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Effects of Non-Contingent Music in the Emission of Vocal Stereotypies in Children with Autism Spectrum Disorder

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ABSTRACT – Vocal stereotypies can be considered a problem behavior because they disrupt the learning environment. Non-contingent music (NCM) access has been used to reduce these responses. This research aimed to verify the effects of an NCM procedure with the differential reinforcement of other responses (MDRO) in reducing vocal stereotypies in two children with ASD using a reversal design. Results indicated an average decrease of 50 to 65% in vocal stereotypies during the intervention sessions for the two participants. The study discusses the maintenance functions of these vocal responses and explores whether music, as a non-contingent auditory reinforcing stimulus, may have altered the motivating operations for the participants' engagement in these stereotyped vocal responses.

***KEYWORDS*:** vocal stereotypy, music, non-contingent reinforcement, Autism Spectrum Disorder.

Efeitos da Música Não Contingente na Apresentação de Estereotipias Vocais em Crianças com Transtorno do Espectro do Autismo

RESUMO – As estereotipias vocais podem ser consideradas um comportamento-problema por prejudicarem o ambiente de aprendizagem. O acesso a música não-contingente (NCM) vem sendo utilizado para reduzir essas respostas. Essa pesquisa teve o objetivo de verificar os efeitos de um procedimento de NCM com reforçamento diferencial de zero respostas (MDRO) na diminuição de estereotipias vocais em duas crianças com TEA com um delineamento de reversão. Os resultados indicaram diminuição de 50 a 65% em média de estereotipias vocais nas sessões de intervenção para os dois participantes. Discutem-se as funções mantenedoras dessas respostas vocais e se a música, como estímulo reforçador auditivo, fornecida de forma não-contingente, pode ter alterado as operações motivacionais para engajamento dos participantes nessas respostas vocais estereotipadas.

***PALAVRAS-CHAVE*:** estereotipia vocal, música, reforçamento não-contingente, Transtorno do Espectro do Autismo.

INTRODUCTION

According to the DSM-5 (Diagnostic and Statistical Manual of Mental Disorders; American Psychiatric Association [APA], 2013), Autism Spectrum Disorder (ASD) is one of the neurodevelopmental disorders characterized by difficulties in communication and social interaction, as well as the presentation of stereotyped, repetitive, and restricted behaviors (Tromans *et al.*, 2018). The term stereotyped behavior (or stereotypy) refers to a series of repetitive actions and movements, sometimes, from the point of view of the observer, decontextualized and without an apparent function, which can negatively impact the quality of life of the individuals involved in these behaviors and, in some cases, the environment and the people around them, as in the case of vocal stereotypies (Lilley, 2017).

Vocal stereotypy can be defined as the oral production of indistinct words, sounds, or noises, that occur repeatedly and continuously for a certain period. This response can occur with high frequency in people diagnosed with ASD and other developmental disorders (APA, 2013; Lanovaz *et al.*, 2011). Wunderlich and Vollmer (2015) suggest examples of vocal stereotyping such as laughter, noises, babbling, and speeches out of context. Gibbs *et al.* (2018) consider vocal stereotypies to be any inappropriate vocalization, such as singing, laughter, decontextualized speech, meaningless sounds, screams, blows, moans, vocal or breathing rhythmic patterns, teeth grinding sounds, lip popping, squealing, and/or repetitive sounds with the mouth closed.

Research has shown that vocal stereotypies can interfere with the learning of adaptive behaviors, such as playing, acquisition of academic repertoire, and social resourcefulness of those who present them (Liu-Gitz & Banda, 2010; Wunderlich & Vollmer, 2015). Because it is a sound response, vocal stereotyping can be considered a disruptive behavior, as it can harm the learning environment of who performs it and those around them (Wunderlich & Vollmer, 2015). Thus, reducing the occurrence of these responses, when they negatively influence learning or social life, can increase the learning opportunities of various repertoires (Lanovaz & Sladeczek, 2012).

Vocal stereotypy, like other forms of stereotypy, is an operant behavior, learned and maintained through positive social reinforcement (such as attention or access to a tangible item), negative reinforcement (such as escape or avoidance from demands or aversive environmental stimuli), positive or negative automatic reinforcement (Chu & Baker, 2011; Cunningham & Schreibman, 2008; Deleon *et al.*, 2005; Durand & Carr, 1987; Gibbs *et al.*, 2018; Lanovaz *et al.*, 2012).

According to Cooper *et al.* (2014), automatic reinforcement is the term used in Behavior Analysis to describe contingencies that do not include consequences mediated by other people. In other words, the response itself produces pleasant or self-stimulating sensory consequences. Cooper *et al.* (2014) exemplify the definition of automatic reinforcement by addressing the class of stereotyped behaviors and emphasize how their products may reinforce repetitive behaviors themselves through sensory pathways.

As there can be different contingencies of reinforcement while maintaining a certain stereotype, it is necessary to know, *a priori*, what the operant function of this response is. That is, what the specific processes and schemes of reinforcement involved would be, and from there, it would be possible to manipulate such contingencies (Durand & Carr, 1987; Kennedy *et al.*, 2000), aiming at reducing or eliminating their occurrences or replacing them with adaptative responses with the same corresponding function (Martin & Pear, 2018).

According to Kennedy *et al.* (2000), behavioral interventions aimed at reducing the occurrence of stereotypies cannot be based solely on topographic descriptions of these responses, it is necessary to conduct a functional analysis (Iwata *et al.*, 1982) to determine the antecedent and consequent stimuli that maintain a given response. In this sense, a given response can have different functions, and the function of a behavior refers to the type of consequence it produces.

Some researches have shown reductions in the frequency of stereotyped responses in children with ASD due to sensory extinction, *i.e.*, breaking the response-reinforcement relation between stereotypy and the sensation it produces (Rincover *et al.*, 1979). It happens by teaching alternative responses that produce the same sensations - such as the Differential Reinforcement of Alternative Responses procedures, in which, , the response of saying "Biscuit" produces access to a biscuit that was previously provided contingently to stereotypy, which is put into extinction (Chu & Baker, 2011; Kennedy *et al.*, 2000) or by providing these sensations regardless of the occurrence of stereotypy (such as Non-Contingent Reinforcement procedures; Gibbs *et al.*, 2018; Lanovaz, *et al.*, 2011; Lanovaz, *et al.*, 2012; Saylor *et al.*, 2012). Some studies (Gibbs *et al.*, 2018; Lanovaz *et al.*, 2012; Saylor *et al.*, 2012) have demonstrated decreased non-adaptative sensory responses (such as vocal stereotypies) when a song is presented in a non-contingent manner.

Lanovaz *et al.* (2012) aimed to identify and use high and low preference music in a non-contingent reinforcement (non-contingent music - NCM) procedure to reduce vocal stereotypies in four 4, 6, and 9-year-old children diagnosed with ASD. The researchers were based on the hypothesis that these stereotypies were maintained by automatic reinforcement, and, although they did not perform a functional analysis, they applied a 40- to 50-minute free operant observation to verify whether the vocal stereotypies would occur, even without social consequences. A preference assessment paired with representative images of each song was carried out. The song most chosen by each participant was selected to play constantly during the high-preference sessions and the one least chosen by the child was played in the low-preference sessions. The authors used a Multiple-Element Design to compare children's rates of vocal stereotypies when accessing high and low-preference music in a non-contingent manner. The results indicated that the non-contingent presentation of more preferred songs generated significant reductions in vocal stereotypies for three of the four participants, while in sessions of less preferred songs, most participants presented vocal stereotypies more frequently, demonstrating that the reduction of stereotypies may be related to the level of preference for the available musical stimulus. The participant who did not show reductions in stereotypies did not receive the intervention. The authors suggest that the environmental conditions under which the effects of non-contingent music were evaluated would limit the applicability of the results. For example, sessions of only 10 minutes are not necessarily generalized for longer durations, as satiation could reduce the effects of non-contingent music.

Saylor *et al.* (2012) investigated the effect of three types of non-contingent auditory stimulation on the vocal stereotypies of two 5- and 6-year-old children with ASD. The three types were children's songs defined as preferred according to parental indication, white noise (defined as sound with all frequencies within the human hearing range, from 20 Hz to 20 kHz) or listening to recordings of their own stereotypy ("*self*"). The experimenters assumed that

vocal stereotypy was being maintained in both cases by automatic reinforcement since their caregivers emphasized how such vocal responses appeared constantly when the children were alone, and a descriptive functional analysis did not find specific antecedents for such responses. During the sessions, participants could play with medium-preference non-auditory toys identified in a preference assessment and they wore headphones to constantly listen to one of three types of auditory stimulation. At no time consequences were planned for the vocal stereotypies of the participants. The Alternate Treatment Design was used, with five sessions for each type of auditory stimulation. The condition that produced the greatest decrease in vocal stereotypies was non-contingent music (children's songs), in which the occurrence of responses was close to zero for both participants.

Gibbs *et al.* (2018) compared the effects of response redirection (RIRD) alone with the effects of NCM presentation plus redirection (NCM+RIRD) in reducing vocal stereotypies in demand situations. Two children with ASD, aged 4 and 7, participated in the research. Through a brief functional analysis, the researchers identified that the vocal stereotypies were maintained, at least partially, by automatic reinforcement. An ABAB Reversal Design was used to compare the levels of vocal stereotypies between RIRD (component A) and NCM+RIRD (component B). In RIRD procedure alone, the participant was interrupted when emitting a vocal stereotypy and directed to emit a vocal response (such as vocal imitation and answering questions). After three correct vocal responses, the procedure was completed and the previous activities were resumed (pre-academic and academic tasks, such as placing pins on a board and typing sentences from a model). If the child performed the vocal demand in RIRD, he was praised; if he did not respond within 5 seconds and continued to stereotype vocally, the instructor gave the answer and demanded it one more time. If the student did not respond again, the experimenter presented another preplanned vocal demand. In NCM+RIRD, the procedure was like RIRD alone, but music was presented uninterruptedly throughout the condition in headphones at a volume that allowed the experimenter's commands to be heard. The results indicated that the NCM+RIRD intervention was more effective in decreasing vocal stereotypy and increasing task engagement for all participants when compared to data obtained with RIRD alone. Gibbs *et al.* (2018) also highlighted the importance of implementing NCM to the results obtained. According to them, being based only on consequence strategies (such as RIRD) usually results in the loss of time necessary for teaching demands, interrupting ongoing activities.

However, Vollmer *et al.* (1997) discussed how the free delivery of preferred stimuli (in NCM, for example) can inadvertently reinforce inappropriate behavior. In order to prevent accidental reinforcement, Vollmer *et al.* (1997) added the Momentary Differential Reinforcement of Other Behavior (MDRO) procedure, or Momentary Differential Reinforcement of Zero Responding (Martin & Pear, 2018). According to Martin and Pear (2018), DRO refers to a differential reinforcement scheme in which the delivery of the reinforcer is planned to occur only to the extent that a target behavior does not occur within a predetermined period.

Vollmer *et al.* (1997) reported an increase in the frequency of severe aggressive behaviors, defined as hitting, punching, grabbing, or pinching the therapist, during the use of isolated non-contingent reinforcement (NCR) and, through a functional analysis, demonstrated that aggressive behaviors were maintained by positive reinforcement (access to items) in a 13-year-old girl with severe intellectual disability. After baseline sessions, which showed increasing levels of aggression responses, continuous NCR treatment was introduced, resulting in a reduction of the participant's aggression responses to zero. Return-to-baseline data in an ABABC design showed aggression levels similar to the initial baseline. Subsequently, the researchers implemented an NCR fading scheme, which involved starting treatment with continuous access to magazines and progressively limiting this access. During the fading of NCR procedure, aggression responses increased significantly (six times more than baseline data), prompting the experimenters to introduce an MDRO treatment phase. In this phase, reinforcers were still available on a non-contingent basis, but if the participant exhibited an aggressive response within 10 seconds before the expected availability of the reinforcer, the delivery was withheld to prevent accidental reinforcement of the aggressive behaviors (Vollmer *et al.*, 1997).

The studies by Saylor *et al.* (2012) and Lanovaz *et al.* (2012) have the limitation of not having performed functional analysis to identify the maintaining consequences of the participants' vocal stereotypies. In addition, in the three studies presented above (Gibbs *et al.*, 2018; Lanovaz *et al.*, 2012; Saylor *et al.*, 2012), auditory stimuli were presented uninterruptedly during all NCM conditions to reduce vocal stereotypies. To expand the findings on the use of NCM in the reduction of vocal stereotypies, in this study, a functional analysis was initially conducted. Instead of providing the music uninterruptedly, an average of the intervals between stereotypes was used to provide the NCM, so that it was possible to identify the causal relations more precisely. It is also worth mentioning that, despite the promising results of NCM use to reduce vocal stereotypies, in a recent literature review, Mantzoros *et al.* (2022) identified few articles on the subject, the most recent being by Gibbs *et al.* (2018).

Therefore, the objective of this research was to verify the effects of an NCM procedure in conjunction with a zero-response momentary differential reinforcement (MDRO) procedure on the frequency of vocal stereotypies in children with ASD in a reversal design.

Method

Participants

The participants were two boys with ASD (VB and LA) who have vocal stereotypies. The Free and Informed Consent Form, previously approved by the Human Research Ethics Committee of the Federal University of São Carlos (no.: 3.636.732, CAAE: 17430619.5.0000.5504), was made available to the participants' guardians to authorize participation in the research. Data collection began only after the form was signed.

VB is a 6-year-old boy diagnosed with ASD by his Neuropediatrician. He has been receiving behavioral intervention 40 hours a week for two years, including speech therapy, occupational therapy, psychopedagogy, and psychology at a specialized institution. During this study, VB did not have vocal verbal operants yet and had recently started using an alternative communication system. His family approached the researcher with concerns about VB spending long periods of the day making noises and screams, which affected routine activities and the quality of life for the whole family. According to a document from his clinical team, VB struggles with personal identification, engages in stereotypies during leisure time, does not name items, follow instructions, or perform self-care tasks independently. VB exhibits vocal stereotypies such as screams, laughter, vocalizations, and nonsensical whispers, including sounds like "Ahnnnnnnn," "Ihhhhhhhh," "Ui ui ui," "Ain-ain," "Tsi-tsi," "Bruuuu," and others. Additionally, during data collection, VB displayed repetitive behaviors like jumping, swinging his arms, hitting a pilates ball, leaning on a ball, crying, standing with feet and hands on the floor, throwing himself on the couch, tapping his foot, manipulating his genitals, climbing and walking on the bed, lying under cushions, walking around the couch, and jumping on the couch.

The last assessment of VB's repertoire was conducted by the child's behavioral team using the Core Skills Assessment (Dickson *et al.*, 2013). In this study, VB scored 125 out of 205 total points and demonstrated pre-academic repertoires such as sitting and waiting for the therapist's instruction, tracking objects and figures, and pairing objects and figures. Additionally, the child showed communication skills like responding with eye contact when called by name, making some spontaneous mands for preferred items, and following simple instructions with visual cues. Social skills included making choices among preferred items, doing imitations with objects, using a routine visual agenda, and waiting a few seconds for preferred items. Personal care skills observed were using the bathroom for necessities and utensils to eat, as well as accepting medications for health and safety. In terms of play, physical education, and community activities, the child was able to walk with a companion and perform physical activities with help. However, during free moments of leisure, VB tended to engage in stereotypies and repetitive behaviors.

LA is a 5-year-old boy diagnosed with ASD by his Neuropediatrician, Sensory Processing Disorder by his Occupational Therapist, and a pre-diagnosis of Speech Apraxia by his Speech Therapist. LA receives 6 to 8 hours per week of behavioral intervention and speech and occupational therapy services. During the current research, he exhibited verbal operants of echoic, mand, and tact of up to two words. His family reported that LA produces echolalia, sounds, and meaningless speech repeatedly, which distracts him from his daily activities. During the sessions, LA also displayed aggressive behaviors (slapping others), crying in situations directed by an adult, and throwing himself on the floor. He engaged in repetitive motor and vocal behaviors such as moving hands and fingers at face level, leaning or throwing himself on the bed, jumping on the floor, putting objects or fingers in his mouth, looking out the window, standing on the bed, resting knees and elbows on the floor, closing and opening eyes with his hands, lifting feet off the ground when sitting, standing on the sofa, standing on top of the sofa with his head resting on the back, stepping on a puzzle, rubbing dough on his body, among others. LA's vocal stereotypies include screams, sighs, laughter, speech, vocalizations, and whispers that are decontextualized and apparently lackmeaning. Some examples are: "Datis-coi Piiiii", "Iiiiii", "Eeeeee", "Dá-dá-dá", "Recieie-it-it", "Dat-is-coi-zi-itesss-zuuu", and shouts like "Hooo!".

In the last assessment carried out by the clinical team using VB-MAPP Protocol (Verbal Behavior Milestones Assessment and Placement Program; Sundberg, 2008), LA scored 71.5 out of 170 total points. According to the report of this assessment, LA fulfilled practically all of Level 1 (skills usually demonstrated by 18 months of age), some Level 2 milestones (skills demonstrated between 18 and 30 months of age), and a few skills in Level 3 (between 30 and 48 months of age). For the Developmental Milestones of this Protocol, LA mands up to 10 items present in the environment without prompt (except "What do you want?") and tacts for up to 50 items, generalizing between three exemplars for each item. Regarding listener behaviors, the participant responds to a speaker's voice, makes eye contact, responds when hearing his name, performs up to 10 actions on command, identifies up to 40 items in arrangements of six available items, selects items by colors and shapes in an arrangement of six items, with at least four colors and four shapes. He also has visual perception skills (follows moving objects, holds objects with pincer movements, attends to books and toys for at least 30 seconds, places objects in jars, separates objects by colors and shapes, and demonstrates generalizations of pairings). As for play and social behaviors, he demonstrates

generalization and independence in playing exploratory movements, using toys in a new environment for at least 2 minutes, engaging in cause-and-effect games for 2 minutes, playing independently in playgrounds for 5 minutes, looking for missing parts of five-piece toys, using toys according to their function, and engaging independently in arts and construction activities for 5 minutes. He makes eye contact with peers as a form of mand, plays near peers for 2 minutes, and indicates that he wants to be helped or play at least twice. He also presents imitation repertoires (imitates more than 40 movements of any type, 20 fine movements with physical prompts, ten actions that require the selection of a specific object, approaching imitation in a generalized way), echoic (imitates vocalizations with the exact topography of words of up to two syllables), and intraverbal (completes up to ten different blank gaps in common sentences of any type). LA had already learned some classroom routines and group skills, such as sitting in a small group for a snack or lunch without exhibiting inappropriate behaviors (for at least 3 minutes) and in a group without trying to get up or exhibit inappropriate behavior (for at least 5 minutes). Finally, the participant had begun to acquire more complex behaviors, such as reading and mathematics.

Experimental Design

The ABAB Reversal Design (Gast & Hammond, 2010) was used in the following sequence: baseline, NCM+MDRO, baseline, NCM+MDRO. The dependent variables were the frequency and duration of vocal stereotypies. In this research, vocal stereotypy was defined as any vocal response that lasted at least two seconds and included screams, laughter, whispers, speech, monosyllabic sounds, and other vocalizations with no apparent meaning (based on the studies of Lanovaz *et al.*, 2012 and Gibbs *et al.*, 2018). The independent variable was the provision of NCM accompanied by MDRO. With VB, it was not possible to perform the second introduction of NCM+MDRO due to private issues of his family, who had to request the interruption of the procedure.

Setting, materials and data collection

The sessions were conducted at the participants' homes, in a place with less probability of sound interference than those provided by the intervention. VB's sessions were conducted in the TV room and LA's sessions were conducted in his bedroom and a playroom. The following materials were used: two cell phones, one used as a timer and the other for recording, a computer for audio playing and various non-sound toys. The sessions were filmed so that the child's behaviors could later be registered by the researcher and by a second observer for calculations of reliability.

Procedure

Functional Analysis. A Brief Functional Analysis of each participant's vocal stereotypy was carried out to identify the possible behavioral function of the response (Ahearn *et al.*, 2007). The conditions of the Functional Analysis were attention, demand, playing and free condition (no attention). These conditions were presented in the following order for the two participants: control, free, control, attention, control, demand. The following is a description of the contingency planning for each condition of the Functional Analysis. Each condition lasted 5 minutes.

In the attention condition, the participant started the session with free access to easy-to-handle materials arranged in front of him, such as toys and leisure items. In the presence of these materials already known to the child, the researcher engaged in reading some papers, approximately 1 meter from the participant, without playing or paying attention to him. In the presence of vocal stereotypies, the researcher would address the participant and immediately say something like "You can't do that" or another vocal form of social disapproval, touching him on the shoulder. Other responses did not produce programmed consequences. In the demand condition, the researcher sat in front of the participant, both at a table, presenting non-vocal activities, such as puzzles and complex games, presented by the family as difficult tasks or that presented resistance. Then, the researcher asked the participant to start the activity. In the presence of vocal stereotypies, the researcher said that he did not need to do the activity, removing and re-presenting it after 15 seconds. If the participant performed the task, no consequences were delivered and after 15 seconds another task was presented.

In the control condition, the participant and the researcher started by sitting on the floor or in a chair with free access to the participant's favorite toys and leisure items as reported by family members, arranged on a table and/or on the floor. The researcher remained silent in the presence of vocal stereotypies. However, at varying intervals, the child was praised and received physical touch by manipulation of the objects arranged, along with other expected responses such as smiling, making eye contact, remaining seated, and playing, if vocal stereotypies were not present. In the free condition, the participant started by standing, sitting, or moving freely in the same room as the researcher. Access to the same materials, such as toys, as in the prior conditions was allowed. The researcher was present but offered no eye contact or attention, sitting in the position opposite to the participant. The researcher remained silent, with her face turned towards the floor, avoiding eye contact and sitting on the opposite side of the participant. For any response other than vocal stereotypy, there were no programmed consequences, and no attention was offered.

Preference Assessment. This phase aimed to define a song for each participant to listen during the intervention. The family indicated three songs and the one during which the participant produced the shortest time in stereotypies was considered ideal for the intervention sessions. The Free Operant Preference Assessment was used as a reference (Pace *et al.*, 1985). After the survey with the family, each song indicated as possibly preferred by the child was presented constantly and separately by the researcher, for five minutes. While each song was presented, the seconds of engagement in stereotyped vocalizations for each participant were recorded. For VB, the following songs were presented: 1. "Seu Lobato" – Turminha Paraíso; 2. "Song of Numbers" – Little Baby Bum and 3. "The Rooster and the Paw" – El Reino Infantil. The song in which there were fewer stereotypes chosen for his intervention was "Seu Lobato". For LA, the songs were: 1. "Fica" – by Anavitória; 2. "Que Bela Sopa" – by Adriana Calcanhotto and 3. "Good Morning" – by Bita. The song in which there were fewer stereotypes chosen for his intervention was "Que Bela Sopa".

Calculation of Intervals Between Stereotypies. This stage occurred simultaneously with the baseline described below and aimed to record the rates of vocal stereotypies in the free condition, where the child had toys available. Three initial sessions were conducted for each participant. The intervals between stereotypies were recorded for each participant. These intervals were used to plan how often NCM would be presented. Subsequently, these intervals were used to calculate an average as follows: Mean interval between stereotypies = Sum of intervals between stereotypies divided by the total number of intervals (results in Table 1).

Table 1
Mean interval between the end of one stereotypy and the beginning of another for each participant.

	Mean interval between stereotypies (in seconds)	
	VB	**LA**
Session 1	12.2	3.6
Session 2	8.1	6.8
Session 3	3.8	6.07
Overall Mean	8.03	5.49

Baseline (BL). These sessions aimed to record the frequency of vocal stereotypies in natural conditions before the introduction of the intervention. There were no consequences or instructions planned for vocal stereotypies. In some sessions, the researcher made requests to the participants (to put away objects, to remove small objects from their mouths or to get out of the window to ensure their safety) or gave support to carry out some activities (bringing puzzle pieces closer together and pointing to some pieces). Several toys already belonging to the participants were available, for free access. Each session lasted approximately 10 minutes.

NCM + MDRO intervention. In NCM, the most preferred song was played for 20 seconds at intervals identified between the stereotypes according to Table 1 throughout the session. The 20-second period corresponds to the maximum time that both participants spent without exhibiting stereotypy during baseline. For example, VB exhibited a stereotypy every 8.03 seconds on average, so the song was started every 8 seconds and played for 20 seconds in a row (NCM). However, if the child exhibited vocal stereotypy for more than 2 seconds during this 8-second pause, the song was not played, and the 8-second interval was restarted (MDRO). There were no planned instructions given to the participants during these sessions. In some cases, the researcher made requests to the participants (such as putting away objects, moving away from the window, ensuring safety) or provided support for certain activities. The same toys available during baseline were also available in this condition. Each session lasted approximately 10 minutes.

Data Recording. Two types of records were used: (i) partial intervals of 10 seconds and (ii) engagement time in stereotypies. In the partial interval record, if vocal stereotypy occurred at any point during the 10-second interval, a "+" was noted in the corresponding space on the datasheet. An interval of 2 seconds without engaging in these responses was considered the criterion for recognizing the end of one stereotype and the beginning of another. In order to record the time spent engaging in stereotypies, a timer was used to record the time the participant remained in vocal stereotypies: the timer was started when the child exhibited the target response and paused if they engaged in a different behavior.

Reliability Calculation and Interobserver Agreement (IOA). In order to ensure data reliability, interobserver agreement testing was performed on 46.6% of the video records (50% of the Functional Analysis videos, 50% of the baseline videos, and 40% of the NCM+MDRO). IOA was obtained by dividing the number of agreements by the sum of the number of agreements plus disagreements and multiplying this result by 100 (Saylor *et al.*, 2012). The second observer was a researcher from the same academic environment, pre-trained in recording. The researcher guaranteed total

confidentiality about the participants' information, and the observer had access only to the video application material for registration. For VB, the overall agreement was 87.01%, with 94.43% for functional assessment (Attention = 85%; Control 1 = 98.3%; Control 2 = 100%), 75.8% for baseline (BL1 = 68.3%; BL3 = 83.3%), and 90.8% for NCM+MDRO (NCM+MDRO2 = 96.6%; NCM+MDRO3 = 85%). For LA, the overall agreement was 79.53%, with 89.43% for Functional Assessment (Control 3 = 88.3%; Alone = 90%; Demand = 90%), 94.16% for baseline (BL1 = 93.3%; BL2 = 95%), and 55% for NCM+MDRO (NCM+MDRO3 = 55%, NCM+MDRO4 = 55%). The lower agreement for LA in the intervention sessions is due to records of his vocalizations as stereotypy made by the second observer based on the recordings, which the researcher, present at the experimental setting, identified as the participant repeating parts of a song (LA was singing).

RESULTS

The results of the Functional Analysis performed for VB and LA can be seen in Figure 1 (the black bars represent VB's data, and the gray ones represent LA's data). VB had higher levels of vocal stereotypies in the free condition (43%) and in the demand condition (26%). LA demonstrated a different pattern, with stereotypies appearing in all conditions, ranging from 26 to 73% of the time. These data suggest that vocal stereotypies were maintained by automatic reinforcement, considering that VB presented more behaviors in the free condition and that LA presented the behaviors in all conditions.

Figure 2 shows the percentages of the intervals, in seconds, of VB's (upper panel) and LA's (lower panel) engagement in vocal stereotypies in baseline and intervention

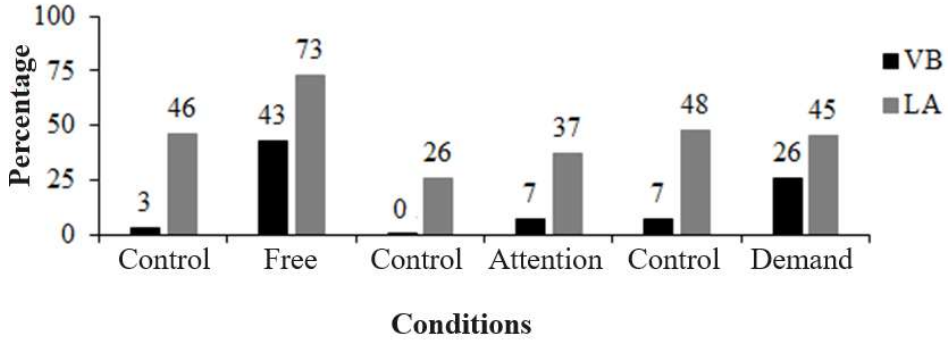

Figure 1. *Percentage of vocal stereotypies in each condition of the Functional Analysis for VB and LA.*

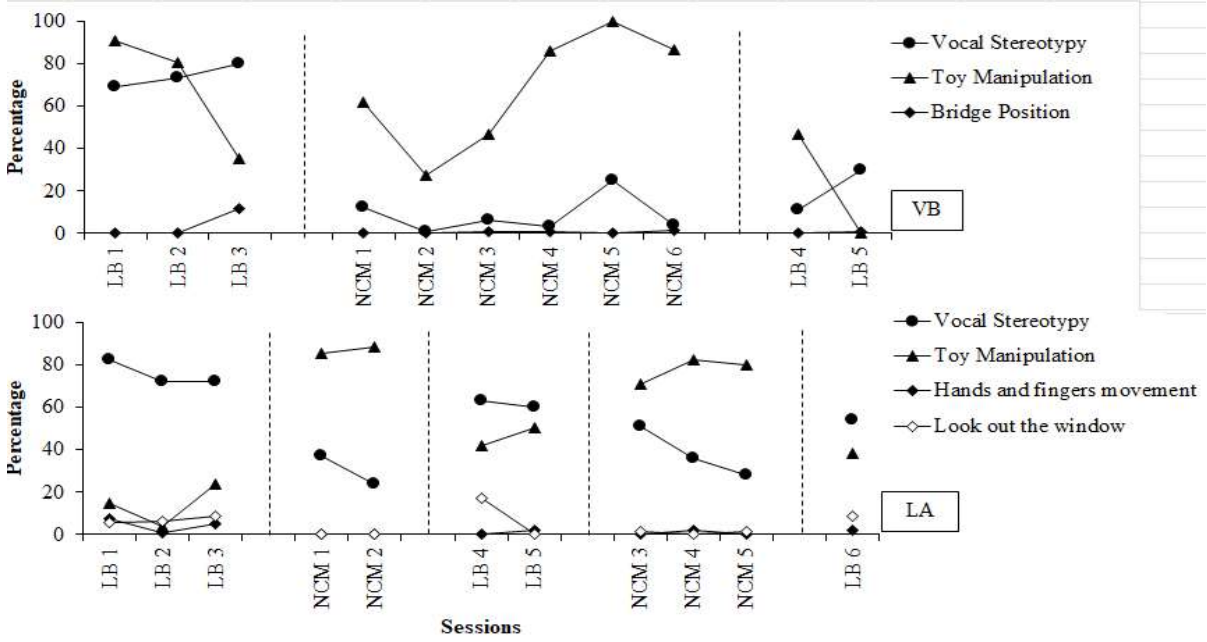

Figure 2. *Percentages of the intervals recorded in seconds, from each session in which VB (top panel) and LA (bottom panel) were engaged in vocal stereotypies or other behaviors.*

sessions, in the sequence they were applied. Other behaviors presented by the participants throughout the experimental conditions are also shown. In general, for both participants, the results indicate a reduction in the time of engagement in vocal stereotypies in the intervention sessions and an increase in returns to baseline. At the same time, appropriate toy-handling behavior increased during intervention sessions and decreased at returns to baseline. Other repetitive behaviors recorded did not show significant changes in engagement time throughout the sessions.

Figure 3 presents the absolute data of the time interval, in minutes, of VB (upper panel) and LA (lower panel) with and without vocal stereotypies. Again, the absolute data indicate that the engagement time in vocal stereotypies is shorter in the intervention sessions.

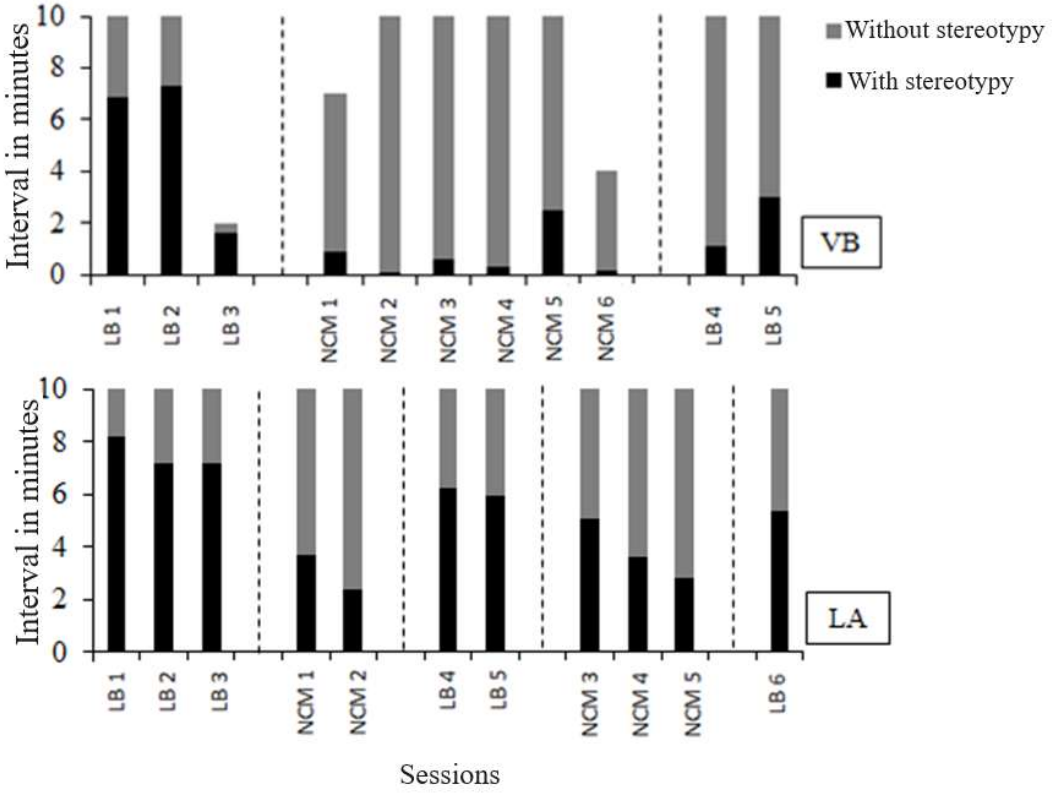

Figure 3. *Intervals, in minutes, of each session in which VB (top panel) and LA (bottom panel) were or were not engaged in vocal stereotypies.*

DISCUSSION

The objective of this research was to verify the effects of an NCM procedure in conjunction with an MDRO procedure on the frequency of vocal stereotypies in children with ASD. The results indicate that the procedure was effective in reducing the frequency of vocal stereotypies in two boys with ASD and the emergence of other inappropriate or stereotyped behaviors was not observed.

These results corroborate other research indicating that vocal stereotypies are maintained by reinforcing auditory consequences (Gibbs *et al.*, 2018; Lanovaz *et al.*, 2012; Saylor *et al.*, 2012). These stereotypies may be a response maintained by the auditory stimulus coming from the vocal response itself (automatic reinforcement). However, it is worth noting that in the present study, unlike the studies cited, an experimental functional analysis was conducted. Instead of providing the music uninterruptedly, an average of the intervals between stereotypies was used to provide NCM, allowing for more precise identification of causal relations.

According to this hypothesis, NCM provided generates an abolishing operation (Michael, 2000) for the emission of these responses, while it becomes the source of auditory stimulation reinforcing for the individual. The auditory stimulation made possible by the procedure may functionally correspond to the ones generated by vocal stereotypies, replacing them.

In addition to the reduction of vocal stereotypies, an increase in play behaviors was also observed in the intervention sessions. These data are in line with what Liu-Gitz and Banda (2010) and Wunderlich and Vollmer (2015) proposed That is, vocal stereotypy can make it difficult to

maintain behaviors expected for a given age group, such as play responses in children. Such data also corroborate those found by Gibbs *et al.* (2018), who indicated that, in situations of NCM implementation, the time of engagement in tasks increased while vocal stereotypies decreased.

These results illustrate how people who present decontextualized vocal responses can have the quality of their teaching-learning processes influenced by constancy (time spent) in these vocalizations. In addition, as evidenced by Gibbs *et al.* (2018), this may be further evidence that music helps reduce vocal stereotypies, leading to the installation or increased frequency of other alternative or incompatible behaviors. On the other hand, these data are in line with the results discussed by Ahearn *et al.* (2003), according to which during the manipulation of preferred objects, some stereotypies momentarily decrease and increase with the removal of these reinforcers.

The other repetitive behaviors recorded for the two participants, as well as vocal stereotypies, were, on average, more frequent during the baseline sessions than in the intervention sessions, suggesting that the intervention may have also been a variable that controlled the decrease in the frequency of these other repetitive behaviors. For these data, some hypotheses would be: (i) for the participants of this study, repetitive motor and vocal behaviors possibly belong to the same class of responses, that is, they are maintained by auto-stimulatory functions; (ii) motor behaviors may have decreased in frequency due to incompatibility with the behavior of playing, which increased in frequency in intervention sessions; (iii) repetitive motor behaviors may have decreased in frequency, as vocal stereotypy may be paired with the emission of repetitive non-vocal responses; (iv) all these behaviors serve as self-regulatory and, as they did not happen concomitantly, the presentation of the song was sufficient to self-regulate the organism as a whole; and (v) vocal stereotypy could have been established as a discriminative stimulus for the emission of motor responses, in a kind of behavioral chain (Sturmey, 1996) and, as this discriminative stimulus decreased its constancy, the frequency of movements also decreased.

The results also indicate that the frequencies of vocal stereotypies in the baseline return are lower than those of the initial baselines. This information suggests a prolonged effect of this reduction in vocal stereotypies, even after withdrawal of the intervention. This hypothesis would need to be tested with a larger volume of sessions and data, as it differs from the findings of Marcus and Vollmer (1996) , according to which the non-contingent reinforcement procedure generally loses effectiveness over time.

In addition, for both participants, at baseline returns, there was an increase in stereotypy levels. Possibly, in these intervention withdrawal conditions, stereotypies once again became the only resource for producing the necessary auditory stimulation, leading to an increase in frequency. These data support the hypothesis that responses maintained by auditory automatic reinforcement can decrease in frequency through musical stimulation (Gibbs *et al.*, 2018; Lanovaz *et al.*, 2012; Saylor *et al.*, 2012) and the auto-stimulatory function of vocal stereotypies (Cooper *et al.*, 2014). The hypotheses constructed from the data of the functional analysis states that the vocal stereotypies of the participants in this study were maintained by automatic reinforcement (self-stimulation). It can be inferred, therefore, that such hypotheses were sufficient to guarantee the effectiveness of the intervention.

It is important to highlight that research arguing that music presented at moments diverging from vocal stereotypies can reduce such responses differs from the method used in this research in an important aspect. Research such as that of Lanovaz *et al.* (2012), Saylor *et al.* (2012), and Gibbs *et al.* (2018) used the NCM procedure uninterruptedly in their experimental conditions. As described by Vollmer *et al.* (1997), there is a risk of accidental reinforcement of unwanted behaviors when performing a non-contingent reinforcement procedure. In addition, listening to music constantly could directly interfere with the motivating operations (Michael, 2000) in place, causing satiation (Marcus & Vollmer, 1996) of the music, which could enable the reappearance of vocal stereotypy at a high frequency. Because of this possibility of accidental reinforcement, as described by Vollmer *et al.* (1997), in this study we used an individual average of time in which the participants produced vocal stereotypies. In this medium range, MDRO was implemented, which avoided the accidental reinforcement of unwanted responses.

Despite the promising data found in this study, some limitations were identified. One of them is the use of the mean of the intervals between stereotypies for the presentation scheme of NCM+MDRO procedure. After data collection, it was noticed that the longer intervals between stereotypies strongly influenced this mean, raising the question of whether the mean was the most appropriate statistical measure for the procedure. Perhaps using the median as a defining measure of time for NCM+MDRO presentation could further reduce participants' vocal stereotypies, as shorter intervals between vocal stereotypies were more frequent during the initial baseline.

Another limitation of this study is that it did not have the stability of the baseline data and the intervention to change the experimental phase. Additionally, the study did not complete the data collection in the intervention phase for both participants, and there was no return to the intervention phase for VB. The researcher's intention, when suddenly removing the procedure, was to verify whether the levels of vocal stereotypies were maintained. However, due to the Covid-19 pandemic, it was not possible to proceed with the collections with greater methodological rigor, as expected from a reversal experimental design (Gast & Hammond, 2010).

As a suggestion for future studies, it is recommended to plan a functional analysis with more steps to investigate hypotheses regarding the functions of stereotyped

vocalizations and other behaviors affected by the intervention. Another suggestion is to teach an alternative response to vocal stereotypies alongside procedures like NCM and MDRO to reduce these behaviors. The child could be taught to request to listen to music or preferred auditory stimuli without resorting to stereotyped vocalizations. Additionally, it is important to assess the potential adverse effects of using NCM in vocal stereotypies, such as accidentally reinforcing unwanted behaviors. This could be achieved by recording these unwanted responses, including vocal stereotypy, only with NCM (without MDRO) to determine if the introduction of NCM leads to an increase in unwanted behaviors and if subsequent implementation of MDRO reduces them.

Finally, it would be important to include new phases of intervention in which the interval of song presentation gradually increases, keeping the frequency of stereotypes low. This would result in savings in reinforcers and effort in the application of the procedure.

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Conflict of interest
The authors have no conflicts of interest to declare.

Data availability statement
The data supporting the findings of this study can be requested from the corresponding author upon reasonable request

Ethics Statement
All procedures performed in this study were in accordance with the ethical standards of the institutional research committee. Approval was obtained by the Comitê de Ética em Pesquisa em Seres Humanos – Universidade Federal de São Carlos (number: 3.636.732). Informed consent was obtained from the parents of the children included in the study.

Author contributions
All authors contributed to the study conception and design. Material preparation and data collection were performed by the first author. Data analyses were performed by both authors. The first draft of the manuscript was written by the first author and revised by the second. Both authors read and approved the final manuscript.

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