimulations were initially considered: internal pressure with a chewy, external pressure with a vibrator, and auditory stimulation using headphones. These stimulations were selected in a similar manner to Patel et al. (2000) in which the author directly observed August bruxing and noted the possible stimulations within each brux. There was no attempt made to measure the intensity of the brux via teeth plates, nor the decibels emitted when she bruxed. However, as the assessment was introduced, variations to the stimulations surfaced.

The external vibration was split into continuous and pulse vibration, and stimulations were combined (i.e., A/E and I/E) to see if the bruxism was multiply-controlled. The internal vibration stimulation (i.e., IPV and ICV) was introduced when August independently removed the vibrator from her cheek and inserted it into her mouth. The development of these variations as the assessment was occurring demonstrated that although a seemingly thorough analysis of the stimulations associated with bruxism were made, miscellaneous stimulations could have been anticipated had the measurement of the brux been collected differently. To better control for the development of miscellaneous stimulations mid-assessment, it is suggested that other measurements of the behavior (i.e., force of each brux, consultation with a dentist, and/or decibel analysis) be conducted prior to the introduction of the assessment.

The second key point that should be noted within the sensory assessment is when the stimulations were initially introduced, reductions were observed in almost all conditions (except for the "I" condition). However, as sessions continued, an increasing trend was observed in five of the eight conditions (i.e., I, ICV, ECV, EPV, and A). This trend demonstrated that the initial reductions were likely due to novelty effects. As the novelty was waning, August likely habituated to the stimulus, thus providing the differentiated trends (cf. McSweeney & Murphy, 2009). The assessment of sensory stimulation data indicated that August's bruxism reduced and remained at low levels when given non-contingent access to a chewy with a pulse vibration (i.e., IPV stimulation). However, even with the reductions observed during the IPV test condition, complete cessation was not observed during the assessment.

As the IPV stimulation was delivered non-contingently during treatment sessions, the occurrence of bruxism reduced. However, the reduction did not happen immediately following the introduction of the treatment. Rather, the reduction occurred across treatment sessions. When the occurrences of bruxism during treatment sessions were compared to the control sessions, differential effects were observed.

Across sessions, August bruxed during fewer intervals during the treatment condition (M= 37%) when compared to the control condition (M= 74%). When within session data were evaluated, there were little to no changes observed from the first to the last minute in both conditions. In other words, the occurrence of bruxing did not generally decrease as treatment was delivered within a session, nor did it generally increase as treatment was absent. These results suggest that the presence or absence of the stimulation established or abolished the act of bruxing as a reinforcer (Piazza et al., 2000), revealing the likelihood of stimulus control.

To parse out whether the reductions were under stimulus control of the room or of the IPV stimulation, treatment was introduced in the same room as the control. The results were distinct between the control and the treatment conditions, suggesting the stimulus control was over the stimulation itself. In other words, when August saw the vibrating chewy it signaled that reinforcement in the form of the matched stimulation was available which may have abolished her motivation to brux. Future research should further evaluate stimulus control by introducing a return to baseline within the room where treatment is delivered.

Although the matched stimulation did result in lower and decreasing levels of bruxism across sessions, bruxism persisted. Several reasons exist for this observation. First is possibility that the matched stimulation did not encompass the entirety of the sensory stimulation of her bruxing. In other words, the pressure and/or vibration of the IPV stimulation may not have matched the intensity of her bruxism. Second, no stimulus preference assessment was conducted. Piazza et al. (2000) noted that when preference of matched stimuli were assessed, the preferred matched stimuli produced more effective results in reducing aberrant behaviors than other matched stimuli. To account for these limitations found within the matched stimulation, future research should include a stimulus preference assessment following the determined matched stimulation. This further assessment may provide researchers to better match the entirety of the stimulation that maintains the bruxism.

The third possibility regarding the persistence of her bruxism is August’s three year history of bruxing. Her history alone may have led to a more resistant change. To evaluate this possibility, future research should replicate and/or extend this study with individuals whom have a shorter history bruxing (i.e., who have recently started to brux, or have only been bruxing for a few months). This would provide the opportunity to evaluate if one's history with bruxism correlates with their response to a function-based treatment.

Another limitation of this study is the duration of treatment. The treatment was only introduced for 21 days (i.e., 37 sessions). Within this duration, the only observation that was able to be made was that this procedure was effectively able to reduce the occurrence of bruxism. It was unable to demonstrate an elimination of the behavior due to the participant leaving the study. Future research should extend these procedures to observe if complete cessation of the behavior is possible as well as to observe the long-term effectiveness of these procedures.

In summary, this study demonstrated that there are options beside punitive measures to treat bruxism. Results confirmed that automatically maintained bruxism can be further assessed and that a functional relation can be found. Results further demonstrated that a function-based treatment can effectively reduce bruxism. As with any first attempt at something novel, limitations were expected and found. However, regardless of its limitations, this study has provided the field of pediatric dentistry with an opportunity to deliver to their clients who engage in diurnal bruxism another option for treatment. And this option is the first that does not involve the use of either punishment or potentially irreversible medical procedures.

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Appendix A: Observer Training Task Analysis

Trainee Initials: ______

Training Start Date: ___________ Training End Date: ____________

Task	**Percentage Correct**	
	Date	**Remediation Date**
Explanation of Definitions (no percentage required, check off to mark done)		
Observer Role Play: Data Collector IOA **Agreements / Agreements + Disagreements** ______________ / ________________=		
Observer Role Play: Deliver Treatment IOA **Agreements / Agreements + Disagreements** ______________ / ________________=		
Written Test		
Oral Test		
Cumulative Percentage		

Circle: PASS / FAILED

Trainee Initials: ______

Training Start Date: ___________ Training End Date: ____________

Task	**Percentage Correct**	
	Date	**Remediation Date**
Explanation of Definitions (no percentage required, check off to mark done)		
Observer Role Play: Data Collector IOA **Agreements / Agreements + Disagreements** ______________ / ________________=		
Observer Role Play: Deliver Treatment IOA **Agreements / Agreements + Disagreements** ______________ / ________________=		
Written Test		
Oral Test		
Cumulative Percentage		

Circle: PASS / FAILED

Scoring: PASS = $\geq$ 90% FAIL = < 90%

Appendix B: Observer Training Explanation of Definitions

Trainee Initials: _______

Training Start Date: ____________ Training End Date: _____________

Training Materials - KEY

Task	Date	Remediation date
Definitions of Study		
Define target behavior: Bruxism is defined as the grinding of the participants upper and lower teeth with enough force to create an audible sound		
Define occurrence of target behavior: When the individual engages in bruxism		
Define non-occurrence of the target behavior: When the individual does not engage in bruxism		
Use of a timer: Timer will be set for 10 minutes and will vibrate for each interval		
Define matched stimulation: The stimulation that maintains the behavior		
Delivery of Treatment		
Define role: Deliver the matched stimulation		
Frequency of delivery: Semi-random fashion		
Duration of delivery: 15 seconds		
Duration of session: 10 minutes		
IOA must be ≥ 90%		
Data Collector Role		
Define role: Record the occurrence/nonoccurrence of the target behavior		
Type of recording method: Partial interval		
Length of interval: 15 seconds		
Duration of session: 10 minutes		
"+" represents: The target behavior occurred within the interval		
"-" represents: The target behavior did not occur within the interval		
IOA must be ≥ 90%		

Date	Correct	Errors	Percentage
Initial:			**< 90% = needs remediation**
Remediation:			**≥ 90% = mastery achieved**

Appendix C: Functional Analysis Data Sheet

***Target Behavior:** The grinding of the participants upper and lower teeth with enough force to create an audible sound.

Date: ________________

Functional Analysis

Staff Initials: _____________ Time: ______________

Condition
I
A
D
P

Time	___:15			___:30			___:45			___:00		
0:00-1:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
3:00-4:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
4:00-5:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -

Condition
I
A
D
P

Time	___:15			___:30			___:45			___:00		
0:00-1:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
3:00-4:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
4:00-5:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -

Condition
I
A
D
P

Time	___:15			___:30			___:45			___:00		
0:00-1:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
3:00-4:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
4:00-5:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -

Condition
I
A
D
P

Time	___:15			___:30			___:45			___:00		
0:00-1:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
3:00-4:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
4:00-5:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -

Condition
I
A
D
P

Time	___:15			___:30			___:45			___:00		
0:00-1:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
3:00-4:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
4:00-5:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -

Conditions:
(I) Ignore: tx does not respond to TB
(A) Attention: tx does not interact with child, if TB occurs tx briefly attends to child (e.g., don't do that, ouch doesn't that hurt?)
(D) Demand: tx presents demand every 10 s., if not responding least to most prompt to respond, if TB occurs removes task for 20 s.
(P) Play: child gets toys, edibles, no demands, and brief interaction every 10 seconds, tx doesn't respond to TB

Appendix D: Assessment of Sensory Stimulation Data Sheet

***Target Behavior:** The grinding of the participants upper and lower teeth with enough force to create an audible sound.

Date: _______________

Assessment of Sensory Stimulations

Staff Initials: _____________ Time: ______________

Stimulation

Intervals

Time	___:15			___:30			___:45			___:00		
0:00-1:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -

Stimulation

Intervals

Time	___:15			___:30			___:45			___:00		
0:00-1:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -

Stimulation

Intervals

Time	___:15			___:30			___:45			___:00		
0:00-1:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -

Stimulation

Intervals

Time	___:15			___:30			___:45			___:00		
0:00-1:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -

Stimulation

Intervals

Time	___:15			___:30			___:45			___:00		
0:00-1:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -

Stimulation

Intervals

Time	___:15			___:30			___:45			___:00		
0:00-1:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -

Stimulation

Intervals

Time	___:15			___:30			___:45			___:00		
0:00-1:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -

Stimulation

Intervals

Time	___:15			___:30			___:45			___:00		
0:00-1:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -

Stimulation

Intervals

Time	___:15			___:30			___:45			___:00		
0:00-1:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -

Appendix E: Intervention Data Sheet

Date: _________________

***Target Behavior:** The grinding of the participants upper and lower teeth with enough force to create an audible sound.

Staff Initials: ______ Time: __________ Baseline / Matched / Unmatched (circle)

Treatment is delivered every ______ seconds for _____ seconds

Time	___:15	___:30	___:45	___:00
00:00-1:00	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -
3:00-4:00	+ -	+ -	+ -	+ -
4:00-5:00	+ -	+ -	+ -	+ -
5:00-6:00	+ -	+ -	+ -	+ -
6:00-7:00	+ -	+ -	+ -	+ -
7:00-8:00	+ -	+ -	+ -	+ -
8:00-9:00	+ -	+ -	+ -	+ -
9:00-10:00	+ -	+ -	+ -	+ -

Intervals: _____/40

Staff Initials: ______ Time: __________ Baseline / Matched / Unmatched (circle)

Treatment is delivered every ______ seconds for _____ seconds

Time	___:15	___:30	___:45	___:00
00:00-1:00	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -
3:00-4:00	+ -	+ -	+ -	+ -
4:00-5:00	+ -	+ -	+ -	+ -
5:00-6:00	+ -	+ -	+ -	+ -
6:00-7:00	+ -	+ -	+ -	+ -
7:00-8:00	+ -	+ -	+ -	+ -
8:00-9:00	+ -	+ -	+ -	+ -
9:00-10:00	+ -	+ -	+ -	+ -

Intervals: _____/40

Staff Initials: ______ Time: __________ Baseline / Matched / Unmatched (circle)

Treatment is delivered every ______ seconds for _____ seconds

Time	___:15	___:30	___:45	___:00
00:00-1:00	+ -	+ -	+ -	+ -
1:00-2:00	+ -	+ -	+ -	+ -
2:00-3:00	+ -	+ -	+ -	+ -
3:00-4:00	+ -	+ -	+ -	+ -
4:00-5:00	+ -	+ -	+ -	+ -
5:00-6:00	+ -	+ -	+ -	+ -
6:00-7:00	+ -	+ -	+ -	+ -
7:00-8:00	+ -	+ -	+ -	+ -
8:00-9:00	+ -	+ -	+ -	+ -
9:00-10:00	+ -	+ -	+ -	+ -

Intervals: _____/40