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Auditory stimulation as enrichment for zoo-housed Asian elephants (Elephas maximus)

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Abstract

*This study explored the effect of auditory stimulation on the behaviour and welfare of four zoo-housed, female Asian elephants (*Elephas maximus*). All animals were exposed, in an ABA design, to two conditions of auditory stimulation: a 'control' (no auditory stimulation), and an 'experimental' condition, during which the animals were presented with a commercially-available CD of classical music. Each condition lasted for five days, with an interim period of two days between each condition (Study 1). The elephants' behaviour was recorded every minute for four hours a day for the full five days of each condition using instantaneous scan-sampling. The procedure was repeated four months later (Study 2), for a shorter period of time (one day per condition, again using an ABA design) to assess whether the results are generalisable. Analysis of both studies revealed that the elephants spent significantly less of their time stereotyping during the experimental conditions than the control. None of the other behaviours recorded were influenced significantly by auditory stimulation. Overall, the findings from this study suggest that auditory stimulation, in the form of classical music, may be a useful method of reducing stereotypic behaviour in zoo-housed Asian elephants, although more long-term work with a larger number of animals is needed before firm conclusions can be drawn.*

Keywords: *animal welfare, auditory stimulation, behaviour, elephants, enrichment, music*

Introduction

Almost 2,000 African (*Loxodonta africana*) and Asian (*Elephas maximus*) elephants are housed in zoos, and other captive environments, worldwide (Koehl 2001). Unfortunately, these animals are notoriously difficult to keep successfully in captivity (Adams 1981; Veasey 2006). Many studies, for example, have reported behaviours like aggression, stereotypic swaying, pacing and head bobbing (activities generally suggestive of reduced welfare) in elephants housed in circuses, zoos and sanctuaries (eg Schmid 1995; Friend 1999; Friend & Parker 1999; Rees 2004). As a consequence, institutions housing elephants have been urged to take measures aimed at improving the animals' social and physical environments (eg Clubb & Mason 2002).

Thus far, only a limited number of studies have explored, scientifically, the effect of environmental enrichment on the welfare of captive elephants. These few studies have focused exclusively on feeding enrichment in light of the fact that wild elephants spend a significant percentage of their time foraging for vegetation (McKay 1973; Vancuylenberg 1977). These investigations, however, have produced mixed results. Wiedenmayer (1998), for example, found that hiding peanuts above an outdoor enclosure structure did not significantly increase searching behaviour in five zoo-housed Asian elephants. Although, more recently, Stoinski *et al* (2000) showed that replacing an equal, dry weight of hay with browse, significantly increased feeding and reduced drinking and inactivity in three zoo-housed, female, African elephants.

Auditory stimulation has long been employed as a method of therapy for humans dwelling in institutional settings. Over the years, music, particularly classical, has been used successfully to reduce pain, depression, stress and anxiety (eg McCaffrey & Good 2000; Hilliard 2001; Vickers & Cassileth 2001), and is now widely employed as an alternative form of therapy for people with emotional problems (eg Lipe 1987; Christie 1992).

Recognition of the benefits associated with music for human well-being has prompted recent research into the value of auditory stimulation as a means of enriching the environment of captive animals. The value of auditory enrichment has been studied in a variety of species, including birds (Gvaryahu *et al* 1989; Ladd *et al* 1992; Nicol 1992; Reed *et al* 1993), cattle (Wisniewski 1977; Evans 1990; Uetake *et al* 1997), horses (Houpt *et al* 2000), dogs (Wells *et al* 2002) and primates (Hanson *et al* 1976; Markowitz & Line 1989; Novak & Drewson 1989; O'Neill 1989; Shepherdson *et al* 1989; Ogden *et al* 1994; Brent & Weaver 1996; Wells *et al* 2006). Many of these studies

Table 1 Ethogram of elephant behaviours recorded in the study (adapted from Olson 2003).

Behaviour	Definition
Stand	More or less stationary, upright, quadrapedal stance
Move	Walking, trotting or running
Socialise	Touching, rubbing or grooming the body of a conspecific
Aggression	Charging at, striking or directing other negative action towards conspecific
Dust-bathe	Throwing sand, browse or other substrate on self
Object	Interacting with inanimate object in exhibit
Eat	Ingesting haylage, produce or other type of food
Drink	Drawing water into the trunk
Vocalise	Trumpeting, rumbling or other type of vocalisation
Abnormal	Performing repetitive, apparently functionless behaviour, eg pacing, swaying, head bobbing

report positive changes in the behaviour and/or physiology of animals exposed to music recordings, radio broadcasts or ecologically-relevant sounds.

To date, the effect of auditory stimulation on elephants remains completely unknown. Elephants are renowned for having a good sense of hearing (eg Reuter *et al* 1998). This study aimed, thus, to determine whether elephants, like humans and other species, respond to their auditory environment, and to elucidate the value of auditory stimulation as a method of enrichment for these animals.

Materials and methods

Subjects

A stable group of four female, Asian elephants (three wild-born, one captive-born), aged between approximately 9–45 years, were utilised as subjects. Two of the elephants had been acquired from circuses, hence their exact age was unknown.

All of the elephants were housed at Belfast Zoological Gardens in Northern Ireland, in an exhibit consisting of an indoor barn (20.5 × 19.3 × 10 m; length × width × height) and outdoor paddock (100 × 50 m; length × width). The floor of the barn consisted of concrete, whilst sand served as the substrate in the outdoor arena. The animals were allowed free access between the barn and paddock as a group, each day, between approximately 0800–1400h after which time they were confined together to their indoor quarters.

The elephants' enclosures were cleaned every morning and the animals were scatter-fed several times a day with a variety of compressed pellets, fresh fruit, vegetables, haylage and branches. Animals were trained by keepers several times a week using positive reinforcement techniques, for the purpose of aiding routine veterinary procedures, eg leg lifting, and a free contact system of interaction between elephants and keepers was employed at this study site.

Auditory stimulation

Two conditions of auditory stimulation were developed for the study. These included: i) a 'control' condition, during which time the elephants were exposed to no auditory stimulation other than that arising naturally from their environment and, ii) an 'experimental' condition, during which the elephants were exposed to a randomly chosen mixture of tracks from *The Very Best of the Classic Experience* (EMI Virgin Records). This CD contains a variety of classical compositions by composers including Mozart, Bach and Beethoven, and has proven successful in improving the short-term welfare of captive-housed dogs (Wells *et al* 2002) and, to a lesser degree, gorillas (Wells *et al* 2006). The music was presented to the elephants using a CD/radio player (RC-BX530, JVC, Japan). The device was placed out of the reach of elephants' trunks in the middle of the indoor barn in such a way as to ensure a relatively equal distribution of sound to all of the animals, regardless of their position. The distance between the sound source and the animals ranged from 4–6 m, depending upon the location of individual subjects. At this distance, the music source produced sound at an amplitude in the range of 47–65 dB.

Procedure

An ABA design was employed in this investigation. Thus, the elephants were first studied in the control condition, followed by the experimental condition, and finally, again, the control condition. The animals were always presented with the acoustic stimulus at the same time of the day during the experimental condition, to prevent any inconsistent exposure to extraneous events in the zoo environment, eg feeding, cleaning. Testing was conducted in May 2005, between 1400–1800h, when the animals were confined to their indoor quarters as part of their routine husbandry practices. Feeding and husbandry regimes were standardised across testing. The number of visitors to the animals' indoor barn, calculated as the number of people who entered the interior exhibit during the testing periods, did not differ significantly ($\chi^2 = 3.15$, df = 2, $P = 0.21$) between the control 1 (mean number of visitors = 394.55 [± 88.90]), experimental (mean number of visitors = 377.12 [± 41.48]) and control 2 (mean number of visitors = 406.87 [± 80.39]) phases of testing. There were no other apparent environmental differences (eg temperature), between the three test periods.

Each condition lasted for five days and was separated by an interim period of two days during which the animals were exposed to no auditory stimulation other than that arising naturally from their environment. The behaviour of each elephant was recorded by one experimenter (RI) for all of the conditions. The observer sat silently for 20 min in the visitors' viewing area in the indoor barn prior to the start of each study session to ensure that the animals were habituated to her presence before each session of data collection. Each elephant's behaviour was recorded every minute over the four-hour recording period per day for each condition using instantaneous scan-sampling (eg Martin & Bateson 1986). At every sample point, the behavioural state of each individual was recorded according to an ethogram adapted from pilot work on this particular group of animals and existing work in this area (see Olson 2003 and Table 1).

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Table 2 Mean (± SD) number of times elephants were recorded exhibiting each behaviour on the ethogram during the 3 phases of testing (control 1, control 2, experimental) in Study 1.

Behaviour	Control 1	Control 2	Experimental	χ^2 (*P*)
Stand	442.75 (± 114.94)	407.00 (± 94.85)	456.5 (± 126.49)	2.00 (± 0.37)
Move	76.00 (± 27.74)	114.25 (± 18.94)	119.50 (± 20.09)	4.50 (± 0.10)
Socialise	21.00 (± 10.51)	22.50 (± 10.41)	18.50 (± 9.03)	4.50 (± 0.10)
Aggression	2.50 (± 4.35)	2.00 (± 2.83)	2.50 (± 2.88)	0.00 (± 1.00)
Dust-bathe	50.25 (± 40.31)	64.75 (± 49.79)	81.75 (± 57.10)	5.73 (± 0.06)
Object	20.00 (± 14.31)	17.75 (± 13.59)	20.25 (± 10.50)	1.28 (± 0.52)
Eat	524.75 (± 88.39)	565.50 (± 124.53)	586.5 (± 179.45)	0.50 (± 0.78)
Drink	23.25 (± 8.26)	19.25 (± 2.06)	13.50 (± 5.19)	2 (± 0.37)
Vocalise	5.75 (± 4.27)	4.50 (± 2.08)	3.00 (± 1.41)	1.20 (± 0.55)
Abnormal	104.25 (± 46.84)	129.75 (± 46.20)	16.75 (± 15.71)	8.00 (± 0.01)*

P-values arising from Friedmann ANOVAs are presented. * denotes significant effect at the 0.05 level.

Table 3 Mean (± SD) number of times elephants were recorded exhibiting each behaviour on the ethogram during the 3 phases of testing (control 1, control 2, experimental) in Study 2.

Behaviour	Control 1	Control 2	Experimental	χ^2 (*P*)
Stand	119.25 (± 23.17)	117.00 (± 19.13)	128.75 (± 24.01)	1.50 (± 0.47)
Move	19.50 (± 6.14)	16.50 (± 6.45)	19.75 (± 3.59)	1.50 (± 0.47)
Socialise	3.00 (± 2.16)	2.25 (± 1.50)	2.75 (± 1.89)	3.71 (± 0.16)
Aggression	0.50 (± 1.00)	1.00 (± 1.41)	0.25 (± 0.50)	3.71 (± 0.16)
Dust-bathe	10.50 (± 9.32)	13.25 (± 10.78)	13.00 (± 10.13)	2.80 (± 0.25)
Object	3.50 (± 3.11)	3.50 (± 1.29)	4.50 (± 1.91)	1.73 (± 0.42)
Eat	120.25 (± 31.83)	121.25 (± 33.26)	123.00 (± 20.51)	0.00 (± 1.00)
Drink	5.25 (± 1.25)	4.50 (± 1.29)	4.25 (± 1.71)	1.73 (± 0.42)
Vocalise	0.50 (± 0.58)	0.25 (± 0.50)	0.50 (± 0.58)	1.00 (± 0.61)
Abnormal	22.75 (± 11.70)	29.50 (± 9.25)	1.75 (±1.71)	6.50 (± 0.03)*

P-values arising from Friedmann ANOVAs are presented. * denotes significant effect at the 0.05 level.

Table 4 Mean number of times individual elephants were recorded exhibiting abnormal behaviour during the 3 phases of testing (control 1, control 2, experimental) in Study 1 and 2.

Elephant	Control 1	Control 2	Experimental
Study 1			
Lulu	155.00	187.00	19.00
Johti	129.00	145.00	38.00
Visesh	83.00	105.00	3.00
Tina	50.00	82.00	7.00
Study 2			
Lulu	35.00	43.00	4.00
Johti	30.00	27.00	2.00
Visesh	16.00	22.00	0.00
Tina	10.00	26.00	1.00

Table 5 The mean (± SD) number of times elephants were recorded exhibiting each behaviour on the ethogram across the 5 days of the experimental condition in Study 1.

Behaviour	Day 1	Day 2	Day 3	Day 4	Day 5	χ^2 (*P*)
Stand	91.75 (± 24.67)	90.00 (± 9.56)	96.25 (± 35.95)	89.75 (± 22.09)	88.75 (± 35.65)	0.40 (± 0.98)
Move	23.75 (± 4.50)	22.25 (± 2.87)	25.00 (± 5.47)	23.25 (± 3.40)	25.25 (± 4.57)	5.10 (± 0.28)
Socialise	3.25 (± 2.22)	3.75 (±1.89)	3.50 (± 2.08)	4.50 (± 1.73)	3.50 (± 2.38)	3.83 (± 0.43)
Aggression	0.50 (± 0.58)	0.50 (± 0.58)	0.50 (± 0.58)	0.75 (± 0.96)	0.50 (± 0.58)	4.00 (± 0.41)
Dust-bathe	16.75 (± 11.64)	14.50 (± 10.85)	20.25 (± 13.89)	16.00 (± 11.51)	14.25 (± 10.72)	3.78 (± 0.44)
Object	4.00 (± 1.82)	4.25 (± 2.63)	3.25 (± 2.06)	4.50 (± 2.88)	4.25 (± 2.75)	1.81 (± 0.77)
Eat	112.50 (± 33.51)	117.25 (± 36.79)	127.00 (± 37.05)	116.00 (± 38.74)	113.75 (± 39.66)	5.00 (± 0.28)
Drink	2.50 (± 1.00)	2.25 (± 0.96)	2.25 (± 1.26)	3.25 (± 2.75)	3.25 (± 1.25)	1.85 (± 0.76)
Vocalise	1.00 (± 0.82)	0.50 (± 0.58)	0.50 (± 0.58)	0.75 (± 0.96)	0.25 (± 0.50)	2.00 (± 0.74)
Abnormal	3.50 (± 2.64)	3.25 (± 3.40)	3.25 (± 4.03)	4.00 (± 1.82)	3.25 (± 3.59)	2.87 (± 0.60)

P-values arising from Friedmann ANOVAs are presented.

In addition to the main study described above (Study 1), a further three days of testing was carried out four months later (September 2005), to assess whether the results were generalisable (Study 2). Thus, four hours worth of control data were collected on one day, four hours worth of experimental data were collected two days later and again, two days later, a further four hours of control data were collected. Testing during these control and experimental sessions followed exactly the same protocol outlined above for the main study.

Data analysis

For Study 1, the total number of occurrences of each behaviour recorded on the scans was summed for each animal for each condition of auditory stimulation (ie control 1, experimental, control 2). The assumptions underlying parametric analysis (eg. Howell 1992) were not sufficiently met (Mauchly Sphericity, and Kolmogorov-Smirnov tests, $P < 0.05$), hence a Friedmann ANOVA (eg Howell 1992) was conducted for each behaviour to determine whether it was influenced by the auditory environment. The same analysis was carried out for Study 2.

Results

Analysis showed that the elephants spent significantly less of their time stereotyping during the experimental conditions than the control for both Study 1 (Table 2) and Study 2 (Table 3). The reduction in abnormal behaviour was apparent for all four elephants under scrutiny for both studies (Table 4). None of the other behaviours were significantly influenced by the auditory environment.

The elephants' behaviour did not change significantly over the length of time the animals were exposed to the auditory stimulation in Study 1, suggesting a lack of habituation ($P > 0.05$ for all Friedmann ANOVAs) (see Table 5).

Discussion

The findings from this study showed that auditory stimulation in the form of classical music had a significant effect upon the behaviour of four zoo-housed, Asian elephants. The experimental condition devised for this study (ie classical music) resulted in a significant decrease in abnormal behaviour in the animals under investigation, both as a group, and individually. Thus, the elephants were observed repetitively swaying, pacing and head bobbing almost ten times less during exposure to music than in the normal auditory environment. Research suggests that calming music may have a beneficial effect on humans and other animals, resulting in diminished agitation, improved mood and lower levels of stress (eg Tabloski *et al* 1995; Ragneskog *et al* 1996; Wells *et al* 2002, 2006). Whilst the specific effect of music on elephants remains unknown, the findings from this study suggest that certain types of auditory stimulation may, as in other species, have a calming influence.

The elephants' behaviour did not change significantly over the length of time the animals were exposed to the auditory stimulation, suggesting a lack of habituation. That said, the influence of longer periods of exposure to auditory stimulation warrants further study, particularly considering the number of elephants housed in captivity long term, ie > 40 years. The range of audio frequencies that influence the welfare of elephants is also worth examining, in light of the fact that these animals can detect infrasound (eg Payne *et al* 1986; McComb *et al* 2003).

Although each of the three conditions (control-experimental-control) designed for Study 1 were relatively short lived (ie five days each), Study 2, conducted four months later, revealed a similar pattern of results to the main investigation. This reduces the likelihood of spurious results and strengthens the case for the statistically-significant effects observed.

Animal welfare implications

Elephants in captivity are highly prone to stereotypic patterns of behaviour, often exacerbated by factors including restraint (Friend & Parker 1999; Gruber *et al* 2000) and rigid management routines (Wilson *et al* 2004). The most common stereotypies displayed by elephants are swaying (or weaving) from side-to-side or forwards and backwards, head bobbing and faeces throwing, although other repetitive behaviours, including trunk tossing and pacing, are not uncommon (see Clubb & Mason 2002). Some trainers and handlers consider such patterns of behaviour to be relatively normal, and even beneficial to the animals, perhaps facilitating circulation in the absence of walking, or aiding digestion (Ormrod 1983; Friend 1999). Others believe that these repetitive patterns of behaviour are a sign of stress, brought about by factors including restricted movement (Schmid 1995; Friend & Parker 1999), social isolation (Kurt & Garai 2001) and impoverished environments and foraging opportunities (Schwammer & Karapanou 1997). The function of stereotypic behaviour in elephants, and indeed other species, is complex, and needs careful investigation. Some stereotypies can develop, for instance, in animals that are excited, and not necessarily under stress (Veasey 1993); moreover, it is believed that the action of performing a repetitive behaviour can be calming, helping to release endorphins and allowing the individual to cope with aversive or uncontrollable stimulation (eg Mason 1991). Whatever the underlying cause and possible function, stereotypies are generally regarded as indicative of reduced welfare and, hence, enrichment methods that are designed to curb or even eliminate these abnormal repetitive patterns of behaviour have been advocated (for review see Mason *et al* 2007). The findings from this study suggest that auditory stimulation in the form of classical music may offer a potentially useful method for reducing stereotypies in zoo-housed Asian elephants.

One must question the mechanism by which auditory stimulation may exert its behavioural effects on captive animals. It is possible that it simply serves as a 'mask', buffering the animals from the noise of visitors and other negative acoustical stimuli. Alternatively, it may be the case that there is something specific and enriching about certain types of auditory stimulation. For instance, whilst still not conclusive, there is some evidence that Mozart's Sonata K 448 may promote cognitive functioning in animals and humans (eg Rauscher *et al* 1993; Hetland 2000). Further work is needed to unravel the specific acoustic elements that animals respond to and determine whether they serve as a mask to extraneous noise or exert an enriching, neurophysiological effect.

It must be borne in mind that this study was conducted on a small group of animals over a relatively short period of time. Further research is needed to determine the long-term effects of auditory stimulation on a larger number of captive elephants before generalised conclusions can be drawn.

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