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The effect of a new vertical structure in mitigating aggressive behaviour in a large group of chimpanzees (Pan troglodytes)

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Abstract

*The availability and complexity of escape routes are key aspects in modulating aggression. The effect of increased vertical space on the occurrence and severity of aggression was studied in a large group of chimpanzees (*Pan troglodytes*). Fifty wooden poles were added to the outdoor enclosure at Chester Zoological Gardens, England, UK. Connected with ropes and nets to form a complex vertical structure, they substantially increased the potential for escape routes during aggression. This study is an investigation into whether the use of the new vertical structure reduced the severity of aggression. Aggressive interactions among 29 chimpanzees (five adult males, 15 adult females, and nine immatures) were recorded whenever observed. We found that the proportion of total aggression involving the use of the vertical structure was much lower than expected based on the time individuals spent on the structure. We also found that no severe aggression was initiated when individuals were on the vertical structure. Most importantly, the proportion of severe aggression was lower when recipients of aggression moved onto the vertical structure than when they stayed on the ground. Furthermore, incidents of serious injuries were reduced after the vertical structure was added. The vertical structure appeared to function as a deterrent of aggression and an important escape route during aggressive interactions, which reduced the severity of aggression. Our results suggest that complex vertical structures are highly beneficial for semi-arboreal species with the potential for severe aggression and should be strongly considered by zoos housing such species.*

Keywords: *aggression, animal welfare, chimpanzee, environmental enrichment, injuries, three-dimensional structures*

Introduction

Animals in the wild live in complex, spatial environments. Primates in particular make extensive use of natural structures and live in a three-dimensional world, moving vertically as well as horizontally. Spatial and other environmental factors are recognised as being important and influential in primate life (Mason 1968) and changes in the physical environment can have a significant impact on behaviour. Most primates are largely arboreal and usually have a vertical flight response, ie climbing or changing level when alarmed (The UK Home Office 1989; Miller & Treves 2006) which underlines the importance of vertical structures for primates in captivity (International Primatological Society 1993). Accordingly, the International Primatological Society (1993) recommends giving primates the opportunity to perch above human eye level in captive settings. In its guidelines for the accommodation and care of primates in scientific research, the UK Medical Research Council also recommends providing stimulating enclosures with opportunities for natural behaviours (Anon 2004).

Modern zoos understand the need to encourage behaviours seen in wild populations, often creating environments resembling the species' natural habitat (Maple & Perkins 1996). Environmental enrichment is used to emulate natural behaviours and promote an animal's psychological and physiological well-being. Three-dimensional structures can increase interest and use of all available space and, thus, are an important source of enrichment for a wide range of species (Maple & Perkins 1996). Several studies have documented the benefits of spatially-enriched enclosures in a variety of primate species. For example, female gorillas (*Gorilla gorilla gorilla*) reproduced more successfully in more complex enclosures, especially with 'privacy refuges' like sight barriers and adjoined cages (Miller-Schroeder & Paterson 1989).

Nagel and Kummer (1974) suggested that higher levels of aggression in confined spaces may be due to lack of cover rather than lack of space. The use of structures as a visual barrier has been investigated in several species and, while the effects on certain behaviours remain ambiguous, cover is always used to avoid aggression (Estep & Baker 1991).

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Figure 1

The vertical structure in the chimpanzee enclosure. Photograph by C Caws.

Neveu and Deputte (1996) reported that the removal of all perches from a group of mangabeys (*Cercocebus albigena*) resulted in an increase in aggressive behaviour. Normal levels were restored by gradually placing more perches, which suggests, perhaps, that a lack of escape routes was responsible for increased aggression. There is also evidence that structural, environmental enrichment provides opportunities to escape and avoid conflicts in a variety of primate species (Maple & Perkins 1996). For example, adult female Japanese monkeys (*Macaca fuscata*) housed in an enclosure which contained wooden perches, to increase usable space, displayed lower rates of agonistic interactions than conspecifics housed in an identical enclosure without such perches (Nakamichi & Asanuma 1998). When pieces of PVC pipe were placed in the enclosure of squirrel monkeys (*Saimiri sciureus*) as visual barriers, allowing eye contact to be broken between disputing animals, fight wounds were reduced by 60% (Ricker *et al* 1995). Hanuman langurs (*Semnopithecus entellus*), which were moved from barren enclosures to a naturalistic exhibit with plants and structures, showed decreased rates of aggression (Little & Sommer 2002). When cement cylinders were placed in the enclosure, female pigtail macaques (*Macaca nemestrina*) living in stable groups, reduced agonistic behaviour, and the cover provided by the cylinders was immediately used to escape aggressors (Erwin *et al* 1976). When a group of stumptailed macaques (*Macaca arctoides*) was provided with additional cover, contact aggression was reduced significantly (Estep & Baker 1991).

In the wild, chimpanzees (*Pan troglodytes*) live in large communities in areas with varying vegetation types, from tropical forest to open savannah with scattered trees (Goodall 1986; Nishida & Hiraiwa-Hasegawa 1987). At various sites, chimpanzees spend approximately half of their active time above the ground (Doran 1996). Trees are used to forage, rest, play and potentially act as escape routes during aggressive

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encounters. Goodall (1986) describes occasions when the victim of aggression retreats up a tree with pursuers displaying underneath. Agonism in captive chimpanzees is influenced by many factors, including lack of space and inability to escape from others, contributing to the general pattern of greater aggression in captive than in wild groups (Bloomsmith & Baker 2001). Although chimpanzees can cope with a temporary reduction of space and escape opportunities by reducing aggressive behaviour (Aureli & de Waal 1997; Caws & Aureli 2003), vertical structures are important features in captive enclosures. Chimpanzees that were moved from a laboratory to a more naturalistic setting, used vertical structures extensively, were more active, and decreased stereotypies and self-directed behaviour (Clarke *et al* 1982). Fritz and Howell (2001) pointed out the importance of providing escape routes and visual barriers during chimpanzee introductions to conspecifics when the risk of aggression and injuries is highest. The overall picture is that multiple escape routes and visual covers should be provided in captive facilities for chimpanzees while avoiding the creation of areas where animals can be cornered (Pruetz & McGrew 2001).

This study contributes to the understanding of the effects of vertical space on the relative occurrence of aggression in chimpanzees. In particular, the study investigated whether the use of a new vertical structure reduced the likelihood of severe aggression and injury in a large group of chimpanzees.

Materials and methods

Subjects and housing

The chimpanzees at Chester Zoo, UK, were observed for a total of 16 months. The group consisted of five adult males, 15 adult females and nine immature individuals, aged between six months and 36 years. All but five of the subjects were born at Chester Zoo. Two adults, one male and one female, were wild born and three adult females came from another UK zoo. Apart from births and deaths the group had been stable since 1990.

The group had lived in the current enclosure since 1989. The enclosure consisted of a round, indoor enclosure of 12 m diameter and 12 m height and a 2,000 m^2 outdoor grassy area surrounded on three sides by a moat. Since March 2000 the outdoor area included a new vertical structure consisting of 50 vertical poles, connected with ropes and nets (Figure 1). The chimpanzees also had an offshow area consisting of seven interconnected pens and were usually given access to two of these areas, the indoor and outdoor enclosures during the day, and the indoor enclosure and pens during the night.

Data collection

Data were collected (by CC) between August 2000 and January 2003. Selected months when chimpanzees were generally outdoors were used for analysis. All aggressive interactions were recorded *ad libitum* between 1000 and 1600h, every week day, recording the actor and recipient of aggression, as well as the intensity and location. Two intensities of aggressive behaviour were used for analysis: mild, including threats, displays, hitting, stamping and chasing, and severe, including bites and fighting (see van Hooff 1971 and Goodall 1986 for descriptions). The highest intensity in a single interaction was recorded and ranged from mild (with little or no physical contact) to severe (involving bites and physical fighting). The location (indoors, outdoors on the ground, or outdoors on the vertical structure), or sequence of locations when the aggression moved between locations (eg the interaction started outdoors on the ground and continued on the vertical structure), was recorded for each interaction. Group scans were also collected throughout the day at 15-minute intervals recording the location of each subject.

Data analysis

The recipient of aggression was used as the unit of analysis. We calculated the proportion of total aggression and the proportion of severe aggression for which the recipient made use of the outdoor vertical structure. The proportion of group scans for which individuals were on the outdoor vertical structure was calculated in order to assess whether the vertical structure was used more often during aggression than expected, based on its overall use. Zoo records of all injuries observed in the group were used to compare the proportion of serious incidents (ie those needing veterinary treatment) for three years before and three years after the vertical structure was erected. Records of injuries were made by animal keepers whenever observed and verified by the head of the section. Data were analysed using Wilcoxon signed rank test using an α level of 0.05.

Results

Although rates of aggressive events overall did not change (mean: 0.004 individual^{-1} h^{-1} before and 0.005 individual^{-1} h^{-1} after the structure), the proportion of total aggression involving the use of the vertical structure was significantly lower than expected, based on the time individuals spent on the structure (Wilcoxon signed ranks test: n = 28, $z = 2.89$, $P = 0.004$; Figure 2). We also found that no incident of severe aggression was initiated when individuals were already on the vertical structure. Most importantly, the proportion of severe aggression initiated outdoors was significantly lower when the recipient of aggression used the vertical structure compared to when they remained on the ground (n = 18, $z = 3.47$, $P = 0.001$; Figure 3).

The proportion of serious injuries out of the total recorded injuries was lower in the three years after (32%) than the three years before (59%) the structure was erected. The proportion of serious injuries occurring during the summer months, when the chimpanzees were most often outdoors, was also lower after the vertical structure was added (Figure 4). The mean (± SD) number of injuries per individual was 0.81 (± 0.22) per year before the structure was erected and 0.63 (± 0.17) afterwards.

Discussion

The use of vertical structures is important for most primates. Arboreal and semi-arboreal species need enclosures which allow movement in the vertical dimension and should be able to use spatial positions above the level of certain group

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Figure 2

Mean percentage (± SEM) of aggressive events that involved use of the vertical structure compared to the expected percentage based on time spent on the structure. $P = 0.004$.

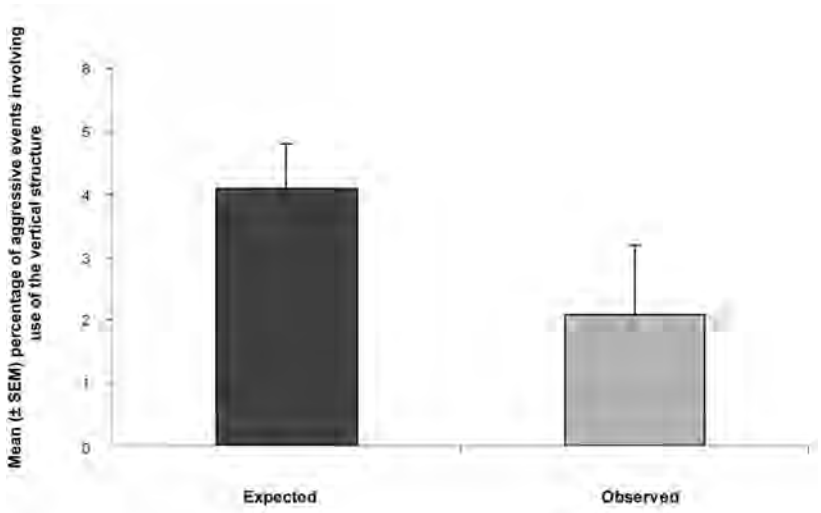


Figure 3

Mean percentage (± SEM) of severe aggression, occurring outdoors, that did (Structure) and did not (Ground) involve used of the vertical structure. $P = 0.001$.

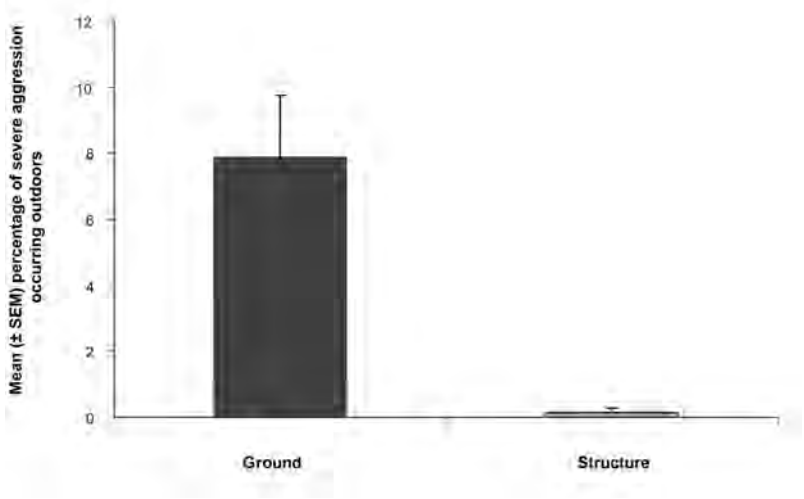
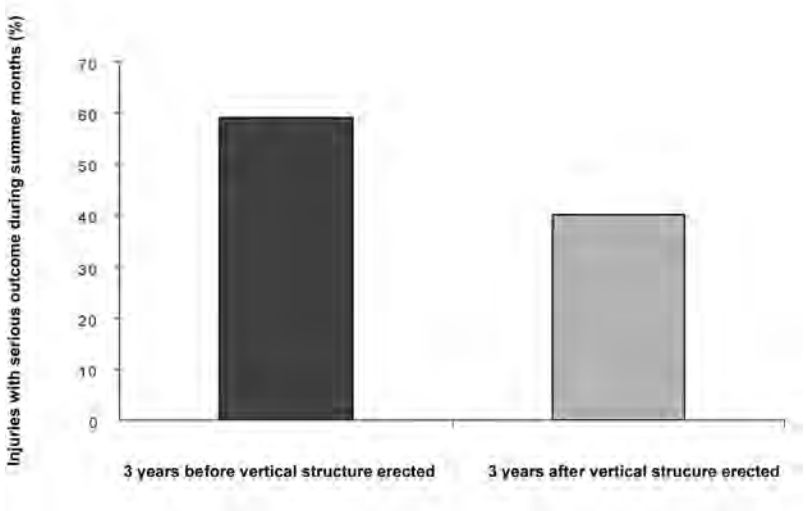


Figure 4

Percentage of injuries with serious outcome in the summer months of the three years before and the three years after the vertical structure was erected.



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mates, threatening humans or potentially-dangerous events in their environment (Kaumanns & Schönmann 1997). In particular, vertical structures can be used as escape routes, thus reducing the likelihood of serious injuries (Maple & Perkins 1996; Nakamichi & Asanuma 1998). Several studies have shown a reduction in aggression when structures are added to the enclosure. For example, Kessel and Brent (1996) reported that after structures, such as a suspended ladder and drum, were added in their enclosures female baboons (*Papio* spp) used these structures to avoid males' aggressive displays. Interestingly, in the Chester chimpanzee group, a male who was often chased by the rest of the group used the structure to 'escape' on 42% of these occasions (Wehnelt *et al* 2006).

The findings of our study support predictions made about the benefits of vertical structures in primate enclosures. The proportion of total aggression in which recipients used the vertical structure was lower than expected, based on the time the chimpanzees spent on the structure. No episodes of severe aggression were initiated while individuals were on the vertical structure. Furthermore, the proportion of severe aggression was significantly higher when the structure was not used during aggressive events than when it was used. Although severe aggression was uncommon in the study group, it could cause injuries. Our study found a reduction in the proportion of serious injuries after the vertical structure was added to the enclosure. The vertical structure, therefore, appeared to function as a deterrent of aggression and an important escape route during aggressive interactions, which was effective in reducing the severity of aggression and serious injuries. Although we could not perform an analysis of the intensity of aggression before and after the structure was erected (because of insufficient data sampled before the structure was added), our study illustrates that the intensity of aggression was lower when the vertical structure was used, compared to not.

Chimpanzees are highly excitable and aggression may be frequent (Goodall 1986), and the lack of three-dimensional space and escape routes may increase aggressive behaviour in captive settings (Bloomsmith & Baker 2001). Our results support previous studies on the benefits of structured environments. In particular, our findings suggest that the building of complex vertical structures is highly beneficial for semi-arboreal species with the potential for severe aggressive interactions, and should be strongly considered by any zoos or other facilities housing such species.

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