

Research article

## Music as enrichment for Sumatran orangutans (*Pongo abelii*)

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**Abstract**

Music is commonly employed as auditory enrichment in non-human primate (NHP) facilities under the assumption that music is as enriching for NHPs as it is for humans (Hinds et al. 2007; Lutz and Novak 2005). The purpose of this study was to assess the utility of music as NHP enrichment by exploring musical preference and discriminative ability in three Sumatran orangutans. In Experiment 1, orangutan preference for music vs silence was tested. Following exposure to a sample of music belonging to one of seven musical genres, orangutans were given the choice via touchscreen to continue to listen to the music sample previously played or to listen to silence instead. Results indicated that all three orangutans either preferred silence to music or were indifferent. No preference for any one of the musical genres tested over others was found. In Experiment 2, orangutans' ability to discriminate music from scrambled music was assessed using a touchscreen delivered standard delayed matching-to-sample (DMTS) task. Results indicated that none of the three orangutans could reliably discriminate "music" from "scrambled music". Taken together, results strongly suggest that these orangutans did not experience the musical stimuli as reinforcing and that use of music as enrichment in captive NHP facilities may be more aversive than enriching for some species.

### Introduction

Environmental enrichment is intended to improve captive animal welfare by modifying an animal's environment in a manner that provides stimulation, enhances species-typical behaviour and affords control and choice in daily life (Miller and Mench 2005). Effective enrichment has proven capable of improving activity and biological functioning as well as reducing fearful, aggressive and abnormal behaviours, including stereotypies and inter-conspecific violence (Gvoryahu et al. 1994; Jones et al. 1991; Miller and Mench 2005; Newberry 1995). Captive animal facilities are now incorporating environmental enrichment as a necessary part of animal care (Swaigood 2007). At the same time, environmental enrichment is becoming increasingly relevant for conservationists for whom captive animal welfare is critically important for *ex situ* conservation (e.g. captive breeding programs, relocation, translocation, release into the wild, etc.) (Swaigood 2007).

Empirical support for the utility of environmental enrichment is also growing. A prominent motivational theory concerning

captive animal welfare suggests that sensory deprivation resulting from insufficient quantity and diversity of stimuli in captive environments is a primary culprit in poor welfare outcomes (McPhee and Carlstead 2010; Swaigood 2007). According to this theory, enriching the senses via visual, auditory, olfactory and somatic environmental complexity reduces negative behavioural (e.g. stereotypies, inactivity) and psychological (e.g. anxiety, depression) effects of captivity (McPhee and Carlstead 2010). In application, this theory has translated into substantial and extensive introduction of a variety of sensory stimulation in captive animal environments. Although application of environmental enrichment theory marks an undeniable step forward in captive animal care, it is equally important to investigate whether or not—and in what situations—enrichment is beneficial, through an examination of the *type*, *source* and *target* of sensory stimuli. Cross-species, universally applicable sensory enrichment modes and mechanisms are improbable. What is more likely is that therapeutic sensory stimuli are particular to species at the least, if not subspecies, groups or even individuals.

However, given the number and diversity of animals kept in captivity, empirical investigation of appropriate species-specific environmental enrichment is daunting. Moreover, anthropomorphic bias can also be a factor. Well-intentioned animal keepers may assume that what is therapeutic for humans is equally so for animals. This is particularly true for species that are phylogenetically and physiologically close to humans, such as nonhuman primates (NHPs). An example of this bias is evidenced by the pervasive use of music as auditory enrichment in captive NHP facilities. Music has been assumed to be as enriching for NHPs as it is for humans, despite inconclusive and contradictory empirical findings (Hinds et al. 2007; Lutz and Novak 2005). Moreover, selection of music type is predominantly based on the preferences of human facilitators, despite lack of confirmation that human and NHP music preferences are analogous (Lutz and Novak 2005).

For the most part, NHP music affinity and preference remains largely unexamined, and those studies that have empirically pursued this line of investigation have yielded mixed results (Brent and Weaver 1996; Hayes et al. 2003; Hinds et al. 2007; Lutz and Novak 2005; Masataka 2007; McDermott and Hauser 2010; Mingle et al. 2014; Sugimoto et al. 2010; Trehub 2001). Sugimoto et al. (2010) observed that, similar to human infants, a juvenile, human-raised chimpanzee (*Pan troglodytes*) preferred consonant-patterned music to dissonant-patterned music. However, McDermott and Hauser (2004) found that captive New World monkeys did not demonstrate a significant preference for consonant over dissonant sounds. Although cotton-top tamarins (*Saguinus oedipus*) and common marmosets (*Callithrix jacchus*) have been shown to prefer slow tempo music to fast tempo music, they also appeared to prefer silence to music (McDermott and Hauser 2007). More recently, Mingle et al. (2014) observed that when 16 chimpanzees (*Pan troglodytes*) were exposed to three different types of "world" music, they spent significantly more time within hearing range of West African akan and North Indian raga music than Japanese taiko music or silence. Mingle et al. (2014) suggest that these results in combination with previous research indicating NHP preference for silence over western music, could indicate that NHPs favour non-western musical and acoustic features.

Investigations of the physiological effects of music on NHPs have also generated varied results. Radio music made available to singly housed baboons (*Papio hamadryas* and *Papio hamadryas-anubis* hybrid) significantly lowered heart rate, but had no observable effect on behaviour or blood pressure (Brent and Weaver 1996). However, in another experiment, harp music did not significantly affect nine African green monkeys' (*Chlorocebus sabaeus*), heart rate, blood pressure, respiratory rate, or body temperature (Hinds et al. 2007). Some studies indicate that when given the opportunity, captive NHPs will spontaneously initiate musical sounds (Line et al. 1990; Lutz and Novak 2005; Markowitz and Line 1989; Novak and Drewson 1989; Videan et al. 2007), and that broadcast music appears to decrease aggression and increase affiliative behaviours in chimpanzees (Howell et al. 2003) and rhesus monkeys (Lutz and Novak 2005; Novak and Drewson 1989). However, because so few species have been tested and findings are conflicting, it is difficult to draw conclusions regarding NHP musical preference(s) or the beneficial physiological effects of music on NHPs.

By and large, studies investigating the effects of music on NHPs have employed proximity-based preference assessment or have not allowed participants to control duration of exposure or music type (Howell et al. 2003; Line et al. 1990; Lutz and Novak 2005; Markowitz and Line 1989; Mingle et al. 2014; Videan et al. 2007). Therefore, in this study, participant-controlled procedures were employed to allow participant-control of various aspects of a stimulus during testing (i.e. duration, type, volume, frequency,

etc.). Compared to other methods of animal preference assessment, this approach allows greater confidence in concluding that nonhuman animals "like" one stimulus more than another, as opposed to concluding that they "dislike" one stimulus less than they dislike another (Lamont 2005; see Ritvo and Allison 2014 for discussion of animal preference assessment).

Orangutans are ideal candidates for computer-driven investigation of musical enrichment for captive NHPs. They have colour vision and are motivated to reliably engage with touchscreen-delivered computer programs (Anderson 2012; Tigges 1963; Marsh and MacDonald 2008; Marsh et al. 2011). Furthermore, considering their solitary lifestyle, orangutans have a surprisingly varied vocal repertoire, the most distinctive component of which is the long call. Emitted by mature males, the long call is a vocalisation composed of a series of groans and bellows that is believed to attract mates (Delgado 2006; Ross and Geissmann 2007; Utami Atmoko et al. 2009). This vocalisation may make orangutans more likely to possess positive associations with pronounced and protracted auditory stimuli.

The purpose of this study was to assess orangutans' (a) preferences for both music vs silence, and music genres typically used as enrichment (i.e. radio music), and (b) ability to discriminate musical from non-musical auditory stimuli. Given the varied results of previous investigations of primate music preferences, no hypotheses were made regarding whether participants would prefer music to silence. However, one of the genres selected, Tuva throat singing (TTS: a type of overtone singing that is produced in the throat through the vibration of the vocal chords, false chords, arytenoid cartilages, aryepiglottic folds, and epiglottic root; Behar et al. 2001) not only represents a categorically non-Western musical genre, but both the music and the way it is physically produced resemble orangutan long calls, which are produced via a series of exhalations aided by the inflation of a large throat sac (Van Schaik 2004). We hypothesised that (a) given these similarities, TTS would be preferred over others tested, (b) with the exception of TTS, familiar genres of music (i.e. used as enrichment at the Toronto Zoo) such as classic rock would be preferred over unfamiliar genres (i.e. pop), (c) music broadcast would result in either positive, or no behaviour change, (d) participants would prove capable of discriminating musical from non-musical stimuli.

## Experiment 1

### Method

#### Participants

The study group consisted of three Sumatran orangutans (*Pongo abelli*) housed at the Toronto Zoo: two females (Sekali, 21 years old; Ramai, 28 years old), and one male (Budi, 6 years old). All participants had been regularly exposed to radio music as environmental enrichment since birth and had been trained to use a dowel to operate a touchscreen computer for previous studies investigating visual preference and discrimination (e.g. Marsh and MacDonald 2008; Marsh et al. 2011). Research participation was voluntary and participants were not deprived of food or water during testing.

#### Apparatus and experimental stimuli

Data were collected in orangutan holding areas accessible only to zookeepers and experimenters. Redundant noise was kept to a minimum where possible during testing sessions (e.g. keeper and animal vocalisations, mechanical sounds, etc.), but a moderate level of ambient noise typical of a functioning captive orangutan holding area was unavoidable. Although the orangutans were physically separated from one another, they had some visual and auditory contact through adjoining enclosures, and mother-offspring pairs were not separated during testing. Participants



**Figure 1.** Budi makes music preference choices on a touchscreen interface in Experiment 1.

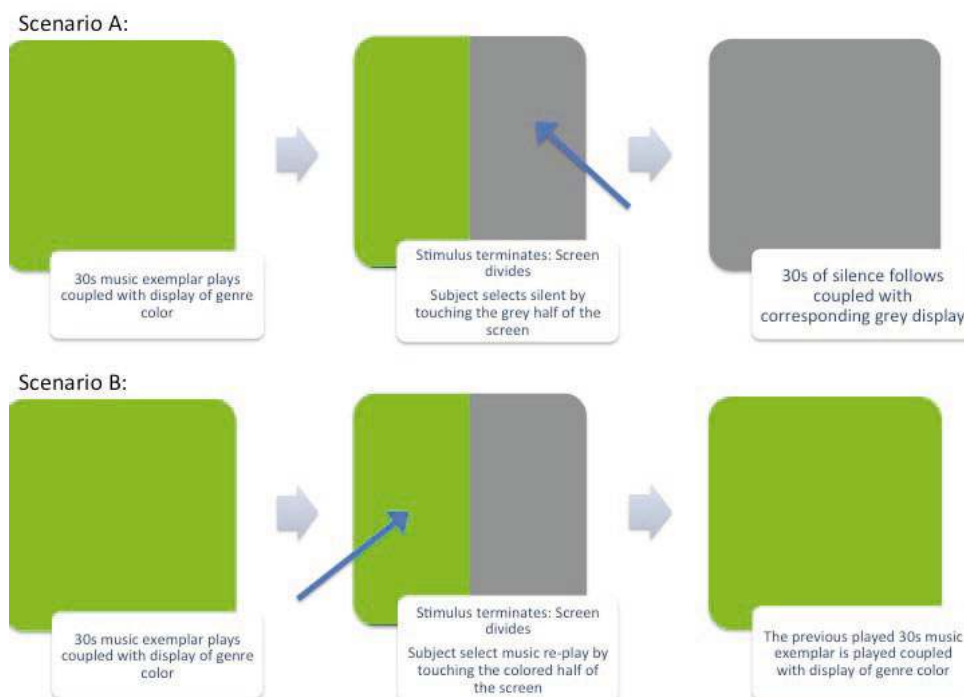
were not related to one another. Experimental sessions lasted 30–60 minutes depending on motivation to participate; the number of trials per session varied accordingly (range: 4–73 trials/session). Participants had access to adjoining enclosures and could leave

the testing area at any time. Absence from the testing area for more than 10 min resulted in the termination of that session. Each participant completed one session per day, 3–4 days per week. Test trials were administered and recorded using a 2.5 GHz dual-core Mac mini and a 21” colour PC computer monitor with a Keytec Magic Touch touchscreen unit attached. Computer hardware was mounted in a mobile wooden housing that allowed the entire unit to be rolled to the front of a participant’s enclosure during test sessions (see Figure 1 for photograph of a test session).

Six music genres were selected based on popular North American genres that participants would be familiar with (i.e. via radio music employed as auditory enrichment), with Tuva throat singing (TTS) included as a seventh genre. Music exemplars were selected based on human preference indicated by the greatest number of purchases on iTunes (Apple Inc. 2013). Specifically, these exemplars were selected from iTunes’ lists of “top albums” for each genre (e.g. “top classical albums”) organised according to the “bestseller” filter. While not an exhaustive number of selections, the sum was intended to be a critical mass of selections highly preferable to a large sample of humans who have expressed preference through their purchasing behaviour. Exemplars were assembled into seven libraries representative of seven musical genres respectively (classical, jazz, rock, pop, children’s music, country and TTS). Each library included 30 exemplars (a 30 s musical segment) of its respective genre. A custom designed software program written in Java generated and delivered the experimental stimuli, with music genre randomised and counterbalanced so that each genre was equally represented.

*Procedure*

To begin a test session, the experimental apparatus was wheeled to the front of the orangutans’ holding area. Test sessions were voluntary; orangutans indicated their intention to participate by spontaneously approaching the experimental apparatus (on average, this occurred in less than 2 min). The experimenter began the first trial by activating the touchscreen program (which initiated the first 30 s musical clip) and offering the wooden dowel used to make touchscreen selections to the participating



**Figure 2.** A visual representation of trials in Experiment 1. Rectangles represent sequential touchscreen screenshots. Blue arrows represent touchscreen contact. Scenario A depicts a trial in which the subject chooses silence over music replay. Scenario B depicts a trial in which the subject chooses music replay over silence.

**Table 1.** Frequency of music genre exposure per participant in Experiment 1.

Genre	Exposure frequency		
	Budi	Ramai	Sekali
Classical	207	180	177
Tuva	201	188	161
Hip hop	207	197	173
Children's	202	203	154
Jazz	202	166	173
Country	197	160	154
Rock	200	164	165
Total	1416	1258	1157

**Table 2.** Frequency of music replay and silence selections per participant in Experiment 1.

Music genre	Selection frequency					
	Budi		Ramai		Sekali	
	Replay	Silence	Replay	Silence	Replay	Silence
Classical	95	112	85	95	11	166
Tuva	79	122	104	84	12	149
Hip hop	83	124	100	97	12	161
Children's	72	130	94	109	12	142
Jazz	58	144	76	90	18	155
Country	71	126	77	83	13	141
Rock	68	132	69	95	15	150
TOTAL	526	890	605	653	93	1064

orangutan. While the clip was playing, a corresponding genre colour appeared full-screen on the monitor. Colours were randomly assigned to genres, and remained consistent throughout testing. When the clip concluded, the screen subdivided into two halves, one of which displayed the genre-colour of the exemplar that had just played, and the other displayed grey. If the coloured half of the touchscreen was contacted with the dowel, the previous 30s musical clip replayed. If the grey side of the touchscreen was contacted, 30s of silence followed (see Figure 2 for visual representation of trials). If neither side of the screen was contacted, the display remained subdivided and fixed indefinitely. To motivate participation, a standardised food reward (i.e. type and portion size) was provided after each selection, regardless of the choice. At the completion of each trial, a new 30 s musical exemplar began playing automatically. The order of exemplars from each musical genre as well as the side of the screen on which either grey (silence) or colour (genre) appeared were randomised and counterbalanced to avoid participant and order effects. Orangutan behaviour during testing was continuously observed and recorded.

*Data analysis*

Preference for musical genre was assessed by a chi-square analysis of the total number of times each participant replayed exemplars in each genre. Preference for music vs silence was assessed by a chi-square analysis of the total number of times each participant chose to replay a music exemplar versus the total number of times each participant chose silence instead. Results were analysed per individual. Chi square statistical analyses were conducted using IBM SPSS Statistics version 21.0. An alpha level of 0.05 was used for all analyses.

**Results and discussion**

*Quantitative analyses*

All test trials were included in analyses, for a total of 39 sessions and 1416 trials for Budi, 37 sessions and 1258 trials for Ramai, and 40 sessions and 1157 trials for Sekali. The number of trials conducted with each genre of music was approximately equal (see Table 1 for music genre exposure frequency, per participant). When given the choice to replay a 30 s music exemplar or listen to 30 s of silence, Budi and Sekali selected silence significantly more often than music ( $\chi^2(1) = 93.57, p < 0.001$ ;  $\chi^2(1) = 814.90, p < 0.001$ ). Although Ramai also made more silence selections than music selections, the difference was not statistically significant ( $\chi^2(1) = 1.83, p < 0.176$ ). See Table 2 for frequency of music replay and

silence selections per participant. In addition, when participants chose to replay a musical exemplar, they did not choose to replay any one genre of music more than any another genre ( $\chi^2(6) = 11.22, p < 0.082$  for Budi;  $\chi^2(6) = 2.67, p < 0.85$  for Sekali; and  $\chi^2(6) = 12.19, p < 0.058$  for Ramai). See Table 3 for the frequency of music replay and silence selections for each genre per participant.

*Qualitative analyses*

Despite voluntary, consistent and continuous participation throughout the experiment, during test sessions all three participants consistently displayed behaviours associated with orangutan distress (Kaplan and Rogers 2000; MacKinnon 1974; Payne and Prudente 2008; Rogers and Kaplan 2000). These behaviours included, but were not limited to, intermittent participation, abandoning sessions prematurely, posturing with raised hair, exaggerated and repetitive scratching of the torso, sputtering, blowing raspberries, spitting, banging the dowel on the ground, breaking the dowel, using the dowel to push the experimental apparatus away from their enclosure, throwing the dowel and/or other found objects, biting conspecifics, banging on walls and poking the experimenter with the dowel. Although these antagonistic behaviours (ABs) were most prevalent early on in the experiment and decreased as test sessions continued, they persisted to varying degrees throughout testing. Sekali displayed the greatest number and most energetic ABs, and persisted in them longest. In comparison, Budi, the juvenile, displayed fewer ABs during testing that reduced in frequency more quickly, and to a greater degree than both Ramai and Sekali. Ramai also displayed fewer ABs that extinguished more quickly than Sekali.

Notably, during times of stress, injury, excessive noise and/or commotion in, and around the orangutan enclosure (e.g. during

**Table 3.** Frequency of music replay and silence selections by genre in Experiment 1.

	Selection frequency	
	Correct	Incorrect
Budi	2045	2077
Ramai	2079	2091
Sekali	2517	2566

construction, when keepers were heard speaking or approaching, or when strangers were present), all participants tended to choose silence more than average or to quit test sessions entirely. For example, during a test session after Budi had sustained a significant injury to his hand, he chose silence 79% of the time, in contrast to choosing silence 63% of the time across all test sessions.

**Experiment 2**

The orangutans’ preferences for silence over music observed in Experiment 1, in contrast to humans’ universal penchant for music, posed the question “do orangutans prefer silence to music because they do not perceive music the same way human do?”. To investigate this hypothesis, we sought to determine if orangutans could perceptually distinguish music from scrambled music. In Experiment 2, we investigated whether orangutans could learn to discriminate between music and scrambled non-music samples, using a DMTS task.

**Method**

*Subjects*

The same orangutans were tested as those assessed in Experiment 1.

*Apparatus and experimental stimuli*

Data were collected in the same experimental setting, using the same apparatus as Experiment 1. Testing sessions lasted 30–60 minutes depending on orangutans’ motivation to participate; the number of trials per session varied accordingly (range: 3–300 trials/session).

Stimuli included five musical clips and five scrambled auditory clips (scrambled versions of the musical clips). Scrambled clips were constructed using an online sound editor (Audacity Team 2013), by dividing each music sample into 0.5 s segments, randomly re-ordering the segments, and playing the randomly re-ordered segments in reverse.

*Procedure*

Orangutans demonstrated their ability to differentiate between categories of auditory stimuli by identifying, via touchscreen computer, if the stimulus playing belonged to category A or B (i.e. A: music, B: scrambled music). To initiate a trial, participants touched an orienting stimulus at the centre of the display with a wooden dowel. This was followed by a 5 s forced-listening period after which the touchscreen display divided in two, one half displaying green, the other half, red. Subjects were required to

contact the touchscreen within 10 s (auditory stimuli continued to play for the total 15 s duration). Touching the green half of the screen was reinforced during presentation of the music sample, and touching the red half of the screen was reinforced during presentation of the scrambled music sample. Comparison colour was counterbalanced across subjects. Reinforcement following a correct choice consisted of a computer-delivered acoustic chime followed by a preferred food item provided by the experimenter. The sounding of a horn (with no reinforcement) followed incorrect responses. Touchscreen contact (i.e. a choice) immediately terminated the auditory stimulus, darkened the screen, triggered the sounding of the chime or horn, and in reinforcement or no reinforcement (dependent on a correct or incorrect response). If no touchscreen contact occurred after a 10 s interval, the stimulus was terminated, the display darkened, and the subject was not rewarded (these trials were labelled as “incomplete trials”). An inter-trial interval (ITI) of 10 s separated each trial from the next. Auditory clips from each comparison category appeared randomly in a session with equal frequency. See Figure 3 for visual depiction of a trial.

Data consisting of the number of correct and incorrect responses were collected following a training period consisting of numerous exposures to the experimental paradigm. Orangutan behaviour during test sessions was closely observed and recorded.

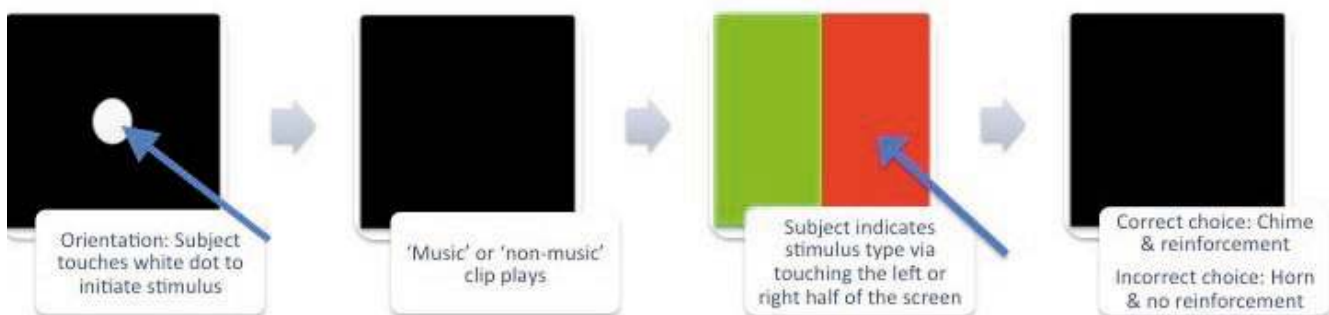
*Data analysis*

Discrimination of music from scrambled music was assessed by chi square analyses of correct vs incorrect responses. The ability to discriminate some exemplars more accurately than others was assessed by chi square analyses of the total number of correct discriminations per exemplar. Group and individual differences were compared. Statistical analyses were conducted using IBM SPSS Statistics version 21.0. An alpha level of 0.05 was used for all statistical analyses.

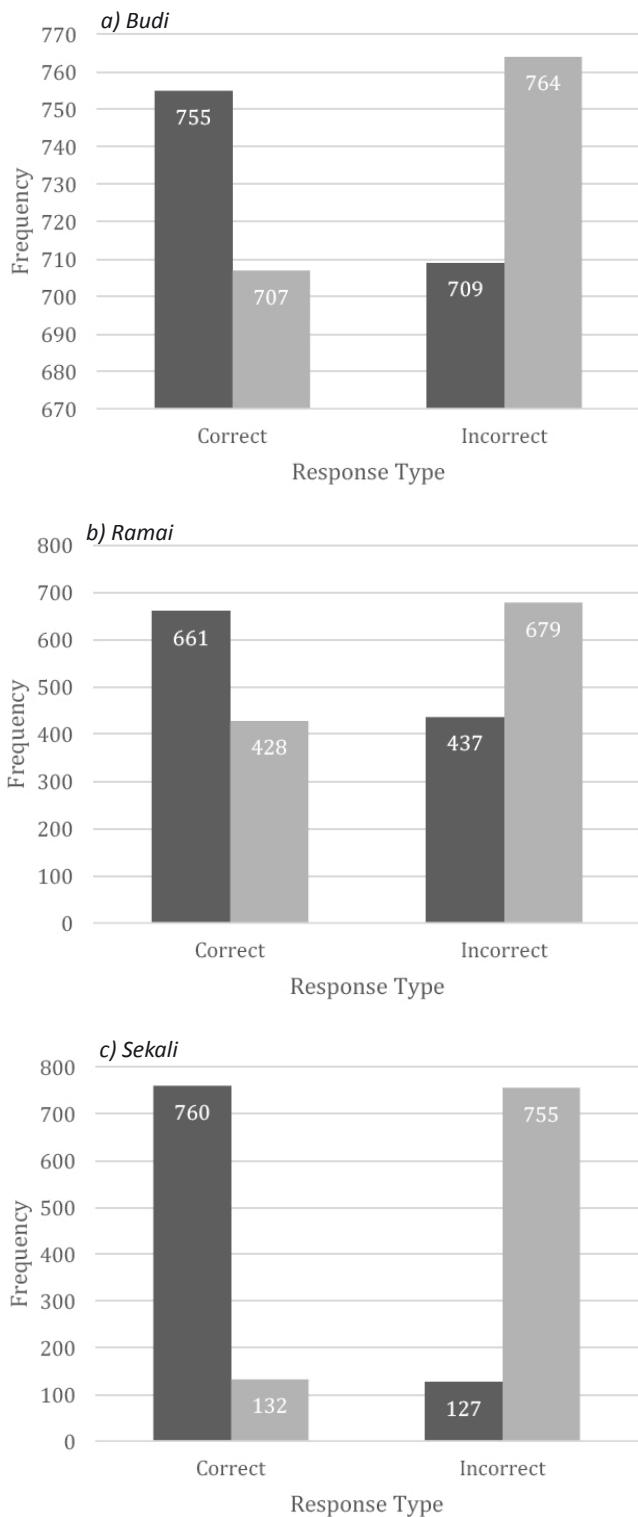
**Results and discussion**

*Quantitative analyses*

All test trials were included in analyses for a total of 4122 trials in 28 sessions for Budi, 4170 trials in 28 sessions for Ramai and 5083 trials in 31 sessions for Sekali. Budi did not make significantly more correct auditory discriminations of music from scrambled music stimuli than incorrect discriminations,  $\chi^2(1) = 0.248, p < 0.618$ , nor did Sekali,  $\chi^2(1) = 0.472, p < 0.492$  or Ramai,  $\chi^2(1) = 0.035, p < 0.853$ . See Table 4 for frequency of correct and incorrect selections per subject, per exemplar. However, Budi did significantly correctly discriminate some music and non-music exemplars more than



**Figure 3.** A visual representation of a trial in Experiment 2. Rectangles represent sequential touchscreen screenshots. Blue arrows represent touchscreen contact.



**Figure 4.** Frequency of correct and incorrect “music” and “non music” discriminations for each orangutan. Dark grey bars = music; light grey bars = non music.

others,  $\chi^2(9) = 358.376, p < 0.001$ . The same was true of Ramai,  $\chi^2(9) = 934.952, p < 0.001$  and Sekali,  $\chi^2(9) = 284.303, p < 0.001$  (see Figure 4).

**Qualitative analyses**

Although all three subjects displayed some of the ABs observed in Experiment 1 at the onset of Experiment 2, these behaviours were less frequent, less vigorous and declined quickly over the

first several test sessions. These behaviours included, but were not limited to, intermittent participation, abandoning sessions prematurely, sputtering, allowing the dowel used for participation to be stolen by conspecifics, pushing the apparatus away, hitting the apparatus with the dowel, banging the dowel on the ground, throwing the dowel and/or other found objects, biting conspecifics, breaking the dowel, running and/or somersaulting away from the testing area, banging on walls and poking the experimenter with the dowel. By the 8th–10th session, ABs had significantly decreased, and were exhibited only in response to the subject making several incorrect choices in a row. Budi, the juvenile, displayed the most ABs in response to incorrect choices, while Sekali displayed a moderate amount, and Ramai, nearly none. Notably, Budi displayed another novel behaviour in response to a series of incorrect choices. On several testing occasions, Budi retrieved a tarp or blanket from his enclosure and hung it over his head while seated in front of the apparatus. By doing so, Budi isolated himself and the touchscreen from external stimuli.

Initially Budi experienced difficulty in orienting to initiate a trial. This was likely a result of his immaturity and lack of experience with touchscreen paradigms relative to the other participants. However, after receiving guidance over several test sessions, he ultimately reached competence comparable to Ramai and Sekali. By the 8th–10th test sessions, all three subjects were participating immediately, energetically, and consistently. This stood in stark contrast to the amount and quality of participation observed in Experiment 1. However, similar to Experiment 1, during times of alarm, excessive noise or commotion (e.g. during construction, when keepers were heard speaking or approaching, or when strangers were present), participants were likely to suspend participation or to quit test sessions entirely.

**Discussion**

The results of Experiment 1 indicate that these orangutans preferred silence to music or were indifferent to either. Moreover, orangutans did not show a preference for any of the musical genres tested. These results support McDermott and Hauser’s (2007) findings that cotton-top tamarins (*Saguinus oedipus*), also preferred silence to music.

However, these results differ from other investigations that have indicated that captive NHPs independently initiate musical sounds (Line et al. 1990; Lutz and Novak 2005; Markowitz and Line 1990; Novak and Drewson 1989), and that broadcast music decreases aggressive and increases affiliative behaviours in chimpanzees (Howell et al. 2003) as well as increasing affiliative behaviours in rhesus monkeys (Lutz and Novak 2005; Novak and Drewson 1989). Although results from Mingle et al. (2014) suggest an NHP preference for non-western music over silence, the orangutans tested here did not prefer TTS to either silence or western music genres. Like the world music tested in Mingle et al.’s study, TTS is a non-western music genre comprised of non-western acoustic features. Relative to Mingle et al.’s (2014) results, it is possible that despite being non-western, TTS does not comprise the acoustic parameters NHPs find appealing. Future investigation of other non-western genres will be important in determining, which, if any, musical parameters orangutans favour.

It is also possible that the methodological difference between Mingle et al.’s (2014) study (a proximity-based design) and this investigation (a touchscreen-delivered dichotomous-choice participant-controlled design) is responsible for the discrepancy in results. In the approach/avoidance paradigm used by Mingle et al. (2014), preference is measured by the number, frequency and/or extent of approaches (movement of the body towards the stimulus) vs non-occurrences (absence of response within a predetermined amount of time) (Ritvo and Allison 2014). However, given the tendency for many species to approach any stimulus regardless

of whether or not it is reinforcing, the utility and accuracy of this paradigm has been questioned (Fernandez et al. 2004). In the type of free-choice, participant-controlled procedures employed in this study, participants are provided a choice between pairs of stimuli (Fernandez et al. 2004). Preference, then, is defined as choosing one stimulus more frequently than another.

As discussed above, participant-controlled procedures are believed to afford clearer conclusions about whether an animal “likes” one stimulus more than another stimulus (Lamont 2005). Finally, it is also possible that although the chimpanzees tested in Mingle et al.’s (2014) study preferred non-Western music to silence, species or group difference account for the fact that the orangutans tested here appeared to prefer silence instead.

The orangutans’ tendency to choose silence and suspend or quit test sessions during times of alarm, excessive noise or commotion, could indicate that observed orangutan preferences for silence over music is associated with music’s potential to a) mask informative sounds in the environment, or b) resemble the threatening rhythmic sounds made during NHP dominance displays (Mingle et al. 2014). However, the results of Experiment 2 imply that the underlying reason may be that orangutans do not perceive music the same way humans do and consequently do not find it appealing. Although humans perceive music as a united, harmonious and pleasurable stimulus, the same may not be true for orangutans. Rather, orangutans may not distinguish defined music as qualitatively different from other fluctuating auditory stimuli, and/or they may perceive music as indiscriminate “noise”. The antagonistic behaviours observed in both Experiment 1 and 2 appear to support this hypothesis (i.e. that the music tested was perceived as aversive).

At the very least, both quantitative and observational results suggest that music selected for inclusion based on human preference in this study was not reinforcing for these orangutans and may not generate the positive therapeutic effects demonstrated in humans. Furthermore, the fact that none of the participants preferred any one genre of music to another suggests that particular music qualities of the genres tested (e.g. the instrumental quality of classical music, or the rhythmic quality of pop music) were not distinguishable or were not specifically favoured either. Importantly, these results, particularly the behavioural observations, in combination with previous studies (McDermott and Hauser 2004, 2007; Sugimoto et al. 2010; Tincoff et al. 2005) indicate that the common practice of using western music for enrichment in NHP care facilities may be unfounded, or result in effects opposite to those intended. Because of our test participants’ extensive exposure to western music prior to testing (used as enrichment at the Toronto Zoo), it is unlikely that a lack of preference for music over silence can be explained by inexperience with these type of stimuli (Lamont 2005).

It is important to note that given research findings on auditory acuity in NHPs, there is reason to believe that NHPs may perceive sound differently than humans. For example, chimpanzees appear more sensitive to higher auditory frequencies than humans (Coleman 2009). Because humans do not perceive a proportion of higher frequencies, some of the music preferred by humans may contain aversive high frequency tones only perceptible by the high frequency-competent listener. Given that experimental music exemplars were selected based on human-preference as indicated by purchasing behaviour, this could explain why orangutans preferred silence to music in this study.

Future research examining music affinity in great apes may benefit from approaching the selection of music from a more great ape-centric perspective. This would involve selection of music exemplars that: (a) focus on lower frequencies and limit higher frequencies, (b) resemble NHP vocalisations, or (c) involve less rhythmic pulses. Species-centric music investigations

of rats (*Rattus norvegicus*) (Akiyama and Sutoo 2011), cotton-top tamarins (*Saguinus oedipus*) (Snowdon and Teie 2010), and domestic cats (*Felis catus*) indicate promise in this respect. It is important to note that in this vein, TTS was employed as a test genre because it distinctly differs from western music and shares some semblance to orangutan long calls. However, it was also not preferred to either silence, or other genres of music.

## Conclusion

Taken together, these results do not provide evidence for a musical affinity in orangutans. The most striking finding of this investigation is that orangutans did not find the music tested reinforcing. They were not independently motivated to listen to any of the music exemplars tested, either preferring silence to music or, alternatively, demonstrating indifference. While humans generally perceive music as a rewarding stimulus, this did not seem to be the case for these orangutans. Consequently, the use of these genres of music as environmental enrichment in captive orangutan facilities appears unfounded and may in fact be aversive, resulting in negative behavioural and/or psychological effects. These findings also focus scientific attention on how the appreciation and perception of music and other auditory stimuli differ for human and nonhuman animals and endorse a more NHP-centric approach to future studies on auditory enrichment for NHPs.

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