Assessment and Treatment of Vocal Stereotypy in
Children With Autism Spectrum Disorders

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CONTRIBUTION OF AUTHORS

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Several children with autism spectrum disorders engage in vocal stereotypy, which are repetitive vocalizations that persist in the absence of social consequences. Although the behavior is physically harmless, vocal stereotypy may considerably interfere with learning and social inclusion. Thus, this dissertation includes a series of four articles, which describe procedures and results to improve the assessment and treatment of vocal stereotypy in children with autism spectrum disorders. In the first article, a sequential assessment model is presented to facilitate the identification of functionally matched interventions for automatically reinforced behavior. The proposed assessment model combines a three-component multiple-schedule with a multielement design to examine the immediate and subsequent effects of interventions on stereotypy. In the second article, the sequential assessment model was used to examine the effects of noncontingent access to sound-producing toys and music on engagement in vocal stereotypy and toy manipulation. Sound-producing toys failed to reduce vocal stereotypy for each participant whereas music decreased vocal stereotypy in three of four participants and produced idiosyncratic effects on toy manipulation in two participants. The results of the study suggest that music may be more likely to reduce engagement in vocal stereotypy than sound-producing toys. In the third article, the intensity and pitch of music were manipulated to examine their effects on vocal stereotypy. The study showed that music reduced engagement in vocal stereotypy in four of five participants. Manipulating the intensity of music produced only marginal effects on engagement in vocal stereotypy whereas no differential effects were detected for pitch. The results indicate that preference
may be a more important parameter to consider than intensity and pitch. In the final article, measuring the structural characteristics of vocal stereotypy showed that the behavior was as variable as motor forms of stereotypy. Furthermore, a reanalysis of three datasets suggests that auditory stimulation may alter the temporal structure of vocal stereotypy, which may facilitate the implementation of other interventions. Finally, the original contributions of the dissertation to knowledge, the clinical implications of the results, and directions for future research are discussed.
RÉSUMÉ

Plusieurs enfants ayant un trouble du spectre de l’autisme font de la stéréotypie vocale, c’est-à-dire des vocalisations répétitives qui persistent en l’absence de conséquences sociales. Même si le comportement est physiquement inoffensif, la stéréotypie vocale peut considérablement interférer avec les apprentissages et l’inclusion sociale. Donc, cette thèse inclut une série de quatre articles qui décrivent des procédures et résultats pour améliorer l’évaluation et le traitement de la stéréotypie vocale chez les enfants ayant un trouble du spectre de l’autisme.

Dans le premier article, un modèle séquentiel d’évaluation est présenté pour faciliter l’identification d’interventions fonctionnelles équivalentes pour des comportements maintenus par du renforcement automatique. Le modèle d’évaluation proposé combine un programme de renforcement multiple à trois composantes avec un devis par alternance de traitement pour examiner les effets immédiats et subséquents d’interventions sur la stéréotypie. Dans le second article, le modèle séquentiel est utilisé pour examiner les effets de l’accès non-contingent à des jouets qui produisent des sons et à de la musique sur la stéréotypie vocale et la manipulation de jouets. Les jouets qui produisent des sons n’ont pas réussi à réduire la stéréotypie vocale de chacun des participants tandis que la musique a réduit la stéréotypie vocale de trois des quatre participants et a produit des effets idiosyncrétiques sur la manipulation de jouets de deux participants. Les résultats de l’étude suggèrent que la musique pourrait être plus efficace pour réduire la stéréotypie vocale que des jouets qui produisent des sons.

Dans le troisième article, l’intensité et le ton (aigüe vs. grave) de la musique ont été manipulés pour examiner leurs effets sur la stéréotypie vocale. L’étude a
montré que la musique a réduit la stéréotypie vocale de quatre des cinq participants. Manipuler l’intensité de la musique a produit des effets marginaux sur la stéréotypie vocale tandis qu’aucun effet différentiel n’a été détecté pour le ton. Les résultats indiquent que la préférence pourrait être un paramètre plus important à considérer que l’intensité et le ton. Dans le dernier article, mesurer les caractéristiques structurelles de la stéréotypie vocale a montré que le comportement est aussi variable que la stéréotypie motrice. De plus, une réanalyse de trois séries de données suggère que la stimulation auditive peut altérer la structure temporelle de la stéréotypie vocale, ce qui pourrait faciliter la mise en place d’autres interventions. Finalement, les contributions originales de la dissertation à l’avancement des connaissances, des implications cliniques des résultats et des directions pour la recherche future sont discutées.
CHAPTER I – INTRODUCTION

Vocal stereotypy is a common problem behavior in children with autism spectrum disorders and may considerably interfere with the social inclusion of individuals who emit the behavior (MacDonald et al., 2007). Researchers have shown that noncontingent access to auditory stimulation may be used to reduce engagement in vocal stereotypy (Lanovaz, Fletcher, & Rapp, 2009; Rapp, 2007), but its application is restricted by the low number and limitations of studies conducted to date. Chapter II provides an overview of these limitations as well as a review of other interventions that have been developed to reduce engagement in vocal stereotypy. The main objective of the dissertation was to extend the research on vocal stereotypy by taking into consideration some of the limitations noted in the literature review.

Chapters III, IV, V, and VI present a series of four articles on the assessment and treatment of vocal stereotypy. Each chapter was written in accordance with the thesis preparation and submission guidelines of the Graduate and Postdoctoral Studies Office. Each article was written as an independent manuscript, but bridges are provided to link them together. Given that the final article involved the same participants as the third article, I edited the chapter so that only new analyses were presented.

In Chapter III, I present an article entitled *Expanding Functional Analysis of Automatically Reinforced Behavior Using a Three-Component Multiple-Schedule*, which was published in the *European Journal of Behavior Analysis* (see Lanovaz, Rapp, & Fletcher, 2010). The purpose of the article was to describe a
sequential assessment model to identify functionally matched interventions for automatically reinforced behavior. The method proposed in the article may be used to identify interventions that will reduce both immediate and subsequent engagement in stereotypy. The sequential assessment model is used in the two following chapters to examine the effects of auditory stimulation on vocal stereotypy.

In Chapter IV, the sequential assessment model is applied in an article entitled *Effects of Auditory Stimulation on Vocal Stereotypy and Toy Manipulation*. Both continuous access to preferred toys that produce auditory stimulation and continuous access to music have been shown to reduce engagement in vocal stereotypy (e.g., Lanovaz et al., 2009), but studies have not compared which procedure was preferable in applied settings. Furthermore, researchers have not examined the collateral effects of auditory stimulation on engagement in appropriate behavior (e.g., toy play). Thus, the purpose of the second article was to (a) examine the effects of noncontingent access to sound-producing toys and music on vocal stereotypy, (b) measure the collateral effects of the intervention on toy manipulation, and (c) implement the procedures in conditions that approximate the environment in which children typically spend their free time.

In Chapter V, I manipulated different parameters of music to examine their effects on vocal stereotypy in an article entitled *Effects of Music on Vocal Stereotypy in Children With Autism*. Portions of the article are currently in press in the *Journal of Applied Behavior Analysis* (see Lanovaz, Sladeczek, & Rapp, in
press). Prior studies have shown that the effects of music on vocal stereotypy may vary considerably from one participant to another (e.g., Rapp, 2007; Lanovaz et al., 2009). To identify parameters that may alter music’s effects on vocal stereotypy, two experiments were designed to examine the effects of manipulating the intensity and pitch of music on engagement in the behavior. Specifically, the purpose of the study was to determine if manipulating either intensity or pitch would alter the effectiveness of music at reducing vocal stereotypy.

In Chapter VI, I examined the intensity, pitch, and temporal structure of vocal stereotypy and how these characteristics are altered by music in a study entitled *Vocal Stereotypy in Children With Autism: Structural Characteristics, Variability, and Effects of Auditory Stimulation*, which has been published in *Research in Autism Spectrum Disorders* (see Lanovaz & Sladeczek, 2011). To our knowledge, no study had previously examined the structural characteristics of vocal stereotypy in children with autism. The study examined how measuring the structural characteristics of vocal stereotypy may provide new avenues for assessment and intervention. Finally, Chapter VII provides a summary of the findings from the four articles, underlines the original contributions to knowledge of the dissertation, outlines practical implications of the results, and suggests directions for future research.
References


CHAPTER II – LITERATURE REVIEW

In general, vocalizations emitted by children and adults are maintained by access to or avoidance of social consequences provided by listeners. Skinner (1957) recognized that vocalizations often have a social function and coined the expression “verbal behavior” to describe behaviors that mediate the behavior of others. Although sounds or words produced by individuals are typically forms of verbal behavior, researchers have shown that some vocalizations persist despite the absence of a listener (e.g., Ahearn, Clark, MacDonald, & Chung, 2007; M. A. Cunningham, 1968; Lovaas, Varni, Koegel, & Lorsch, 1977). For example, a recent survey shows that nearly seven out of ten drivers sing or hum along a melody on the radio in their car (Pew Research Center, 2006). The vocalizations persist even though most drivers are alone in their car and thus no listeners are present to respond to the sounds emitted during the journey. Albeit not intended for a listener, humming or singing alone in one’s car is generally perceived as socially acceptable because it does not interfere with social inclusion and engagement in other tasks (e.g., driving).

In children with autism spectrum disorders, vocalizations with a nonsocial function can be problematic because the behavior may (a) occur at significantly higher rates than in typically developing children and (b) interfere considerably with learning and social inclusion (MacDonald et al., 2007). These repetitive vocalizations share defining features with stereotypy, which are repetitive and invariant movements that persist in the absence of social reinforcement (see Rapp & Vollmer, 1995). Thus, the term “vocal stereotypy” is often used to refer to
repetitive vocalizations that are maintained by nonsocial consequences. In this paper, vocal stereotypy will be used to refer to any repetitive acontextual sounds or words produced by an individual’s vocal apparatus that persist in the absence of social consequences.

In recent years, there has been a considerable increase in the amount of research conducted on the assessment and treatment of vocal stereotypy (e.g., Ahearn et al., 2007; Athens, Vollmer, Sloman, & St. Peter Pipkin, 2008; Falcomata, Roane, Hovanetz, Kettering, & Keeney, 2004; Lanovaz, Fletcher, & Rapp, 2009; Liu-Gitz & Banda, 2010; Rozenblat, Brown, Brown, Reeve, & Reeve, 2009). Vocal stereotypy can take on a wide variety of forms because the definition is based on the function of the repetitive vocalizations. Some examples of topographies of vocal stereotypy reported in the research literature include humming (e.g., Taylor, Hoch, & Weissman, 2005), producing instrument sounds (e.g., Falcomata et al., 2004), repeating previously heard words (e.g., Mancina, Tankersley, Kamp, Kravits, & Parrett, 2000), squealing, and grunting (e.g., Ahearn, Clark, Gardenier, Chung, & Dube, 2003).

Other terms such as aberrant vocalizations and echolalia have also been used to refer to repetitive vocalizations that share similar topographical characteristics with vocal stereotypy (e.g., Gunter et al., 1984; Mancina et al., 2000). The term vocal stereotypy should be preferred when the function of the repetitive vocalizations has been confirmed as nonsocial because other terms only describe the form of the behavior; thus, their utility in facilitating the identification and implementation of function-based interventions is somewhat
limited (see A. B. Cunningham & Schreibman, 2008). For example, researchers
generally agree that echolalia (e.g., immediate, delayed, mitigated) is the
acontextual repetition of previously heard sounds, words, or sentences (Fay, 1969;
Foxx, Schreck, Garito, Smith, & Weisenberger, 2004; Prizant & Duchan, 1981;
Sturmey, Seiverling, Ward-Horner, 2008). Using this definition alone, the
consequence maintaining the behavior remains unclear. Some children may emit
echolalia for social purposes (e.g., seeking attention; see Prizant & Duchant,
1981; Prizant & Rydell, 1984) whereas others may emit the behavior because it
produces its own reinforcing stimulation (vocal stereotypy). Notwithstanding their
lack of specificity, terms such as echolalia and aberrant vocalizations may still be
used when the function has not been identified, but a more specific terminology
should be employed when the function is known.

Vocal Stereotypy and Children With Autism Spectrum Disorders

The exact prevalence of vocal stereotypy in children with autism spectrum
disorders is currently unknown. Most studies on prevalence have examined
acontextual repetitive vocalizations without consideration for the function of the
behavior. In a study of autistic symptomatology, parents have reported that more
than 85% of children and adolescents with autism emitted atypical, repetitive
vocalizations or speech (Mayes & Calhoun, in press). In another recent study,
Macdonald et al. (2007) compared the duration of vocal stereotypy among 2-, 3-, and
4-year-old children with and without autism spectrum disorders. The results
indicated that children with autism spectrum disorders displayed considerably
more vocal stereotypy than typically developing children and that the duration of
vocal stereotypy in children with autism spectrum disorders was higher in 4-year-old children than in 2-year-old children. Although the previous studies did not experimentally demonstrate that the repetitive vocalizations were solely maintained by nonsocial consequences, the results suggest that vocal stereotypy is common in children with autism spectrum disorders.

Researchers have shown that high levels of vocal and motor stereotypy are generally associated with more significant adaptive and social impairments (Matson, Kiely, & Bamburg, 1997; Matson, Minshawi, Gonzalez, & Mayville, 2006; Reese, Richman, Zarcone, & Zarcone, 2003). The occurrence of stereotypy may compete with the occurrence of other appropriate behaviors (e.g., listening to instructions, completing a task, conversing with others) and decrease the number of opportunities to learn or emit new behavior (e.g., Koegel & Covert, 1972; Lang et al., 2009, 2010). Alternatively, identifying stimuli that will effectively compete with the occurrence of vocal stereotypy can be difficult, and without effective reinforcing stimuli, more appropriate vocalizations can be difficult to teach.

Regardless of the underlying mechanism responsible for the relation between stereotypy and social and adaptive impairments, assessing and treating vocal stereotypy in children with autism spectrum disorders is important to reduce stigmatization and facilitate social inclusion (Jones, Wint, & Ellis, 1990).

Given that vocal stereotypy is repetitive and maintained by nonsocial consequences, the vocalizations are assumed to produce some type of reinforcing stimulation (see Lovaas, Newsom, & Hickman, 1987). The process is referred to as automatic reinforcement in the behavioral literature because the occurrence of
the vocalization “automatically” produces reinforcement (Vollmer, 1994; Kennedy, 1994). However, the specific source of the reinforcing stimulation maintaining vocal stereotypy in individuals with autism spectrum disorders often remains unidentified. For example, a child may emit vocal stereotypy because the auditory stimulation (i.e., sounds) produced by the repetitive vocalizations is reinforcing the behavior. Then again, the vibration of the vocal cords could also be the form of stimulation that is maintaining vocal stereotypy. Several researchers have shown that sound- and music-producing stimuli decreased engagement in vocal stereotypy, which suggests that auditory stimulation is often the form of stimulation maintaining repetitive vocalizations (e.g., Aiken & Salzberg, 1984; Gunter et al., 1984; Lanovaz et al., 2009; Rapp, 2007). Nonetheless, more research must be conducted to further examine the types of sensory product that may maintain engagement in vocal stereotypy.

**Assessment of Vocal Stereotypy**

Before labeling repetitive vocalizations as vocal stereotypy, clinicians and researchers must first demonstrate that (a) acontextual repetitive sounds or words are produced by the vocal apparatus and (b) the vocalizations are maintained by automatic reinforcement. The first condition is clearly observable and does not require complex manipulations. The operational definition of vocal stereotypy should include acontextual sounds and words produced by the vocal apparatus and interobserver agreement should be measured. However, the second condition requires the implementation of a functional assessment to show that the repetitive vocalizations persist in the absence of social consequences.
Functional assessment methodology has been initially developed to identify the function of problem behavior. In recent years, the methodology has also been used to identify the function of vocalizations (e.g., Ahearn et al., 2007; Lerman et al., 2005; Taylor et al., 2005). There are three types of methods to conduct functional assessments, the informant-based assessment, the descriptive analysis, and the experimental functional analysis (Iwata & Dozier, 2008). In the informant-based assessment, a caregiver or educator completes a questionnaire, checklist, or interview to identify the function of the repetitive vocalizations. In the descriptive analysis, the child is observed in his or her natural environment and data are collected on the events correlated with the repetitive vocalizations. In the experimental functional analysis, antecedent and consequent events are systematically manipulated in order to identify causal relations.

Some studies have used informant-based assessments (e.g., Matson, Bamburg, Cherry, & Paclawskyj, 1999) and descriptive analyses (e.g., McKerchar & Thompson, 2004) to identify the function of problem behavior, but the two methods have serious limitations that restrict their use in identifying the function of repetitive vocalizations. First, researchers have shown that descriptive analyses produce a high proportion of false positives for the attention function (Hall, 2005; Lerman & Iwata, 1993; Thompson & Iwata, 2007). That is, attention is often correlated with problem behavior regardless of its function because caregivers typically provide attention (e.g., a verbal reprimand) when a problem behavior occurs. Second, informant-based assessments may erroneously identify the function of the target behavior and may also be unreliable (Hall, 2005;
In contrast, researchers have shown that the experimental functional analysis identified a function for 85% to 95% of participants (Iwata, Pace, Dorsey, et al., 1994; Vollmer, Marcus, Ringdahl, & Roane, 1995) and the methodology has been validated by decreasing behaviors with interventions that match the function identified by the assessment (affirmation of the consequence; e.g., Iwata, Pace, Cowdery, & Miltenberger, 1994; Wacker et al., 1990). Since indirect and descriptive assessments may incorrectly categorize repetitive vocalizations as being maintained by social reinforcement, experimental functional analyses should be conducted to identify the function of repetitive vocalizations. Furthermore, the high validity and the high identification percentage of the experimental functional analysis are also advantages over indirect and descriptive assessment methods.

To complete an experimental functional analysis, various conditions are alternated within multielement or reversal designs (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994; Vollmer et al., 1995). Each condition is designed to test the sensitivity of the repetitive vocalizations to given antecedents and consequences. For example, in the attention condition, a mild verbal reprimand (e.g., say “no” to the child in a neutral tone of voice) and a brief physical contact (e.g., touching the child’s shoulder) are provided contingent on the occurrence of the repetitive vocalizations. The manipulation is conducted to match the type of attention that the child may be receiving in his or her environment for emitting the
target vocalizations. Patterns that would indicate that repetitive vocalizations are automatically reinforced include (a) the highest levels of vocalizations are observed in no-interaction conditions, (b) high and variable levels of vocalizations are observed across all conditions, or (c) high levels of vocalizations are observed in conditions in which stimulation is low (Hagopian et al., 1997). The persistence of vocalizations across a series of no-interaction conditions would also be indicative of a behavior maintained by automatic reinforcement (Vollmer et al., 1995). Thus, repetitive vocalizations that display any of these patterns during a functional analysis could be labeled as vocal stereotypy.

**Treatment of Vocal Stereotypy**

A variety of antecedent-based and consequence-based procedures have been used to reduce stereotypic behaviors (see Rapp & Vollmer, 2005). Even though the treatment of vocal stereotypy presents unique challenges (e.g., inability to physically stop its occurrence), most of the interventions designed to decrease repetitive vocalizations have been originally developed to treat other forms of stereotypy. Researchers have adapted these procedures to deal with the specific challenges posed by vocal stereotypy.

**Antecedent-Based Treatments**

During antecedent-based treatments, specific events are manipulated independent of the occurrence of the target behavior. In terms of vocal stereotypy, antecedent-based procedures often involve noncontingent reinforcement, which consists of providing access to stimuli (e.g., toys) on time-based schedules or on a continuous basis (Carr et al., 2000; Leblanc, Patel, & Carr, 2000). The stimuli
presented during the intervention may be either unmatched or matched to the sensory product of vocal stereotypy (i.e., auditory stimulation). A structurally unmatched stimulus provides stimulation that does not match the putative sensory product of vocal stereotypy. For example, a teacher may provide access to a preferred stimulus that does not produce auditory stimulation (e.g., a puzzle, figurines) to decrease engagement in vocal stereotypy. In contrast, a structurally matched stimulus provides stimulation that matches the putative sensory product of vocal stereotypy. In this case, an educator may provide access to a preferred stimulus that produces auditory stimulation (e.g., sound-producing toys, music) to decrease the repetitive vocalizations. Given that noncontingent reinforcement does not require the undivided attention of a trainer, the intervention is practical to implement in environments in which staff or caregivers are unable to intervene contingent on every occurrence of the behavior.

A handful of researchers have investigated the effects of unmatched and matched stimulation on vocal stereotypy (Ahearn, Clark, DeBar, & Florentino, 2005; Lanovaz & Argumedes, 2009; Lanovaz et al., 2009; Rapp, 2007). In general, researchers have found that the effects of unmatched and matched stimuli on immediate levels of vocal stereotypy were highly idiosyncratic. That is, the structurally matched stimuli were more effective at decreasing vocal stereotypy for some individuals (e.g., Lanovaz et al., 2009) whereas the structurally unmatched stimuli were more effective for others (e.g., Ahearn et al., 2005). Providing continuous access to matched and unmatched stimuli may interfere with engagement in other behavior (e.g., completing tasks, listening to
instructions). As such, the intervention is often implemented for short periods of time interspersed with activities or tasks that the individual has to complete. Thus, some recent studies have also examined the effects of noncontingent reinforcement on subsequent engagement (i.e., when the intervention procedures are withdrawn) in vocal stereotypy. To date, researchers have found that only noncontingent access to structurally matched stimuli (e.g., music, sound-producing toys) decreased subsequent engagement in vocal stereotypy, but the results have been inconsistent across participants (Lanovaz et al., 2009; Rapp, 2007). When the intervention decreases subsequent engagement in vocal stereotypy, the auditory stimulation is said to be “functionally matched” because its effects on subsequent engagement are functionally equivalent to the stimulation produced by the behavior.

A limited number of studies have also investigated other antecedent procedures to decrease vocal stereotypy such as noncontingent physical exercise (Levinson & Reid, 1993; Prupas & Reid, 2001) and self-management procedures (Haley, Heick, & Luiselli, 2010; Mancina et al, 2000). For example, Levinson and Reid (1993) showed that vigorous exercise (i.e., 15 min of jogging) decreased subsequent engagement in vocal stereotypy for one of three participants with autism, but that prior baseline levels of stereotypy were recovered within 1.5 hr following the termination of the exercise session. In a study on self-management, Mancina et al. (2000) taught a child with autism to self-monitor her vocal stereotypy and to provide self-reinforcement for meeting a specific criterion. The procedures were successful at reducing vocal stereotypy, but required regular
prompting from the teacher. Similarly, Haley et al. (2010) have taught a child with autism to refrain from engaging in vocal stereotypy in the presence of a specific stimulus (i.e., a red card labeled quiet). The intervention reduced engagement in vocal stereotypy, but the prompting procedure (i.e., putting the card 6 inches in front the child’s face) may have functioned as a mild punisher, which questions whether the intervention was antecedent-based. Nonetheless, physical exercise and self-management are promising alternatives in the treatment of vocal stereotypy, but more research is needed before a widespread implementation in applied settings can take place.

**Consequence-Based Treatments**

During consequence-based treatments, events are manipulated contingent on the occurrence or nonoccurrence of vocal stereotypy. Consequence-based treatments can be divided into three broad intervention categories. Reinforcement-based procedures involve the delivery of a reinforcer, punishment-based procedures involve the delivery of an aversive stimulus or the withdrawal of a stimulus with known reinforcing effects, and extinction involves the termination of a response-reinforcer contingency.

Two types of interventions based on reinforcement have been used to decrease vocal stereotypy in individuals with autism spectrum disorders, response interruption and redirection (RIRD) and differential reinforcement of other behavior (DRO). Ahearn et al. (2007) used RIRD to decrease vocal stereotypy in four children with autism. Following each occurrence of vocal stereotypy, a trainer asked three social questions (e.g., how old are you?) or made three verbal
imitation requests (e.g., say “ball”) and socially reinforced the child’s correct responses. The intervention was successful at decreasing vocal stereotypy in all four children and increased appropriate vocalizations in three of them, but the treatment component responsible for the behavior change remained unclear. The social reinforcement provided for responding to the requests may have been competing with the stimulation generated by vocal stereotypy; alternatively, the interruption of vocal stereotypy with contingent demands may have functioned as a mild punisher that decreased levels of vocal stereotypy. The reinforcement contingency alone is unlikely to be responsible for the reduction in levels of vocal stereotypy because social reinforcement was already provided for appropriate responding during baseline. Therefore, the results suggest that the contingent demand may have been an essential component of treatment.

Other researchers have also shown that RIRD may reduce engagement in vocal stereotypy (Liu-Gitz & Banda, 2010) and increase engagement in spontaneous appropriate vocalizations (Miguel, Clark, Tereshko, & Ahearn, 2009). The main benefit of RIRD is that the procedures may also produce an increase in appropriate vocalizations, which may facilitate the social inclusion of children who emit the behavior. However, the intervention may require frequent prompting, which prevents its implementation in settings in which staff or caregivers are unavailable to deliver prompts contingent on every occurrence of vocal stereotypy. Furthermore, the implementation of the procedures may not be possible with individuals who are unable to imitate vocalizations or who use an alternative form of communication.
In a study on using DRO to reduce vocal stereotypy, Taylor et al. (2005) compared the effects of DRO and noncontingent reinforcement on a child with autism. The researchers showed that providing access to sound-producing toys for the absence of vocal stereotypy during 1-min periods (i.e., DRO) was more effective at decreasing engagement in vocal stereotypy than noncontingent delivery of the same toys every 1 min (i.e., independent of the occurrence of vocal stereotypy). The main advantages of DRO are that the intervention does not interfere with ongoing activities when provided on a lean schedule (e.g., 1 min) and does not require the delivery of a mild punisher contingent on vocal stereotypy. However, Rozenblat et al. (2009) have found that the duration of the intervals during which vocal stereotypy must be absent for the child to receive a reinforcer may need to be very short (e.g., 2 or 3 s) for DRO to effectively reduce vocal stereotypy in some individuals with autism, which may be challenging to implement in applied settings. Under dense schedules of stimulus delivery, researchers have suggested that matched stimulation may be more practical to implement than DRO (Lanovaz & Argumedes, 2009). Furthermore, DRO does not teach the individual an alternative communicative response (as in RIRD).

Punishment-based procedures such as verbal reprimands (Rapp, Patel, Ghezzi, O’Flaherty, & Titterington, 2009), contingent demands (Athens et al., 2008), and response cost (Falcone et al., 2004) have all been successful at reducing engagement in vocal stereotypy in individuals with autism spectrum disorders. For example, Falcone et al. (2004) have shown that withdrawing access to a preferred stimulus contingent on the occurrence of vocal stereotypy in
a young adult with autism reduced engagement in the behavior to near-zero levels when noncontingent reinforcement alone had been ineffective. Although punishment-based procedures may produce rapid reductions in vocal stereotypy when other interventions have failed to do so, the treatment may produce several side effects that are clinically undesirable. Rapp (2007) showed that verbal reprimands may decrease immediate engagement in vocal stereotypy, but also increase engagement in the behavior when the treatment is withdrawn. As hypothesized by Timberlake and Allison (1974), restricting access to vocal stereotypy may cause deprivation, which subsequently increases the reinforcing value and the occurrence of the behavior. In light of the previous results, the use of punishment to reduce vocal stereotypy should be closely monitored to ensure that the intervention is not producing a subsequent increase in the behavior.

Using punishment procedures to decrease vocal stereotypy may also lead to an increase in other forms of stereotypy (Rapp, 2005; Rapp, Vollmer, St. Peter, Dozier, & Cotnoir, 2004). Furthermore, punishment may need to be applied for every occurrence of vocal stereotypy to remain effective (see Lerman & Vorndran, 2002). Thus, punishment-based procedures are generally impractical in applied settings because caregivers and educators are often unable to punish every occurrence of the behavior. One promising approach to facilitate the implementation of punishment-based procedures in applied settings is to establish inhibitory stimulus control over stereotypic behavior by correlating a stimulus with the procedure, but the results so far have been mixed (Rapp et al., 2009).
An alternative to punishment is extinction, which usually involves the termination of reinforcement contingent on the occurrence of a behavior (see Lerman & Iwata, 1996). A single study has investigated the effects of extinction on vocal stereotypy (Aiken & Salzberg, 1984). Aiken and Salzberg (1984) provided access to white noise via headphones in order to mask the auditory stimulation generated by the vocal stereotypy of children with autism. The treatment was effective at decreasing vocal stereotypy to near-zero levels. Aiken and Salzberg attributed their results to extinction, but several methodological problems limit the conclusions that may be drawn from their data. A functional analysis was not performed prior to the implementation of treatment. Thus, the repetitive vocalizations may have been maintained by social reinforcement. Similarly to the effects of music, the white noise may have functioned as a matched stimulus rather than eliminated the sensory product maintaining vocal stereotypy. The scarcity of research on the extinction of vocal stereotypy is not unintended; current technology makes it difficult to eliminate the auditory stimulation produced by vocal stereotypy. Furthermore, the withdrawal of the apparatus that eliminates or attenuates the sensory product of vocal stereotypy would likely increase vocal stereotypy above baseline levels (Rapp, 2006, 2007).

**Some Current Limitations in Research**

Although studies on the topic have yielded several effective interventions, there are still gaps in the research literature on the assessment and treatment of vocal stereotypy. No prior study has examined the structural characteristics (e.g., intensity, pitch, inter-response time, bout duration) of vocal stereotypy, which
may provide new avenues for assessment and treatment. For example, knowing the intensity and pitch of vocal stereotypy would allow matching the properties of the auditory stimulus (e.g., music) more closely to the structural characteristics of the behavior, which may increase the abative effects of matched stimulation. Similarly, measuring the structural characteristics of vocal stereotypy may facilitate the identification of an effective intervention procedure. Given that DRO is difficult to implement on dense schedules, knowing the mean inter-response time of vocal stereotypy (i.e., the temporal structure) may allow the identification of children for whom the implementation of the intervention would be feasible and identify those for whom a less time-consuming procedure (e.g., matched stimulation) would be more practical to implement.

The lack of studies comparing different interventions directly together also limits the current scope of the research literature on vocal stereotypy. In a notable exception, Taylor et al. (2005) compared DRO and matched stimulation, but in nearly all other studies, researchers compared a single intervention against a baseline condition. Although showing that an intervention decreases a behavior compared to baseline is important, the results do not assist clinicians in selecting an intervention over another in specific circumstances. For example, whether using sound-producing toys or using music during matched stimulation is more effective at reducing vocal stereotypy remains unclear. In this case, the lack of research prevents clinicians from taking decisions based on scientific evidence.

Given the lack of comparison studies, clinicians mostly rely on trial and error to identify interventions that will effectively decrease vocal stereotypy. For
example, a clinician who designs an intervention plan to reduce engagement in vocal stereotypy in a child with autism does not know whether matched stimulation, RIRD, or DRO is more likely to reduce the behavior. Relying on the trial and error method presents several disadvantages for children who emit vocal stereotypy: (a) a longer amount of time may be spent identifying an intervention that produces desirable effects, (b) the individual may not receive the intervention that would produce the most desirable effects, and (c) the side effects of the selected intervention may be less desirable than those of another intervention which would have had the same effects on vocal stereotypy. To improve service delivery, researchers should develop an assessment model that would reduce the amount of time spent identifying functionally matched interventions for vocal stereotypy. To this end, the multiple-schedule has been adopted by researchers to identify functionally matched interventions for stereotypy, but the procedures and data analysis vary from one study to another (e.g., Lanovaz et al., 2009; Rapp, 2007; Simmons, Smith, & Kliethermes, 2003). Thus, a more systematic assessment model needs to be developed to provide clear guidelines on identifying functionally matched interventions for vocal stereotypy and other automatically reinforced behavior in applied settings.

A further limitation is that most interventions for vocal stereotypy are impractical to implement when an individual is engaging in other appropriate behaviors such as academic or vocational tasks. That is, the intervention may compete with the occurrence of other behaviors. For example, RIRD may need to be implemented over 100 times across an entire day to reduce vocal stereotypy
(Miguel et al., 2009). Similarly, matched stimulation often involves providing continuous access to toys, which undoubtedly interferes with ongoing activities. In these cases, measuring the subsequent effects of the intervention (i.e., when withdrawn) on vocal stereotypy is crucial to ensure that the procedures do not evoke subsequent engagement in the behavior (e.g., Rapp, 2007). Given that prior studies on the subsequent effects of interventions on vocal stereotypy have yielded mixed results (e.g., Lanovaz et al., 2009), more research must be conducted to examine how the withdrawal of an intervention alters engagement in the behavior.

With the exception of RIRD that has been shown to increase engagement in appropriate vocalizations (Ahearn et al., 2007; Miguel et al., 2009), studies on vocal stereotypy have mainly focused on the reduction of the behavior. It is unclear how reducing vocal stereotypy alters engagement in other appropriate behavior (e.g., toy play, academic tasks). Rapp and colleagues (Rapp, 2005; Rapp et al., 2004) have shown that reducing one form of stereotypy may produce an increase in another response-form, but the results do not indicate whether the response reallocation may shift towards appropriate behavior. To be considered effective from a clinical standpoint, interventions should not only reduce engagement in vocal stereotypy but also increase engagement in behavior that will ultimately facilitate the child’s social inclusion. Recently, researchers have started examining the effects of reducing motor forms of stereotypy on engagement in appropriate behavior (e.g., Chung & Cannella-Malone, 2010; Lang et al., 2010).
As such, similar studies should be conducted to examine the collateral effects of interventions designed to reduce engagement in vocal stereotypy.
References


BRIDGING MANUSCRIPTS

Chapter II suggests that research is limited insofar as a systematic assessment procedure must be developed to identify functionally matched interventions for vocal stereotypy in applied settings. Given that this limitation also applies to automatically reinforced behavior in general, the next chapter proposes a sequential assessment model to identify functionally matched interventions for behaviors maintained by automatic reinforcement. The methodology proposed may be applied to evaluate the effectiveness of various interventions at reducing immediate and subsequent engagement in vocal stereotypy.
CHAPTER III – ARTICLE 1

Expanding Functional Analysis of Automatically Reinforced Behavior Using a Three-Component Multiple-Schedule

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Abstract

Current functional analysis methodology provides the general label “automatic reinforcement” for behaviors that persist in the absence of social consequences. Likewise, current treatment-evaluation methods may demonstrate that a given intervention decreases automatically reinforced behavior. However, neither yields results that indicate whether an intervention contains stimulation that is functionally matched to the product of automatically reinforced behavior. We present a sequential assessment model to evaluate interventions for automatically reinforced behavior using a three-component multiple-schedule. This three-component multiple-schedule can be used to identify interventions that produce an abolishing operation for subsequent engagement in automatically reinforced behavior. We provide a step-by-step description of the procedures and data analysis, as well as a general overview of our findings to date. The potential clinical utility of the methodology and applications for future research are also discussed.

*Keywords:* automatic reinforcement, functional analysis, motivating operations, multiple-schedule, stereotypy
Expanding Functional Analysis of Automatically Reinforced Behavior

Using the Three-Component Multiple-Schedule

The results from a traditional functional analysis (e.g., Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994; Vollmer, Marcus, Ringdahl, & Roane, 1995) typically indicate whether a behavior is socially or nonsocially reinforced. Hagopian et al. (1997) suggested that at least three patterns from a functional analysis indicate that the target behavior is nonsocially or automatically reinforced. These three patterns are as follows: (a) highest levels of the behavior are observed during the no-interaction conditions and comparatively low levels during the control conditions; (b) high and variable levels of the behavior across all conditions; or (c) high levels of the behavior during conditions in which ambient stimulation is generally low. Although these criteria can help clinicians determine when a behavior is automatically reinforced, current functional assessment methodology is limited because sources of reinforcement that could potentially substitute for the sensory product of the behavior are not identified. Therefore, the reinforcing stimulation that is generated by such behavior cannot be delivered independent of the target behavior, contingent on the omission of the target behavior, or contingent on an alternative behavior (Rapp & Vollmer, 2005; Vollmer, 1994). Likewise, the consequent stimulation cannot be directly withheld.

As a result, clinicians and researchers must rely on indirect methods to infer a possible sensory function of automatically reinforced behavior. For example, some studies have utilized sensory extinction procedures to isolate specific nonsocial consequences that maintained automatically reinforced
behaviors (e.g., Kennedy & Souza, 2005; Rapp, Miltenberger, Galensky, Ellingson, & Long, 1999; Rincover, Cook, Peoples, & Packard, 1979). As a whole, procedures that are intended to separate automatically reinforced behavior from the consequent sensory stimulation can be time-consuming and complex. Moreover, even if such procedures identify a potential sensory consequence that contributes to the maintenance of the target behavior, additional procedures are typically needed to evaluate a suitable function-based intervention that includes alternative sources of reinforcement (for an example, see Kennedy & Souza, 2005). Thus, there is a need for further development of a behavior-analytic methodology to empirically identify nonsocial reinforcers for problem behavior.

One popular treatment for automatically reinforced behavior consists of providing noncontingent access to competing stimulation (Carr et al., 2000; Leblanc, Patel, & Carr, 2000; Rapp & Vollmer, 2005). Numerous studies have shown that continuous access to preferred stimulation decreases immediate levels of automatically reinforced behavior (e.g., Ahearn, Clark, DeBar, & Florentino, 2005; Piazza, Adelinis, Hanley, Goh, & Delia, 2000; Rapp, 2007; Vollmer, Marcus, & LeBlanc, 1994). However, treatments that are based on noncontingent reinforcement do not necessarily contain stimulation that is similar to the consequent event that maintains the automatically reinforced behavior. That is, even though access to or delivery of a preferred stimulus decreases immediate levels of an automatically reinforced behavior, it is typically not known whether the removal of the preferred stimulus occasions decreased or increased engagement in the automatically reinforced behavior.
Based on this problem, some recent studies have deliberately evaluated the extent to which access to preferred stimulation decreases subsequent engagement in automatically reinforced behavior (e.g., Lanovaz, Fletcher, & Rapp, 2009; Rapp, 2006, 2007; Simmons, Smith, & Kliethermes, 2003). To this end, Rapp and colleagues (i.e., Rapp, 2007; Lanovaz et al., 2009) make a distinction between two types of interventions, structurally matched and functionally matched interventions. A structurally matched intervention delivers stimuli that match the putative sensory product of the target behavior. In contrast, a functionally matched intervention should produce effects similar to those produced by prior access to the target behavior (see Rapp, 2004). That is, the removal of a “functionally matched” intervention should occasion either (a) continued reductions in the target behavior or (b) increases in the target behavior that do not exceed prior baseline levels. Ideally, a functionally matched intervention would also decrease automatically reinforced behavior when it was present. Nonetheless, because interventions with dense schedules may compete with engagement in academic programming in much the same way as engagement in automatically reinforced problem behavior, what happens to the target behavior after preferred stimuli are removed may be more important than what happens when the stimuli are present (Lanovaz et al., 2009).

In the case of automatically reinforced behavior, the response-reinforcer relation is linked in such a way that changes in the rate or duration of a target behavior are likely to be indicative of changes in the reinforcing value of engaging in automatically reinforced behavior. That is, decreases in an
individual’s engagement in an automatically reinforced behavior signify the decreased value of the sensory stimulation that is generated by the respective behavior (and vice versa). Based on the concepts described by Laraway, Snycerski, Michael, and Poling (2003), abolishing operations (AOs) decrease the reinforcing value of stimulation generated by and engagement in automatically reinforced behavior, whereas establishing operations (EOs) increase the reinforcing value of the stimulation generated by and engagement in automatically reinforced behavior. Both EOs and AOs are subsumed by the larger concept of motivating operations (MOs; Laraway et al., 2003). When evaluating the effects of an intervention on automatically reinforced behavior, the effects of MOs can be further subcategorized as either “immediate” or “subsequent.” Specifically, immediate MOs alter levels of the target behavior while an intervention is present, whereas subsequent MOs alter levels of the target behavior after the intervention has been withdrawn.

An intervention containing stimulation that is functionally dissimilar to the stimulation generated by an automatically reinforced behavior may decrease an individual’s engagement in that behavior; however, the intervention may impose deprivation for the stimulation that was generated by the automatically reinforced behavior. This deprivation may be evidenced by increased engagement in the target behavior following the removal of the intervention (see Timberlake & Allison, 1974). That is, imposing deprivation for stimulation produced by automatically reinforced behavior may produce a subsequent EO for engagement in the automatically reinforced behavior. For example, Rapp (2006, 2007) has
shown that restricting an automatically reinforced behavior produced an EO for
subsequent engagement. Similarly, Ahearn, Clark, Gardenier, Chung, and Dube
(2003) found that levels of automatically reinforced behavior were higher
following access to preferred stimuli on a VT schedule than following a period of
no access to the stimuli.

As an extension of the methodology provided by Simmons et al. (2003),
we describe the use of three consecutive components (of equal duration) within
two or more specified sequences (a given sequence is comprised of three
components) to identify functionally matched interventions for automatically
reinforced problem behavior. To ensure maximum sensitivity for detecting
changes in MOs, we recommend that evaluators use continuous duration
recording or momentary time sampling with 10-s intervals for duration events
(Meany-Daboul, Roscoe, Bourret, & Ahearn, 2007; Rapp et al., 2007; Rapp,
Colby-Dirksen, Michalski, Carroll, & Lindenberg, 2008) and continuous
frequency recording or partial-interval recording with 10-s intervals for frequency
events (Meany-Daboul et al., 2007; Rapp et al., 2008). What follows is a detailed
account of how three-component multiple-schedules can be used to identify
functionally matched interventions for automatically reinforced behavior. Toward
this end, we provide examples of the three patterns that we have encountered in
our research and clinical work.

Using Multiple-Schedules to Identify Functionally Matched Interventions

Data collected within multiple-schedules can be analyzed in at least two
ways to identify an intervention that decreases engagement in automatically
reinforced behavior. First, patterns across sequences for each component can be examined for the immediate and subsequent effects of an intervention. For example, the third component of a baseline sequence can be compared to the third component of a test sequence to determine the subsequent effects of the stimulus on the target behavior; this is referred to as a between-sequence analysis. Second, patterns within the test sequence can be examined to determine the effects of the intervention on subsequent engagement in the automatically reinforced behavior (i.e., after it is removed). For example, levels of the target behavior in the first and third components of a test sequence can be compared to examine whether the intervention decreases subsequent engagement in the target behavior. Inspection of data in this manner is referred to as a within-sequence analysis. The between-sequence analysis is conducted first because it shows stronger experimental control by comparing responding in each component of the respective sequences and is sensitive to both molecular and molar patterns of behavior. By contrast, the within-sequence is sensitive to only molecular patterns.

Figure 1 displays a sequential assessment model for the functional analysis of automatically reinforced behavior. The first step involves conducting a traditional functional analysis or a series of no-interaction conditions to identify the ‘general’ function of the behavior. If the assessment shows that the behavior persists in the absence of social consequences (e.g., Iwata & Dozier, 2008; Vollmer et al., 1995), the second step is to conduct a stimulus preference assessment (SPA) to identify a preferred stimulus that will be used as part of an intervention to reduce the target behavior. When continuous access to a preferred
stimulus is provided during the second component of the test sequence, a
duration-based SPA such as the free-operant stimulus preference assessment (e.g.,
Roane, Vollmer, Ringdahl, & Marcus, 1998) should be conducted to increase the
likelihood that the individual will interact with the stimulus during most if not all
of the component. When access to the preferred stimulus is not continuous (e.g.,
differential reinforcement of an alternative behavior, time-based delivery of
preferred edible items), a trial-based SPA such as the paired-choice stimulus
preference assessment (Fisher et al., 1992) or the multiple-stimulus without
replacement preference assessment (DeLeon & Iwata, 1996) should be conducted
because the conditions under which the stimuli are selected (i.e., several trials of
short durations) more closely approximate the conditions under which the stimuli
are delivered in the intervention. Generally, a highly preferred stimulus that
matches the putative, overt sensory product of the automatically reinforced
behavior should be provided as part of the intervention first because the stimulus
is more likely to decrease the automatically reinforced behavior (Lanovaz et al.,
2009; Piazza et al., 2000; Rapp, 2007; but see Ahearn et al., 2005).
Figure 1. Sequential assessment model for the functional analysis of automatically reinforced behavior.

The third step is to alternate a baseline sequence with a test sequence in a pairwise fashion. Each of the two sequences contains three components of equal duration (e.g., 10 min). Specifically, the stimulus identified from the preference assessment is presented only during the second component of the test sequence. The alternation of the two sequences should be conducted in a pseudo-random fashion to ensure that each sequence is conducted during a comparable number of sessions. We recommend conducting three to six sessions for each sequence to avoid false positives (i.e., chance differentiation in data paths for components.
from the respective sequences). In the baseline sequence, the three components are no-interaction (NI) conditions during which intervention is absent (i.e., no social consequences are provided for engaging in the target behavior). The baseline sequence is needed to evaluate possible changes in automatically reinforced behavior across the three components in the absence of programmed intervention. In the test sequence, the first and third components are also NI conditions, but the second component involves the intervention; in this example, the intervention is continuous or FT presentation of an empirically identified preferred stimulus.

In multiple-schedules, each component with a different intervention or schedule is signaled by a specific discriminative stimulus (e.g., Reynolds, 1961). In the assessment of functionally matched interventions, the items related to the intervention (e.g., preferred stimuli, proximity of the trainer) within the components serve as the discriminative stimuli in the intervention component, and the context (e.g., absence of preferred stimuli or trainer) serves as the discriminative stimulus in the NI components. The differences between the two types of components (i.e., presence vs. absence of intervention) should be sufficiently salient to signal the schedule.

When plotted in line graphs, the data paths from the first components of each sequence should be undifferentiated because the components are conducted in the absence of an intervention. If the first components are differentiated, additional sessions should be conducted until the components are undifferentiated. Next, between-sequence patterns should be examined for differentiation in the
data paths during the second components and the third components of the baseline and test sequences.

In terms of identifying an intervention that produces a subsequent AO for engagement in automatically reinforced behavior, we have argued that what occurs in the third component (after the intervention is removed) of the test sequence is more important than what occurs in the second component (when the intervention is present) of the test sequence. Nonetheless, assume that the intervention decreases the target behavior during the second component of the test sequence in comparison to the second component of the baseline sequence. This outcome would suggest that the intervention produced an immediate AO for automatically reinforced behavior. Given this result for the second components of the two sequences, there are three possible outcomes for the third components. First, the target behavior is lower in the test sequence than in the baseline sequence. This pattern suggests that the intervention produced an AO for subsequent engagement in automatically reinforced behavior (proceed to Step 4). Second, the target behavior is higher in the test sequence than in the baseline sequence. In combination with the results from the second components, this pattern suggests the intervention produced an EO for subsequent engagement in the automatically reinforced behavior; the clinician or researcher should conduct a new SPA (return to step 2) and repeat step 3 with a different stimulus, a different intervention, or both. Third, the data paths for the third components of the two sequences are undifferentiated. To further evaluate possible changes in MOs as a function of the intervention, a within-sequence analysis should be conducted (see
Figure 1: Step 3b). If the results of the within-sequence analysis of the test sequence reveal that the second component is typically the lowest, and that the third component is lower than the first component, this pattern would suggest that the intervention produced an AO for the target behavior. The clinician or researcher should proceed to step 4. By contrast, if the aforementioned pattern is not detectable or the third component is typically higher than the first component, which suggests that the intervention produced an EO for subsequent engagement in the target behavior, the evaluator should return to step 2.

To illustrate the process of using between- and within-sequence analyses to evaluate automatically reinforced behavior, we provided examples of different behavior patterns that have been produced when preferred stimuli were presented in the second component of a multiple-schedule. In the next two sections, we present representative data sets for three individuals who engaged in automatically reinforced problem behavior. For the remainder of this paper, we generically refer to each participant’s automatically reinforced problem behavior as the “target behavior.” Likewise, we referred to the preferred stimulus that is provided in the second component of the test sequence as the “intervention.” Specific details about the analyses that are conducted in step 3 are provided in the following two sections.

**Between-Sequence Analysis**

To examine the immediate and subsequent effects of an intervention, levels of the target behavior in each component can be compared across sequences. Figure 2 contains line graphs with the percentage of time each
individual engaged in the target behavior across the first, second, and third components of baseline and test sequences within multielement designs. Ideally, the data paths for the first components (left panels of Figure 2) should be undifferentiated to verify that each sequence contains comparable levels of the target behavior prior to introducing the intervention. Differentiated data paths during the first component would indicate that an extraneous variable systematically influenced the target behavior in one or both of the sequences or that an insufficient number of sessions have been conducted (i.e., the apparent differentiation is an example of chance).

*Figure 2.* Between-sequence analysis showing the percentage of time Nevin (three upper [from left to right] panels), Billy (three center panels), and Adam (three lower [from left to right] panels) engaged in the target behavior across the first, second, and third components of baseline and test sequences within multielement designs.
lower panels) engaged in the target behavior across the first (left [from top to bottom] panels), second (middle panels), and third (right panels) components of baseline and test sequences.

The second components (middle panels [from top to bottom] of Figure 2) show whether the intervention decreased immediate levels of the target behavior. Figure 2 shows that levels of the target behavior were always lower in the second component of the test sequence than in the second component of the baseline sequence for Nevin, Billy, and Adam, indicating that the intervention decreased immediate levels of the target behavior for each participant. However, the results from the second components alone do not indicate whether the intervention produced an AO for subsequent engagement in the target behavior. An examination of patterns during the third component is necessary to address this issue.

As previously noted, levels of the target behavior during the third component (right panels of Figure 2) may conform to one of three patterns. The third component of the test sequence may be lower than the third component of the baseline sequence. Regardless of the immediate effects of the intervention in the second component, such a pattern would indicate that the intervention produced a subsequent AO for engagement in the target behavior. For example, Nevin’s data (upper middle and upper right panels) show that levels of the target behavior were typically lower in the test sequence than in the baseline sequence during the second and the third components, suggesting that the intervention
produced an AO for immediate and subsequent engagement in the target behavior. Alternatively, as shown with Billy’s target behavior, the data paths for the third components of the baseline and test sequences (center, right panel of Figure 2) may be relatively undifferentiated. To some extent, this pattern may also be desirable because it indicates that the intervention had the same effects on the target behavior as providing access to the stimulation generated by the target behavior (i.e., removal of the intervention did not occasion increased engagement in the target behavior). However, as highlighted in Figure 1, further analysis of within-sequence patterns is warranted for Billy’s target behavior. Thus far, we have found that a majority of our data sets require a within-sequence analysis in order to identify subsequent AOs or EOs for automatically reinforced behavior (see section below on within-sequence analysis).

Finally, access to the preferred stimulus in the second component of a test sequence may increase engagement in the target behavior during the third component of the test sequence. For example, Adam’s data show that the intervention decreased the target behavior during the second component (lower, middle panel), but increased the behavior during the third component (lower, right panel); this outcome suggests that the intervention produced a subsequent EO for engagement in the target behavior. To date, this outcome has been least common with our participants; however, our treatment evaluations have been primarily limited to continuous delivery of highly preferred items. Thus, this between-sequence EO pattern may occur more frequently with interventions that have not been evaluated with the methodology.
When the differences between the third components are clear, data analysis can stop at the between-sequence level. If an intervention produces an AO for subsequent engagement in automatically reinforced behavior (as for Nevin), it should be used in a broader function-based intervention (move to step 4). By contrast, additional assessments should be conducted with different stimuli if the preferred stimulus produces an EO for subsequent engagement in the behavior (as for Adam).

**Within-Sequence Analysis**

In a manner not unlike a within-session analysis of data collected with a traditional functional analysis (Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993), a within-sequence analysis of the three components in the test sequence may be conducted to clarify the results from between-sequence analyses (as for Billy). Recall that the intervention is only presented in the second component of the test sequence. The comparison of the third component with the first component may indicate whether the intervention produces an AO or an EO for subsequent engagement in the target behavior. That is, a pattern wherein the third component was typically lower than the first component in the test sequence would indicate that the intervention produced an AO for subsequent engagement in the behavior. By contrast, a pattern wherein the third component was typically higher than the first component would indicate that the stimulus produced as an EO for subsequent engagement in the behavior.

Figure 3 (upper panel) depicts the data for Billy’s target behavior during each component within baseline and test sequences (5 sessions of each) in bar
graphs to facilitate a visual inspection of within-sequence patterns. The results for Billy’s target behavior show that the third component was lower than the first component for 4 of 5 test sequences. By contrast, the same pattern was not produced by the baseline sequence. The results of this analysis suggest that the intervention produced a subsequent AO for Billy’s engagement in the target behavior. Based on our findings to date, this is the most common outcome for empirically identified preferred items that are structurally matched to a given automatically reinforced behavior.

*Figure 3.* Within-sequence analysis showing the percentage of time Billy engaged in the target behavior across the first, second, and third components of baseline
(BL) and test sequences (upper panel). Within-sequence analysis of Billy’s target behavior with modified data for the first components of the test sequence to illustrate an EO pattern for subsequent engagement in the target behavior (lower panel).

For purposes of additional illustration, Figure 3 (lower panel) shows alternative data for Billy (we systematically decreased the actual level of the target behavior by 20% in the first component of each test sequence). Following our alteration of the data in the first component, the within-sequence analysis shows that his behavior was *higher* in the third component than in the first component for 4 of 5 test sequences, which suggests that the intervention produced an EO for subsequent engagement in the target behavior. Again, by comparison, the same pattern is not evident in the baseline sequences. Based on this hypothetical outcome, it would have been necessary to conduct a new SPA and repeat step 3 in an attempt to identify an intervention that produced both an immediate and subsequent AO for Billy’s behavior.

**Conclusions**

The proposed sequential model of functional analysis provides a potential extension of current methodology for evaluating automatically reinforced problem behavior. To date, we have utilized this methodology to evaluate the effects of interventions for approximately 20 individuals. For a majority of these participants, we identified a subsequent AO using the within-sequence analysis, which is similar to the effects produced by satiation; however, we also identified a
subsequent EO for a handful of participants via between-sequence analyses and within-sequence analysis, which is similar to the effects produced by response deprivation (Klatt & Morris, 2001; Timberlake & Allison, 1974). By using the three-component methodology, behavior analysts can implement interventions that decrease an individual’s immediate and subsequent engagement in automatically reinforced problem behavior.

On a practical level, interventions that produce both immediate and subsequent AOs for automatically reinforced behavior can be provided prior to critical training periods so that motivation to engage in automatically reinforced behavior is minimized during training. It seems reasonable to make the assumption that reducing the amount of time an individual engages in automatically reinforced behavior should increase the amount of time the individual engages in other behavior (e.g., listening to instructions, completing tasks) to contact other reinforcers (e.g., edibles, attention). Preliminary results obtained by Lang et al. (2009) suggest that interventions that decrease subsequent engagement in automatically reinforced behavior may also increase engagement in appropriate play behavior. Nonetheless, future research examining the effects of treatment on subsequent engagement in socially appropriate behavior should be conducted to provide additional support for the methodology.

The methodology described in this paper is potentially limited insofar as it is theoretically predicated on the assumption that the target behavior is maintained by automatic positive reinforcement. Although recent review papers on the assessment and treatment of automatically reinforced behavior support our
assumption (LeBlanc et al., 2000; Rapp & Vollmer, 2005), it is not clear whether this methodology will be useful for evaluating behavior that is maintained by automatic negative reinforcement. In addition, all of our data sets were collected during daily 30-min sessions that were conducted within a pre-specified 2-hour window of time. Currently, it is not known whether the same results can be obtained by conducting multiple sessions on a given day or by altering the times at which sessions are conducted across days. Therefore, additional research is needed to determine the amount of flexibility with which this methodology can be used to assess automatically reinforced behavior.

Future research on multiple-schedules should also examine the optimal component durations to determine whether the duration of the assessment can be decreased. As suggested by Simmons et al. (2003), future research should also expand the use of the methodology by assessing the effects of other treatments on subsequent engagement in problem behavior and by conducting research under a variety of conditions. For example, the three-component multiple-schedule can be used to evaluate the effects of punishment or response blocking on automatically reinforced behavior (see Rapp, 2006, 2007). The methodology could also be extended to verify the social functions of problem behavior. As an example for attention-maintained problem behavior, a trainer could provide noncontingent or contingent (as in functional communication training) attention during the second component of a three-component multiple-schedule to determine whether an AO for attention-maintained problem behavior is generated in the third component. The increased use of multiple-schedules may not only benefit individuals who
emit problem behavior by providing a thorough assessment of their behavior, it may also benefit applied behavior analysis as a science by expanding the realm of functional analysis.
References


VOCAL STEREOTYPY


BRIDGING MANUSCRIPTS

The sequential assessment model proposed in the previous chapter can be used to evaluate the effects of any intervention on vocal stereotypy. In the next chapter, I used the same model to extend research on the treatment of vocal stereotypy using noncontingent access to auditory stimulation. Specifically, the study compared two different procedures to provide noncontingent access to auditory stimulation to children with autism spectrum disorders. Furthermore, the collateral effects of the intervention were also examined to assess whether reductions in vocal stereotypy were associated with desirable changes in appropriate behavior (i.e., toy manipulation).
CHAPTER IV – ARTICLE 2

Effects of Auditory Stimulation on Vocal Stereotypy and Toy Manipulation

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Abstract

A series of three experiments was conducted to examine the effects of sound-producing toys and music on engagement in vocal stereotypy and toy manipulation in four children with autism spectrum disorders. The results of the first experiment indicated that vocal stereotypy was automatically reinforced for each participant and that noncontingent access to toys may evoke engagement in the behavior. In the second experiment, we showed that sound-producing toys were ineffective at reducing vocal stereotypy in three participants and that low engagement with the matched stimuli may interfere with the implementation of the procedures. In the third experiment, noncontingent music (a) reduced immediate engagement in vocal stereotypy for three of four participants, (b) reduced subsequent engagement in vocal stereotypy for one participant, and (c) produced idiosyncratic effects on toy manipulation for two participants. The clinical implications of the results are discussed in terms of improving the assessment and treatment of vocal stereotypy.

Keywords: autism, matched stimulation, music, noncontingent reinforcement, vocal stereotypy
Rapp and Vollmer (2005) have defined stereotypic behavior as repetitive and invariant movements that persist in the absence of social consequences. That is, engaging in stereotypy generates some type of perceptual reinforcer, which maintains the occurrence of the behavior (Lovaas, Newsom, & Hickman, 1987). Researchers have shown that stereotypy may be reduced by providing noncontingent access to stimuli that produce the same type of perceptual reinforcement as the behavior (Piazza, Adelinis, Hanley, Goh, & Delia, 2000). The treatment is generally referred to as matched stimulation and has been shown to reduce engagement in several different forms of stereotypy (e.g., Higbee, Chang, & Endicott, 2005; Rapp, 2006, 2007; Simmons, Smith, & Kliethermes, 2003).

In recent years, a growing number of studies have examined the effects of matched stimulation on engagement in vocal stereotypy (e.g., Lanovaz, Fletcher, & Rapp, 2009; Rapp, 2007). In the case of vocal stereotypy, matched stimulation generally involves continuous access to stimuli that produce auditory stimulation. For example, Lanovaz, Fletcher, and Rapp (2009) have shown that both sound-producing toys and music may decrease engagement in vocal stereotypy in children with autism. When compared to other interventions for vocal stereotypy such as differential reinforcement of other behavior (DRO; e.g., Rozenblat, Brown, Brown, Reeve, & Reeve, 2009; Taylor, Hoch, & Weissman, 2005) and response interruption and redirection (RIRD; e.g., Ahearn, Clark, MacDonald, & Chung, 2007; Miguel, Clark, Tereshko, & Ahearn, 2009), a potential advantage of
providing noncontingent matched stimulation is that the procedures do not require the undivided attention of a trainer. Thus, the intervention is well-suited for free time periods (e.g., breaks, play periods) during which the trainer may need to attend to other tasks.

Nonetheless, research on the effects of matched stimulation on vocal stereotypy is currently limited in at least four ways. First, researchers have provided noncontingent access to auditory stimulation by using two different procedures. The first procedure involves conducting a preference assessment with an array of stimuli that includes sound-producing stimuli and then providing continuous access to the most preferred sound-producing stimuli to the child (e.g., Lanovaz & Argumedes, 2009). The second procedure involves providing access to music on a continuous basis (e.g., Rapp, 2007). Although the two procedures can be used to provide access to matched stimulation, researchers have not examined whether one procedure produces more desirable changes in behavior than the other. In a notable exception, Lanovaz et al. (2009) examined the effects of sound-producing toys and music against a baseline condition. However, the comparison between the baseline and music conditions was very brief, which precluded a clear demonstration of the effects of noncontingent music on vocal stereotypy.

A second limitation of current research is the restricted number of studies examining the effects of reducing vocal stereotypy on collateral behavior. Rapp and colleagues (Rapp, 2004, 2005; Rapp, Vollmer, St. Peter, Dozier, & Cotnoir, 2004) have conducted a series of experiments showing how response restriction
may produce response reallocation towards other forms of stereotypy, but the studies did not focus on changes in appropriate behavior (e.g., toy play). In a more recent example, Lang et al. (2009, 2010) have shown that reducing engagement in toy stereotypy (e.g., spinning, tapping) by producing an abolishing operation (AO) for the behavior may increase engagement in functional play. Given that the reductions in stereotypy produced by matched stimulation are generally conceptualized in terms of motivating operations (MOs), noncontingent access to auditory simulation may produce similar effects. However, research must be conducted to confirm this hypothesis.

A third limitation of current research is that the effects of matched stimulation on subsequent engagement in vocal stereotypy have been mixed. Some studies have reported that matched stimulation decreases subsequent engagement in vocal stereotypy (e.g., Lanovaz & Argumedes, 2009; Rapp, 2007) whereas other studies have failed to detect a clear effect on subsequent engagement in the behavior (e.g., Lanovaz et al., 2009). Matched stimulation may interfere with engagement in other behavior and produce satiation when continuous access to the stimulus is provided for prolonged periods of time (Lanovaz, Rapp, & Fletcher, 2010). Therefore, the intervention is generally implemented during short periods of time interspersed by other daily activities. As such, examining the effects of matched stimulation on subsequent engagement in stereotypy is important. For example, the clinical utility of an intervention that reduces immediate engagement in stereotypy but increases engagement when it is withdrawn is limited. Similarly, an intervention that would reduce subsequent
engagement in appropriate behavior (e.g., social initiations, play) should not be continued.

Finally, previous studies have typically implemented matched stimulation in controlled environments in which access to alternative sources of stimulation was minimized (e.g., Ahearn, Clark, DeBar, & Florentino, 2005; Lanovaz et al., 2009; Piazza et al., 2000). The approach eliminated the effects of potential confounding variables (i.e., unmatched stimuli) and facilitated the demonstration of experimental control, but the conditions did not closely approximate applied settings. For example, a child who has access to a sound-producing toy (i.e., matched stimulus) in an environment in which several other toys are available simultaneously may be less likely to interact with the matched stimulus than if no other toys had been present. The lower levels of engagement with the matched stimulus may alter the effectiveness of the intervention at reducing vocal stereotypy.

The purpose of the study was to extend prior research by taking into consideration the previous limitations. First, the study aimed to examine which type of stimulus (i.e., sound-producing toys or music) would produce the most desirable changes in the behavior of children who emit vocal stereotypy. Second, the effects of matched stimulation on toy manipulation were monitored to examine whether decreases in vocal stereotypy produced by matched stimuli were correlated with increases in engagement in appropriate behavior (e.g., toy play). Third, the subsequent effects of matched stimulation on vocal stereotypy and on toy manipulation were examined. Given that matched stimulation is typically
implemented for short periods of time between activities or tasks, the intervention should reduce or at least not increase engagement in stereotypy following its implementation (see Rapp, 2006, 2007). Finally, the experimental conditions were more closely matched to the environments in which children typically spend their free time to examine the practicability of the procedures.

**General Method**

**Participants and Settings**

Four children with autism spectrum disorders who emitted vocal stereotypy participated in the study. Tim was an 11-year-old boy diagnosed with autism whose vocal stereotypy consisted of a variety of nonsense monosyllable sounds. Peter was a 10-year-old boy diagnosed with autism who emitted humming and screeching sounds. Jimmy was a 9-year-old boy diagnosed with autism whose vocal stereotypy consisted of nonsense syllables. Matt was a 10-year-old boy diagnosed with a pervasive developmental disorder not otherwise specified (PDD-NOS) who engaged mostly in humming and noises resembling vowel sounds. None of the participants engaged in vocal manding, but each participant had an alternative system of communication (i.e., pictorial or gestural). All sessions were conducted in each child’s home. We conducted no more than one session per day for two to three times per week with each participant.

**Data Collection and Reliability**

Trained undergraduate and graduate students measured the duration of vocal stereotypy and the duration of toy manipulation for each participant using laptop computers equipped with data collection programs. Vocal stereotypy was
defined as acontextual audible sounds or words produced by the vocal apparatus.

Toy manipulation was defined as any contact between the child’s hand and one of the toys. For toys that produced songs, we scored engagement until the toy stopped playing the song, which generally varied between 10 s and 30 s in duration. Interobserver agreement (IOA) was measured for at least 33% of each condition for each participant using the block-by-block method with 10-s intervals (Mudford, Taylor, & Martin, 2009). Mean IOA scores for vocal stereotypy and toy manipulation were respectively 93% (range, 87% to 100%) and 97% (range, 93% to 100%) for Tim, 90% (range, 82% to 96%) and 96% (range, 86% to 100%) for Peter, 86% (range, 82% to 91%) and 97% (range 87% to 100%) for Jimmy, and 91% (range, 88% to 94%) and 98% (range, 92% to 100%) for Matt.

Data Analysis

During the second and third experiments, we used three-component multiple-schedules combined with multielement designs to examine the effects of matched stimulation on immediate and subsequent engagement in vocal stereotypy and toy manipulation. Each session was divided into three equal-duration components. The first component represented pre-intervention levels of vocal stereotypy and was used as a comparison to examine the subsequent effects of matched stimulation. If the data from baseline and intervention sequences were differentiated during the first component, within-sequence analyses were conducted to control for the differences observed in pre-intervention levels of vocal stereotypy. The second component involved the implementation of the intervention and was designed to examine its immediate effects on vocal
stereotypy. The third component represented post-intervention levels of vocal stereotypy and was used to examine the subsequent effects of matched stimulation.

To analyze the data, we followed the sequential assessment model proposed by Lanovaz et al. (2010). First, levels of vocal stereotypy during the second component (i.e., when the intervention was implemented) of baseline and intervention sequences were compared on a line graph. If levels of vocal stereotypy were lower in the intervention sequences than in the baseline sequences, we conducted a between-sequence analysis of the third components (see below). If levels of vocal stereotypy remained undifferentiated during the second component or matched stimulation increased engagement in the behavior, we stopped the analysis (i.e., the third components were not analyzed) and concluded that the intervention did not produce desirable changes in behavior. During the between-sequence analysis of the third components, we compared post-intervention levels of vocal stereotypy across the two sequences by visually inspecting the line graph. If the paths of the intervention and baseline sequences were differentiated, the analysis stopped at the between-sequence level. If the data remained undifferentiated, we conducted a within-sequence analysis. During the within-sequence analysis, the levels of vocal stereotypy during the first component of the intervention sequence were compared to the levels observed in the third component of the intervention sequence. A pattern with lower levels of vocal stereotypy in third component than in the first component indicated that the intervention decreased subsequent engagement in the behavior whereas a pattern
with higher levels of vocal stereotypy in the third component than in the first component indicated that the intervention increased subsequent engagement.

**Experiment 1: Functional Analysis**

Before including a participant in the study, the first step was to conduct a functional analysis to ensure that the repetitive vocalizations met the defining features of stereotypy (see Rapp & Vollmer, 2005). Specifically, the repetitive vocalizations had to persist in the absence of social consequences to be considered a form of vocal stereotypy. Thus, the purpose of the first experiment was to examine the function of the repetitive vocalizations.

**Procedures**

The functional analysis consisted of a multielement design and a series of no-interaction conditions (Vollmer, Marcus, Ringdahl, & Roane, 1995). During the multielement portion, four conditions were alternated in the order in which they are described below. Sessions lasted 5 min and were separated by a 1-min break. In the no-interaction condition, the child did not have access to toys and no consequences were delivered for engagement in repetitive vocalizations. In the attention condition, the child had access to toys. An adult pretended to be engaged in other tasks (e.g., reading) and provided a verbal reprimand with a brief physical contact (e.g., saying “no” while putting one hand on the child’s shoulder) contingent on the occurrence of repetitive vocalizations), which was a common consequence provided by most of the parents in the natural environment. In the control condition, the child also had access to toys. An adult played with the child and provided positive comments every 30 s. In the demand condition, requests
were presented every 30 s by an adult. If the child did not comply with the request within 5 s, a gestural prompt was provided. If the gestural prompt did not produce responding within 5 s, the adult provided a physical prompt. Prompted and unprompted compliance with the demand resulted in brief praise from the adult. When the child engaged in repetitive vocalizations, the adult withdrew the demand and interrupted the prompting sequence.

If levels of repetitive vocalizations remained undifferentiated after at least three sessions of each type of condition or were higher in the no-interaction conditions, a series of no-interaction conditions was conducted to examine whether the behavior persisted in the absence of social consequences. When levels of vocal stereotypy were higher in the control condition than in one or more test conditions (as for Peter and Tim), we conducted a series of no-interaction conditions with and without toys to examine how the presence of toys altered levels of vocal stereotypy.

**Results and Discussion**

Figure 1 shows the percentage of time each participant engaged in vocal stereotypy during the functional analysis. The first panel shows that Tim engaged in higher levels of vocal stereotypy during the control condition ($M = 37\%$) than during the no-interaction ($M = 13\%$), attention ($M = 12\%$), and demand ($M = 19\%$) conditions. To examine the evocative effects of toys on vocal stereotypy, we conducted a series of no-interaction conditions with and without toys. The toys were the same that were already presented in the control and attention conditions. The results suggest that the presence of toys did not considerably change
engagement in vocal stereotypy ($M = 21\%$) when compared to the condition without toys ($M = 12\%$) and that the behavior persisted in the absence of social consequences. Similarly to Tim, the second panel shows that Peter engaged in vocal stereotypy more during the control condition ($M = 89\%$) than during the no-interaction ($M = 37\%$) and attention ($M = 55\%$) conditions. Levels of the behavior were also high during the demand condition ($M = 85\%$). During the pairwise comparison, levels of vocal stereotypy were higher when toys were present ($M = 34\%$) than when the toys were absent ($M = 16\%$), suggesting that the toys increased engagement in vocal stereotypy for Peter. Although stereotypy persisted in the absence of social consequences, levels were lower than during the multielement portion of the analysis.

The third panel of Figure 1 shows that levels of vocal stereotypy remained undifferentiated across the no-interaction ($M = 24\%$), control ($M = 36\%$), attention ($M = 33\%$), and demand ($M = 25\%$) conditions during the multielement portion of the functional analysis for Jimmy and that the behavior persisted across six no-interaction conditions ($M = 52\%$). The fourth panel shows that vocal stereotypy was highest in the no-interaction condition ($M = 39\%$) when compared to the control ($M = 30\%$), attention ($M = 13\%$), and demand ($M = 29\%$) conditions during the multielement design and that the behavior continued across the series of no-interaction conditions ($M = 45\%$) for Matt. Vocal stereotypy was lowest during the attention condition suggesting that the contingent verbal reprimand may have functioned as a mild punisher.
Figure 1. Percentage of time each participant engaged in vocal stereotypy during the multielement and series of no-interaction (NI) conditions portions of a functional analysis.
The results indicate that the repetitive vocalizations persisted across a series of no-interaction conditions for each participant, which suggests that the behavior was at least partly automatically reinforced. Interestingly, levels of vocal stereotypy were higher when toys were present for at least one participant. This observation is conflicting with the general notion that automatically reinforced behaviors are evoked by low levels of stimulation (e.g., Hagopian et al., 1997), but is consistent with the results of other studies which have shown the evocative properties of idiosyncratic stimuli (e.g., Friman, 2000; Rapp, 2004; Van Camp et al., 2000). The results suggest that high levels of stereotypy in the control condition may be indicative of an automatically reinforced behavior evoked by the presence of toys. In this case, conducting further analyses is important because the intervention may differ for individuals who display higher levels of stereotypy in the absence of alternative sources of stimulation than for those who display higher levels of stereotypy when alternative sources of stimulation are available.

**Experiment 2: Effects of Sound-Producing Toys on Vocal Stereotypy**

Both sound-producing toys and music may decrease immediate and subsequent engagement in vocal stereotypy (Lanovaz et al., 2009; Rapp, 2007). In addition to reducing vocal stereotypy, sound-producing toys may increase the value of the stimulation generated by engaging with other items or toys. The reinforcing stimulation (i.e., auditory) is provided on a response dependent basis (e.g., for pressing a button), which may strengthen an appropriate behavior. In contrast, music generally provides auditory stimulation on a response independent basis. Furthermore, children have control over the auditory stimulation produced
by sound-producing toys, which may more closely match the stimulation provided by vocal stereotypy (Rapp, 2008). Because we expected sound-producing toys to be more effective at reducing vocal stereotypy and to produce higher levels of toy manipulation, we examined the effects of sound-producing toys on vocal stereotypy first. If sound-producing toys reduced vocal stereotypy and increased play, the intervention could be implemented on a regular basis without the need to examine the effects of music. Alternatively, if sound-producing toys did not reduce engagement in vocal stereotypy or decreased engagement in play, a new matched stimulus (i.e., music) could be evaluated to identify an intervention that produces desirable changes in behavior.

**Experimental Design and Procedures**

During the second experiment, we first conducted a free-operant stimulus preference assessment as described by Roane, Vollmer, Ringdahl, and Marcus (1998) to identify preferred sound-producing toys. Then, the preferred sound-producing toys were provided on a noncontingent basis to examine how the matched stimuli altered engagement in vocal stereotypy. Initially, the four participants had been included in the experiment. However, Matt did not participate in the examination of the effects of sound-producing toys because he did not considerably engage with any of the sound-producing toys during the stimulus preference assessment.

**Stimulus preference assessment.** Each child participated in three to five stimulus preference assessment sessions. Six or seven toys (selection based on availability and parental reports) were assessed for each participant. Most of the
toys were sound-producing, but we also included one to three toys that did not produce sounds to ensure that given the choice, the participant would engage with the sound-producing toys. Prior to each session, a trainer prompted the child to sample each toy. Then, the child was free to engage with any of the toys for a 10-min period. No social consequences were delivered during the stimulus preference assessments. The trainer recorded the duration that the child manipulated each toy.

**Effects of sound-producing toys.** A three-component multiple-schedule was combined with a multielement design to examine the effects of the preferred sound-producing toys on engagement in vocal stereotypy. Each session consisted of a 15-min sequence with three 5-min components. Baseline sequences and matched toys sequences were alternated in a pseudo-random fashion. The first (i.e., pre-intervention) and third (i.e., post-intervention) components of both sequences were always free-operant conditions during which (a) the child had continuous access to toys that did not produce auditory stimulation (non-auditory toys) and (b) no social consequences were provided for engagement in vocal stereotypy or toy manipulation. The non-auditory toys present in the room were selected by the parents based on the child’s preference at home. The second component of the baseline sequence was identical to the first and third components. During the second component of the matched toys sequence, the child also had access to one to three preferred sound-producing toys (as identified by the stimulus preference assessment).
Results and Discussion

Figure 2 shows the percentage of time the four participants engaged with the toys during the free-operant stimulus preference assessment. The first panel shows that Tim preferred to engage with the musical phone ($M = 31\%$), the singing Elmo ($M = 23\%$), and the radio ($M = 18\%$). To increase the probability that Tim would play with at least one sound-producing toy, we provided access to the three most preferred toys in the second component of matched toys sequences. The second panel shows that Peter preferred the musical guitar ($M = 41\%$) and the musical steering wheel ($M = 37\%$) among the array of stimuli assessed. Peter had access to both preferred stimuli during the second component of matched toys sequences. The third panel shows that the only toy that Jimmy engaged with was the drum ($M = 61\%$), which was subsequently provided during the second component of matched toys sequences. The fourth panel shows that Matt did not engage consistently with any of the musical toys. His most preferred toy was a wand ($M = 61\%$), which did not produce any sounds. Even when engagement with the wand was lower (i.e., sessions 2 and 4), engagement with sound-producing toys did not increase above 50%. The results suggested that Matt was unlikely to allocate responding to the sound-producing toys for the entire duration of a session. Thus, we did not examine the effects of matched toys on his vocal stereotypy.
Figure 2. Percentage of time each participant engaged with each toy during the free-operant stimulus preference assessment.

Figure 3 shows the percentage of time that Tim, Peter, and Jimmy engaged in vocal stereotypy during the second component of baseline and matched toys sequences. The data from the first components (i.e., pre-intervention) were not
depicted on graphs, but remained undifferentiated for each participant. Given that the intervention failed to reduce immediate engagement in vocal stereotypy for each participant, the effects of the sound-producing toys on subsequent engagement in vocal stereotypy and on engagement in non-auditory toy manipulation were not analyzed. The upper panel shows that Tim engaged in higher levels of vocal stereotypy when the sound-producing toys were present ($M = 24\%$) than when the sound-producing toys were absent ($M = 13\%$), suggesting that the auditory stimulation produced by the toys evoked engagement in vocal stereotypy. During the second component of the matched toys sequences, Tim played with the sound-producing toys for more than half the time ($M = 54\%$; data not depicted). The middle panel shows that levels of vocal stereotypy were similar across the baseline ($M = 40\%$) and the matched toys ($M = 32\%$) sequences for Peter, suggesting no differential effects of sound-producing toys. Peter played with the sound-producing toys for nearly 100% of the time during the second component of the matched toys sequences. Finally, the lower panel shows that levels of vocal stereotypy remained undifferentiated during the baseline ($M = 47\%$) and matched toys ($M = 49\%$) sequences for Jimmy, also suggesting that noncontingent access to a preferred sound-producing toy did not change his levels of vocal stereotypy. Jimmy did not play with the sound-producing toy during the matched toys sequences ($M = 2\%$), which may explain why its introduction did not alter engagement in vocal stereotypy. The drum had been previously provided for another intervention, which may have produced satiation.
Figure 3. Percentage of time each participant engaged in vocal stereotypy during the second component of baseline and matched toys sequences.

The second experiment has shown that the matched toys increased vocal stereotypy for one participant (i.e., Tim) and did not reduce vocal stereotypy for the other two participants. The results are inconsistent with prior studies which have shown that sound-producing toys were effective at reducing immediate engagement in vocal stereotypy (e.g., Lanovaz & Argumedes, 2009; Lanovaz et
al., 2009). Furthermore, the stimulus preference assessment data for Matt indicate that some children who emit vocal stereotypy may not prefer sound-producing toys over unmatched stimuli. Similarly, Jimmy did not interact with the sound-producing toy during the matched toys sequences. Prior studies have shown that unmatched toys may be more preferred than matched toys (e.g., Ahearn et al. 2005; Lanovaz et al., 2009), which may account for the lack of engagement with the sound-producing toys. Nonetheless, both Tim and Peter manipulated preferred sound-producing toys during the second component of matched toys sequences and, in both cases, the toys did not reduce engagement in vocal stereotypy.

**Experiment 3: Effects of Music on Vocal Stereotypy and Toy Manipulation**

The second experiment has shown that providing access to sound-producing toys did not reduce engagement in vocal stereotypy. In their typical environment, children may allocate their responding to more preferred non-auditory toys rather than engage with matched stimuli provided by a trainer. Even when the child activates the sound-producing toys, engagement alone does not ensure that noncontingent access will reduce vocal stereotypy. In these cases, music may be an effective alternative because the participant does not need to emit a response to access the auditory stimulation. As such, the problem related to lack of engagement and competition from other stimuli is eliminated. The purpose of the third experiment was to examine the effects of music on vocal stereotypy and toy manipulation.
Experimental Design and Procedures

The four individuals were invited to participate in the third experiment. The design and procedures were identical to the second experiment except that a music sequence replaced the matched toys sequence. The first and third components of the music sequence were the same as those described for the baseline sequence. During the second component of the music sequence, each participant had access to the same non-auditory toys as during the baseline sequence. The only difference was that music played during the entire duration of the component. The selection of music was based on parental reports of child preference. The music provided during the music sequence was different from the music produced by engagement in sound-producing toys in Experiment 2.

Results and Discussion

For each participant, data from the first components and from the within-sequence analyses were only presented in graphs if the data paths were differentiated. Figure 4 shows the percentage of time Tim engaged in vocal stereotypy (two upper panels) and toy manipulation (two lower panels) during the second (closed data points) and third components (opened data points) of baseline and music sequences. For Tim, levels of vocal stereotypy remained undifferentiated across the two sequences during the first component. The first panel shows that Tim engaged in lower levels of vocal stereotypy when music was playing ($M = 2\%$) than when music was not playing ($M = 9\%$). In the third component (second panel), post-intervention levels of vocal stereotypy remained similar across baseline ($M = 10\%$) and music ($M = 12\%$) sequences. Because
patterns remained undifferentiated in the third component after the between-sequence analysis, we conducted a within-sequence analysis to compare levels of vocal stereotypy in the first and third components during music sequences (data not depicted). The analysis has shown that pre-intervention ($M = 7\%$) and post-intervention ($M = 12\%$) levels of vocal stereotypy were similar during the music sequences.

The third panel of Figure 4 shows that levels of toy manipulation were generally higher when music was playing ($M = 51\%$) when compared to baseline ($M = 24\%$). The fourth panel shows that the increase in toy manipulation observed during the second component persisted even following the withdrawal of the music ($M = 48\%$) whereas baseline levels were comparable to those observed during the second component ($M = 23\%$). In sum, music produced an AO for Tim’s immediate engagement in vocal stereotypy and establishing operations (EOs) for his immediate and subsequent engagement in toy manipulation. That is, Tim’s engagement in vocal stereotypy did not increase above baseline levels following the removal of music, but his engagement with toys continued at levels that were higher than in the baseline sequences.
Figure 4. Percentage of time Tim engaged in vocal stereotypy and toy manipulation during the second (closed data points) and third (opened data points) components of baseline and music sequences.
VOCAL STEREOTYPY

Figure 5 shows the percentage of time Peter engaged in vocal stereotypy and toy manipulation across the baseline and music sequences. For Peter, data paths were differentiated during the first component (first panel) and indicated that levels of vocal stereotypy were generally lower in the music sequences ($M = 21\%$) than in the baseline sequences ($M = 38\%$). That is, the sequences were differentiated prior to the introduction of the independent variable (i.e., music). The second panel shows that immediate levels of vocal stereotypy were also marginally lower in the music sequences ($M = 22\%$) than in the baseline sequences ($M = 35\%$). During the third component, the third panel shows that levels of vocal stereotypy were lower in the music sequences ($M = 22\%$) than in the baseline sequences ($M = 43\%$). In contrast, the within-sequence analysis (data not depicted) suggests that levels of vocal stereotypy were similar during the first ($M = 21\%$) and third ($M = 22\%$) components of the music sequences. Because the first components of the two sequences were differentiated, no conclusions can be drawn regarding the immediate effects of music on vocal stereotypy. However, the within-sequence analysis provides control over the differentiation observed during the first component and has clearly shown that music did not decrease subsequent engagement in vocal stereotypy.
Figure 5. Percentage of time Peter engaged in vocal stereotypy and toy manipulation during the first (gray data points), second (black data points), and third (opened data points) components of baseline and music sequences.
Even though the modest differentiation in the first component interfered with the analysis of the data for vocal stereotypy, differentiation was not observed in the first component of toy manipulation for Peter (data not depicted). Thus, the effects of music on toy manipulation were examined. The introduction of music in the second component (fourth panel of Figure 5) decreased engagement in toy manipulation ($M = 9\%$) below levels observed during baseline ($M = 64\%$). Post-intervention levels of toy manipulation (fifth panel) remained lower in the music sequences ($M = 33\%$) than in the baseline sequences ($M = 70\%$). Contrarily to Tim for whom noncontingent access to music produced EOs for toy manipulation, the intervention produced AOs for stimulation generated by engaging with toys for Peter.

Figure 6 shows the percentage of time Jimmy engaged in vocal stereotypy and toy manipulation in baseline and music sequences. Levels of vocal stereotypy remained undifferentiated in the first component across both sequences. Immediate engagement in vocal stereotypy (first panel) was considerably lower in the music sequences ($M = 7\%$) than in the baseline sequences ($M = 50\%$). The second panel shows that the post-intervention levels of vocal stereotypy were similar in the baseline ($M = 51\%$) and music ($M = 45\%$) sequences. The within-sequence analysis showed that levels of vocal stereotypy were also similar during the first ($M = 50\%$) and third ($M = 45\%$) components of the music sequences. The introduction of music (third panel) did not produce differential effects on toy manipulation in the second component across the two sequences ($M = 12\%$). During the first seven sessions, post-intervention levels of toy manipulation
(fourth panel) were generally higher following the withdrawal of music ($M = 29\%$) than following a sequence with no music ($M = 9\%$), but toy manipulation did not occur during the last four sessions. The results suggest that music produced an AO for Jimmy’s immediate engagement in vocal stereotypy; however, the effects of music on his toy manipulation did not persist across sessions and thus remained unclear.
Figure 6. Percentage of time Jimmy engaged in vocal stereotypy and toy manipulation during the second (closed data points) and third (opened data points) components of baseline and music sequences.
Figure 7 shows the percentage of time Matt engaged in vocal stereotypy during the baseline and music sequences. Data for toy manipulation were not presented because the behavior remained at 0% for all but one session (session 1). The upper panel shows that music decreased vocal stereotypy ($M = 23\%$) when compared to baseline ($M = 63\%$). Furthermore, the lower panel shows that vocal stereotypy remained modestly lower when music was withdrawn ($M = 58\%$) than when the previous component was a baseline condition ($M = 72\%$). Thus, music produced AOs for Matt’s immediate and subsequent engagement in vocal stereotypy.

*Figure 7. Percentage of time Matt engaged in vocal stereotypy during the second (closed data points) and third (opened data points) components of baseline and music sequences.*
Overall, the results of the third experiment suggest that music decreased immediate engagement in vocal stereotypy for three of four participants. Marginal reductions persisted following the withdrawal of music for one of the participants (i.e., Matt), which indicates that a functionally matched intervention (i.e., noncontingent access to music) was identified. In the remaining three participants, music in the second component did not increase vocal stereotypy in the third component, which is also clinically desirable. Music also produced idiosyncratic effects on immediate and subsequent engagement in toy manipulation. For example, music increased immediate and subsequent engagement in toy manipulation for Tim, but produced the converse for Peter.

The third experiment was limited insofar as we did not conduct a preference assessment for music, but prior research has suggested that parental reports of preference could be used to identify music to decrease vocal stereotypy (e.g., Lanovaz et al., 2009). Furthermore, the music that was provided noncontingently was different from the music that was generated by toy manipulation, which may have produced the differential effects. Finally, the definition of toy manipulation included any contact between a child’s hand and a toy, which may have included nonfunctional play. However, anecdotal observations suggest that the participants rarely used the non-auditory toys to engage in stereotypic behavior.

**General Discussion**

Together, the three experiments have shown that (a) toys may evoke higher levels of vocal stereotypy and (b) noncontingent access to music may alter
vocal stereotypy, engagement in toy manipulation, or both. Unexpectedly, music reduced vocal stereotypy in two participants for whom sound-producing toys either increased or did not alter engagement in the behavior. For one participant (i.e., Jimmy), the lack of engagement with the sound-producing toys during the sessions may account for the discrepancy, but the other participant (i.e., Tim) engaged with the sound-producing toys for most of his sessions. Given that the children had control over the source of auditory stimulation during noncontingent access to sound-producing toys, the matched toys sessions more closely approximated the control that the participants exerted over their vocal stereotypy (see Rapp, 2008 on conjugate reinforcement). Having to provide a response to activate the auditory stimulation may have rendered the sound-producing toys less effective at reducing vocal stereotypy than music, which was provided continuously independent of responding. Engaging in the activation response may reduce the amount of time that the child “consumed” the auditory stimulation. Albeit minimal, the toys required a response effort to produce the sounds (e.g., pressing a button, tapping hands) whereas music did not require a response. Finally, the auditory stimulation produced by the toys may have been less preferred than the auditory stimulation produced by the music, which may have led to the differential effects.

Music also altered engagement in toy manipulation for two participants. For one participant, the increase in toy manipulation was associated with a reduction in vocal stereotypy. Similarly to prior research which has shown that reducing one response-form of stereotypy may shift responding to another
response-form (e.g., Rapp et al., 2004; Rapp, 2005), reducing vocal stereotypy may have produced reallocation towards toy manipulation. However, reallocation cannot account for the decrease in toy manipulation observed in Peter. Anecdotal observations suggest that when music played, Peter stopped engaging in all activities and oriented himself towards the sound source. In this case, music evoked or elicited a response that competed with engagement in toy manipulation. Subsequent engagement in toy manipulation increased for the participant for whom music increased immediate engagement in toy manipulation and decreased for the participant for whom music decreased immediate engagement in toy manipulation. Some researchers have suggested that prior access to a behavior should abate subsequent engagement whereas lower levels should evoke subsequent engagement (Klatt & Morris, 2001; Timberlake & Allison, 1974), which was not the case for toy manipulation. The results of the current study suggest that the MO effects produced by music in the second component may have continued into the next component.

The study extends prior research in several ways. First, we examined the effects of both sound-producing toys and music on vocal stereotypy. The results clearly show that music may be an effective alternative to reduce vocal stereotypy when sound-producing toys do not produce the desired behavior changes. Second, we extended research by examining the effects of music on a collateral behavior. For some participants, music produced larger changes for engagement in toy manipulation than for engagement in vocal stereotypy, which suggests that the
intervention has strong collateral effects that should be monitored closely in future research.

Third, the intervention was implemented in conditions that more closely approximated those to which children are exposed to in applied settings. Most prior studies have implemented matched stimulation in environments with minimal sources of alternative stimulation to prevent confounding variables from interfering with the behavior (e.g., Ahearn et al., 2005; Lanovaz et al., 2009; Piazza et al., 2000), which does not necessarily reflect environments in which children typically spend their free time. We showed that non-auditory toys present in the environment may compete with engagement in sound-producing toys and thus limit the applicability of the intervention. Finally, the results of the study extend research on functionally matched interventions (e.g., Rapp, 2006, 2007; Simmons et al., 2003). That is, items that are structurally matched to an overt product of automatically reinforced behavior may not be functionally matched (Lanovaz et al., 2009). Therefore, an assessment of immediate and subsequent effects should be conducted to examine whether an intervention for vocal stereotypy is functionally matched (see Lanovaz et al., 2010).

The clinical implications of the results of the study are numerous. Taken together, the results of the second and third experiments suggest that clinicians should consider evaluating the effects of music on vocal stereotypy before evaluating the effects of sound-producing toys. For the participants in the current study, examining the effects of music first would have reduced the number of sessions required to identify an intervention that decreases the target behavior.
When a child does not engage with external stimuli without prompting, music also has the advantage of not requiring the child to be actively engaged with the stimulus. The results of the third experiment also suggest that music may increase or decrease engagement in toy manipulation. Interventions that decrease immediate and subsequent engagement in toy manipulation (as for Peter) may not be clinically desirable. On the other hand, interventions that reduce vocal stereotypy and increase engagement in toy manipulation (as for Tim) are most desirable. From a clinical standpoint, these results suggest that measuring the collateral effects of interventions on other desirable behavior may be important.

The differentiation observed prior to the introduction of the independent variable (i.e., music) for Peter indicates that differences in vocal stereotypy may be produced by uncontrolled variables outside the experimental setting. Thus, clinicians should measure pre-intervention levels of the behavior to control for the variability produced by uncontrolled variables on a day-to-day basis.

The patterns observed during Peter’s functional analysis also provide implications for assessment. When levels of the target behavior are higher in the control condition than in the test conditions (e.g., no-interaction), further analyses are warranted. Specifically, a pattern wherein the target behavior is high in the control condition, but low in the no-interaction condition, may be produced by (a) a behavior that is maintained by avoidance or escape from attention (e.g., Hagopian, Wilson, & Wilder, 2001) or (b) an automatically reinforced behavior that is evoked by the presence of leisure items. To clarify, clinicians and researchers should conduct a series of no-interaction conditions with leisure items
to determine whether the behavior persists in the absence of social consequences, which would be consistent with a nonsocial function.

At least three limitations of the study should be noted. First, we never directly compared the effects of sound-producing toys and music. Although the results suggest that only music decreased vocal stereotypy when compared to a baseline condition, a direct comparison would allow a more thorough examination of the relative effectiveness of each intervention. Furthermore, the effects of sound-producing toys were evaluated before the effects of music for each participant. The order was selected because we had initially anticipated that sound-producing toys would be more effective than music at reducing vocal stereotypy and increasing toy manipulation. As such, we would not have implemented noncontingent music if the initial treatment had been effective at reducing vocal stereotypy. Finally, the clinical applicability of the results is limited by the short session duration. Sound-producing toys and music were only provided for 5-min periods. In applied settings, interventions may be implemented for more extended periods of time, which warrants further investigation in the future.

To extend the results of our study, future research should directly compare the effects of sound-producing toys and music. Furthermore, a music preference assessment (see Horrocks & Higbee, 2008) may be conducted prior to the intervention to examine how preference alters the effect of music on engagement in vocal stereotypy. Researchers may also provide music and sound-producing toys simultaneously to examine whether the combination produces stronger
abative effects. The effects of music on other desirable collateral behavior such as task engagement and compliance should also be measured in future studies. New appropriate behavior may be prompted and reinforced to examine whether music interferes with learning (e.g., Lang et al., 2010). If music interfered with learning to a lesser extent than vocal stereotypy, noncontingent music could be played learning periods. The changes observed in toy manipulation for some of the participants in the current study indicate that continuing the examination of music on other behavior is needed to ensure that the intervention is not only reducing stereotypy but also increasing engagement in behavior that facilitate the social inclusion of children with autism.
References


In the previous chapter, noncontingent access to music reduced engagement in vocal stereotypy for three of four participants, but subsequent levels remained unchanged for three participants. Previous research has also shown that noncontingent access to music may produce idiosyncratic changes in vocal stereotypy (Lanovaz, Fletcher, & Rapp, 2009). In the next chapter, I examined parameters that may potentially explain why music sometimes fails to reduce immediate or subsequent engagement in vocal stereotypy. Manipulating the properties of music may produce changes in vocal stereotypy in the same manner as manipulating the taste of an edible item may alter its effectiveness at reducing engagement in mouthing (Piazza, Adelinis, Hanley, Goh, & Delia, 2000). Using the sequential assessment model presented in Chapter III, the intensity and pitch of music were manipulated to examine their effects on engagement in vocal stereotypy in children with autism.
CHAPTER V – ARTICLE 3

Effects of Music on Vocal Stereotypy in Children With Autism

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Abstract

Researchers have shown that noncontingent access to music may decrease immediate and subsequent engagement in vocal stereotypy, but the results vary considerably across studies and participants. The discrepant results may have been produced by methodological limitations (e.g., the low number of sessions conducted) or by variables that remained unexamined. To extend research on the effects of auditory stimulation on vocal stereotypy, we manipulated the intensity and pitch of music in a three-component multiple-schedule combined with reversal and multielement designs with five children diagnosed with autism. Noncontingent access to music decreased immediate engagement in vocal stereotypy for four participants and the effects continued across multiple brief sessions. Manipulating the intensity of music produced only marginal effects on engagement in vocal stereotypy whereas no differential effects were detected for pitch. The implications of the results and applications for future research are discussed.

Keywords: autism, intensity, matched stimulation, music, pitch, vocal stereotypy
Effects of Music on Vocal Stereotypy in Children With Autism

Vocal stereotypy is a common problem behavior that occurs in children with autism spectrum disorders (MacDonald et al., 2007). The behavior consists of repetitive vocalizations that persist in the absence of social consequences (e.g., Ahearn, Clark, MacDonald, & Chung, 2007; Lanovaz, Fletcher, & Rapp, 2009; Taylor, Hoch, & Weissman, 2005). Punishment-based procedures (e.g., Athens, Vollmer, Sloman, & St. Peter Pipkin, 2008; Falcomata, Roane, Hovanetz, Kettering, & Keeney, 2004), differential reinforcement of alternative behavior (e.g., Ahearn et al., 2007; Liu-Gitz & Banda, 2010), differential reinforcement of other behavior (DRO; e.g., Rozenblat, Brown, Brown, Reeve, & Reeve, 2009; Taylor et al., 2005), and noncontingent reinforcement (e.g., Lanovaz et al., 2009; Rapp, 2007) have all been used to decrease engagement in vocal stereotypy.

However, most current treatment procedures are time consuming and may be difficult to implement across entire days. For example, punishment procedures must be applied on a continuous schedule to maintain a target behavior at near-zero levels (Lerman & Vorndran, 2002). As such, using punishment-based procedures to decrease vocal stereotypy in a classroom with many children for one teacher is nearly impossible. To facilitate the implementation of punishment, researchers have attempted to establish inhibitory stimulus control over stereotypic behavior by correlating a stimulus with the procedure, but the results have been mixed (e.g., McKenzie, Smith, Simmons, & Soderlund, 2008; Rapp, Patel, Ghezzi, O’Flaherty, & Titterington, 2009).
Response interruption and redirection (RIRD), which involves interrupting engagement in vocal stereotypy by making three requests contingent on the occurrence of vocal stereotypy and socially reinforcing correct responses to the requests, also shares a similar drawback. Although RIRD may decrease vocal stereotypy and also increase spontaneous engagement in appropriate vocalizations (Ahearn et al., 2007), the treatment may require the undivided attention of a trainer when the target behavior has a very high frequency (Miguel, Clark, Tereshko, & Ahearn, 2009). Likewise, DRO may need to be applied on dense schedules (e.g., 3 s) to decrease vocal stereotypy to near-zero levels (Rozenblat et al., 2009), which prevents the trainer from engaging in other tasks. In addition to being difficult to implement across long periods of time, dense schedules (as in DRO and noncontingent reinforcement) may also produce satiation and reduce the value of the reinforcer being delivered.

In most applied settings, treatments for vocal stereotypy can only be implemented for short periods of time interspersed by learning or vocational tasks. In such cases, levels of vocal stereotypy after the treatment is withdrawn may be equally important to the effects of the treatment during implementation (Lanovaz et al., 2009). The withdrawal of treatment should either (a) decrease stereotypy below levels expected if the treatment had not been implemented, or (b) not increase stereotypy above previously observed levels. Clinicians should avoid treatments that increase vocal stereotypy when they are withdrawn. For example, Rapp (2006, 2007) has shown that the withdrawal of response blocking or verbal reprimands may increase stereotypy above its baseline levels. In
contrast, noncontingent access to auditory stimulation may decrease subsequent engagement in vocal stereotypy (Lanovaz & Argumedes, 2009; Rapp, 2007).

The immediate and subsequent effects of treatments are generally discussed in terms of motivating operations (MOs), which are stimulus events that alter both the value of a consequence and the occurrence of the behavior maintained by the consequence (Laraway, Snycerski, Michael, & Poling, 2003). In terms of vocal stereotypy, abolishing operations (AOs) decrease the value of the reinforcer and the occurrence of the behavior whereas establishing operations (EOs) increase the value of the reinforcer and the occurrence of the behavior. From a clinical standpoint, treatments that produce an AO for subsequent engagement in vocal stereotypy are most desirable. Research suggests that producing an AO for subsequent engagement in an automatically reinforced behavior may increase learning a new behavior (e.g., functional play; Lang et al., 2009, 2010). If a treatment reliably decreases subsequent engagement in vocal stereotypy, brief treatment sessions can be implemented prior to critical periods of time (e.g., instruction).

To examine the subsequent effects of treatment, Simmons, Smith, and Kliethermes (2003) described a methodology using a three-component multiple-schedule. The target behavior is measured during three consecutive equal-duration components. Then, post-intervention levels of the target behavior are compared to pre-intervention levels to determine if the treatment produced an AO for subsequent engagement in the target behavior. The methodology has been used by researchers to study the effects of noncontingent matched stimulation (e.g.,
Lanovaz et al., 2009), punishment (Rapp, 2007), and DRO (Lanovaz & Argumedes, 2009) on vocal stereotypy. To date, only noncontingent matched stimulation, which generally involves providing continuous access to auditory stimuli (e.g., music, sound-producing toys), has been shown to decrease subsequent engagement in vocal stereotypy but not in all participants (Lanovaz & Argumedes, 2009; Lanovaz et al., 2009; Rapp, 2007). For example, Lanovaz et al. (2009) found that music did not produce an AO for subsequent engagement in vocal stereotypy for three participants whereas Rapp (2007) found the converse for one participant. The results of prior studies are limited by the low number of sessions containing music conducted with each participant (i.e., 2 or 3). Thus, researchers need to examine whether the effects continue across a larger number of sessions.

Furthermore, auditory stimulation may sometimes fail to decrease subsequent engagement because the physical properties of the stimuli (e.g., pitch, intensity) are not optimal in decreasing vocal stereotypy. With socially reinforced behavior, researchers have shown that differing magnitudes of reinforcement during noncontingent delivery may produce different effects (Carr, Bailey, Ecott, Lucker, & Weil, 1998). Similarly, altering the magnitude (i.e., volume) of music may change its effectiveness at reducing vocal stereotypy. For example, doubling the intensity of music during the treatment of vocal stereotypy may be equivalent to doubling the amount of edible items in the treatment of mouthing. The intensity of the auditory stimulus may be directly linked to its effectiveness; thus, higher
intensities may produce stronger abative or abolishing effects than lower intensities.

Pitch, the frequency (i.e., cycles per second) of sound waves, is another property of sounds that may alter the effects of music on vocal stereotypy. That is, altering pitch may be analogous to delivering two stimuli that stimulate the same sensory modality (e.g., auditory, gustatory) but with a different quality. For example, Piazza, Adelinis, Hanley, Goh, and Delia (2000) showed that providing noncontingent access to stimuli that trigger the same sensory modalities (e.g., edibles) did not necessarily have the same effects on stereotypy. Similarly, varying the quality (e.g., pitch) of an auditory stimulus may change its effects on vocal stereotypy. Auditory stimuli, which initially failed to decrease subsequent engagement in vocal stereotypy, may become effective once the intensity or pitch has been altered.

Previous studies on the effects of music on vocal stereotypy were limited by methodological restrictions and inconsistent results. Thus, the purpose of the current study was to extend prior research by examining variables that may have produced the discrepant results. First, we conducted a larger number of music sessions to examine whether the effects continued across multiple brief sessions. Second, we replicated the Rapp (2007) and Lanovaz et al. (2009) studies to identify functionally matched stimuli for vocal stereotypy, but we did so with a larger number of participants to examine the generality of the results. Finally, physical properties of music were manipulated to verify whether altering intensity
and pitch would produce differential effects on immediate and subsequent engagement in vocal stereotypy.

**General Method**

**Participants and Settings**

Five children diagnosed with autism who displayed vocal stereotypy participated in the study. Each child was diagnosed with autism by an independent clinical multidisciplinary team using the *DSM-IV-TR* criteria (American Psychiatric Association, 2000). Amy was a 5-year-old girl and her sessions were conducted in an empty room with a two-way mirror. Michael was a 6-year-old boy and his sessions were conducted in his bedroom which included a bed, a chest of drawers, a cupboard, and a toy chest. Michael had access to toys that did not produce auditory stimulation during all of his sessions because a prior study conducted with the participant suggested that vocal stereotypy remained high and stable even when toys were present. Leo was a 6-year-old boy and his sessions were conducted in a room with a bed and a desk. Max was a 7-year-old boy and his sessions were conducted in the family’s basement. Finally, Liam was a 9-year-old boy and his sessions were conducted in his bedroom, which had two beds. Rooms were selected and organized to ensure that the participant could never be more than 3 m away from the sound source. None of the children used oral language adequately to communicate. The youngest participant received early intensive behavioral intervention services for 20 hr per week. The other participants received home support services, which involved regular visits from an
educator to provide training and support to the parents. To assess the effects of music, we conducted sessions once per day, three to five days per week.

**Dependent Measure, Data Collection, and Reliability**

Trained undergraduate and graduate research assistants videotaped all sessions and subsequently measured the duration of vocal stereotypy using computers equipped with data collection programs. Vocal stereotypy was defined as acontextual audible sounds or words that were produced by the vocal apparatus (e.g., tongue, lips, nasal cavity, vocal cords). Because the offset of vocal stereotypy was generally difficult to measure, a 2-s offset criterion was used by the observers. That is, we stopped scoring the occurrence of the behavior when the participant had not emitted vocal stereotypy for 2 consecutive seconds. A second observer measured the duration of vocal stereotypy for at least 39% of sessions for each participant. Interobserver agreement scores were calculated by dividing each session into 10-s blocks. Next, the lowest duration was divided by the highest duration and multiplied by 100 for each block. Finally, the sum of all the blocks was divided by the number of blocks. Mean interobserver agreement scores were 90% (range, 81% to 95%) for Amy, 93% (range, 88% to 96%) for Michael, 93% (range, 89% to 95%) for Leo, 90% (range, 78% to 98%) for Max, and 91% (range, 82% to 96%) for Liam.

**Functional Analysis**

Each child participated in a functional analysis to identify the function of his or her repetitive vocalizations (see Vollmer, Marcus, Ringdahl, & Roane, 1995). The conditions were alternated within a multielement design in the
following order: no-interaction, attention, control, and demand. A tangible condition was not included because none of the parents reported providing tangible items contingent on the occurrence of repetitive vocalizations. The trainer unintentionally altered the order of presentation of the conditions for Michael, but the alteration did not change the number of times each condition was presented.

Each session lasted 5 min and was followed by a 1-min break. If patterns of the repetitive vocalizations remained undifferentiated after 12 sessions, a series of 5 to 10 consecutive no-interaction conditions were conducted to examine whether the behavior persisted in the absence of social consequences.

During the no-interaction condition, the child was in a room with no preferred stimulation and no consequences were delivered for the occurrence of repetitive vocalizations. During the attention condition, an adult pretended to be engaged in a task (e.g., reading) while the child played with preferred stimuli (identified via parental reports). Contingent on the occurrence of the target behavior, the adult delivered a verbal reprimand (e.g., saying “stop doing that”, “no”) accompanied by a brief physical contact (e.g., putting her hand on the child’s shoulder), which was a common consequence provided by most of the parents contingent on repetitive vocalizations in the natural environment. During the play condition, an adult provided attention (e.g., playing with the child, enthusiastic comment) every 30 s regardless of the occurrence of the repetitive vocalizations while the child had access to preferred stimuli. No consequences were delivered contingent on the occurrence of vocal stereotypy. During the demand condition, an adult presented demands (identified during parental
interviews) every 30 s. If the child did not comply within 5 s, a gestural prompt was provided. If the child did not comply within 5 s following the gestural prompt, a physical prompt was provided. Contingent on the completion of the demand, brief praise was delivered. If repetitive vocalizations occurred at any time during the demand and prompting sequence, the demand was withdrawn and the prompting sequence interrupted.

**Data Analysis**

Data were analyzed using both between- and within-sequence analyses (see Lanovaz, Rapp, & Fletcher, 2010). First, we examined whether the stimulus (i.e., music) decreased immediate engagement in vocal stereotypy (i.e., in the second component) using between-sequence analyses. That is, data paths on the reversal graphs were visually analyzed to determine whether music decreased immediate engagement in vocal stereotypy in the second component. If the stimulus produced an immediate decrease, we analyzed the data from the third component. The analysis stopped at the second component if music did not decrease immediate engagement in vocal stereotypy.

When a decrease in vocal stereotypy was demonstrated in the second component, the between-sequence analysis was conducted on the third component (i.e., post-intervention levels of vocal stereotypy). If the between-sequence analysis showed that music decreased subsequent engagement in vocal stereotypy, we concluded that the stimulus was functionally matched. The failure to detect an effect in the third component at the between-sequence level did not necessarily indicate that the stimulus had no subsequent effects. Comparing pre- and post-
intervention levels of vocal stereotypy within each sequence may be a more sensitive measure of change (Lanovaz et al., 2009). When no differences were observed with the between-sequence analysis, pre-intervention levels of vocal stereotypy (i.e., first component) were directly compared to post-intervention levels (i.e., third component) for each intervention sequence. Patterns wherein levels of vocal stereotypy in the first component were generally higher than levels of vocal stereotypy in the third component indicated that the stimulus introduced in the second component decreased subsequent engagement in vocal stereotypy. If levels of vocal stereotypy were typically lower in the first component than in the third component, we concluded that the stimulus increased subsequent engagement in the behavior.

**Experiment 1: Effects of Manipulating the Intensity of Music on Vocal Stereotypy**

Researchers have found that magnitude of edible reinforcement may alter engagement in socially reinforced behavior (Carr et al., 1998). Whether or not the same could apply to auditory stimulation remains to be investigated. For auditory stimulation, magnitude or intensity is generally measured in decibels (dB). Decibels are a logarithmic measure of sound pressure with 0 dB being the threshold of hearing. The audibility threshold may vary according to age, sex, and sound frequency (Blandy & Lutman, 2005). Sound pressure (in dB) and perceived loudness are not equivalent. A 10-dB increase, which is an approximately threefold increase in pressure, is equal to an approximately twofold increase in perceived loudness (Rossing, Moore, & Wheeler, 2002). In the first experiment,
we examined the effects of manipulating the intensity of a song on the vocal stereotypy of three children with autism.

**Participants, Experimental Design, and Procedures**

Amy, Michael, and Leo participated in the first experiment. A reversal design was combined with a three-component multiple-schedule and a multielement design to assess the effects of manipulating the intensity of music on their vocal stereotypy. Each session lasted 15 min and was divided into three consecutive 5-min components. During the baseline phase, we conducted three to five baseline sequences. In the baseline sequence, the three 5-min components were free-operant (FO) conditions during which only the stimuli mentioned previously were present and no social consequences were provided for the occurrence of vocal stereotypy. During the treatment phase, we alternated a high-intensity (HI) sequence with a low-intensity (LI) sequence as in a multielement design for four to six sessions each. In the HI and LI sequences, the first and third components remained FO conditions identical to the baseline sequence. In the second 5-min component, the participant had noncontingent access to a song with a HI (i.e., 70 dB) during the HI sequences and noncontingent access to a song with a LI (i.e., 50 dB) during the LI sequences.

For each participant, the HI stimulus and the LI stimulus were the same; only the intensity of the stimulus was manipulated. Initially, each participant listened to the same song (excerpts of the *Carnival of Animals* by Saint-Saens) because (a) the song was novel for all participants and (b) a prior study using experimenter-selected music had been successful at decreasing vocal stereotypy.
(Lanovaz et al., 2009). However, the experimenter-selected song was ineffective at reducing immediate engagement in vocal stereotypy for Michael. Because he repeated excerpts from his favorite shows, we next used songs from these shows as HI and LI stimuli. The average intensity of the HI stimulus was 70 dB, which is approximately the intensity of a vacuum cleaner at a distance of 3 m. An average is provided because intensity continuously varies within songs. The average intensity of the LI stimulus was 50 dB, which is approximately the intensity of someone talking at a distance of 1 m. Given that the children were free to move around the room, the actual intensity of music experienced by the participants likely varied slightly within sessions. A 20-dB difference and small rooms were used to ensure that the HI stimulus was generally louder than the LI stimulus wherever the child stood within the room. Moreover, the perceived loudness increases approximately fourfold from 50 dB to 70 dB (Rossing et al., 2002).

The intensity of music was adjusted by using a Radioshack® digital sound level meter (range 50 dB to 126 dB, ± 2dB). To verify the intensity, the sound level meter was placed 1 m in front of the sound source for the first 30 s of the song. Then, the amplitude of the song was altered until the desired intensity was reached. A voice analysis program, Praat 5.0.35 (Boersma & Weenink, 2008), was used to validate the measurements made by the sound level meter. That is, the program confirmed that both stimuli had a 20-dB difference.

**Results and Discussion**

Figure 1 shows that vocal stereotypy persisted in the absence of social consequences for Amy, Michael, and Leo suggesting that the behavior was
automatically reinforced for each participant. Figures 2 and 3 depict the data for the between-sequence and within-sequence analyses of the effects of music on vocal stereotypy for each participant. To ease the visual analysis of the effects of the HI and LI stimuli in the second and third components, the data from first components (i.e., pre-intervention) were not depicted in the Figures. Furthermore, the data for stimuli that had no effect on immediate engagement in vocal stereotypy were not displayed on graphs.

Figure 1. Percentage of time Amy, Michael, and Leo engaged in vocal stereotypy during the multielement and series of no-interaction portions of a functional analysis.
Figure 2 (upper panels) shows the percentage of time Amy engaged in vocal stereotypy across baseline, HI, and LI sequences. During the second component (first panel), levels of vocal stereotypy were initially moderate ($M = 39\%$) in the baseline phase and immediately decreased when the HI ($M = 9\%$) and LI ($M = 14\%$) sequences were introduced. Mean baseline levels of vocal stereotypy doubled during the second baseline phase ($M = 78\%$) and once again decreased when the HI ($M = 6\%$) and LI ($M = 14\%$) sequences were reintroduced, suggesting that both stimuli produced AOs for immediate engagement in vocal stereotypy.

The second panel of Figure 2 shows that levels of vocal stereotypy in the third component of the first baseline phase ($M = 56\%$) were marginally higher than in the third component of the following HI ($M = 48\%$) and LI ($M = 47\%$) sequences. The return to baseline increased vocal stereotypy to higher levels than previously observed ($M = 82\%$) whereas the reintroduction of the HI ($M = 43\%$) and LI sequences ($M = 52\%$) decreased vocal stereotypy. Because there was overlap across phases and trends were unfavorable to the demonstration of experimental control, a within-sequence analysis was used to compare pre- and post-intervention levels of vocal stereotypy. To facilitate the within-sequence analyses, we depicted the first and third components of the HI sequences on the same graph and we did the same with the LI sequences. The third panel shows that levels of vocal stereotypy in the first component ($M = 58\%$) were marginally higher than in the third component ($M = 46\%$) during the HI sequences (left side), but were undifferentiated in the first ($M = 44\%$) and third ($M = 49\%$) components.
of the LI sequences (right side). The results suggest that noncontingent access to the HI stimulus may have produced a marginal AO effect on subsequent engagement in vocal stereotypy whereas the LI stimulus did not produce the same effect.

*Figure 2.* Percentage of time Amy and Michael engaged in vocal stereotypy in the second (first and fourth panels) and third (second and fifth panels) components of
baseline (BL), high-intensity (HI), and low-intensity (LI) sequences. The third and sixth panels depict the first (opened data points) and third (closed data points) components of HI (left panels) and LI (right panels) sequences.

Figure 2 (lower panels) shows the percentage of time Michael engaged in vocal stereotypy across baseline, HI, and LI sequences. Initially, we attempted to reduce his vocal stereotypy with the experimenter-selected stimuli (data not depicted). Immediate engagement in vocal stereotypy failed to decrease in the presence of the experimenter-selected HI ($M = 74\%$) and LI ($M = 74\%$) songs. Thus, only the data from the preferred HI and LI stimuli are depicted in the Figure. In the second component (fourth panel of Figure 2), levels of vocal stereotypy were high in the first baseline phase ($M = 76\%$) and immediately decreased when the preferred HI ($M = 13\%$) and LI ($M = 18\%$) songs were introduced. The withdrawal of the HI vs. LI phase increased levels of vocal stereotypy back to previous baseline levels ($M = 63\%$) and the final reintroduction of the HI ($M = 23\%$) and LI ($M = 23\%$) songs in the second component produced reductions in vocal stereotypy. The results indicate that the HI and LI stimuli produced AOs for immediate engagement in vocal stereotypy.

The fifth panel of Figure 2 shows undifferentiated responding in post-intervention levels of vocal stereotypy in the baseline ($M = 65\%$), HI ($M = 51\%$), and LI ($M = 55\%$) sequences during the first two phases. The reintroduction of baseline produced increased levels of vocal stereotypy ($M = 71\%$). The final phase shows that levels of vocal stereotypy during the HI ($M = 54\%$) and LI
sequences ($M = 44\%$) remained largely undifferentiated. The within-sequence analysis (sixth panel) shows that levels of vocal stereotypy were generally higher in the third component ($M = 52\%$) than in the first component ($M = 35\%$) of HI sequences (left panel). In contrast, levels remained similar across the first ($M = 46\%$) and third ($M = 50\%$) components in the LI sequences (right panel). The results indicate that noncontingent access to HI music produced an EO for subsequent engagement in vocal stereotypy, but that the same effect was not apparent following noncontingent access to LI music.

Figure 3 shows the percentage of time Leo engaged in vocal stereotypy across the second and third components of baseline, HI, and LI sequences. The first panel shows that vocal stereotypy remained high ($M = 65\%$) during the initial baseline phase. The introduction of the HI song initially reduced vocal stereotypy, but baseline levels were recovered within five sessions ($M = 49\%$). Contrarily, levels of vocal stereotypy generally decreased with repeated exposure to the LI song ($M = 62\%$). When the second baseline phase was introduced, levels of vocal stereotypy remained similar to the preceding phases ($M = 55\%$). During the second HI vs. LI phase, levels of vocal stereotypy were lower in the HI sequences ($M = 18\%$) than in the LI sequences ($M = 40\%$). The return to baseline produced a gradual increase in vocal stereotypy ($M = 51\%$). The final phase shows that the reintroduction of the HI ($M = 29\%$) and LI ($M = 25\%$) stimuli reduced engagement in vocal stereotypy. Experimental control was thus demonstrated across the last four phases. Altogether, the results suggest that both stimuli
produced modest AOs for immediate engagement in stereotypy, but that the HI stimulus generally produced stronger abative effects than the LI stimulus.

The second panel of Figure 3 shows that levels of vocal stereotypy during the third component were initially lower in the HI sequences ($M = 38\%$) than in the preceding ($M = 73\%$) and following ($M = 65\%$) baseline phases whereas levels of vocal stereotypy in the LI sequences ($M = 62\%$) were generally similar to baseline. Levels of vocal stereotypy during the second HI vs. LI phase became undifferentiated between the HI ($M = 40\%$) and LI ($M = 49\%$) sequences. During the following return to baseline, levels of vocal stereotypy increased compared to the previous phase ($M = 59\%$). Finally, levels of vocal stereotypy in the final phase were higher in the HI sequences ($M = 70\%$) than in the LI sequences ($M = 62\%$). Experimental control was demonstrated for the HI stimulus during the first four phases, but the effects were marginal. Thus, we conducted a within-sequence analysis for both stimuli. The third panel shows that levels of vocal stereotypy remained similar across the first ($M = 50\%$) and third ($M = 46\%$) components during the HI sequences (left panel) and the same patterns were observed during the LI sequences ($M = 52\%$ for both components), suggesting no clear effects on subsequent engagement in vocal stereotypy.
The results of the first experiment indicate that music decreased immediate engagement in vocal stereotypy for the three participants. The experimenter-selected song was effective at reducing vocal stereotypy for two participants and a preferred song that shared topographical characteristics with the child’s vocal stereotypy was necessary to decrease Michael’s behavior. Manipulating intensity produced marginal differential effects across participants. For Amy, the HI song, but not the LI song, reduced subsequent engagement in vocal stereotypy. For
Michael, the HI stimulus increased subsequent engagement in vocal stereotypy whereas the LI stimulus did not produce the same behavior change. Finally, the HI stimulus produced stronger abative effects than the LI stimulus on immediate engagement in vocal stereotypy for Leo. Although manipulating intensity produced differential effects, these differences were marginal and may not be clinically significant.

**Experiment 2: Effects of Manipulating the Pitch of Music on Vocal Stereotypy**

Pitch may also be a variable that changes the effectiveness of auditory stimuli at decreasing levels of vocal stereotypy. Pitch is generally measured in hertz (Hz), which is the number of cycles per second of a sound wave. In terms of hearing, humans can perceive pitches from 20 Hz to 20,000 Hz, but adults tend to lose the ability to hear pitches in the higher band as they grow older (Cutnell & Johnson, 1998). In music, pitches are generally organized in octaves, which are equal to the interval between the original pitch and either double or half the same pitch (Rossing et al., 2002). In the second experiment, we examined the effects of manipulating the pitch of a song on the vocal stereotypy of two children with autism.

**Participants, Experimental Design, and Procedures**

Max and Liam participated in the second experiment, which examined the effects of manipulating pitch on vocal stereotypy. The pitch of the song was altered using “Audacity” (2008), which is a free digital audio editor. Specifically, we manipulated each song so that the pitch would be either one octave higher
(high pitch [HP]) or one octave lower (low pitch [LP]) than the original song. We also examined the effects of the song with the unaltered, normal pitch for Liam.

The results for Michael in the first experiment suggested that preferred music was more likely to decrease vocal stereotypy than experimenter-selected music. Thus, a modified paired-choice preference assessment was conducted to identify a preferred song for each participant in the second experiment (see Horrocks & Higbee, 2008). Five different songs, which were selected by the parents, were evaluated for each participant. Two cardboards of different colors were placed in front of the child. The child was prompted to touch the right cardboard and one of the two songs played for 30 s. Next, the child was prompted to touch the left cardboard and the other song played. Finally, the child had 30 s to choose either cardboard. The song associated to the cardboard was then played for 30 s. During the assessment, each song was presented with each other song once. The procedure was repeated once and the side on which each song was presented was counterbalanced. To measure IOA, two observers recorded the song selected on each trial and the number of agreements was divided by the total number of trials. Interobserver agreement was 100% for each participant.

Max was only exposed to the preferred song identified by the preference assessment, but the pitch was modified (i.e., LP and HP). Because Liam had started his participation in the experiment when the complete results for Michael were still unavailable, he was exposed to both the experimenter-selected and the preferred HP and LP songs. The procedures were the same as in the first experiment. However, songs with LI and HI were replaced by songs with LP and
HP. As such, the song and its intensity remained constant, but the pitch was either one octave higher (i.e., HP) or one octave lower (i.e., LP). The preferred song with a normal pitch was also evaluated with Liam because the results suggested that the altered songs did not decrease immediate engagement in vocal stereotypy.

**Results and Discussion**

Figure 4 (first and second panels) shows the results of the functional analysis for Max and Liam. Vocal stereotypy was largely undifferentiated across conditions and persisted in the absence of social consequences for each participant, suggesting that the behavior was automatically reinforced. The third and fourth panels show the results of the stimulus preference assessment. Max’s preferred song was *Square House* by Al Corley, which he selected on all trials, whereas Liam preferred the *Mickey Mouse* song, which he selected on 75% of trials.
Figure 4. Percentage of time Max and Liam engaged in vocal stereotypy during the multielement and series of no-interaction portions of a functional analysis (first and second panels). Percentage of trials each song was selected for Max and Liam during the stimulus preference assessment (third and fourth panels).
Figure 5 shows the percentage of time Max engaged in vocal stereotypy across baseline, HP, and LP sequences. The first panel shows that following the initial baseline phase ($M = 51\%$), the introduction of the HP ($M = 9\%$) and LP ($M = 12\%$) sequences decreased immediate engagement in vocal stereotypy to near-zero levels. Next, levels of vocal stereotypy increased in the return to baseline phase ($M = 34\%$) and decreased once again when the HP ($M = 10\%$) and LP ($M = 7\%$) sequences were reintroduced. The results suggest that the HP and LP stimuli both produced AOs for immediate engagement in vocal stereotypy.

*Figure 5.* Percentage of time Max engaged in vocal stereotypy in the second (first panel) and third (second panel) components of baseline (BL), high-pitch (HP), and low-pitch (LP) sequences. The third panel depicts the first (opened data points) and third (closed data points) components of HP (left panel) and LP (right panel) sequences.
The second panel of Figure 5 shows that post-intervention levels of vocal stereotypy during the first baseline phase ($M = 56\%$) were similar to those observed during the following HP ($M = 59\%$) and LP ($M = 54\%$) sequences. During the second baseline phase, levels of vocal stereotypy were considerably lower ($M = 24\%$), but continued to overlap with levels observed in the HP ($M = 26\%$) and LP ($M = 34\%$) sequences in the last phase. The within-sequence analysis (third panel) shows that vocal stereotypy remained undifferentiated across the first and third components of HP sequences ($M = 45\%$ and $M = 43\%$, respectively) and LP sequences ($M = 39\%$ and $M = 44\%$, respectively), which indicates that the stimuli did not produce differential effects on subsequent engagement in the behavior.

Figure 6 shows that all the auditory stimuli failed to decrease immediate engagement in vocal stereotypy for Liam when compared to baseline. That is, levels of vocal stereotypy in the second component remained undifferentiated across the baseline ($M = 35\%$), experimenter-selected HP ($M = 39\%$), experimenter-selected LP ($M = 34\%$), preferred HP ($M = 28\%$), preferred LP ($M = 35\%$), and preferred normal pitch ($M = 32\%$) conditions. In general, the results of the second experiment suggest that the HP and LP stimuli decreased immediate engagement in vocal stereotypy for one participant, but did not decrease subsequent engagement in the behavior. Furthermore, manipulating pitch did not alter the effects of auditory stimulation on vocal stereotypy.
Figure 6. Percentage of time Liam engaged in vocal stereotypy in the second component of baseline (BL), high-pitch (HP), low-pitch (LP), and normal pitch (NP) sequences.

**General Discussion**

The results of the two experiments show that music produced AOs for immediate engagement in vocal stereotypy for four of five participants and that the effects continued across multiple brief sessions. Manipulating intensity produced marginal differences in engagement in vocal stereotypy for each participant whereas no differential effects were detected for the two values of pitch. Furthermore, Michael’s data suggest that preference may be a more important parameter to consider than both intensity and pitch. The novel song did not decrease Michael’s vocal stereotypy, but a song that he preferred decreased the behavior to near-zero levels. Interestingly, the novel song decreased Leo’s immediate engagement in vocal stereotypy only during the second and third HI vs. LI phases. Taken together, the results for Michael and Leo indicate that prior exposure to a song may alter its effects on vocal stereotypy. Nonetheless, the second experiment shows that preferred songs do not always reduce vocal stereotypy. Music may have failed to decrease immediate engagement in vocal stereotypy for Liam because (a) the songs were not sufficiently similar to his
behavior or (b) another sensory product of vocal stereotypy (e.g., vibration of the rib cage) was maintaining the behavior.

The study extends prior research on the effects of music on vocal stereotypy in at least two ways. First, prior studies on the immediate and subsequent effects of music had included music in a limited number of sessions. We conducted a large number of sessions with music with each participant and the effects of the stimulus did not decrease with repeated exposure for most participants. One notable exception is Michael’s vocal stereotypy for which an increasing trend is observable in the second component of the last HI vs. LI phase. Second, no prior study had examined the effects of manipulating properties of music on vocal stereotypy. Although only marginal differential effects were detected for intensity and no differential effects for pitch, the study highlights the need for more research to be conducted on parameters that may influence the effects of music on vocal stereotypy. Given the limited number of participants in the study, replications should be conducted to continue examining the effects of the two properties (i.e., intensity and pitch) on vocal stereotypy.

The increasing trend in vocal stereotypy observed for Michael during the second component of the last HI vs. LI phase (Figure 2, fourth panel) may have clinical implications. These data suggest that, from a practical standpoint, the effects of music on vocal stereotypy should be monitored regularly to detect any changes to its abative effects over time. Furthermore, the changes in vocal stereotypy observed in the third component were relatively small compared to those produced in the second component and were only measured for 5-min
periods, which may not be long enough to determine if the effect is clinically significant. Nonetheless, the dissimilar patterns observed between participants may suggest different clinical outcomes. For example, the HI stimulus led to a mean 17% increase (i.e., 51 s) in vocal stereotypy from pre- to post-intervention for Michael whereas the HI stimulus produced a mean 12% reduction (i.e., 36 s) for Amy. The nearly 30% difference between the two participants may be considerable when teaching an individual with autism a new behavior. In two recent studies, Lang et al. (2009, 2010) have shown that even small reductions in stereotypy may improve the acquisition of new behavior; but more research is clearly needed to validate their observation.

Although the experiments extend prior research on vocal stereotypy, the results of the study have some limitations. First, trends between phase changes were sometimes unfavorable for visual analysis. Unfavorable trends were inevitable because we were attempting to demonstrate experimental control simultaneously in the second and third components. For example, the baseline phase may show an increasing trend in the third component, but a decreasing trend in the second component (or vice versa). Second, only two different intensities and only songs separated by two octaves were compared. Alternatively, we could have matched the pitch and intensity of music to the pitch and intensity of vocal stereotypy. Because no prior studies had manipulated pitch and intensity to examine their effects on vocal stereotypy, we chose to select two stimuli with large differences. Finally, the intensity to which each child was exposed during the first experiment varied according to the child’s distance from the sound
source. For example, standing at 1 m of the sound source when the HI stimulus was playing produced a mean intensity of 70 dB whereas standing at 2 m of the sound source reduced the sound pressure to approximately 64 dB. As mentioned in the method section of Experiment 1, the large difference between the LI and HI stimuli (i.e., 20 dB) and the small rooms that were used to conduct the sessions ensured that the HI stimulus was generally louder than the LI stimulus wherever the child stood in the room. Anecdotally, the participants typically maintained approximately equal distances to the sound source regardless of the intensity of the stimulus.

The implementation of noncontingent music as an intervention for vocal stereotypy presents several challenges that warrant future research. First, clinicians may typically provide noncontingent access to music for periods longer than 5 min, which limits the applicability of the current results. As such, researchers should conduct a parametric analysis of session duration to examine whether the abative effects of music persist across longer sessions (see Lindberg, Iwata, Roscoe, Worsdell, & Hanley, 2003). Second, continuous access to music may be as disruptive as vocal stereotypy in classroom environments. In the future, children who emit vocal stereotypy should wear headphones to listen to music, which would extend research by ensuring a constant intensity across sessions and preventing music from distracting others. Third, the subsequent effects of music have been shown to be variable within and across participants. Researchers should continue exploring the properties of music that may produce abative effects. For
example, the effects of a wider range of intensities or matching the intensity of music to the intensity of the child’s vocal stereotypy may be examined.

Altogether, the results of the experiment replicate other studies that have used music to decrease vocal stereotypy (Lanovaz et al., 2009; Rapp, 2007). Given the variability observed in subsequent engagement in vocal stereotypy, however, clinicians are encouraged to monitor the behavior both during and after music delivery. The main advantage of noncontingent music compared to other treatments (e.g., DRO, RIRD) is that the intervention does not require the undivided attention of a trainer. However, music may interfere with engagement in other behavior. Thus, researchers should examine whether music interferes with tasks that do not require listening. For example, the study may be replicated in conditions in which a trainer provides prompts at regular intervals. If music has less of an effect on task completion than vocal stereotypy, individuals with autism may listen to music while engaging in academic or vocational activities.
References


vocalizations maintained by automatic reinforcement. *Journal of Applied Behavior Analysis, 37, 83-87.*


The results presented in the previous chapter suggest that manipulating the intensity and pitch of music did not produce large differential changes in vocal stereotypy. Furthermore, music failed to reduce engagement in vocal stereotypy for one participant. In the study, the two values of intensity and pitch were set arbitrarily without consideration for the actual intensity and pitch of the child’s vocal stereotypy. Matching the properties of the auditory stimulation more closely to the structural characteristics of vocal stereotypy may produce stronger abative effects. However, no study has yet examined and developed a method to measure the structural characteristics of vocal stereotypy (e.g., intensity, pitch). Measuring these characteristics may provide new avenues for intervention. For example, auditory stimulation (i.e., music) may be manipulated to match some of the characteristics of vocal stereotypy. Alternatively, knowledge of the structural characteristics may assist practitioners in selecting an intervention over another. If an assessment of structural characteristics shows that the temporal structure of vocal stereotypy has a long mean inter-response time (IRT), interventions that are more practical to implement with long intervals (e.g., differential reinforcement of other behavior) may be selected. In contrast, an assessment that would show that vocal stereotypy has short IRTs may suggest that matched stimulation would be more practical to implement. In the final article, the structural characteristics and variability of vocal stereotypy were measured and then three datasets from the previous chapter were reanalyzed to examine the effects of auditory stimulation on the temporal structure of the behavior.
Vocal Stereotypy in Children With Autism: Structural Characteristics, Variability, and Effects of Auditory Stimulation

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Abstract

Two experiments were conducted to examine (a) the relationship between the structural characteristics (i.e., bout duration, inter-response time [IRT], pitch, and intensity) and the overall duration of vocal stereotypy, and (b) the effects of auditory stimulation on the temporal structure of the behavior. In the first experiment, we measured the structural characteristics of vocal stereotypy in five children with autism during five 30-min free-operant sessions. The results suggest that the structure of vocal stereotypy varied considerably within and across participants. Furthermore, the overall duration of vocal stereotypy was positively correlated with bout duration and negatively correlated with IRT. In the second experiment, reversal designs were used to examine the effects of noncontingent access to auditory stimulation (i.e., music) on the temporal structure of vocal stereotypy in three participants. Noncontingent access to music produced an increase in the mean IRT of vocal stereotypy for two of the participants. The implications of the results are discussed in terms of measuring the structural characteristics of vocal stereotypy to identify matched stimuli to reduce engagement in the behavior and using music to facilitate the implementation of other interventions.

Keywords: autism, matched stimulation, music, structural characteristics, variability, vocal stereotypy
Vocal Stereotypy in Children with Autism: Structural Characteristics, Variability, and Effects of Auditory Stimulation

According to the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 2000), one defining characteristic of autism is an impairment in communication, which may consist of repetitive or stereotyped vocalizations. Repetitive vocalizations can take on many forms and functions in individuals with autism. For example, a child may repeat previously heard words because the behavior was reliably followed by caregiver attention whereas another child may repeatedly hum because the vocalizations are maintained by auditory stimulation. When repetitive vocalizations persist in the absence of social consequences, the term “vocal stereotypy” is used to refer to the behavior (e.g., Ahearn, Clark, MacDonald, & Chung, 2007; Lanovaz, Fletcher, & Rapp, 2009; Taylor, Hoch, & Weissman, 2005). Although vocal stereotypy is physically harmless, stereotypy in general has been associated with impairments in social skills and adaptive behavior (e.g., Matson, Kiely, & Bamburg, 1997; Matson, Minshawi, Gonzalez, & Mayville, 2006; Reese, Richman, Zarcone, & Zarcone, 2003) and may also interfere with learning (e.g., Koegel & Covert, 1972; Lang et al., 2009, 2010).

In the past five years, the number of studies on vocal stereotypy has considerably increased (e.g., Ahearn et al., 2007; Athens, Vollmer, Sloman, & St. Peter Pipkin, 2008; Lanovaz & Argumedes, 2009; Lanovaz et al., 2009; Liu-Gitz & Banda, 2010; MacDonald et al., 2007; Rapp, 2007; Rapp, Patel, Ghezzi, O’Flaherty, & Titterington, 2009; Rozenblat, Brown, Brown, Reeve, & Reeve,
2009; Taylor et al., 2005), but our understanding of the behavior still lags behind motor forms of stereotypy. Specifically, nearly all studies conducted on vocal stereotypy have focused on the effects of interventions to reduce the behavior. Given that vocal stereotypy may take on many forms (e.g., humming, repeating words, grunting, squealing), examining structural variability may provide more information on the defining characteristics of the behavior and suggest new avenues for assessment and intervention.

Several studies have been published, however, on the structural characteristics of motor forms of stereotypy such as body rocking and hand flapping (e.g., Berkson & Andriacchi, 2000; Crosland, Zarcone, Schroeder, Zarcone, & Fowler, 2005; Hall, Thorns, & Oliver, 2003; Lewis, MacClean, Johnson, & Baumeister, 1981; Newell, Incledon, Bodfish, & Sprague, 1999). For example, Newell et al. (1999) have shown that the kinematic variability (i.e., the variability of motion in space across time) of body rocking was lower in individuals without disabilities than in individuals with intellectual disabilities, which suggests that the absence of variability may not be a defining feature of stereotypy. In a study comparing children who displayed tics with children who emitted stereotypy, Crosland et al. (2005) used a force sensitive platform to show that stereotypy had more rhythmic qualities than tics. The results may allow the development of a technology to differentiate between stereotypy and tics, which may lead to the detection of subtle differences that predict intervention effectiveness. That is, rhythmic qualities may be used to differentiate between
stereotypy and tics and assist clinicians in selecting an intervention designed specifically for the target behavior.

A limitation of prior studies on the structural characteristics of stereotypy is that functional analyses were not conducted prior to the inclusion of participants. As such, the repetitive behaviors measured in these studies did not necessarily share the defining features of stereotypy, which includes the persistence of the behavior in the absence of social consequences (see Rapp & Vollmer, 2005). The structural characteristics may vary depending on whether the repetitive behavior is maintained by social or nonsocial reinforcement. Therefore, the function of the repetitive behavior should be measured before including a participant in a study on the structural characteristics of stereotypy.

The purpose of the current study was to extend prior research in several ways. First, a functional analysis was conducted with each participant to ensure that we excluded those who emitted repetitive vocalizations maintained by social reinforcement. Second, we specifically measured the structural characteristics of vocal stereotypy in contrast with prior studies which focused on motor forms of the behavior. Finally, the effects of auditory stimulation (i.e., music) on the structural characteristics of vocal stereotypy were examined.

**General Method**

**Participants and Settings**

Five children diagnosed with autism who displayed vocal stereotypy participated in the study (i.e., the same participants as in Chapter V). Amy was a 5-year-old girl whose vocal stereotypy consisted mainly of noises resembling
vowels and simple syllables. Michael was a 6-year-old boy whose vocal stereotypy consisted of humming and repeating excerpts from television shows. Max was a 7-year-old boy whose vocal stereotypy consisted mostly of noises resembling vowels. Leo was a 6-year-old boy whose vocal stereotypy consisted of word approximations and vowel sounds. Finally, Liam was a 9-year-old boy whose vocal stereotypy consisted mainly of humming. None of the participants used speech to communicate adequately.

The sessions were conducted in each participant’s home. During sessions, the children were free to move around and interact with the objects present in the room (e.g., chair, pillow, desk). Only Michael had access to toys that did not produce auditory stimulation because a prior analysis had shown that it did not compete with his vocal stereotypy. Sessions were typically conducted two to three times per week and at approximately the same time of day for each participant.

**Data Collection and Reliability**

The dependent measures included in both experiments were percentage of time engaged in vocal stereotypy, mean bout duration, and mean inter-response time (IRT). Vocal stereotypy was defined as acontextual audible sounds or words produced by the vocal apparatus. Due to the erratic nature of vocal stereotypy, a 2-s offset criterion was used to measure the duration of the behavior. That is, the observer stopped scoring a bout of vocal stereotypy when the participant paused for 2 s. Trained undergraduate and graduate research assistants measured the duration of vocal stereotypy on video recordings of the sessions using laptop computers equipped with a data collection program. The overall duration was
converted into a percentage of time by dividing the duration of vocal stereotypy by the duration of the session and by multiplying the total by 100. Mean bout duration was computed by the dividing the overall duration by the frequency (i.e., the number of bouts) of vocal stereotypy. To compute mean IRT, we measured the duration between the offset of each bout and the onset of the following bout and then calculated the mean for each session. A second observer measured the duration of vocal stereotypy for at least 40% of sessions for each participant. Interobserver agreement (IOA) was calculated using the block-by-block method with 10-s intervals (Mudford, Taylor, & Martin, 2009). Mean IOA scores were 86% (range, 81% to 89%) for Amy, 91% (range, 88% to 93%) for Michael, 90% (range, 83% to 98%) for Max, 93% (range, 89% to 95%) for Leo, and 90% (range, 82% to 94%) for Liam.

**Experiment 1: Functional and Structural Characteristics of Vocal Stereotypy**

To determine the structural characteristics of vocal stereotypy, observations should be conducted under conditions in which individuals are free to emit the behavior uninterrupted with minimal external stimulation. The results may provide (a) more specific defining features of the behavior, (b) a baseline as to how the structure of the behavior varies under free-operant conditions, and (c) data that may lead to the development or improvement of intervention procedures. For example, measuring the specific structural characteristics of vocal stereotypy may facilitate the identification of preferred stimuli that more closely match the structure of the behavior. Then, these matched stimuli could be provided on a noncontingent basis to reduce engagement in vocal stereotypy (see Lanovaz et al.,
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2009; Rapp, 2007). However, a functional analysis must first be conducted to
demonstrate that the repetitive vocalizations are not maintained by social sources
of reinforcement. The purpose of the first experiment was to examine the
variability of vocal stereotypy and the relationships between the structural
characteristics and the overall duration of the behavior.

Participants and Data Collection

The five children mentioned above participated in the first experiment. In
addition to measuring percentage of time, bout duration, and IRT, we also
recorded the fundamental frequency (i.e., pitch) and intensity produced by vocal
stereotypy. To measure pitch and intensity, the participants wore a subminiature
omnidirectional (i.e., sensitive to sounds from any direction) lavalier microphone
(Audio-Technica® AT899c) that measured sounds from 30 Hz to 20,000 Hz with
a 109-dB range. The microphone was connected to a body pack (i.e., a small
portable transmitter) of a VHF wireless system (Audio-Technica® ATW-251),
which sent a wireless signal to a receiver. The body pack was clipped on the
backside of the child’s pants and the microphone on the front side of the collar of
his or her shirt. The receiver was connected to an external sound card (M-Audio
Fast Track Pro®), which amplified the electrical signal. A laptop computer was
connected to the external sound card to record the sound in a .wav file format
(11,025 Hz, 16-bit mono). The recordings were analyzed using Praat 5.0.35
(Boersma & Weenink, 2008), which is a freeware developed for the analysis of
voice recordings. To calibrate the intensity measure, a Radioshack® sound level
meter (range 50 dB to 126 dB SPL, ± 2dB) was used to determine the intensity of
a pink noise prior to each session. The pink noise was also recorded on the audio file that would contain the child’s vocal stereotypy. Before the analysis of the audio file, the recording containing the pink noise and the vocal stereotypy was modified using Praat to match the intensity measured by the sound level meter.

**Procedures**

Each child had already participated in a functional analysis to identify the function of his or her repetitive vocalizations (see Chapter V). The results will not be presented here again, but showed that the repetitive vocalizations persisted in the absence of social consequences for each participant. Thus, we concluded that the repetitive vocalizations were automatically reinforced and were forms of vocal stereotypy.

We conducted five 30-min free-operant sessions with each participant. Due to an accident that occurred during the last session (i.e., the child accidentally hurt himself by attempting to jump on furniture), Leo’s data for the fifth session were incomplete and thus could not be included in the analysis. During each free-operant session, the participant was in a room with no external sources of auditory stimulation. The child was free to engage in vocal stereotypy and no consequences were delivered for engagement in the behavior. The trainer only intervened to interrupt attempts at touching the recording apparatus (e.g., microphone, body pack, camcorder).

**Results and Discussion**

Table 1 presents the mean and the variability of bout duration, IRT, pitch, and intensity of vocal stereotypy for each participant. The mean percentage of
time each participant engaged in vocal stereotypy ranged from 30.7% to 63.9% 
\((M = 50.8\%)\). Mean bout duration varied considerably across participants \((M = 8.9 
\text{s, range 4.7 s to 12.2 s})\). Furthermore, the coefficients of variability \((\text{CV})\) 
computed by dividing the standard deviation by the mean were above 0.80 for 
four of five participants suggesting that the duration of bouts was also variable 
within sessions (i.e., the standard deviation was at least 80% of the mean). The 
IRT was also variable across participants, but the range was shorter than for bout 
duration \((M = 8.2 \text{s, range 6.2 s to 10.7 s})\). Within-participant variability was also 
relatively high with the CVs of all participants being larger than 1.00.

Table 1

*Mean and Variability of Structural Properties of Vocal Stereotypy*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Overall (%)</th>
<th>Bout duration</th>
<th>IRT</th>
<th>Energy (dB)</th>
<th>Pitch (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(M / SD) (s)</td>
<td>CV</td>
<td>(M / SD) (s)</td>
<td>CV</td>
</tr>
<tr>
<td>Amy</td>
<td>48.7</td>
<td>10.0 / 11.2</td>
<td>1.11</td>
<td>10.6 / 11.2</td>
<td>1.04</td>
</tr>
<tr>
<td>Michael</td>
<td>58.2</td>
<td>10.6 / 10.9</td>
<td>0.95</td>
<td>6.9 / 11.8</td>
<td>1.68</td>
</tr>
<tr>
<td>Max</td>
<td>52.4</td>
<td>6.9 / 5.8</td>
<td>0.82</td>
<td>6.2 / 8.1</td>
<td>1.28</td>
</tr>
<tr>
<td>Leo</td>
<td>63.9</td>
<td>12.2 / 16.2</td>
<td>1.22</td>
<td>6.3 / 8.3</td>
<td>1.22</td>
</tr>
<tr>
<td>Liam</td>
<td>30.7</td>
<td>4.7 / 3.0</td>
<td>0.62</td>
<td>10.7 / 14.5</td>
<td>1.33</td>
</tr>
<tr>
<td>All</td>
<td>50.8</td>
<td>8.9 / 9.4</td>
<td>0.94</td>
<td>8.2 / 10.8</td>
<td>1.31</td>
</tr>
</tbody>
</table>

*Note.* CV = coefficient of variability; IRT = inter-response time

The intensity produced by each participant’s vocal stereotypy was at a 
mean of 87 dB (range 79 dB to 97 dB). Amy had a considerably higher intensity 
level than the other participants, which increased the overall mean. A CV was not
computed for intensity because the measure is not a ratio value (i.e., 0 dB is the threshold of hearing, but not the absolute zero of sound intensity). The pitch ($M = 343$ Hz, range 285 Hz to 396 Hz) remained within the range expected for children (Glaze, Bless, Milenkovic, & Susser, 1988). The highest mean pitch was produced by the only female participant, Amy, whereas the lowest pitch was produced by the oldest participant, Liam.

Figure 1 shows the relationship between the percentage of time engaged in vocal stereotypy and the structural characteristics of vocal stereotypy (i.e., bout duration, IRT, pitch, and intensity) for each participant. Each type of data point (e.g., square, triangle) represents a different participant and each data point a different session. In addition, the graph shows the Spearman rank correlation coefficient for each pair of variables depicted. To control for the family-wise error rate produced by computing several correlations, we only considered a $p$ value of less than .01 as being statistically significant. The Spearman rank correlations suggest that there was a statistically significant positive correlation between bout duration and percentage of time engaged in vocal stereotypy ($r_s = .76, p < .01$). A negative correlation was also significant between IRT and percentage of time engaged in vocal stereotypy ($r_s = -.79, p < .01$). Correlations were non-significant when percentage of time engaged in vocal stereotypy was compared to pitch ($r_s = .41, ns$) and intensity ($r_s = .07, ns$). Because IRT and bout duration were both correlated with percentage of time, we computed the correlation between the two variables (data not depicted). The correlation between IRT and bout duration was not statistically significant ($r_s = -.28, ns$).
Figure 1. Mean bout duration, mean inter-response time (IRT), mean pitch, and mean intensity of vocal stereotypy compared to the percentage of time each participant engaged in vocal stereotypy across 30-min free-operant sessions for Amy (opened diamonds), Michael (crosses), Max (opened circles), Leo (closed squares), and Liam (closed triangles). Spearman’s rank correlations are presented for each relationship. * $p < .01$

The results suggest that similarly to motor stereotypy, vocal stereotypy is considerably variable within and across participants. The CVs computed for bout duration of vocal stereotypy were similar to those measured for motor forms of stereotypy (see Hall et al., 2003). The intensity level was considerably high ($M = 87$ dB) when compared to study of voices. For example, Albertini et al. (2010)
found that the mean intensity produced by the voice of children of typical development was approximately 60 dB. In the current study, the microphone was positioned on the child’s collar, which is close to the child’s mouth (within 10 cm to 20 cm). As the microphone is placed closer to the sound source, the intensity measured grows exponentially. Thus, the intensity measure was probably inflated by the proximity of the microphone. Nonetheless, vocal stereotypy was generally perceived as louder than a normal speaking voice, but more research is needed to confirm this observation. The results are also consistent with voice studies, which have shown that younger children tend to have voices with higher pitches (Glaze et al., 1988). Unexpectedly, intensity was not positively correlated with percentage of time. Intensity was measured throughout the session, which included periods of silence with very low intensity. Therefore, higher durations of stereotypy were expected to produce higher mean levels of intensity. If each bout had had a constant intensity, the variable should have been highly correlated with percentage of time. In this light, the results suggest that the intensity of vocal stereotypy also varied considerably within sessions.

**Experiment 2: Effects of Music on the Structural Characteristics of Vocal Stereotypy**

The results from the first experiment showed that as overall duration of vocal stereotypy increased, the bout duration generally increased and the IRT decreased. However, bout duration and IRT did not covary, which suggests that both temporal properties may be altered differently by intervention. Furthermore, the mean IRT was very short for each participant (i.e., 11 s or less) making the
implementation of interventions for vocal stereotypy such as differential reinforcement of other behavior (DRO; e.g., Rozenblat et al., 2009) and response interruption and redirection (RIRD; Ahearn et al., 2007) challenging in applied settings. With short IRTs, both DRO and RIRD would require the undivided attention of a trainer who would have to intervene frequently.

An alternative to DRO and RIRD is using matched stimulation by providing continuous access to music to reduce vocal stereotypy. Although researchers have shown that music may decrease engagement in vocal stereotypy (Lanovaz et al., 2009; Rapp, 2007), it is not clear whether music decreases bout duration, increases IRT, or both. Knowing the effects of music on these variables is important because noncontingent auditory stimulation does not necessarily reduce vocal stereotypy to zero (e.g., Lanovaz et al., 2009). If music did not reduce stereotypy to zero but increased the IRT considerably, DRO or RIRD may become more practical to implement for longer periods of time. Therefore, the purpose of the second experiment was to examine the effects of music on bout duration and IRT.

Participants, Data Collection, and Procedures

In the second experiment, we reanalyzed the data from a prior experiment (see Chapter V) collected on Max, Leo, and Liam. The three participants were selected because their data had previously shown three different types of effects of music on vocal stereotypy: large, marginal, and no effects. Given that the purpose was to examine how the temporal structure of vocal stereotypy is altered while music is playing and that the previous study had shown minimal subsequent
effects, only data from the second component were reexamined. Furthermore, the data from only one of the two auditory stimuli were reanalyzed (i.e., the high-intensity song for Michael, and the high-pitch song for Max and Liam) because the results suggested that altering intensity and pitch did not produce large differential effects on immediate engagement in vocal stereotypy.

The procedures for measuring the percentage of time, the bout duration, and the IRT were the same as in the first experiment. We did not record pitch and intensity because the music produced by the external speakers would have interfered with measurement. As described in Chapter V, reversal designs were used to examine the effects of music on vocal stereotypy. During the initial phase, we conducted five or six baseline sessions with each participant. The procedures were the same as in the first experiment except that the sessions lasted only 5 min. During the second phase, the procedures were the same as during baseline except that music played through speakers at 70 dB during the entire duration of the session. The baseline and music phases were repeated once or twice depending on the demonstration of experimental control.

Results and Discussion

Figure 2 shows the percentage of time, the bout duration, and the IRT of vocal stereotypy for Max (upper panels) and Leo (lower panels). Data points for IRT are not depicted when no bout or a single bout occurred during the session because we needed at least two bouts to compute IRT. During the initial baseline phase for Max (upper panels), engagement in vocal stereotypy was initially high ($M = 51\%$) while bout duration ($M = 7.6$ s) and IRT ($M = 7.2$ s) remained
approximately the same. The introduction of music decreased vocal stereotypy to near-zero levels ($M = 8\%$) whereas bout duration decreased ($M = 2.7$ s) and IRT increased ($M = 24.6$ s). The return to baseline produced an increase in vocal stereotypy ($M = 34\%$), no considerable changes in bout duration ($M = 3.5$ s), and a decrease in IRT ($M = 6.2$ s). During the final phase, music decreased vocal stereotypy ($M = 10\%$) and increased IRT ($M = 21.1$ s) while bout duration ($M = 3.5$ s) remained the same.

The lower panels of Figure 2 shows that Leo’s engagement in vocal stereotypy was generally high ($M = 65\%$) and bout duration ($M = 11.4$ s) was typically longer than IRT ($M = 5.0$ s). The introduction of music produced initial reductions in vocal stereotypy ($M = 49\%$) and bout duration ($M = 7.4$ s), and an increase in IRT ($M = 6.6$ s), but the effects did not persist beyond two sessions. The withdrawal of music did not produce considerable changes in engagement in vocal stereotypy ($M = 55\%$), bout duration ($M = 8.4$ s), and IRT ($M = 8.1$ s). During the following music phase, engagement in vocal stereotypy decreased considerably ($M = 18\%$), bout duration decreased marginally ($M = 4.1$ s), and IRT increased ($M = 15.2$ s). The return to the baseline phase produced a gradual increase in vocal stereotypy ($M = 51\%$) and in bout duration ($M = 8.0$ s), and a gradual decrease in IRT ($M = 8.4$ s). Finally, the final phase shows that the reintroduction of music produced reductions in engagement in stereotypy ($M = 29\%$) and bout duration ($M = 4.8$ s) and an increase in IRT ($M = 41.6$ s). Experimental control of music over engagement in vocal stereotypy was demonstrated across the last four phases.
Figure 2. Percentage of time, inter-response time (IRT), and bout duration of vocal stereotypy during sessions without music (i.e., baseline) and with music for Max (two upper panels) and Leo (two lower panels).
Figure 3 shows the effects of music on the percentage of time engaged in vocal stereotypy, bout duration, and IRT for Liam. During the initial baseline phase, Liam engaged in vocal stereotypy for a mean of 37% of the sessions with a mean bout duration of 7.6 s and a mean IRT of 7.8 s. The introduction of the music phase did not considerably alter engagement in vocal stereotypy ($M = 39\%$), bout duration ($M = 6.0$ s), and IRT ($M = 10.0$ s). Engagement in vocal stereotypy ($M = 28\%$) and IRT ($M = 16.3$ s) became more variable during the second baseline phase, but bout duration remained similar ($M = 5.4$ s). A preferred song was introduced during the final phase to examine whether it would alter engagement in the target behavior. Engagement in vocal stereotypy ($M = 28\%$), bout duration ($M = 4.8$ s), and IRT ($M = 12.8$ s) did not change following the introduction of the preferred song.

*Figure 3.* Percentage of time, inter-response time (IRT), and bout duration of vocal stereotypy during sessions without music (i.e., baseline) and with music for Liam.
The results of the second experiment indicate that music produced idiosyncratic effects on the temporal structure of vocal stereotypy in two participants. For Max, music increased the mean IRT but produced no clear effect on bout duration whereas for Leo, music increased mean IRT and also marginally decreased bout duration. In contrast, music did not alter the temporal structure of Liam’s vocal stereotypy. A visual analysis of data trends within participants shows that bout duration generally followed similar, yet less pronounced, trends than percentage of time whereas the trends for IRT were inverse to the trends for percentage of time. These results are consistent with the correlations observed in the first experiment, which suggested that bout duration increased and IRT decreased when percentage of time increased.

**General Discussion**

Overall, the results of the study indicate that vocal stereotypy shows considerable variability within and across participants. Furthermore, music alters the temporal structure of vocal stereotypy for some, but not all, children with autism. As such, the two experiments extend prior research in several ways. First, the results of the first experiment suggest that vocal stereotypy may be as variable as other forms of stereotypy. Specifically, the variability in bout duration of vocal stereotypy was slightly higher than the variability reported by Hall et al. (2003) in a study on motor forms of stereotypy. This variability is consistent with the perceptual reinforcement hypothesis proposed by Lovaas, Newsom, and Hickman (1987) to explain the maintenance of stereotypy. That is, the structure of vocal
stereotypy may vary slightly during sessions so that the behavior maintains its reinforcing value over time (i.e., to prevent satiation).

Second, we examined the effects of auditory stimulation on the bout duration and IRT of vocal stereotypy. When music decreased vocal stereotypy, IRT considerably increased whereas marginal reductions in bout duration were observed. When music had no effect (for Liam), the temporal structure of stereotypy was similar as to what was observed during baseline. In a study on motor stereotypy, Hall et al. (2003) had observed that participants who engaged in the most stereotypy were those whose behavior was the least sensitive to environmental factors. In contrast, the participant who engaged in the least stereotypy in our study was the only one whose stereotypy remained insensitive to environmental stimulation (i.e., music). One potential explanation for this discrepancy is that the reinforcing product maintaining Liam’s vocal stereotypy may not have been auditory stimulation, which would describe why music failed to reduce engagement in the behavior. Third, a functional analysis was conducted with each participant prior to their inclusion in the study. This step was essential to ensure that we excluded participants who engaged in repetitive vocalizations to access social reinforcement.

The method proposed to measure the structural characteristics may be useful when attempting to identify matched stimuli for vocal stereotypy. Prior research has shown that matched stimuli may, or may not, reduce engagement in vocal stereotypy (Lanovaz et al., 2009). If the properties of the stimulus (i.e., music) were more closely matched to the structural characteristics (e.g., pitch,
intensity, temporal distribution) of vocal stereotypy, matched stimulation may be more likely to reduce the behavior. To this end, researchers need to conduct studies on matching the properties of auditory stimulation with some of the structural characteristics of vocal stereotypy.

Noncontingent access to music decreased vocal stereotypy for two participants, but not to consistent near-zero levels. Specifically, music reduced engagement in vocal stereotypy to a mean of 9% for Max and 32% for Leo. The short IRTs observed during baseline (i.e., 7 s for both participants) would have required the frequent delivery of consequences by a trainer during DRO or RIRD. For example, reinforcers would have needed to be delivered following the absence of vocal stereotypy for 6 s or less during DRO (Rozenblat et al., 2009), which would have prevented the trainer from engaging in other activities. In the case of RIRD, the trainer would have needed to initially interrupt vocal stereotypy every 7 s on average, which would have been nearly impossible in group settings (Miguel, Clark, Tereshko, & Ahearn, 2009). One solution to this problem is to provide noncontingent access to music while simultaneously implementing other interventions. The mean IRTs during the music phases were increased to 13 s and 21 s respectively for Max and Leo, which indicates that the trainer would have needed to intervene less often to implement other procedures. Once the behavior had been reduced to acceptable levels, the music could have been gradually faded making other interventions more manageable for the person intervening with the child.
The current study is limited insofar as a 2-s offset criterion was used to measure vocal stereotypy. The 2-s criterion was used to facilitate data collection and to make the offset of each bout clearer. Adding 2 s at the end of each bout does not change the overall conclusions of the study because adding a constant does not alter correlations or trends. Nonetheless, researchers and clinicians may attempt to measure vocal stereotypy more precisely with a shorter offset criterion in the future. Another limitation is the absence of pitch and intensity measures during the second experiment. Although music did not alter IRT and bout duration for Liam, music may have changed other structural characteristics of his vocal stereotypy (e.g., intensity, pitch) to complement the external stimulation. Given that external speakers were used to play music, we could not reliably measure pitch and intensity during the second experiment.

In the future, researchers should consider using headphones to provide music to each participant, which would allow pitch and intensity to be measured during the intervention. Researchers should also combine music with other interventions to examine whether auditory stimulation facilitates implementation by increasing IRT. Most importantly, researchers should examine whether the structural characteristics of vocal stereotypy may predict treatment effectiveness. Currently, clinicians must generally rely on trial and error to identify an effective intervention to reduce engagement in vocal stereotypy. However, the identification of structural characteristics which predict whether an intervention will be effective or not at reducing vocal stereotypy would be most useful for
clinicians and would considerably improve service delivery to individuals who emit vocal stereotypy
References


CHAPTER VII – CONCLUSION

Summary of Findings and Original Contributions to Knowledge

Altogether, the series of articles presented in this dissertation extend prior research on the assessment and treatment of vocal stereotypy in several ways. The first article (see Chapter III) proposes a systematic approach to identify functionally matched interventions for automatically reinforced behavior. Specifically, the model extends prior research by proposing a systematic sequence to analyze the data collected from three-component multiple-schedules. Most interventions for vocal stereotypy can only be implemented for short periods of time interspersed by other activities or tasks. As such, the subsequent effects of interventions should be measured to ensure that the behavior does not increase following the interruption of the intervention. To this end, the sequential assessment model allows the identification of interventions that will reduce immediate and subsequent engagement in vocal stereotypy.

The second article (see Chapter IV) took into consideration limitations in prior research to examine the effects of auditory stimulation on vocal stereotypy. Specifically, two different procedures to provide access to matched stimulation were compared to examine which intervention produced the most desirable changes in behavior. The results showed that sound-producing toys failed to reduce engagement in vocal stereotypy in three children with autism spectrum disorders whereas music decreased immediate engagement in vocal stereotypy for three of four participants. Furthermore, music produced idiosyncratic effects on toy manipulation for two of the participants.
The results of the study make an original contribution to knowledge in at least three ways. First, researchers had not previously examined whether clinicians who implement matched stimulation to reduce vocal stereotypy should begin by using sound-producing toys or music. Given that noncontingent access to music decreased engagement in vocal stereotypy in participants for whom sound-producing toys failed to do so, the results suggest that clinicians should consider assessing the effects of music first. Second, the study examined the effects of matched stimulation on collateral behavior. Some prior studies (e.g., Rapp, 2005; Rapp, Vollmer, St. Peter, Dozier, & Cotnoir, 2004) had shown that reducing engagement in one response-form of stereotypy may produce reallocation to another response-form of stereotypy, but the effects on appropriate behavior had not been examined. The current study showed that music may increase, decrease, or have no effect on toy manipulation depending on the participant. Therefore, measuring the collateral effects of interventions designed to reduce vocal stereotypy may be important. Third, in this study, implementation of the intervention occurred in environments in which children typically spend their free time whereas prior studies had used controlled environments to reduce the effects of confounding variables on vocal stereotypy (e.g., Ahearn, Clark, DeBar, & Florentino, 2005; Lanovaz, Fletcher, & Rapp, 2009). The results suggest that the presence of other stimuli in the environment may reduce engagement with the sound-producing toys, which may restrict the effectiveness of matched stimulation at reducing vocal stereotypy.
In the third article (see Chapter V), I examined some parameters that may explain the discrepant effects produced by music across participants. The purpose of the study was to manipulate the intensity and pitch of music to examine their effects on engagement in vocal stereotypy. The results showed that music reduced engagement in vocal stereotypy in four of five participants, but that manipulating intensity only produced marginal effects on engagement in the behavior. Although the manipulations did not produce strong differential effects, the study contributes to knowledge by showing that intensity and pitch may not be critical parameters that make music effective at reducing vocal stereotypy. Thus, researchers should examine other parameters (e.g., preference) that may alter the effects of music on vocal stereotypy. For example, results obtained with two participants suggest that repeated exposure and preference may dictate whether a specific stimulus will be effective at reducing vocal stereotypy. The results also extend prior research by showing that the effects of music may continue across a large number of sessions.

Finally, the fourth article (see Chapter VI) examined the structural characteristics of vocal stereotypy and how the temporal structure can be altered by auditory stimulation. The results showed that bout duration, inter-response time (IRT), intensity, and pitch of vocal stereotypy varied considerably within and across participants. Furthermore, the overall duration of vocal stereotypy was positively correlated with bout duration and negatively correlated with IRT, but both variables did not covary. An analysis of the effects of auditory stimulation on engagement in vocal stereotypy suggested that music may alter the temporal
structure of the behavior. That is, music produced an increase in mean IRT for two of the participants.

The final article also makes original contributions to knowledge. First, I developed and evaluated a new method to measure the structural characteristics of vocal stereotypy. The method may be useful to identify auditory stimuli that more closely match the structural characteristics of vocal stereotypy. Second, the variability of vocal stereotypy observed under free-operant conditions provides support for the perceptual reinforcement hypothesis proposed by Lovaas, Newsom, and Hickman (1987). That is, the structure of vocal stereotypy may vary within participants so that the behavior maintains its reinforcing value over time. The results are also consistent with the variability observed in a study conducted on motor forms of stereotypy (Hall, Thorns, & Oliver, 2003). Finally, the increase in mean IRT observed during intervention suggests that music may facilitate the implementation of other interventions for vocal stereotypy. For example, using music to increase IRT may facilitate the implementation of differential reinforcement of other behavior (DRO; e.g., Rozenblat, Brown, Brown, Reeve, & Reeve, 2009) and response interruption and redirection (RIRD; e.g., Ahearn, Clark, MacDonald, & Chung, 2007) in applied settings by decreasing the number of times that the trainer has to provide a consequence.

**Clinical Implications**

In each article, different clinical implications for the assessment and treatment of vocal stereotypy were ascertained. The first article was specifically designed to propose a methodology that can be applied in clinical settings. Using
the sequential assessment model may allow clinicians to identify a functionally matched intervention, which reduces both immediate and subsequent engagement in vocal stereotypy in children with autism spectrum disorders.

Given that music may produce desirable and undesirable changes in toy manipulation, the results of the second article underline the importance of measuring the collateral effects of interventions designed to reduce vocal stereotypy. Furthermore, music reduced engagement in vocal stereotypy for three of four children whereas sound-producing toys did not reduce engagement in three participants. The results suggest that clinicians should consider evaluating the effects of music before the effects of sound-producing toys. Thus, the amount of time spent identifying an effective intervention for vocal stereotypy should be reduced. Finally, the results of the functional analysis suggest that high levels of a behavior in the control condition compared to the no-interaction condition may be indicative of an automatically reinforced behavior evoked by the presence of toys. As such, clinicians should conduct further analyses when this pattern is observed to examine whether the presence of toys evoked engagement in the target behavior.

Although in the third article findings indicated that manipulating intensity and pitch did not produce large differential changes in behavior, the results still provide some implications for clinical practice. For example, music produced differential effects on subsequent engagement in vocal stereotypy. The small changes in behavior observed in the third component (i.e., post-intervention) may add up and facilitate or hinder the implementation of interventions to increase
appropriate behavior (see Lang et al., 2009, 2010). Therefore, the results indicate that measuring the subsequent effects of interventions may be important. The findings also showed that the effects of music persisted across multiple brief sessions. For one participant, an increasing trend is observable towards the end of the last phase, which suggests that clinicians should continue monitoring the effects of music regularly even when the stimulus has been shown to be initially effective at reducing vocal stereotypy.

Finally, in the last article, a method is proposed to measure the structural characteristics of vocal stereotypy. From a clinical standpoint, the method may be used to match the properties of an auditory stimulus to the structural characteristics of vocal stereotypy. However, more research is needed to examine whether more closely matched stimuli produce larger reductions in vocal stereotypy. Furthermore, the study has also shown that music may increase mean IRT. Clinicians may use music to increase IRT in order to facilitate the implementation of other procedures such DRO and RIRD in applied settings.

**Future Research**

The results of the studies offer many different directions for future research. In the dissertation, the sequential assessment model was only implemented to examine the effects of noncontingent access to auditory stimulation on vocal stereotypy; however, the proposed model should also be used to examine the effects of other treatments on automatically reinforced behavior. Researchers should also identify the optimal session duration to measure the effects of treatments on vocal stereotypy. In the current study, 5-min components
were typically used to assess the effects of auditory stimulation. Future research should examine whether levels of vocal stereotypy in the first 5 min predict responding during sessions with longer durations. In addition, researchers should also manipulate session duration to determine the effects of prolonged exposure to noncontingent auditory stimulation on engagement in vocal stereotypy (see Lindberg, Iwata, Roscoe, Worsdell, & Hanley, 2003).

For most participants, the selection of music was based on parental reports of preference. In the future, researchers should further examine how preference alters the effects of music on engagement in vocal stereotypy (see Horrocks & Higbee, 2008). The effects of interventions that reduce vocal stereotypy on other collateral behavior such as task completion and social interactions should also be investigated. Given that vocal stereotypy is physically harmless, the purpose of reducing the repetitive vocalizations is often to increase engagement in socially appropriate behavior. Future research should also continue examining parameters that may potentially improve the effectiveness of music at reducing vocal stereotypy. More specifically, researchers may use the method presented in the final article to match the properties of the auditory stimulus to some of the structural characteristics of vocal stereotypy. Because providing music through external speakers may be disruptive, future research should examine the use of headphones to provide noncontingent access to auditory stimulation.

Researchers may also study the effects of combining several interventions together. For example, providing noncontingent access to music and sound-producing toys simultaneously may produce larger reductions in vocal stereotypy.
than either intervention alone. Alternatively, noncontingent music may be provided with other interventions to examine their combined effects on engagement in vocal stereotypy. Finally, researchers should examine whether the structural characteristics of vocal stereotypy can predict treatment effectiveness.

Currently, clinicians must rely on trial and error to select an intervention to reduce engagement in vocal stereotypy. If certain characteristics of vocal stereotypy could be associated with better outcomes for a given intervention, children who display the behavior may receive an effective intervention more rapidly than if the clinician had relied on trial and error. Alternatively, a treatment hierarchy could be developed and evaluated to determine in what order the treatments should be implemented to (a) reduce assessment time and (b) produce the most desirable changes in vocal stereotypy and collateral behavior.

**Concluding Remarks**

Vocal stereotypy is a common problem behavior in children with autism spectrum disorders that may interfere with their learning and daily functioning. In the current study, assessment and intervention procedures were examined to assist clinicians in identifying interventions that will reduce engagement in vocal stereotypy and potentially increase behavior that will facilitate social inclusion. The series of experiments has produced interesting results that may improve the assessment and treatment of vocal stereotypy in children with autism spectrum disorders, but has also yielded many new research questions. To this end, continuing research on vocal stereotypy is not only important to contribute to our knowledge on how environmental events alter engagement in automatically
reinforced behavior but also to improve the quality of life of children with autism spectrum disorders by decreasing their vocal stereotypy and facilitating their social inclusion.
References


COMPLETE BIBLIOGRAPHY


APPENDIX

Consent Form

RESEARCH CONSENT FORM

Project submitted to, and approved by, the JREC/RCIDI-ASD (CÉRG-0055) and McGill University's REB-III

You and your child are invited to participate in a research project on the effects of music on the vocal stereotypy (i.e., acontextual vocalisations) of children with developmental disabilities. Your child was identified as a potential participant because he or she emits vocal stereotypy. Before agreeing that your child participates in this project, please take the time to understand and consider carefully the following information.

This consent form explains the goal of this study, the procedures, the advantages, the risks and drawbacks, and whom to contact if needed. It is important that you understand all the information in this consent form. Do not hesitate to ask questions to the interviewer, the researchers or any other staff member involved in the project if there is something you do not understand or if some information is not clear to you.

Title of the Research Project

Assessment and treatment of vocal stereotypy in children with developmental disabilities.

Principal Investigators

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Department of Educational and Counselling Psychology
McGill University

Ingrid Sladeczek, Ph.D.
Dissertation director and associate professor
Department of Educational and Counselling Psychology
McGill University

Objective Description

Objectives:

1. Assess your child’s preference for different properties of music (e.g., low volume/high volume, low-pitched/high-pitched).
2. Compare the effects of manipulating the properties of music on your child’s immediate and subsequent vocal stereotypy.
3. Identify natural variations in duration, intensity, and pitch of your child’s vocal stereotypy in the absence of intervention.
4. Determine the most accurate and effective method to measure the duration of vocal stereotypy.

April 5, 2009
Method:

Ten children with developmental disabilities will participate in this research project. The study is divided into five experiments. Your child will participate in one of the first three experiments. The last two experiments require no participation from your child; they involve a re-analysis of the data collected during the three initial experiments. Each of the first three experiments is divided into three phases, (1) the functional analysis, (2) the preference assessment, and (3) the comparison of the effects of different properties of music. The experiments are identical except that one different property of music will be manipulated in each experiment. The music played during the sessions will be classical music compositions. The volume (low vs. high) of music will be manipulated for children in the first experiment, the pitch (low vs. high) will be manipulated for children in the second experiment, and both volume and pitch will be manipulated simultaneously for children in the third experiment. Your child will participate to two to three sessions per week over a period of ten to twenty weeks (according to the number of sessions per week). Each session will last approximately 15 to 30 minutes.

The fourth experiment will involve an analysis of your child’s audio recordings using a computer program to measure the duration, pitch, and intensity of his or her vocal stereotypy in the absence of intervention. The fifth experiment will involve the observation of eight to ten recordings from your child by four independent observers to examine factors that can alter the measure of the behaviour.

Your child’s participation in this study is entirely voluntary. Should you agree to your child’s participation, you are also free to withdraw his or her participation from the project at any time.

Nature and Duration of Participation

If you agree to your child’s participation in this research project:

1. During the first phase, your child will have an initial assessment of 3 hours to identify the reason why he or she emits vocalisations. The assessment will be conducted over two sessions. If your child appears tired or disinterested, the assessment can be stopped by you or the researcher and be completed at another time agreed upon with you. During the assessment, your child will participate in four different conditions to determine if his or her behaviour is maintained by a social consequence (e.g., she receives attention when she exhibits the behaviour, he avoids a demand when he exhibits the behaviour) or by a non-social consequence (e.g., he enjoys the sensation produced by the behaviour). If the assessment determines that the behaviour is maintained by a social consequence or if the duration of the behaviour remains too low (i.e., less than 15%), your child will not be invited to participate in the next two phases of the experiment.

2. During the second phase, we will evaluate your child’s preference for different properties of music. Three to six 5-minute sessions will be completed on the same day. A room will be divided in two equal sections and each side of the room will produce the same music, but with a different volume and pitch.

3. During the third phase, we will evaluate the effects of music on your child’s vocal stereotypy. Approximately thirty to forty 15- or 30-minute sessions (depending on patterns observed during the initial assessment) will be completed for a total of 10 to 20 hours. Each session will be divided into three equal-duration components (i.e., three 5- or 10-minute
components). During the first and last component, no consequences will be given if your child emits vocal stereotypy. During the second component, one of the following three conditions will be implemented: (1) no intervention will be implemented, (2) music will play during the entire component, or (3) the same music with a different volume and/or pitch will play during the entire component.

4. We will make audio (using a wireless microphone system) and video recordings (using a camcorder) of all sessions to measure the duration of vocal and motor stereotypy. The audio recording system is similar to those used by newsmen on television. Your child will wear a small microphone on his or her shirt's collar, which will be connected to an emitter positioned near his or her hips. A research assistant will watch or listen to at least 33% of the recordings to check inter-observer agreement.

It is recommended that the functional analysis (phase 1) be conducted at the 7100 Champlain Blvd. in Verdun. However, if you are unable to travel, this phase may be conducted in your home. The preference assessment sessions (phase 2) and the comparison of the different properties of music (phase 3) can be conducted in your home, in a room at one of the re-adaptation centres or at another location acceptable to you. The session schedule for your child will be determined with you prior to the onset of his or her participation.

Possible Benefits of Participation

Your child will benefit from a thorough assessment of his or her vocal stereotypy. The principal investigator will meet you to present your child's results at the end of his or her participation in the study. Furthermore, your child could benefit from a reduction in vocal stereotypy and an increase in appropriate behaviour (e.g., completing tasks, playing appropriately alone). As a parent, you could also benefit from learning effective intervention strategies.

The study will have clinical and scientific outcomes. The data collected will allow a better understanding of (a) the effects of music on vocal stereotypy in children with developmental disabilities, (b) the variations of the behaviour in the absence of intervention, and (c) the different methods for measuring the behaviour.

Possible Risks and Drawbacks of Participation

Your child may become agitated because he or she will need to remain in the same room during a 15- to 30-minute period. In the event that your child becomes agitated, the session will be terminated and, following a brief period of calm, the child will be returned to his or her regular activities.

The presence of observers in your home may be an inconvenience for your family. To minimize inconveniences, you will approve the schedule of sessions prior to the onset of the study. As a parent, you may withdraw your consent for your child's participation in this study at any time.

Apart from the above-mentioned inconveniences, to our knowledge, there are no other risks to your child's participation in this research project.

Financial Compensation

You will not receive any financial compensation for your child's participation in this research project.

April 5, 2009
Withdrawal of Participation

Your child’s participation in this research project is completely voluntary. You are, therefore, entirely free to agree or to refuse that your child participates in the project. Should you agree to your child’s participation, you are also free at any time to withdraw his or her participation from the project. Whether or not you decide that your child participates in the project and whether or not you withdraw his or her participation will have no influence on the services that your family presently receives or might receive in the future from the West Montreal Readaptation Centre, the Lisette-Dupras Readaptation Centre, or McGill University, and will in no way cause you any prejudice or loss of the benefits to which you and your child are entitled. You can inform the researchers verbally or in writing of your child’s withdrawal. Should you withdraw from the project, all documents (including audio and video recordings) that concern your child will be destroyed.

Confidentiality

The data gathered are strictly confidential and will only be used for this project. To ensure confidentiality of the information concerning your child, a fictitious name will be used to identify your child’s electronic files. The child’s fictitious name will replace your child’s name in all documents used in the research project. All data files will be kept on a password-protected computer and will be deleted five years after the publication of the results of the study.

The master list that links the child’s name with his or her fictitious name will be kept in a different place from the electronic files. The consent forms and the master list will be kept in a locked filing cabinet (located in Marc Lanovaz’ working premises at the Lisette-Dupras Readaptation Centre) and only authorized research staff will have access to these documents. The master list as well as the consent forms will be destroyed securely five years after the completion of the study.

The audio recordings will be kept on DVDs and on an external hard drive in a locked file cabinet. The videotapes will be kept in the same location. The audio and video recordings cannot be used for purposes other than those stated in the consent forms, that is to measure the duration of your child’s vocal and motor stereotypy. These videotapes will be destroyed and the audio files deleted within a period of five years following the completion of the study.

When the results of this study are disseminated (e.g., through publication in a scientific journal or presentation at a conference), no information will be presented that could lead to the identification of the child or his or her family.

It is possible that granting bodies or governing bodies, such as the Joint Research Ethics Committee, review the research files as part of their follow-up and monitoring function. This project has been submitted to, and approved by, the Joint Research Ethics Committee for Rehabilitation Centres for Intellectual Disability and Autism Spectrum Disorders (JREC/RCIDI-ASD) and McGill University’s Research Ethics Board III (REB III) and these committees will ensure that ethical rules are respected throughout the entire project.

Responsibility Clause

By agreeing to participate in this study, you do not give up any of your rights nor do you free the researchers and the institutions involved from their legal and professional responsibilities.
Questions About the Study

If you have any questions about the research project, do not hesitate to ask the interviewer about them now. If other questions come to mind during the meeting, you will be able to ask them as well.

Contact Persons

If you wish to ask questions about the project, report any problems, or share your comments, you may, at any time, contact:

Marc Lanovaz, M.Sc., BCBA, Doctoral Student at McGill University
(514) 364-2282, ext. 2379
marc.lanovaz@mail.mcgill.ca

Ingrid Sladeczek, Ph.D., Dissertation Director and Associate Professor in the Department of Educational and Counselling Psychology at McGill University
(514) 398-3450
ingrid.sladeczek@mcgill.ca

For any questions related to your rights and recourses or about your participation in this research project, please contact:

Karoline Girard, Coordinator of Research Ethics for the JREC/RCID-ASD
(819) 376-3084, ext. 235
karoline_girard_csdii@ssss.gouv.qc.ca

Lynda McNeil, McGill University’s Research Ethics Officer
(514) 398-0831
lynda.mcneil@mcgill.ca

For any complaints regarding the research project, please contact:

Dominique Normand, Local Commissionner for Complaints and for Quality of Services for the West Montreal Readaptation Centre and the Lisette-Dupras Readaptation Centre
(514) 364-2282, ext. 2150
dominique.normand@ssss.gouv.qc.ca

If you agree to your child’s participation to this research project, a copy of this document will be given to you.
Consent

I, the undersigned, have read and understand the content of this form that was communicated to me, enabling me to give full consent. All my questions have been answered to my satisfaction. I have had sufficient time to decide whether or not to participate in this study. I understand that my child is free to participate in the project and that I remain free to withdraw his or her participation from the project at any time, without any penalties. I freely consent to my child participating in this study.

I consent to my child’s, ______________________, participation in this research project.

Name of child

Name of legal tutor ______________________________ Signature ___________________________ Date ________

I consent to audio and video recordings of my child being made to measure his or her vocal and motor stereotypy.

Name of legal tutor ______________________________ Signature ___________________________ Date ________

Commitment Form

I, the undersigned, certify that I have explained to the participant’s legal guardian all the terms contained in this form, that I have answered the questions to the best of my knowledge, and that I have explicitly told the participant that she or he remains free to withdraw from the research project at any time. I certify that I will ensure that the participant gets a copy of this information and consent form. I also ensured that the minor and disabled participant understood and accepted all aspects of his or her participation to the present study, and this, to the maximum extent of his or her capacities.

Name of the interviewer __________________________ Signature ___________________________ Date ________