

Evaluation of Sound Enrichment in the Behavior of *Sapajus xanthosternos* (Wied-Neuwied, 1826) (Primates: Cebidae) in Captivity

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Abstract: Techniques of environmental enrichment are used to ameliorate stress that captivity imposes on animals. They consist of modifications to the captive environment aiming to benefit the animals there present, providing for activities that are closer to their natural behavior, minimizing the occurrence of abnormal behaviors, expanding the behavioral repertoire, increasing positive exploration, and increasing their capacity to deal with the challenges the environment imposes. This study applied a sensory enrichment technique as a resource for improving conditions of captivity, verifying the influence of sound enrichment with classical music on the behavioral display of yellow-breasted capuchins, *Sapajus xanthosternos*, being kept in the Wild Animal Screening Center in Vitória da Conquista, Bahia, Brazil. We recorded their behavior at three stages—pre-enrichment, enrichment and post-enrichment—using all occurrences and focal animals. Behavioral displacement, interaction with ordinary items, feeding, threatening, escape, standing idle, stereotypical movement, and tail manipulation were most commonly recorded in the pre-enrichment stage, decreasing progressively during the enrichment and post-enrichment stages. The behaviors of running away, standing idle and stereotypic movements showed significant differences. The use of sound enrichment was correlated with a reduction in behaviors of rest, escape and stereotyped behaviors, suggesting that they spent more time in other activities such as foraging, and also in an increased behavioral repertoire, including sexual behavior. The application of new techniques of sensory enrichment, such as auditory stimulation is indicated as an alternative environmental enrichment. The present study showed that classical music had an anxiolytic effect, reducing behaviors associated with stress, and as such measurably improving behavioral conditions in captivity. This form of enrichment is easily combined with other enrichment techniques to improve the behavioral and social environment of captive primates.

Key words: Classical music, non-human primates, sensory enrichment.

Resumo: Devido aos fatores de estresse que o cativeiro impõe aos animais, são sugeridas técnicas de enriquecimento ambiental, que consiste em modificações no ambiente de cativeiro visando o benefício dos animais ali presentes, tornando suas atividades mais próximas do comportamento natural, minimizando a ocorrência de comportamentos anormais, ampliando o repertório comportamental, a exploração positiva do ambiente e a capacidade de lidar com os desafios impostos. Este estudo aplicou a técnica de enriquecimento sensorial como recurso estratégico para a melhoria das condições de cativeiro, com o intuito de verificar influência do enriquecimento sonoro com utilização de música clássica na exibição comportamental de *Sapajus xanthosternos* Wied-Neuwied, 1826, mantido em um Centro de Triagem de Animais Silvestres em Vitória da Conquista (Bahia, Brazil). A observação comportamental foi realizada em três etapas (pré-enriquecimento, enriquecimento e pós-enriquecimento) através do método de amostragem de todas as ocorrências (*ad libitum*) e animal focal. Os comportamentos deslocamento, interação com itens ordinários, consumir item da dieta, ameaçar, fugir, parado inativo, movimento viciado e manipular o rabo foram mais expressos pelos macacos-prego na fase de pré-enriquecimento, diminuindo progressivamente nas fases enriquecimento e pós-enriquecimento. Mas apenas os comportamentos de fugir, parado inativo e movimento viciado apresentaram diferença significativa. A utilização do enriquecimento sonoro mostrou redução em comportamentos de descanso, de fuga e em comportamentos estereotipados, sugerindo que houve maior aproveitamento do tempo para desempenhar outras atividades comportamentais, como a de forrageamento, e ainda aumento do repertório comportamental, com o comportamento sexual de demonstração. A aplicação de novas técnicas de enriquecimento sensorial, como a estimulação auditiva

mostra-se como uma alternativa de enriquecimento ambiental, no qual o presente estudo evidenciou que a música clássica demonstrou efeito ansiolítico, reduzindo comportamentos sugestivos de estresse, contribuindo para as condições comportamentais de animais em cativeiro, podendo também ser usado em associações com outras técnicas de enriquecimento para a melhoria das condições comportamentais de animais cativos.

Palavras-chaves: Enriquecimento sensorial, música clássica, primatas não humanos.

Introduction

The yellow-breasted, or buff-headed capuchin, *Sapajus xanthosternos*, is endemic to Brazil, occurring in the Atlantic Forest and dry forest and scrub in the states of Bahia, Minas Gerais and Sergipe. It is categorized as Critically Endangered on the IUCN Red List of Threatened Species, due largely to habitat loss and hunting (Canale *et al.* 2021), besides illegal wild-animal trafficking for pets which, through the removal of individuals from nature, leads to the disruption of social groups and to population decline (Levacov *et al.* 2011).

Captive monkeys apprehended by the competent authorities or by the public are sent to Wild Animal Screening Centers (CETAS) where they stay until permanent housing can be found (Brazil, MMA, ICMBio 2015). Usually, the captive environments do not offer opportunities that allow the interaction of the animals with the environment, preventing them from developing sensory and cognitive abilities, and even species-specific behaviors (Morgan and Abwe 2006). Abnormal or stereotypical behaviors are defined according to Dantzer (1986) as recurring actions that are fixed in form and orientation, performed for no apparent reason. Usually, they are developed in conditions of physical restriction, fear, frustration, or of reduced stimuli (Mason 1991). Characteristic models of abnormal behaviors exhibited by animals created in captivity are auto-mutilation, walking from one side to the other and shaking the head constantly (Mason and Rushen 2006).

Due to factors of stress that captivity imposes on the animals, techniques of environmental enrichment are suggested, which consist of modifications to the captive environment, aiming to benefit the animals there present, making their activities closer to the natural behavior, minimizing the occurrence of abnormal behaviors, increasing the behavioral repertoire, increasing positive exploration of the environment and magnifying the capacity to deal with the challenges imposed by the environment (Gaspar 1993; Young 2003).

Techniques of sensory enrichment are being widely used to exercise the functioning of one or more of the senses (Wells 2009). In sensory enrichment, auditory stimulation has been used as an enrichment tool for animals in captivity considering the recognition of the benefits for human well-being. The behavioral implications (physiological and psychological) of the use of classical music were reported by

Gvaryahu *et al.* (1989), Sousou (1997), Uetake *et al.* (1997), Yalch and Spangenberg (2000), Papoutsoglou *et al.* (2007), Kogan *et al.* (2012) and Papoutsoglou *et al.* (2013). They showed that, following the sonorous intervention, there were notable expressions of well-being besides a reduction of behaviors indicative of stress.

The use of the sonorous enrichment technique using classical music for non-human primates has been examined in chimpanzees, *Pan troglodytes*, where the results indicated that the music reduced agitated, aggressive behavior, and solitary exploration, and increased social exploration and behavior (Howell *et al.* 2003). In a study with the western lowland gorilla, *Gorilla gorilla gorilla*, their exposure to classical music was accompanied by a drop in aggressive and abnormal behaviors and an increase of behaviors indicative of relaxation (Wells *et al.* 2006).

In this study, we examine the effect of sound enrichment on the behavior of *S. xanthosternos* held in the Wild Animal Screening Center (CETAS), victims of animal trafficking, at Vitória da Conquista, Bahia, Brazil. Considering the findings mentioned above, we expected that: (i) there would be a decrease in stereotypical behaviors and (ii) a decrease in aggressive behaviors.

Methods

Study animals

The study was carried out at the Wild Animal Screening Center (CETAS), in the Periperi Serra Municipal Park, in the city of Vitória da Conquista, Bahia, Brazil. We studied the behavior of seven capuchins, all *S. xanthosternos*—four adult males and three adult females—each easily identified by their appearance and their morphological features.

These seven individuals were grouped into one trio and two pairs, which were distributed in three similar enclosures, each with (i) an inner section for protection against inclement weather (1.85 m in length by 1.55 m in width and 2.16 m in height), and (ii) two external areas (each 1.0 m high by 1.05 m wide and 2.05 m long), one on each side of the internal compartment of the enclosure, so that the animals could get some sun. These “open” areas were screened and protected (Fig. 1). The three enclosures were located next to each other (Fig. 2). Each enclosure had a drinking fountain. Their diet was composed of fruits (apple, banana, cucumber), peanuts, and tubers (cassava and sweet potato). Food was provided once a day, in the morning.

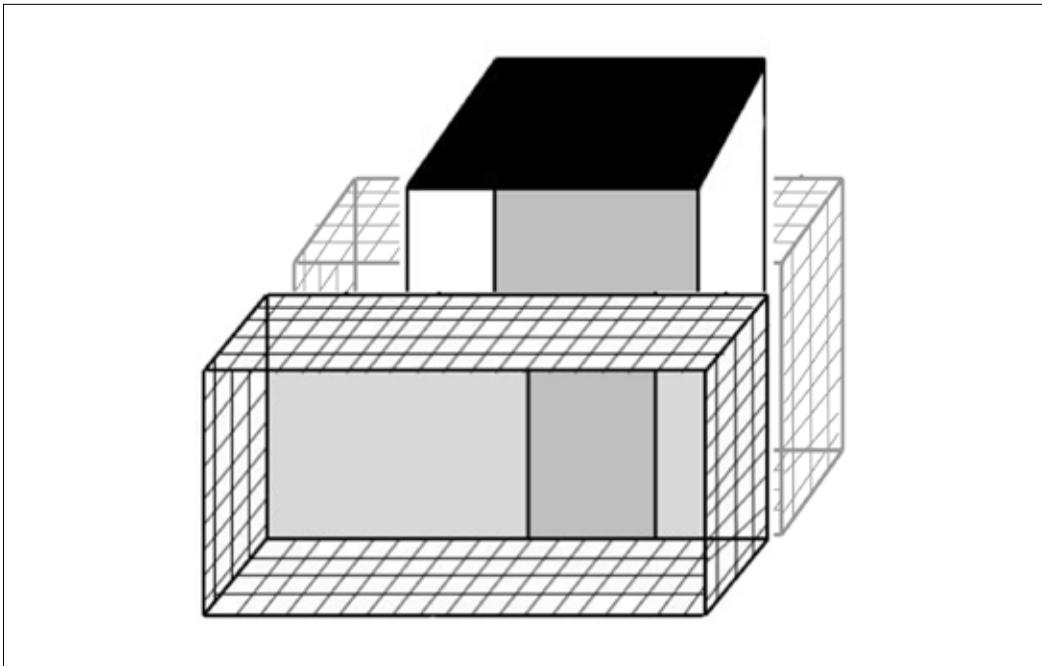


Figure 1. Schematic drawing of one of the three enclosures where the capuchin monkeys were housed. Each enclosure consisted of an internal area to protect them from the weather and two external areas, one on each side of the inner area, shielded on all sides for sunbathing.

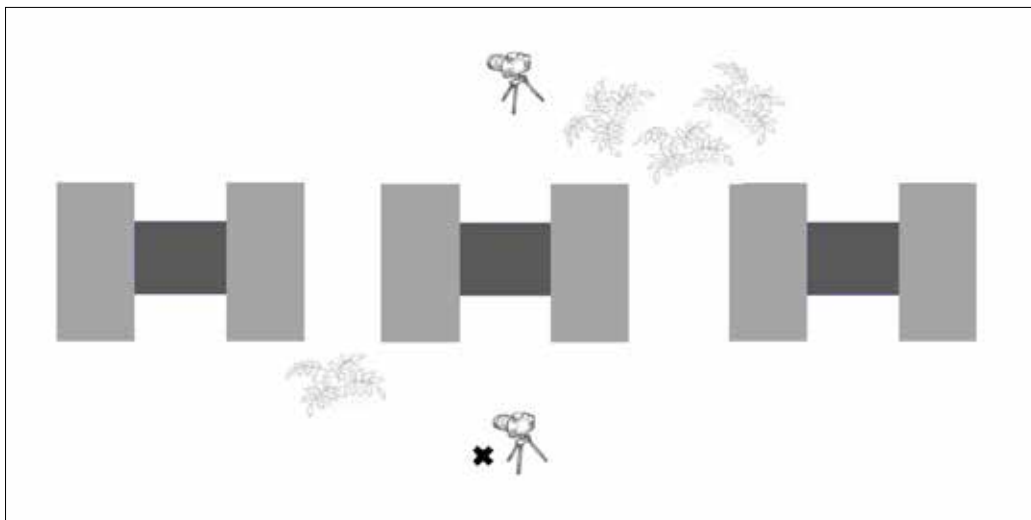


Figure 2. Schematic drawing of the layout of the three enclosures where the seven capuchin monkeys were allocated during the behavioral observations. In the drawing, the three enclosures are represented by three H-shaped sets, the cameras at the front and back of the enclosures show the location of the two video devices used for recording and the black X, approximately at the bottom center of the figure, represents the location of the sound device during the enrichment phase.

Study design and overview

Behavioral information was collected recording “all occurrences” besides focal animal sampling (Altmann 1974). Initially the list of behaviors (ethogram) of the study group was drawn up using all occurrences during 32 h of observation in morning and afternoon shifts (3 h per shift). The ethological terms and the structure of the ethogram were based on those already existing for other non-human primates (Carosi and Visalberghi 2002; Albuquerque

and Codenotti 2006; Mendonça-Furtado 2006; Santos and Roberto 2009; Coutinho 2012; Back 2015), with adjustments for the behavioral activity patterns observed specifically in *S. xanthosternos* in captivity during this prior evaluation (Table 1).

The environmental enrichment technique used was auditory stimulation, using only one song, the String Quartet number 1 in G major (K.80 / 73f), by Wolfgang Amadeus Mozart, as was used by Dávila *et al.* (2011). The device

Table 1. Definition of the behaviors performed by *Sapajus xanthosternos* in captivity, grouped by behavioral category. *Coutinho (2012), **Albuquerque and Codenotti (2006), ***Santos (2009) ****Mendonça-Furtado (2006), *****Carosi and Visalberghi (2002) and Back (2015).

BEHAVIOR	ACRONYM	DESCRIPTION
LOCOMOTION	MV	Movement at the moment of record*
Movement	MVJ	Walking, running, jumping or climbing through the perch*
EXPLORATION	EX	Searching, capturing and/or manipulating items available in the enclosure*
Foraging in the Enclosure	FOR	Active search of alimentary items spread through the enclosure*
Interaction with Ordinary Items	MAO	Touching, hitting and/or transporting any object located in the enclosure*
FEEDING	FE	Tearing, chewing and ingesting alimentary resources*
Consuming Diet Items	CDI	Ingesting offered daily feeding items*
AFFILIATIVE INTERACTION	IN	Way of maintaining and establishing social relation*
Grooming	GRP	Investigation and removal of ectoparasites. Active and passive*
AGONISTIC INTERACTION	IN	Aggressive social behaviors in or out of the group*
Threatening	THR	Showing teeth, raising body and tail, vocalizing, shaking grille and/or similar attack*
Fleeing	FLE	Before danger, the animal moves away, running under pressure and threats from other(s)**
MAINTENANCE	KP	Execution or not of an action without showing movement*
Active Stationary	TST	Staying still, occupying with self-grooming, scratching, drinking water, defecating or urinating*
Inactive Stationary	IST	Staying still, with eyes open or closed, without doing any observable activity*
STEREOTYPIES	SE	Repetitive movements executed by the animal, without any apparent function***
Addicted Movement	CAM	Repeated movement through the same path, may begging slow and increase and rhythm and/or body balance. Including turning the head*, ****
Manipulating the Tail	MPT	Chasing, enrolling over the body or pulling the tail between the legs*****
SEXUAL	SX	Sexual behavior between members*****
Display	DEM	Individual performs friction in the chest region with one hand and the other extended in the genital region, moving the body from one side to the other*****

*Coutinho (2012), **Albuquerque and Codenotti (2006), ***Santos (2009) ****Mendonça-Furtado (2006), *****Carosi and Visalberghi (2002) and Back (2015).

used in the experiment was a Bowers & Wilkins® speaker, model B&W A5, which has: (i) a minimum frequency of 47 Hz and maximum of 22000 Hz; (ii) 4 drivers of 100 mm each and (iii) 4 × 20W of audio. During enrichment, the volume was maintained at the maximum, with the device 2 m away from the pond. The capuchins had free access to the internal concrete area of the enclosure, where they could stay in a quieter place if they wished. The speaker was camouflaged with leaves from the vegetation surrounding the enclosures, hidden so as to make only the music the object of their attention.

Their behavior was recorded at three stages: (i) before playing the music (pre-enrichment phase, lasting 4 days), (ii) when playing the music (enrichment phase, lasting 5 days); and (iii) when the music was no longer played

(post-enrichment phase, lasting 4 days). There was an interval of two days between each phase. We recorded their behavior twice a day, in the morning and in the afternoon. We used two digital cameras (Canon® T5i 18:55), one in front and one behind the cages, which were able to simultaneously record all three enclosures (Fig. 2), and later transcribed the results onto check sheets. In the enrichment phase, the music was played continuously throughout the recording sessions. Using recorded video, for focal animal sampling, each of the seven capuchin monkeys was observed in 10 periods, five in the morning shift and five in the afternoon shift, lasting five minutes each, with a one-minute interval between each observation period, so in total each animal was observed for 50 minutes per day, totaling 5 hours and 50 minutes of observation per day.

The pre-enrichment and post-enrichment phases each had a duration of 23 hours and 20 minutes, and the enrichment phase lasted 29 hours and 10 minutes, making for 52 hours and 30 minutes of behavioral observation.

Statistical data analysis

The normality of the data was evaluated through the Shapiro-Wilk Test. As they did not present a normal distribution, the frequencies of the behaviors were compared between the three steps of the study using the non-parametric Friedman test, with post-hoc Dunn's. A significance level of 95% ($p \leq 0,05$) was considered for all the tests.

Results

Moving around, interacting with ordinary items, eating, threatening, sitting still stationary, stereotyped movements and manipulating the tail were all expressed more strongly by the capuchin monkeys in the pre-enrichment phase, decreasing during the following phases (Table 2). Foraging in the enclosure and active stationary were expressed more during the sound enrichment phase, decreasing in the post-enrichment phase. This same pattern was observed for display behavior, which was expressed more during the sound enrichment (Table 2).

The frequency of stereotypic behaviors declined significantly over the three phases, it being highest during the pre-enrichment phase, and declining in the enrichment and post-enrichment phases (Table 2). Two individuals (a male and a female) stood out in showing accentuated exhibitions of stereotypical behavior in the pre-enrichment phase which decreased consistently with the music, reaching its minimum in the post-enrichment phase (Fig. 3).

The behaviors flee and inactive stationary also showed significant statistical differences (Table 2). The rates of these behaviors were significantly higher in the pre-enrichment phase, decreasing significantly only in post-enrichment (Fig. 3). Fleeing was notable in an evidently subordinate individual, who responded to any threat by running away, preventing him from even eating—behavior that was much less frequent in the subsequent phases. Sexual displays and behavior were exhibited only during the sound enrichment phase, extending to the post-enrichment phase (Fig. 3).

Discussion

Listening to classical music, in this case to Mozart's String Quartet number 1 in G major, K.80 / 73f, reduced the incidence of stereotyped behaviors. Repetitive movements differed significantly. This demonstrates the effectiveness of sound enrichment for animal welfare resulting from the harmonic vibratory frequencies (Areias 2016).

Other studies also show that music improves well-being. In humans, music causes an anxiolytic effect (Zatorre 2005), stimulates brain cells, increases the level of serotonin and improves mood or disposition (Areias 2016), reduces negative emotional states and stress (Bernardi *et al.* 2006; Labbé *et al.* 2007; Todres 2006) and minimizes anxiety and pain (Chan *et al.* 2003).

Based on the effects observed in humans, it is suggested that they are also present in non-human primates as these also present serotonin production and have anatomical, physiological, endocrinological and behavioral similarities with humans (King *et al.* 1988; Barros *et al.* 2003; Santos and Hughes 2009; Wellman and Brandone, 2009; Quinsani 2014; Almeida *et al.* 2015; Marsh and Legerstee 2015).

Table 2. Mean \pm standard error of the number of behavioral records and results of the Friedman tests for the behaviors exhibited by the robust capuchin monkeys (*Sapajus xanthosternos*) in captivity during the three phases of the study (pre-enrichment, enrichment and post-enrichment).

Behavior	Phases			F	p-value
	Pre-enrichment	Enrichment	Post-enrichment		
MVJ	12.84 \pm 2.66	8.82 \pm 1.5	8.05 \pm 1.4	5.43	0.08
FOR	3.32 \pm 1.34	4.29 \pm 1.2	2.68 \pm 0.9	2.00	0.49
MAO	1.73 \pm 0.98	1.61 \pm 1.01	2 \pm 1.33	0.96	0.62
CDI	6.86 \pm 2.6	6.09 \pm 2	5.71 \pm 1.5	0.67	0.77
GRP	0.23 \pm 0.3	0.34 \pm 0.4	0.25 \pm 0.3	0.61	0.77
THR	0.43 \pm 0.4	0.39 \pm 0.33	0.27 \pm 0.24	0.57	0.77
FLE	2.95 \pm 2.4 ^{ab}	0.75 \pm 0.5	0.20 \pm 0.2 ^b	9.33	<0.01*
TST	7.75 \pm 2	7.77 \pm 2	6.25 \pm 1.7	3.70	0.20
IST	5.57 \pm 1.71 ^{ab}	1.73 \pm 0.8	0.79 \pm 0.5 ^a	13.00	<0.01*
CAM	70.82 \pm 42.85 ^{ab}	29.48 \pm 19.88 ^b	29.48 \pm 19.88 ^b	9.82	<0.01*
MPT	1.93 \pm 1.79	0.50 \pm 0.56	0.50 \pm 0.56	4.00	0.11
DEM	-	0.11 \pm 0.19	0.11 \pm 0.19	3.20	0.24

F = Friedman Test; * = Significant values. Superscript letters = significantly different according to Dunn's *post hoc* test.

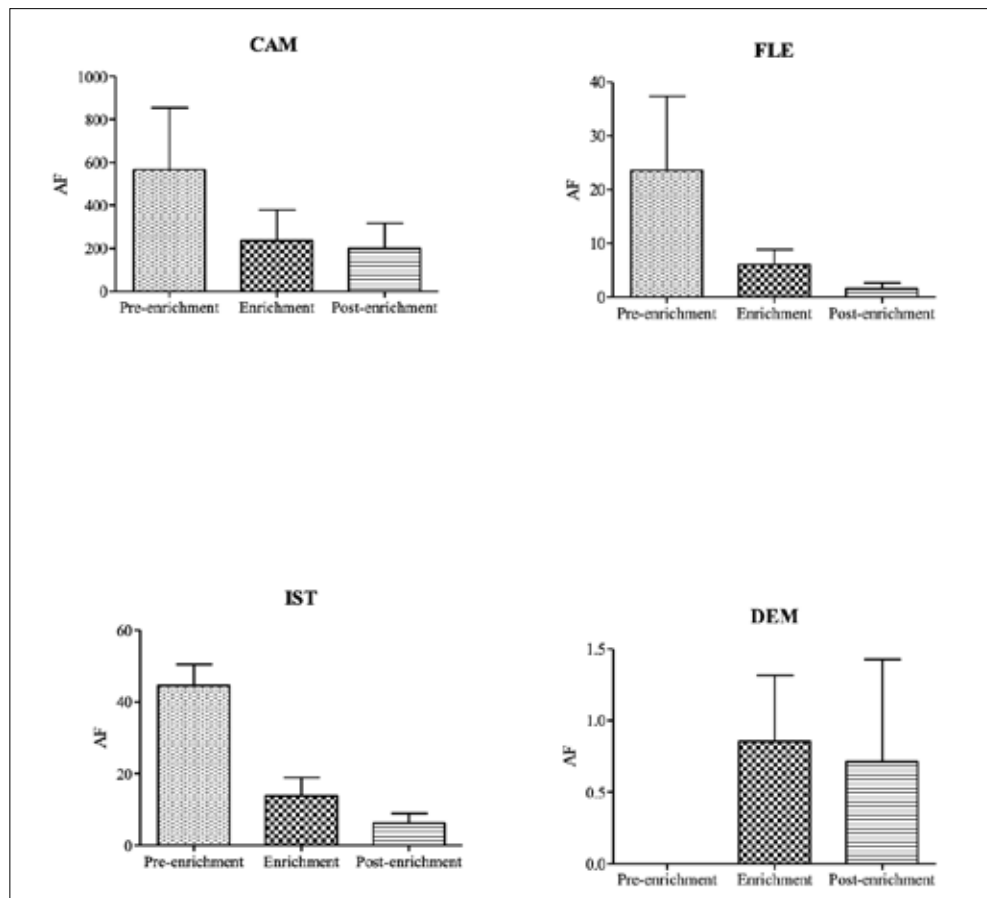


Figure 3. Four behaviors of *Sapajus xanthosternos* that differ in frequency the pre-enrichment, enrichment and post-enrichment phases. AF= Absolute Frequency; CAM= Stereotypical behavior; FLE= Flee; IST= Inactive Stationary; DEM= Sexual display.

Sound enrichment also made them move about less, probably because classical music predisposes to a condition of tranquility.

Using environmental enrichment (physical and food) for robust tufted capuchins in captivity, Costa *et al.* (2013) found a high frequency of locomotion behavior in the stages without environmental enrichment and physical enrichment. As for food enrichment, possibly due to the interest aroused by individuals in enrichment items, there was a decrease in this type of behavior, similar to that observed in the present study.

Regarding agonistic interactions, the frequency of threats and, consequently, running off, was higher in the pre-enrichment phase, decreasing in the enrichment and post-enrichment phases. Similar results were observed by Coutinho (2012) studying environmental enrichment in capuchin monkeys. These results suggest a greater harmony in the social behavior of these animals.

For maintenance behaviors, it was observed that the activity “active stationary” was more expressive during the enrichment phase. For the “inactive stationary” behavior, the opposite was observed, showing that the auditory intervention may have stimulated the “stopped active” maintenance activity. This indicates the possibility that individuals

began to reduce this inactive behavior as a result of better use of time to perform other behavioral activities. Similar results were observed by Jacobsen *et al.* (2010) in a study of *S. apella* in captivity, where a decrease in inactivity was observed in the presence of enrichment, indicating improved welfare.

Exploratory behaviors (foraging in the enclosure and interaction with ordinary items) did not present a significant statistical difference, however the results obtained show an increase in the frequency of these behaviors in the enrichment and post-enrichment phases. Although food enrichment was not implemented in the present study, there was increased foraging on food falling to the floor of the enclosure. This reveals that there was a stimulus for investigation and exploration (Pinto, 2006).

Studying *S. apella*, Pinto (2006) found that animals in the wild spend a greater part of their time looking for food than consuming it. In the wild, it is more difficult to acquire food compared to the free meals in captivity. The expression of investigation and exploration manifested in the present study for *S. xanthosternos* during auditory interference is more comparable to these behaviors in free-living capuchins. The tendency to investigate things for their maintenance is essential. This may mean that music can improve

the adaptation of these animals in a possible reintroduction into nature.

Feeding was preeminent in the pre-enrichment phase. They ate less in the enrichment phase. Excessive consumption can be an indication of stress (Boere, 2001).

Affiliative interactions consisted only of “grooming” and by just a few individuals (two males), sporadically. Statistically significant differences were lacking in the enrichment phases. Grooming is the most common social interaction performed by primates (Sussman et al. 2005) and this low frequency of social contact demonstrates an unusual behavior for *Sapajus* sp. (Auricchio 1995). Cutrim (2013) found few grooming and resting events for the same species, which is explained by the fact that capuchin monkeys devote more time and effort to searching for food than to social interaction.

Displays of sexual behavior were not recorded in the pre-enrichment phase but, although infrequent, were manifested in the sound enrichment phase extending into post-enrichment. This behavior was shown by males to courting females. Back (2015), likewise, found few instances of displaying, but in this case by females towards males. We suggest that the display behavior occurred in an affiliative context, as the pairs that exhibited this behavior did not manifest, throughout the study, aggressive behavior among themselves and no other sexual behaviors were observed between these pairs that would sustain the possibility of a sexual context.

Research on sound enrichment with other species of non-human primates, where animals could interact with the equipment and choose between different sounds and silence, has revealed differences in preference between individuals, but in general they tended to choose sounds instead of silence (Piitulainen and Hirskyj-Douglas 2020; Truax and Vonk 2021). We were unable to investigate this aspect, but it would be important to test this individuality for *S. xanthosternos* in the future

We can say that sound enrichment can play an effective role in improving the well-being of *S. xanthosternos* in captivity. It also provides positive stimuli in harmonic behavior between individuals and in their adaptation, increasing their behavioral repertoire. The application of new sensory enrichment techniques, such as auditory stimulation, is an alternative for environmental enrichment that can be used in association with other enrichment techniques to improve the behavioral conditions of captive animals. This technique is a low-cost, easy-to-apply environmental enrichment technique and has no limitations for associations with other types of environmental enrichment. Thus, sound enrichment with classical music is a viable alternative for captivity and for future reintroduction.

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