



Stereotypic behaviour in a male Polar Bear (*Ursus maritimus*)

The cause of stereotypic behaviour in a male Polar Bear (*Ursus maritimus*)
at Ouwehands Zoo, Rhenen

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Summary

Polar bears have a long history of high popularity in zoo settings. However, many studies indicate that this wide-ranging species expresses a wide variety of abnormal repetitive behaviours in captivity, such as stereotypic walking, head swinging and repetitive swimming bouts. This is also the case in the 13 year old male polar bear in this study, which spends large portions of his day expressing stereotypic behaviour. The expression of natural species-specific behaviours is important for Ouwehands Zoo to maintain appropriate levels of animal welfare, create a satisfying visitor experience and also enable proper public education. To enable positive visitor experiences and public education about polar bears and their natural species-specific behaviour, the stereotypies present in this polar bear's behavioural repertoire need to be reduced. His long-term stereotypies must be treated however, this can only be accomplished if the cause of the behaviour is identified and targeted. Stereotypic behaviour can have a neurological or motivational frustration origin, but a coping mechanism can also be the cause of his stereotypies. In motivational frustration the animal's nature tells him to perform certain behaviours but is restricted in completing this, which then elicits a repetitive behaviour related to this. A neurological defect can be caused by high levels of stress in the early development years of an animal and in a coping mechanism an abnormal repetitive behaviour is expressed for the release of endorphins that an animal then uses to cope with continuous stressful situations. For this study external factors that could trigger the stereotypies from 3 different categories (i.e. husbandry-, geographical- and environment-related) were investigated because it was expected that the polar bear's stereotypies came from a motivational frustration origin. Through continuous recording and focal sampling the male polar bear's behaviour was observed to determine the cause and the extent of his stereotypic behaviour. A total of 116 observation sessions of 28 minutes on average were conducted over a 24-day period. All relevant polar bear behaviours were video recorded and all observed abnormalities and external factors that possibly had an effect on the male polar bear's behaviour were noted down on an observation sheet. The Observer XT 7.0 computer program was used to create a digital score form. While watching the observation session on video, information about- and related to, the male polar bear's behaviour was scored in digital event logs. Through use of GLM all husbandry-, geography- and environment-related factors thought to have an effect on the male polar bear's stereotypic behaviour were tested. Sequence analysis was used to find significant effects of behaviour modifiers on the male polar bear's 'active', 'stereotypic' and 'out of sight' behaviour as well as shifts between these behaviours. Over 116 observation sessions the male polar bear Victor on average was 'active' for 16.29% (± 2.34), 'inactive' for 1.75% (± 1.0), 'stereotypic' for 45.54% (± 3.89) and 'out of sight' for 35.79% (± 3.87). Victor displayed 292 head swings, 69 yawns and 144 variations. The male polar bear displayed significantly more stereotypic behaviour in early morning compared to late afternoons ($F(3,104)=5.358$; $P=0.002$) and was significantly more in his night den in the late afternoon ($F(3,112)=4.591$; $P=0.005$). The polar bear displayed significantly less stereotypic behaviour during observation sessions where he was fed ($F(2,88)=10,920$; $P=0.001$). The male polar bear only displayed stereotypic behaviour on concrete surfaces, with a preference for two specific areas in his enclosure. Keeper presence decreased stereotypic behaviour and elicited increased shifting between 'active' and 'out of sight' behaviour ($X^2=237.190$; $df=8$; $P\leq 0.001$). This increased shifting between 'active' and 'out of sight' behaviour was also observed whenever the male polar bear was aware of the fact that another polar bear was inside a neighbouring night den ($X^2=86.385$; $df=8$; $P\leq 0.001$). An increased employee count near the exhibit elicited an increase in the point behaviour 'variation', while traffic passing his exhibit, or noises over 70dB showed to cause an increase in stereotypic point behaviours 'head swing' and 'variation'. Many external factors affected the polar bear's behaviour both positively and negatively. It was therefore impossible to point out one specific stressor that is causing his stereotypies. Due to the large number of factors affecting his behaviour positively and negatively motivational frustration seems like a less likely cause while coping now seems more plausible. To either support or discard the finding in this study, further experimental research is recommended. It is also recommended to assess the polar bear's current living conditions and maybe consider different housing and husbandry strategies in the near future.

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1. Introduction

1.1 Problem Description

Ouwehands Zoo has been keeping polar bears ever since the mid-1930s (de Boer, 2007). Currently the zoo holds 7 polar bears. The adult male is called Victor and two adult females are named Freedom and Huggies. Freedom has two 1-year old cubs named Siku and Sesu and Huggies gave birth to twins on the 1st of December 2011.

Despite the polar bears' long history of high popularity in zoo settings, many studies indicate that this wide-ranging species expresses many abnormal repetitive behaviours in captivity (Moore and Shepherdson, 2010), such as stereotypic walking, head swinging and repetitive swimming bouts (Wechsler, 1991; 1992). This is also the case in the male polar bear of Ouwehands Zoo who expresses different stereotypic behaviours depending on the exhibit he is in (van der Kolk, 2011).

Victor, the 13-year old male from Ouwehands Zoo, expresses these stereotypies daily throughout the year when he is kept separated from the female polar bears. His most defined stereotypy occurs in both of the old Hagenbeck exhibits, built in the mid-1930s where he walks a distinct circular routine up to the slide door of his indoor enclosure, does a head swing and walks another circle. Less distinct stereotypies can also be seen in the new Nose to Nose exhibit that was built in 2000, where he paces up and down the indoor enclosure slides. (van der Kolk, 2011)

Stereotypic behaviour often is a sign of a decreased welfare in an animal (Olssen *et al.*, 2011) because their options for expressing natural behaviour patterns have become limited (Clubb and Mason, 2003). Clubb and Mason (2003) found that the lack of expressing natural behaviour patterns causes a reduction in the animal's abilities to behave flexible and appropriately to stimuli. Their study indicates that the captive housing of species which have naturally wide home ranges, like the polar bear, should either be severely improved or phased out because their particular natural lifestyle causes them to be very susceptible to welfare problems in captivity. For example, a polar bear's enclosure in captivity is about one-millionth of its minimum home-range size in the wild. There is evidence that wide-ranging species show more signs of stress and psychological dysfunction in captivity than other species. (Clubb and Mason, 2003a)

The expression of natural species-specific behaviours is important to maintain appropriate levels of animal welfare (Skibieli *et al.*, 2007), create a satisfying visitor experience and also enable proper public education about the animal's behaviour in the wild (van der Kolk, 2011).

Animal welfare, visitor experience and public education are very valuable factors for Ouwehands Zoo and are therefore incorporated into their zoo goals. For the zoo it is very important that their animals maintain a high level of physical and mental well-being by providing proper husbandry and management, sufficient medical care, and preventing and/or treating stereotypic behaviours (van der Kolk, 2011). Animal activity and stereotypies have also been linked to how long visitors spent time at a species' exhibit and can therefore affect their perception of the animals. The use of behavioural enrichment can also increase opportunities for public education. (Kutska, 2009)

Creating a positive visitor experience is important to the zoo to achieve high visitor numbers and good public education enables the zoo to promote their successful participation in the EEP (European Endangered Species Programme) polar bear breeding project. (van der Kolk, 2011)

As the zoo is a successful participant of the EEP polar bear program, public education about animal welfare and conservation of species and their natural species-specific behaviour is very important (Ouwehands, 2011). However, public education about the zoo's goal to maintain high standards of animal welfare in polar bears is very difficult to achieve, if their male polar bear Victor, expresses more stereotypies than natural species-specific behaviours which can be seen in wild polar bears.

For that reason, Ouwehands Zoo wants to reduce the stereotypies present in Victor's behavioural repertoire to be able to provide him with a high level of animal welfare, treat his long-term stereotypies and to enable public education about polar bears and their natural species-specific behaviours (personal communication Van der Kolk, 2011). However, this can only be accomplished if the cause of the behaviour is identified and targeted. Finding the source of his stereotypic behaviour may result in a suitable solution to target this behaviour however, identification of the underlying source is first required. (Vickery and Mason, 2003a)

The source of Victor's stereotypic behaviour is unknown, but one or more of three main reasons described by Olsson *et al.* (2011), may hold the cause. The first described cause of stereotypies can be related to motivational frustration where significant factors, (e.g. the polar bear's inability to for example 1: migrate (Clubb and Mason, 2003), 2: reproduce (Morgan and Tromborg, 2007) or 3: deliberately avoid conspecifics (Renner and Kelly, 2006), can elicit the repetitive behaviour which normally has a designated purpose. A neurological defect could be a second cause of stereotypic behaviour that 'compromises the ability to inhibit inappropriate responses that result in behavioural inflexibility and the continuation or recurrence of an activity without the appropriate stimuli. Impaired brain development may lead to an inability to behave flexible and appropriately to such stimuli (Clubb and Mason, 2003), which can result in neurological-related stereotypies. These stereotypies can be caused by chronic stress imposed by poor environments, both socially and physically (Olsson *et al.*, 2011). The third and last reason for stereotypic behaviour described by Olsson *et al.* (2011) is that the stereotypic behaviour might also have a rewarding factor that works as some kind of coping mechanism that the individual developed to deal with certain stressful or frustrating situations.

Looking at Victor's background, a neurological defect as a cause of his stereotypic behaviour is less plausible. Vickery and Mason (2003) state that past experience during the early rearing period, can affect motivations experienced later in life, and for example fear of humans or of novel objects. However there is no evidence of impaired brain development when Victor was a cub, nor of chronic stress imposed by a socially- or physically poor environment. (Olsson *et al.*, 2011) In addition Victor developed his stereotypic behaviour when he was already four years of age (van der Kolk, 2011; van 't Hof, 2011), therefore a different cause of his behaviour seems more plausible.

Coping behaviour is a response to aversive situations (Wechsler, 1995). The coping effect associated with performing certain behaviours is hypothesized to reinforce it, thereby leading to the repetitive performance of typical stereotypies (Mason and Rushen, 2006). If a coping mechanism would be the source of his stereotypic behaviour, he would express repetitive behaviour without a specific purpose. Again there are no signs of severe aversive situations in Victor's history, which might suggest this type of stereotypies.

In this case, it is assumed that Victor's stereotypic behaviour comes from an inability to completely execute a natural behaviour because neurological- and coping mechanism causes seem invalid, which leads us to believe his behaviour relates to motivational frustration. Therefore, this research will be focussed on stereotypies with a motivational frustration-related cause.

Motivational frustration-related stereotypies are caused by a lack or excess of appropriate stimuli (Skibieli *et al.*, 2007) and may be reduced by providing appropriate zoo environments that increase the potential for a wide spectrum of natural, species-specific behaviours (De Rouck *et al.*, 2004).

When investigating this type of stereotypic behaviour, it is assumed that the behaviour has an environmental source, where external factors in Victor's environment limit him from completing an otherwise normal behaviour with a designated purpose. It would suggest that his stereotypy is the start of a natural species-specific behaviour that cannot be completely executed and turns into the currently displayed repetitive behaviour (Olsson *et al.*, 2011).

To investigate this type of stereotypic behaviour, the external factors that could trigger the stereotypies need to be assessed (Vickery and Mason, 2003a). For this study external factors from 3 different categories (i.e. husbandry, geography and environment) are investigated because it is expected that the polar bear's stereotypies come from an environmental source.

These 3 categories will contain and therefore assess all relevant environmental factors that might elicit his repetitive behaviour. The following factors are selected for assessment after examination of the research site.

Within the husbandry-related category, feeding times (AZA Bear TAG, 2009; Grandia *et al.*, 2001; Kolter, 2002), food item preferences (AZA Bear TAG, 2009), keeping routines (Vickery and Mason, 2003b), and also enrichment objects (Carlstead *et al.*, 1991; Fortman *et al.*, 1992; Law and Reid, 2010) can be factors that affect stereotypic behaviour daily.

Geography-related factors like the exhibit Victor is confined in (Ames, 1990s), his use of the exhibit space (Renner and Kelly, 2006; Ross, 2006) and different substrates (Ames, 1994) may also give an indication as to why his stereotypies occur more heavily under certain circumstances.

The final environment-related category also holds factors that could play a role in Victor's stereotypic behaviour. Nachtigall *et al.* (2007) stated that polar bears have a hearing mean threshold of 70·dB at 4·kHz obtained in fluctuating noise conditions around 40–50·dB. Therefore traffic and construction work noises higher than 70dB could affect Victor's behaviour (AZA Bear TAG, 2009; Corrigan, 2001). Also temperatures and weather conditions (Corrigan, 2001; Ross, 2006), visitor numbers and employees (Corrigan, 2001), the behaviour of the other polar bears at the zoo (Renner and Kelly, 2006) and time of day (Vickery and Mason, 2003b) can have an effect on stereotypies.

When these described external factors are assessed, it may be possible to identify what motivational frustration-related factor(s) triggers of Victor's stereotypic behaviour and appropriate cause-directed adjustments could be made to reduce his stereotypies.

1.2 Research Goal & Questions

The goal of this study is to see if the cause of the stereotypies expressed by the male polar bear Victor from Ouwehands Zoo is motivational frustration-related.

Correlations between Victor's stereotypic behaviour and external factors within the Ouwehands Zoo setting are investigated and will thereby answer the following research questions:

1. **What husbandry-related factors correlate with the stereotypic behaviour of the male polar bear (*Ursus maritimus*) Victor, at Ouwehands Zoo?**
 - a. *In what way is Victor's stereotypic behaviour related to feeding times?*
 - b. *In what way is Victor's stereotypic behaviour affected by different food items?*
 - c. *In what way is Victor's stereotypic behaviour affected by keeper presence?*
 - d. *In what way is Victor's stereotypic behaviour related to specific keeper activities (e.g. cleaning, food prep, feeding, etc.)?*
 - e. *In what way is Victor's stereotypic behaviour affected by specific enrichment objects?*
2. **What geography-related factors correlate with the stereotypic behaviour of the male polar bear (*Ursus maritimus*) Victor, at Ouwehands Zoo?**
 - a. *In what way is Victor's stereotypic behaviour related to housing in the different exhibits?*
 - b. *In what way is Victor's stereotypic behaviour related to substrate use?*
3. **What environment-related factors correlate with the stereotypic behaviour of the male polar bear (*Ursus maritimus*) Victor, at Ouwehands Zoo?**
 - a. *In what way is Victor's stereotypic behaviour affected by visitor numbers and employees?*
 - b. *In what way is Victor's stereotypic behaviour related to the behaviour of the other polar bears?*
 - c. *In what way is Victor's stereotypic behaviour affected by construction work noises?*
 - d. *In what way is Victor's stereotypic behaviour related to time of day?*

2. Polar Bears

2.1 Description & Taxonomy

Species

Class: Mammalia Genus: *Ursus*
Order: carnivora Species: *Ursus maritimus* (Phipps, 1774)
Family: Ursidae

During the late Pleistocene age, the polar bear (*Ursus maritimus*) branched off from its common ancestor, the present-day brown bear (*Ursus arctos*). The polar bear taxon is not subdivided into subspecies

Polar bears have muscular bodies with stout legs, large paws, and a short tail (Figure 2.1). The body of a polar bear typically is stocky, but lacks a shoulder hump exhibited by *arctos*. Polar bears have a longer neck and smaller head than other ursids (Stirling, 1998; 2006).



Figure 2.1: Polar bear Victor from Ouwehands Zoo (Cremers, 2012)

Polar bears are the largest species of bear. Adult males reach their maximum size at 8-14 years old. They measure 240-260 cm total length and usually weigh 400-600 kg, but some large males can weigh more than 800 kg. Adult females are smaller than males and reach adulthood at 5-6 years when they weigh 150-250 kg with a maximum of 400 kg (Amstrup, 2003; Derocher *et al.* 2005). Maximum life span is about 25 years for males and 30 years for females (Amstrup, 2003).

Polar bears are completely furred except for the tip of the nose. Pelage density is more even than in other ursids. Even the pads of the feet of polar bears may be covered with hair.

Furred foot pads may provide a more secure purchase on the slippery sea ice surface and add another layer of insulation between the bear's foot and the substrate of ice and snow. Their claws are shorter and more curved than those of brown bears and larger and heavier than claws of black bears (Amstrup, 2003).

The skin of polar bears is uniformly black and polar bear fur appears white when it is clean and in even sunlight, because it actually is without pigment. In spring and late winter, however, many polar bears are "off-white" or yellowish because of oils from their prey and other impurities that have attached to and been incorporated into their hair. (Amstrup, 2003)

2.2 Behaviour

Polar bears are the apex predator in the Arctic and the keystone species in their ecosystem. Being the most predatory of all bear species, the polar bear mainly hunts for ringed seals (*Phoca hispida*) of which the fatty parts are preferred over for example muscle tissue. They appear to digest fat better than protein and that is why this species firstly consumes the fat layers of freshly killed seals. Polar bears are seen to feed on berries, kelp and other terrestrial forage in autumn when some of them are forced to move to the main land due to melting sea-ice. The value of this supplemental terrestrial food is poorly understood because their digestive system is not well equipped to digest plant material which leads to believe that, except for few fruits, plant material will contribute little to their energy balance in the wild (Amstrup, 2003). It could provide a limited nutrition to the bears, or may be a displacement behaviour that can function to decrease aggression between the hungry, congregating bears when they are in close proximity to one another (AZA, 2009).

A polar bear's behaviour and physiology is well adapted to a feast-and-famine feeding regime because their ability to survive food deprivation is higher evolved than other *ursids*. At any time of the year, Polar bears can shift into a hibernation-like metabolic pattern when they are confronted with periods of food deprivation. (Amstrup, 2003)

Reproduction

Females reach sexual maturity at 5-6 years of age, males around 8-10 years of age (Unknown Author, Cites; 2009). In captivity the average age of first reproduction in males is lower and they are believed to reach sexual maturity on the age of 3.

Mating season is from March till June, with a peak around April. The embryo implantation is delayed until autumn, and birth is believed to occur in November till January.

Pregnancy is about 200 to 250 days and females go into hibernation when pregnant. Cubs are born in these hibernation dens where they stay until they reach an average weight of 10kg and they are approximately 3 months old (Both, 1994). Average litter size is 2 cubs and they are born with closed eyes and have a thin fur. Cubs wean at 2-3 years old and are independent after two years. Unfortunately there is a high cub mortality, around 70%, which means there are fewer individuals to contribute to the species survival. Females reproduce every 3 years. (Schliebe *et al.*, 2008)

2.3 Habitat and Distribution

In the wild, polar bears only occur in the northern hemisphere (Figure 2.2). Their range is limited to areas in which the sea is covered in ice for much of the year. Most polar bears stay in ice covered areas for the entire year where they travel over 50km per day at a 4km per hour speed, however many of them are forced to wander onto the main land for shorter periods of time when seasonal changes cause the ice to melt.

Polar bears are common in the Chukchi and Beaufort Seas, north of Alaska. They occur throughout the East Siberian, Laptev, and Kara Seas of Russia and the Barent's Sea of northern Europe. They are found in the northern part of the Greenland Sea, and are common in Baffin Bay, which separates Canada and Greenland, as well as through most of the Canadian Arctic Archipelago. Because their principal habitat is the sea-ice surface rather than adjacent land masses, they are classified as marine mammals. (Amstrup, 2003)

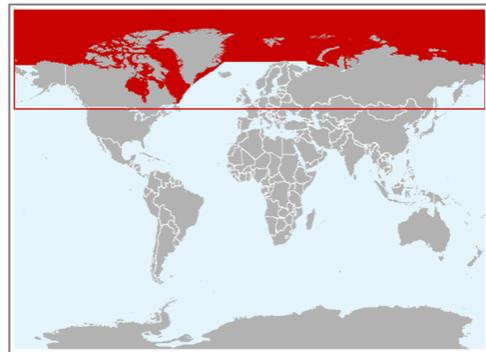


Figure 2.2: Polar bear distribution (IUCN, 2008)

2.4 In- Situ Situation

There are presently believed to be between 20,000 and 25,000 polar bears in 19 putative populations. While the overall population size estimate has varied little over the past 15 years, individual population estimates have become more precise.

The number of polar bears is decreasing throughout their range (Schliebe *et al.*, 2006; IUCN/SSC PBSG 2009). The PBSG concluded that 1 of 19 subpopulations is currently increasing, 3 are stable and 8 are declining. For the remaining 7 subpopulations, available data were insufficient to provide an assessment of current trend.

In 2008, the IUCN listed the polar bear as Vulnerable based on IUCN criterion A3c based on a suspected population reduction of >30% within three generations (45 years) due to decline in area of occupancy, extent of occurrence and habitat quality (Schliebe *et al.* 2008). Some experts have concluded that polar bears will not survive due to the complete loss of summer sea ice (Derocher *et al.*, 2004; (Unknown Author, Cites; 2009)

The polar bear is highly vulnerable due to the loss of its habitat, the North Pole, by global warming. Sea ice has been reduced by 8 percent in the past 30 years alone, while summer sea ice has been reduced by 15-20 percent (Unknown Author, Cites; 2009). Records were collected on retreating sea ice in 2007 and 2008 and continued a 30-year trend (IUCN/SSC PBSG 2009). In some locations where sea ice already completely disappears in summer - for example, the

Canadian Arctic islands and Svalbard, northern Alaska and Russian Chukotka - use of land by polar bears is increasing (Schliebe *et al.*, 2006). The amount of time on land is critical because polar bears are not able to capture normal prey items and are more likely to be killed by human hunters (Stirling and Derocher, 2007).

2.5 Ex-Situ situation

There are about 100 polar bears in captivity in Europe and another 100 animals in the rest of the world. According to the animal registration program ZIMS, there were 207 polar bears in captivity worldwide on January 1st, 2010 (ZIMS, 2012). The main problem is that a lot of these animals live in zoos with old enclosures. These zoos do not have the possibility to create a good breeding situation. Therefore more and more zoos decide to stop holding polar bears. In Europe there are only about 10 zoos which regularly breed polar bears. (Author unknown, 2009)

In the last years, several zoos build new polar bear enclosures (Rhenen, Aalborg, Rotterdam, and Hannover). These enclosures have several parts to keep the animals solitary and have a breeding burrow to give females all the rest they need to give birth. When more zoos decide to build new polar bear facilities a larger breeding program can be created which will increase the survival chance of this species in the future. Now Ouwehands Zoo in Rhenen is responsible for almost half of the captive births in the EEP (van der Kolk, 2012)

2.6 Polar Bears in Ouwehands zoo

Ouwehands Zoo, Rhenen, opened its doors almost 80 years ago on the 18th of June 1932. The zoo was founded by Mr C.W. Ouwehand and originally started out as a chicken farm.

In the mid-1930s the first polar bears arrived at the zoo and it was as early as 1938 when polar bear Maxie gave birth to a healthy cub (Figure 2.3). But unfortunately this cub did not survive because of an accident in the enclosure.

Two years later, in 1940, the first polar bear twins in captivity were born. This time it was a great success and Maxie turned out to be a very good mother. The polar bear twins became only four years old, since they were shot in the Second World War. After these turbulent years it took more than 30 years before the next polar bear was born in Ouwehands zoo. Ouwehands Zoo has been very successful in breeding with their Polar bears ever since and are participating in the EEP (de Boer, 2007).



Figure 2.3: Polar bear Maxie and her cubs born in 1938 (de Boer, 2007)

Present polar bear group

The present Polar bear group kept at Ouwehands Zoo consists of 2.3.2 animals (Table 2.1). The 7 polar bears currently held at the zoo are Victor, Freedom and her two 1-year old cubs Siku and Sesu and Huggies with her two new born cubs.

Table 2.1: Current polar bear group of Ouwehands Zoo

Name	Sex (M/F)	Birth date	Birth type	Rearing	Sire/Dam
Victor	M	18-12-1998	Captive born	Parent reared	Churchill/Wienerin
Freedom	F	06-12-2001	Captive born	Parent reared	Nuuk/Huggies
Siku	M	24-11-2010	Captive born	Parent reared	Victor/Freedom
Sesi	F	24-11-2010	Captive born	Parent reared	Victor/Freedom
Huggies	F	~ -01-1994	Wild born	Unknown	Unknown
Unknown	?	01-12-2011	Captive born	Parent reared	Victor/Huggies
Unknown	?	01-12-2011	Captive born	Parent reared	Victor/Huggies

Huggies came to Ouwehands Zoo in 1994, after Russian researchers found her floating on a small iceberg near the Siberian coastline when she was only 5 months old. She was then transported to Ouwehands Zoo from Moscow and in 1998, she was sent to Kolmarden Zoo in Sweden, for breeding. As Huggies is wild-born, she is of genetic importance for captive breeding programs. In March 2002 she returned to Ouwehands Zoo with her daughter Freedom. (De Boer, 2007) On her return, she was kept at the zoo along with Victor, who arrived at the zoo in April of 2000 originally.

Victor was born in Rostock Zoo in Germany and they recorded no abnormalities in his development, nor did he suffer from any diseases. He was housed together with his mother Wienerin in an exhibit of similar size and substrates as the Old Hagenbeck exhibit of Ouwehands Zoo (van der Kolk, 2011). At the age of 16 months he was sent to Ouwehands Zoo. In November 2002, when he was almost four years old, he went on a breeding loan to Natura Artis Magistra in Amsterdam, where he was kept together with Katrien, the zoo's female polar bear. The exhibit was much smaller than his exhibits in Ouwehands Zoo and Rostock Zoo. The floor size of the polar bear exhibit in Artis Zoo was about 36m² with elevations and a moat of approximately the same size. During the day the polar bears were kept outside and at night they also gained access to their night dens. They were fed at random times to avoid food anticipation (van 't Hof, 2011). It is uncertain where Victor's stereotypic behaviour started exactly. Before Victor went to Artis Zoo, he might have already developed a head swing. This head swing probably later developed in a more advanced stereotypic routine where he would continually walk up to the ridge of the top plateau in his exhibit, wave his paw over the ridge, turn around, walk up to the wall and swing his head. The polar bear keepers tried to reduce this behaviour by offering him some enrichment items and use scatter feeds during the day. Because of the death of the female, Victor was kept on his own for another 6 months and returned to Ouwehands Zoo in October 2003 (van 't Hof, 2011).

On his return, Victor and Huggies soon appeared to be highly compatible, resulting in a unique birth in November of 2005 when she gave birth to triplets who now live in Dierenrijk Europa in The Netherlands and Orsa Bearpark in Sweden. In December 2008, Huggies and Victor had another cub named Walker who now lives at Highland Wildlife Park in Scotland. (ISIS, 2011)

Freedom was born in Kolmarden Zoo in December of 2001 and came to Ouwehands Zoo with her mother Huggies when she was 3 months old. In 2005 she spent five months (January until May) at Dierenrijk Europa in The Netherlands. At the age of 6, Freedom and Victor had their first cub named Sprinter who went to Hannover Zoo in February of 2010. Three years later in November of 2010, Freedom gave birth to twin cubs Siku and Sesi, who are now 1 year old and were once again fathered by Victor. (ISIS, 2011)

3. Material & Method

3.1 Housing and Husbandry

3.1.1 Group composition

Normally Huggies and her daughter Freedom are held together in the same exhibit. At present however, they are kept separated because of Huggies' pregnancy and the presence of Freedom's two cubs is too exhausting for her. She retreated to her nursing den at the end of November. This had some implications for the husbandry of the remaining polar bears (see chapter 3.1.3). (Van der Kolk, 2011)

Victor is kept separated from the other polar bears for most of the year. During mating season he is placed together with one of the females. When either of the females has cubs, Victor is also kept separated from the group, because of the fear of infanticide. (Ouwehands, 2011)

All polar bears can see, hear and smell each other (van der Kolk, 2011).

3.1.2 The Enclosures

The polar bears in Ouwehands Zoo have one indoor holding area and three outdoor exhibits (Table 3.1). See appendix I for floor plans. The indoor holding facility is divided into 13 sections (including two nursing dens) that can be used for indoor lock up, shifting between exhibits and/or separation of individual polar bears. The old exhibit, which was built in the mid-1930s, primarily consists out of concrete and is a typical Hagenbeck exhibit. This exhibit was later divided into two exhibits (Exhibit 1 and 2, Table 2) so every adult polar bear can be kept separately if necessary, which is the case at moment (van der Kolk, 2011).

Table 3.1: Description Polar bear enclosures

	Indoor enclosure	exhibit 1*	exhibit 2*	exhibit 3*
Enclosure Size	13 4m ² cages (incl. 2 nursing dens)	250m ²	150m ²	2500m ²
Substrate	100% concrete	85% concrete 5% sand 10% water	30% concrete 40% sand 20% grass 10% water	15% concrete 5% sand 40% grass 40% water
Barriers	- Metal bar fences - Manual sliding doors - Concrete walls	- Hagenbeck walls - Moat - Glass wall	- Hagenbeck walls - Moat - Glass wall	- Electric fence - Glass wall (7cm thick) - Walls
Furnishing		- Rocks - Enrichment items	- Rocks - Tree trunk - Enrichment items	- Rocks - Trees (& tree trunks) - Waterfall - Enrichment items
Water	x	150.000 L Moat	150.000 L Moat	1.000.000 L basin
Filters	x	Connected to zoo's complete moat system, including filters		Sand filters

* Floor plans of the exhibits can be found in Appendix I.

In 2000 the Nose to Nose exhibit was built (Exhibit 3, Table 2). This new exhibit was built on the opposite side of the two old Hagenbeck exhibits, with the indoor enclosures in-between to divide them. This is a more naturalistic tundra exhibit with a large basin that contains over a million litres of water. It has a large, thick glass wall between the basin and the visitors, so they can observe the polar bears swim from up-close. In the Nose to Nose exhibit there is a shelter made from rocks and there are several deciduous trees that have electric wires around them to ensure the bears do not climb them. There are several tree trunks placed at the waterside as a climbing apparatus.

3.1.3 Husbandry measures

Male polar bear Victor was kept in exhibit 1, Huggies in exhibit 2 and Freedom and her cubs were located in the Nose to Nose exhibit. After Huggies retreated to her nursing den to give birth to her cubs in November, the male polar bear also gained access to exhibit 2.

In the normal husbandry routine, the polar bears are shifted regularly between the three outdoor enclosures and have access to their night dens most of time. Usually they do not spend more than one or two days in one exhibit, however during this research, all polar bears stayed in the same exhibits because the shifting activities could cause too much stress to Huggies and her new cubs. Other husbandry routine changes due to Huggies pregnancy were cleaning and provision of enrichment.

In a normal situation faecal matter is removed daily from each enclosure, as are leaves, torn enrichment items, bones and other left over food items from a previous day. Three times a month the two Hagenbeck exhibits are cleaned with a high pressure cleaner to remove any remaining debris, stains and algae residues from the hard surfaces in the enclosures. The Nose to nose exhibit is only cleaned with a high pressure cleaner once a month. Daily cleaning activities take up about 1 hour in the zoo keeper's schedule. High pressure cleaning will take approximately 4.5 hours. (Dirks, 2011) This cleaning routine was not observed during our study period. The male polar bear's exhibits were cleaned twice during the study period.

There was no steady established daily husbandry- and feeding routine for the polar bears. All polar bears are fed once or twice every other day (Dirks, 2011). They are fed at random times to reduce predictability and avoid food anticipation. (Van der Kolk, 2011) Their diet varies every 2-4 months depending on the season. Most of the year (September till May) the polar bear diet consists of meat (i.e. beef, beef fat, chicken, lamb and tripe) and fish products (i.e. mackerel and herring), raisins and nuts. In summer months (June till August), the amount of meat and fish is reduced and, different fruits (i.e. apple, strawberry and melon) vegetables (i.e. carrot and endive), eggs and liver are added. In summer, raisins and nuts are also fed. (Van Appeldoorn, 2011) For an example of two months of the complete diet fed to Victor, Huggies and Freedom in 2010, see Appendix II.

Medical care is provided whenever necessary. Polar bears get a vitamin shot when they are 4 months old and are de-wormed annually throughout their lives. (Dirks, 2011)

Enrichment items were present at all times in the three enclosures. Some enrichment items are; barrels, boomer balls, tyres, jerry cans, frozen and/or novel food items, new scents, scatter feed and a rattler for the polar bear cubs. New enrichment item are introduced regularly, usually once every one or two weeks. (Dirks, 2011)

3.2 Observations

The male polar bear's behaviour was observed to determine the cause and the extent of his stereotypic behaviour. First two preliminary observations were done on the 3rd and the 16th of November during a pilot study, to test the recording method and to set the behavioural categories and their precise criteria.

After all data collection parameters were evaluated and improved, the observation method was perfected and the camera locations were determined, the actual behavioural observations started at Tuesday the 22nd of November 2011. Appendix III holds all definitions of the different variables collected in this research.

Continuous recording and Focal Sampling were used as a sampling recording method (Martin and Bateson, 2007).

Between the 22nd of November 2011 and 3rd of January 2012, a total of 116 observation sessions were conducted over a 24-day period. 54 hours and 18 minutes of data was collected, spread over an average of 5 observation sessions daily from Monday to Friday between 09.15 and 17.15 daily (Table 3.2). A 10-day Christmas holiday occurred from the 24th of December until the 2nd of January.

Table 3.2: Time schedule observation sessions

Session/ Time Segment	Early	Late
1	09.15 - 09.45	
2	10.15 - 10.45	10.45 - 11.15
3	11.15 - 11.45	11.45 - 12.15
4	12.15 - 12.45	12.45 - 13.15
5	13.15 - 13.45	13.45 - 14.15
6	14.15 - 14.45	14.45 - 15.15
7	15.15 - 15.45	15.45 - 16.15
8		16.45 - 17.15

Fewer 1st time segments were conducted due to many public transport delays in mornings and fewer 8th time segments occurred because it was too dark to collect usable data through camera footage. Low battery life of the camera lead to an afternoon break on the 4th or 5th time segment to charge the batteries. To compensate for the low number of early morning observations (N=7) and late afternoon observations (N=4) especially, a 'combined time segment' variable was developed (Table 3.3).

Table 3.3: Converted time segments (N=116)

Time segment	N=116	Combined Time segment	N	Time
1	7	1	29	09.15 - 11.15
2	22			
3	22	2	36	11.15 - 13.15
4	14			
5	14	3	31	13.15 - 15.15
6	17			
7	16	4	20	15.15 - 17.15
8	4			

All relevant polar bear behaviours were video recorded. These video recordings were made by 2 digital cameras. Each observation of the male polar bear was recorded onto a 16GB SD card through use of an Aiptek High definition®, 16.0 Megapixel video recorder which was placed on a tripod. The second camera was a Canon Powershot A630®, 8.0 Megapixel digital camera with a 4GB SD card (named 'Female camera' from now on) and was placed facing the 'Nose to Nose' exhibit where one of the female polar bears and her cubs was located.

Preparation for each new observation session started 10 minutes before the planned session. The female camera was positioned and switched on first. Then the observer took her position

next to the male polar bear's enclosure and started the observation at the scheduled time. The brief time window between starting the female camera and the start of the actual observation session was clocked by use of a stopwatch.

These video cameras recorded the polar bears' behaviours during observation sessions that each lasted 28 minutes on average. During data processing the female and her cubs' behaviours that were of interest, were compared with the male's behaviour at that exact same time.

Simultaneously with the cameras, a sound level meter 'Voltcraft SL100[®]' was used to keep track of the surrounding noises. This sound level meter had a range of 30 to 130dB with a precision of 2dB and a range from 31 to 8000 Hz.

As mentioned in the introduction, research showed that polar bears have a hearing mean threshold of 70dB and sounds above this level are considered uncomfortable (Nachtigall *et al.*, 2007). Therefore any sound peaks higher than 70dB were scored as modifiers and allowed for measuring any relations between loud noises and the male polar bear's behaviour. During the pilot study, sound levels from both inside the male polar bear's exhibit and outside were measured to compensate for any possible differences. The sound levels of the environmental noises were measured on three different locations in exhibit 1. Sound levels within the exhibit did not differ substantially from those outside the exhibit. Both inside and outside the exhibit, average measured sound levels ranged from 55dB to 67dB on a regular day.

The observation circumstances and frustration-related factors (paragraph 3.2.3) were noted down on the small observation form (Appendix IV), prior to each session. All observed abnormalities and external factors that possibly had an effect on the male polar bear's behaviour during the observation sessions were immediately noted down on the observation sheet including the time at which the event occurred. After the observation session, the cameras were taken back to the office and the new footage was uploaded on to a laptop immediately for further processing.

3.2.1 Behaviour male polar bear

State behaviours

The male polar bear's behaviour was recorded with 'Victor's camera'. His behaviour was divided into four categories. He could express either 'Active behaviour' (A), 'Inactive behaviour' (IA), 'Stereotypic behaviour'(S) or he was 'Out of Sight' (OOS). These behaviours were mutually exclusive so only one of these state behaviours could occur at a certain time. Frequency, duration and location of the behaviour were scored. Only these four categories were chosen as state behaviours, because this research is mainly focussed on the male's stereotypic behaviour and therefore it was irrelevant to specify the different types of behaviours.

Shifting between state behaviours

After collecting data about the frequency and duration of the different state behaviours, shifts between these behaviours can also indicate relations between the polar bear's behaviour and external factors. Therefore shifts between the different state behaviours were counted (Table 3.4) for a baseline situation and in presence of external factors (Paragraph 3.2.2 & 3.2.3). 'Inactive' behaviour was excluded due to the low number of times it occurred.

Table 3.4: Possible behavioural transitions

Shift	Code
Unchanged Active	A-A
Active into Stereotypic	A-S
Active into Out of sight	A-OOS
Stereotypic into Active	S-A
Unchanged Stereotypic	S-S
Stereotypic into Out of Sight	S-OOS
Out of Sight into Active	OOS-A
Out of Sight into Stereotypic	OOS-S
Unchanged Out of sight	OOS-OOS

Point behaviours

Besides the state behaviours and shifts between them it was important to also focus on a few more specific short reoccurring point behaviours. Besides the four state behaviours that were mutually exclusive, these point event behaviours were also scored, because they could be related to frustration and/or stereotypic behaviour. These point behaviours occurred only a few seconds at a time and could be expressed while the male was in an active or stereotypic behaviour state. The three chosen point behaviours that were scored were 'Yawn' (Y), 'Head swinging' (K) and 'Variation' (V). Yawning can be a sign of stress (Carlstead *et al.*, 1991) and head swinging is a stereotypy often seen in all bear species including polar bears (Fortman *et al.*, 1992; Law and Reid, 2010). The point behaviour 'Variation' was developed to be able to score certain variations in his stereotypies. These variations could not have been predicted at forehand but might be indicators of a small behaviour change related to for example his environment.

Location of behaviours

The male polar bear's location was scored to determine if there was a relation between certain areas in his enclosure and his behaviours. This scoring also gave insight in which areas he used most. The different locations in his enclosure were categorised into the different substrates present in each enclosure. These are concrete, sand, grass and water. Because some substrates cover a large part of an exhibit, some areas that were scored with Victor's location were divided into multiple sections of the same substrate (Appendix I).

3.2.2 Baseline

To later on see what effect external factors (i.e. observation circumstances and frustration-related factors) had on the polar bear's shifting between state behaviours, baseline data points were collected. A total of 354 data points were taken from 55 randomly chosen observation sessions to gather baseline data about the state behaviours and shifts between them. These baseline data points ranged in lengths between 10 seconds and 30 minutes and present behavioural shifts between the 'active', 'stereotypic' and 'out of sight' behaviours (paragraph 3.2.1) at moments where no external factors were occurring. Behavioural shifts that occurred during external factor events were then tested against the different behavioural shifts found in the baseline data to see whether there is a significant difference between them. It must be noted that unchanged behaviours (i.e. A-A, S-S and OOS-OOS) can only occur once because it means that the bear's state behaviour did not change during event. Other behavioural shifts however, could occur more often within one specific event.

3.2.3 External Factors

Observation circumstances

Before each observation session the observation circumstances were noted down on small observation forms (Appendix IV). These small observation forms provided information about: date & time, daily temperature & weather conditions (Table 3.5), observer name and whether the male polar bear was kept in exhibit 1 or 1 & 2 combined.

Table 3.5: Six weather categories according to Baal and Beckman (2010)

	Weather Type	Description
1	Sunny and dry	The sun is visible with possibly some clouds present, with a minimal of 2/3 blue sky. There is no precipitation.
2	Sunny and precipitation	The sun is visible, some clouds may be present, with a minimal of 2/3 blue sky. There is precipitation in forms of rain, snow or hailstone.
3	Clouded and dry	The sky mainly exists out of clouds, with some blue sky 'pieces' visible, with a minimal of 2/3 sky that's clouded. There is no precipitation.
4	Clouded and precipitation	The sky mainly exists out of clouds, with some blue sky 'pieces' visible, with a minimal of 2/3 sky that's clouded There is precipitation in forms of rain, snow or hailstone.
5	Grey and dry	The sky is completely clouded and the sky is grey. There is no blue sky visible and there is no precipitation.
6	Grey and precipitation	The sky is completely clouded and the sky is grey. There is precipitation in forms of rain, snow or hailstone.

Other variables that were noted down on the small observation forms during each session included presence of food- and enrichment items. These items could either be fresh, old or absent. When a food item was old, it was already present and provided at a previous observation session. When an enrichment item was old, it was already present and provided at a previous observation day.

The interaction time with the present food items and specific food types (meat, fish or other) and interaction with different enrichment items (feeding, toys, and substrates) were scored when the footage was processed by laptop.

Frustration-related factors

During each session any abnormalities and possible influencing factors were scored. Some factors were known at the start of the observation and were always noted down.

Data about keeper presence and reason of presence (activities) was collected as much as possible, because of their possible effect on the male polar bears' behaviour. On occasion the polar bear keepers walked by to inform the observers about their presence. Keeper activities non-feeding related activities (i.e. cleaning, check-up and administration) and feeding related activity (i.e. food preparation and feeding). Food preparation was not observed and excluded from any testing.

The total number of exhibit visitors within an observation session was counted. A zoo visitor will be called an exhibit visitor when he or she walks past the polar bear enclosure where the male polar bear is located within a 3 meter range. Also the number of Ouwehands Zoo employees walking by within a 3 meter range of the exhibit was counted during each observation session.

All traffic passing the polar bear's exhibit was scored on type and duration. The duration of noise events over 70dB that occurred near the exhibit were also noted down.

Through the use the 'Female camera', relevant events of the 'group' (female Freedom and her cubs) was recorded at the same time as the male's behaviour. The reason for the collection of the female and cub events was to find out if certain situations and accompanying behaviours displayed by the female or the cubs might have affected the male polar bear and his behaviour. After each observation session, when all videos from both male and the group were uploaded onto a laptop, the footage of the group was assessed. The events that were scored from the female and cubs were defecating, vocalizing, the presence of food in their exhibit, being within sight in the outside exhibits and being inside the night dens. These events were chosen because of their visual-, sound- and/or scent aspects, which could affect the male polar bear's behaviour. Vocalizations and defecations were not observed and therefore excluded from any testing. This way any correlations between the male's behaviour and the other polar bears' activities could be measured.

3.3 Data Processing and Analysis

3.3.1 Data processing

Video footage of each observation session was uploaded onto a laptop and processed with The Observer XT 7.0[®] from Noldus Information Technology. (Noldus, 2011)

The Observer XT 7.0 computer program (Observer from here on) was used to create a digital score form. While watching the observation session on video, information about- and related to, the male polar bear's behaviour was scored in digital event logs. The frequency, duration and location of the occurring state behaviour were scored, as well as the number of occurring point behaviours. Within Observer, 'observation circumstances' were classed as independent variables and 'influencing factors' and 'female group events' were classed as behaviour modifiers. These independent variables and behaviour modifiers were scored to indicate when certain events occurred and whether they affect the male polar bear's behaviour.

3.3.2 Data analysis

Through the analysis function of Observer, the collected data was processed and the total number of occurrences and total duration of each behaviour, behaviour modifier and location was calculated over the total observation period. The Observer's visualization function and event logs were used to register what behaviours (including point behaviours) and behaviour changes occurred during behaviour modifiers. Data processed and analysed with Observer was exported to Microsoft Excel[®] and checked on errors and possible dissimilarities between the observers. After a full error-check on the independent variables, behaviours, behaviour modifiers and locations, the data was then copied to the IBM SPSS 19[®] statistics program (SPSS from now on) for further analysis.

Effect of behaviour modifiers were tested in two ways through use of a General Linear Model (GLM) and through Sequence Analysis.

General linear model

Through use of GLM all factors stated in the research questions thought to have an effect on the male polar bear's stereotypic behaviour were tested. To approach normality percentages of time spent in each behavioural state was transformed by an arcsine square-root transformation. Normality and graphical structure of the residuals for each model was then checked through use of Shapiro-Wilks test (Hill, 2005). Stereotypic behaviour was used as a dependent variable against food presence, food item, enrichment presence, enrichment item, visitors, employees, keeper presence and time of day (described in paragraph 3.2.3) to find out what factors have a significant effect on the male polar bear's behaviour. All tests were two tailed and the significance threshold was set at 5%. For this GLM analysis four datasets were created in SPSS. The first one was a complete dataset with all observations (N=116) that were conducted during the data collection period and the second dataset excluded 22 observations where the male polar bear was 'out of sight' for the entire observation session (N=94). This smaller dataset was used to answer the research questions on the effects of food and enrichment on the stereotypic behaviour of the male polar bear because for these specific variables it is impossible to say anything about effects on behaviour if the animal is completely out of the observer's sight for the entire observation session. For all other research questions the larger 116 observation session dataset was used because in other situations 'out of sight' behaviour is a relevant behaviour state. The third and fourth GLM models were created to test effects between all husbandry-, geography- and environment-related variables and the 'active' and 'out of sight' behaviour of the male polar bear.

To come to the final GLM model, a stepwise elimination procedure was used to remove the least significant variables (Hill, 2005). In the end, only significant factors were present in this model. Pair wise comparisons were done for all significant variables with a Post Hoc Bonferroni test, to test the interaction within subjects.

Pearson's Correlation

The Pearson's Correlation test was used to find a correlation between two continuous independent variables. Pearson's correlation test was used to test the relation between the percentage stereotypic behaviour of the male polar bear and the percentage of time the male polar bear spent on a substrate. And also the correlation between the percentage stereotypic behaviour and the percentage of time 'traffic' was driving by or high 'decibel' levels occurred was tested.

Sequence Analysis

Sequence analysis was used to find significant effects of behaviour modifiers on behavioural shifting between 'active', 'stereotypic' and 'out of sight' behaviours. All tests were two tailed and the significance threshold was set at 5%. 'Inactive' behaviour was left out of these calculations due to the low frequency in which inactive behaviour occurred during this study.

Effects of behaviour modifiers on the polar bear's behaviour were tested over all modifier events within the total observation period and compared to baseline data. This baseline consists of 354 data points over 55 randomly chosen observation sessions where no behaviour modifiers occurred. The total number of changes, as well as the polar bear's first behavioural reaction to a modifier was taken into account. Substantial differences in event length were observed and ranged from an average of 10 seconds for traffic events to 30 minutes for keeper and female group events. Behaviours and behaviour changes were tested including repetition. This means that when the male polar bear did not shift between behaviours (i.e. unchanged behaviour) this was also scored and included in data analysis. Data about the behavioural shifting was copied to a SPSS dataset and crosstabs were used to create transition matrixes and Pearson's chi-squared testing was used to find significant effect on the polar bear's behaviours in relation to behaviour modifiers. To see if any of these more or less occurring behaviours and behaviour changes was caused by a behaviour modifier, they were tested against the baseline data points and increases and decreases in different behavioural shifts were presented in pathway diagrams. These diagrams were used to visualise the transition matrixes of all found relations between behaviour modifiers and the polar bear's behaviour in the baseline situation. The thickness of the arrows increases along with greater difference in percentages compared to the baseline data.

4. Results

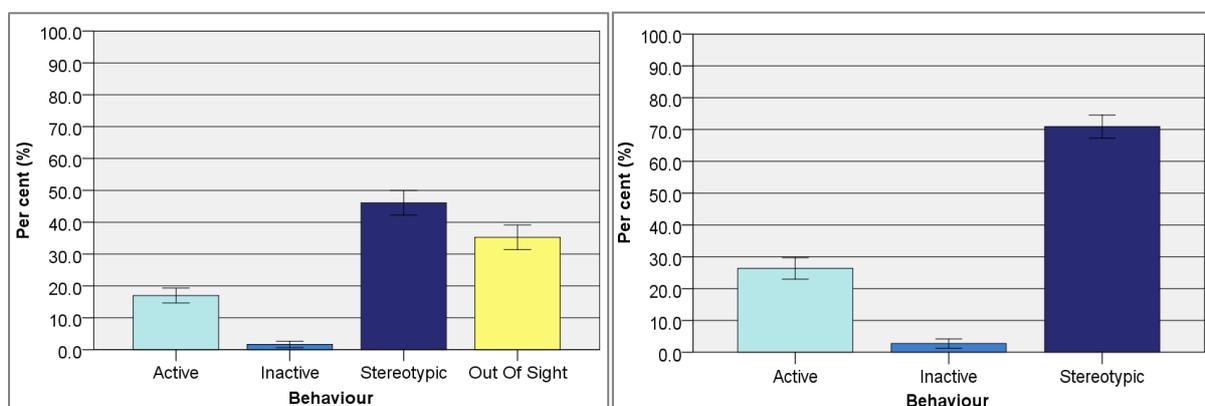
During this behavioural study the male polar bear was observed for 54 hours and 18 minutes (195502 seconds) spread over 116 observation sessions of 28 minutes on average per session. 37.95% of the total observation period, external factors were present (i.e. traffic, decibel, keeper presence and possible influencing female group behaviour) that could influence the male polar bear's behaviour.

4.1 Behaviour

4.1.1 State Behaviours

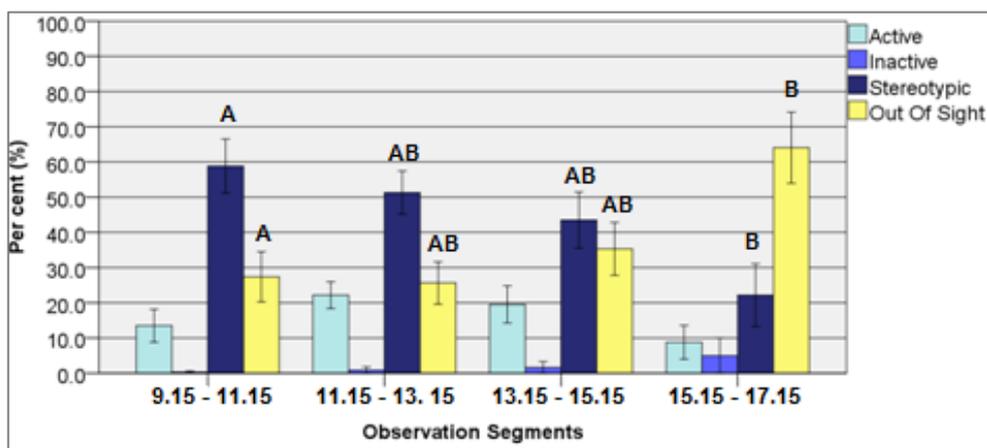
The male polar bear Victor was observed to be 'stereotypic' for 24 hours and 43 minutes (89029 seconds) of the total observation period. During this study 'stereotypic' behaviour was the behaviour most displayed by the male and this behaviour represented 45.54% (± 3.89 SEM) of an average observation session. The male polar bear displayed 'out of sight' behaviour for 19 hours and 30 minutes (69979 seconds), which meant that the male was insight his night den and/or not visible to the observers for 35.79% (± 3.87) of an average observation session. 'Active' behaviour was recorded for 39 hours and 11 minutes (33071 seconds) and represented 16.29% (± 2.34) of an average observation session. 'Inactive' behaviour occurred 4 times, lasting a total of 1 hour (3423 seconds) during the entire observation period and covered 1.75% (± 1.0) of an average observation session (Graph 4.1a).

When the amount of time the male polar bear spent out of the observer's sight was removed from the data, 94 observation sessions remained and higher percentages of 'active', 'inactive' and 'stereotypic' behaviours were found per average observation session (Graph 4.1b). Average duration, percentage and standard deviation of all behaviours can be found in Table V.1 of Appendix V.



Graph 4.1a (N=116), 4.1b (N=94); Average "active", "inactive", "stereotypic" and "out of sight" behaviour in percentages (%) over the total observation period. Error Bars: ± 1 SE

Time of day has a significant effect on the 'stereotypic' ($F(3.104)=5.358$; $P=0.002$) and 'out of sight' ($F(3.112)=4.591$; $P=0.005$) behaviour of the male polar bear. Pairwise comparisons were done with a Bonferroni test and showed that the male polar bear expressed significantly more 'stereotypic' behaviour in the morning between 09.15 and 11.15 ($N=29$)(58.84%; ± 7.65) compared to afternoons between 15.15 and 17.15 ($N=20$)(22.18%; ± 8.93)($P=0.013$). The percentage 'out of sight' on the contrary, is significantly higher in the afternoon (64.03%; ± 10.09) compared to morning between 09.15 and 11.15 ($P=0.011$)(Graph 4.2). Like 'stereotypic' state behaviour, the average number of point behaviours is highest in the first time block (7.88 point behaviours). (Table V.2 of Appendix V)



Graph 4.2: Average activity budget of the polar bear per time of day, divided over 4 observation segments with pairwise comparisons (N=4), calculated over the total observation period (N=116); Error Bars: +/- 1 SE; A significantly differs from B, AB does not differ from A nor B.

4.1.2 Point behaviours

During this study the male polar bear expressed 505 point behaviours, which were spread over 292 head swings and 69 yawns. He also expressed 144 variations in his stereotypic routine. This comes down to an average 3.12 (± 0.65), 0.73 (± 0.13), and 1.53 (± 0.18) point behaviours respectively within an average 28 minute observation session (Table V.3 of Appendix V).

Of this total of 292 head swings, 69 yawns and 144 variations, 126 head swings, 27 yawns and 70 variations were observed during the 37.95% of the total observation period where possible influencing factors were present. This represented 43.15%, 39.13% and 48.61% respectively of the total number of point behaviours. More details about point behaviours during modifiers are presented in Table V.4-7 of Appendix V.

4.1.3 Exhibit use

The male polar bear was located in exhibit 1, during 21 observation sessions and in exhibit 1+2 combined during 95 observation sessions. In this study, he was never seen in exhibit 2 or exhibit 3 (Table V.8 of Appendix V).

The polar bear spent most time on concrete substrate, 62.5% when he was located in exhibit 1 (N=21) and 54.9% when he was located in exhibit 1+2 (N=95). The polar bear used 'concrete 1' and 'concrete 4' in particular.

The male polar bear used his water bodies for 1.10% (Ex1; N=21) and 1.85 % (Ex1+2; N=95) of the total observation period. The water body he used most was 'Water 2' (1.10% and 1.80% respectively of the total observation period). The total time the polar bear male spent on 'soft substrates' was 12.41% (Ex1; N=21) and 6.20% (Ex1+2; N=95) respectively. Figure 4.4 and table V.9 of Appendix V show the precise exhibit use of the male, per exhibit in average percentages.

A significant relation was found between the percentage of stereotypic behaviour the male polar bear expressed and the amount of time he spent on the three different substrates. Significant more 'stereotypic' behaviour was observed on concrete than on soft substrates or water ($R=0.685$, $P\leq 0.001$). Significantly more 'stereotypic behaviour was seen on 'concrete 4' ($R=0.426$, $P\leq 0.001$) and significantly less on 'concrete 2' and 'concrete 3' ($R=-0.387$, $P\leq 0.001$ & $R=-0.245$, $P=0.017$). (Table V.10 in Appendix V)

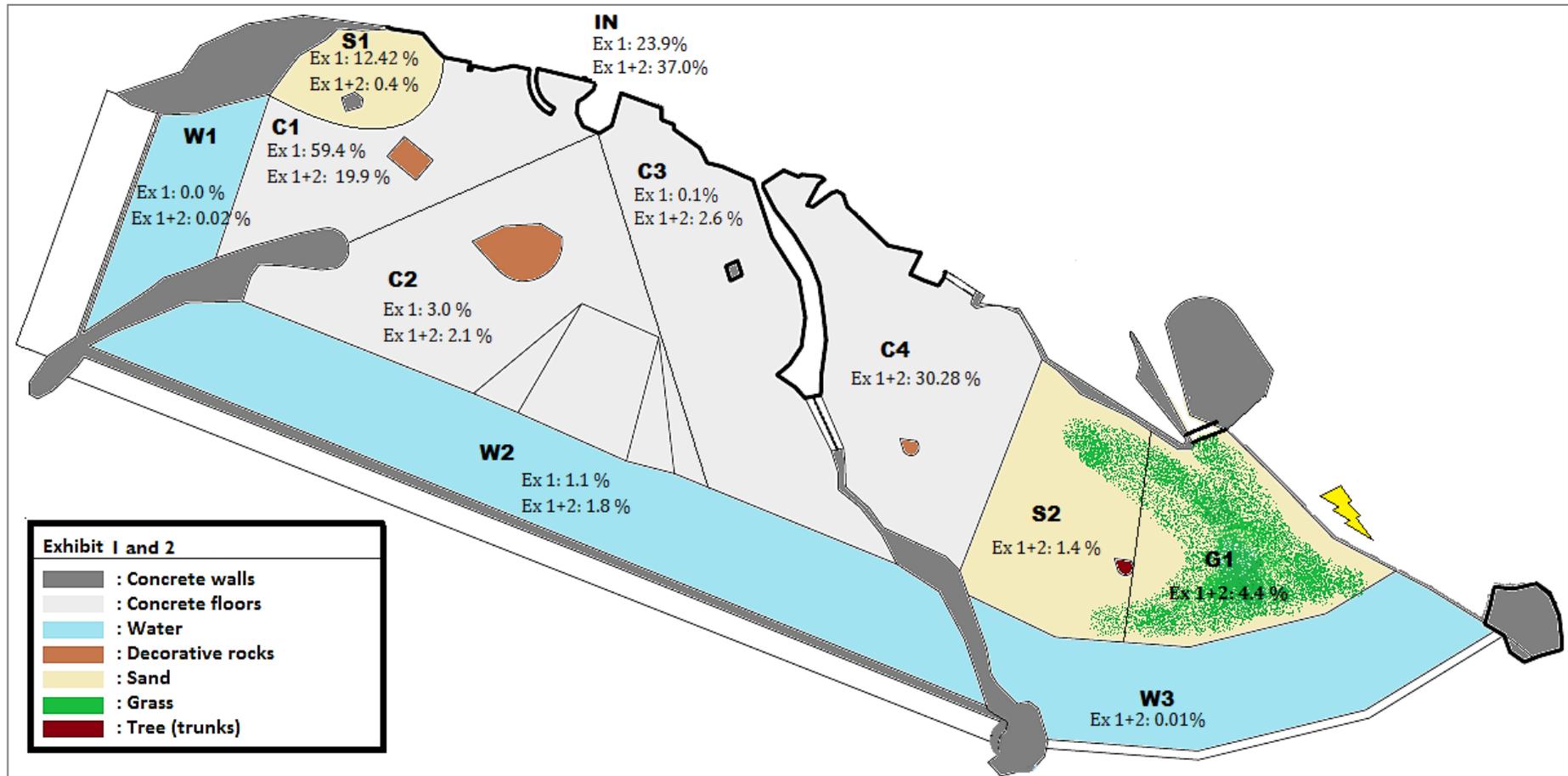


Figure 4.4: Exhibit floor plan divided into different locations and substrates, including location-use percentages over exhibit 1 (N=21) and exhibit 1 + 2 (N=95)

4.2 External factors

4.2.1 Effect on stereotypic behaviour

Weather conditions

During the observation period in November and December, the average daily temperature was 5.16°C (± 0.259) (1°C – 11°C min/max). Weather conditions were divided into six categories and the number of times each category occurred can be found in Table V.11 of Appendix V. There was no significant relation found between weather conditions and the polar bear's stereotypic behaviour. (Table V.16-17 in Appendix V)

Visitors and Employees

Over the total observation period (N=116) 1164 visitors passed the polar bear exhibit ($\bar{x}=10.3$; ± 1.090 ; per average observation session) and 579 employees ($\bar{x}=4.99$; ± 0.3499) (Table V.12 of Appendix V). A significant increase in the number of variations in the polar bear's stereotypic state was observed, as the number of employees walking by the polar bear exhibit increased ($F(1.114)=5.330$; $P=0.023$) (Table V.16-17 in Appendix V).

Feeding times

During 19 observation sessions (spread over 18 days) the male polar bear was provided with 'new food'. 'Old food' was observed 24 times and for 73 observation sessions 'no food' was provided.

A significant relation between food presence and the 'stereotypic' behaviour of the male was found ($F(2.88)=10.920$; $P=0.001$). The bear's stereotypic behaviour decreased when provided with 'new food' in comparison to 'old food' ($P=0.001$) and 'no food' ($P\leq 0.001$) which showed to have no effect in the behaviour.

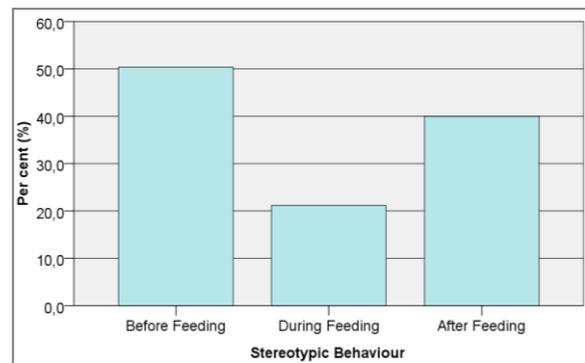
There is also a relation found between food presence and active behaviour ($F(2.113)=28.356$;

$P<0.001$). The active behaviour of the male polar bear was significantly higher when 'new food' was present compared to when 'old food' ($P\leq 0.001$) or 'no food' was present ($P\leq 0.001$). The male polar bear also showed significantly less 'yawns' ($F(2.91)=3.333$; $P=0.040$). The number of 'yawns' was significantly lower when 'new food' was present then if there was 'no food' ($P=0.031$). The final significant relation was found in 'variation' in stereotypic pacing of the male polar bear and food presence ($F(2.91)=4.006$; $P=0.022$). Similar to yawning, the number of 'variations' displayed was significantly lower when the male polar bear was presented with new food compared to when there was 'no food' present ($P=0.007$).

The duration of 'stereotypic' behaviour of the male polar bear before, during and after being fed is displayed in Table V.13 of Appendix V. On average the 'stereotypic' behaviour was highest before feeding and decreased after feeding (Graph 4.3). Furthermore, the percentage of 'stereotypic' behaviour decreased on days the male polar bear was fed (N=18) in contrast to days where no food (N=6) was presented ($F(2.88)=10.041$; $P=0.002$) (Table V.16-17 in Appendix V).

Food Items

The male polar bear interacted with his food on 48 occasions, lasting 2 hours and 30 minutes (10206seconds). This was 5.22% of the total observation period. The interaction time per food item is almost even between 'meat' and 'fish', however the average duration per interaction is twice as high for 'fish', namely 6 minutes (392.15 seconds) compared to 2 minutes (145.94



Graph 4.3: Total time spent (%) in stereotypic behaviour before, during and after feeding events (N=19)

seconds) for 'meat' items (Table V.14 of Appendix V). The male polar bear showed less stereotypic behaviour when provided with either meat or fish ($F(3.88)=3,070$; $P=0.032$) (Table V.16-17 in Appendix V).

Enrichment interaction

The male polar bear was presented with 7 'new enrichment' items during this study. These items were identified as new to the male for 25 observation sessions. 'Old enrichment' was scored 54 times and for 37 observations 'no enrichment' was present in his enclosure. No significant relations were found between the male polar bears behaviour and enrichment (Table V.16-17 in Appendix V).

The total enrichment interaction time of the male polar bear and the 7 enrichment items was 2 hours and 40 minutes (6073 seconds). This was 3.12% of the total observation period. The male polar bear interacted with an enrichment item 17 times of which, 'substrate enrichment' interaction occurred most, namely 11 times lasting 1 hour and 15 minutes (4537 seconds). This is 2.32% of the total observation period (Table V.15 of Appendix V).

4.2.2 Effect on behavioural shifting

Baseline

In the baseline situation, when there are no behaviour modifiers that can influence the male polar bear's behaviour, shifting between behaviours occurred less frequent than staying the same behavioural state ($X^2=209.011$; $df=4$; $P\leq 0.001$). Unchanged 'active', 'stereotypic' and 'out of sight' behaviours were observed more frequent. Except for 'out of sight' into 'active' which showed no significant in- or decreases, all possible shifts between behaviours occurred significantly less than expected (Figure 4.4).

All baseline behaviours were compared to the different behaviours expressed during keeper presence, female group events and traffic and noise events (Table V.18 in Appendix V).

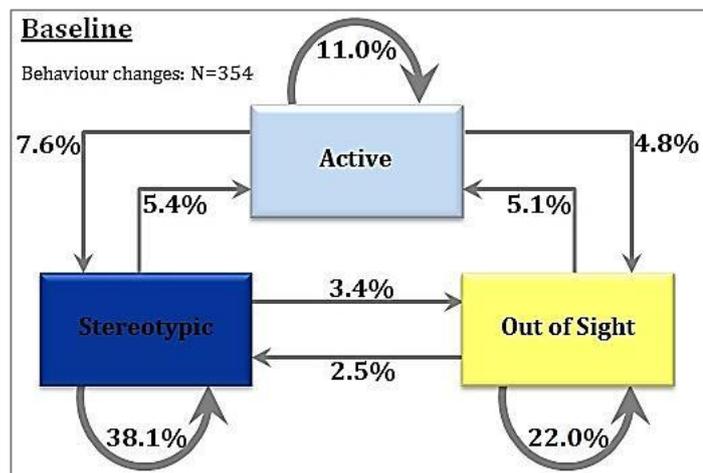


Figure 4.4: Behavioural shifts (%) between Active (A), Stereotypic (S) and Out of Sight (OOS) behaviour that occurred during the baseline situation. ($X^2=209.011$; $df=4$; $P\leq 0.001$)

Keeper presence

A keeper was observed to be present at the polar bear exhibits 43 times over 35 observation sessions. Keeper presence for feeding occurred 13 times and covered 1 hour and 10min (2.34%) of the total observation period (Table V.19 in Appendix V). An average feeding event lasted 6 minutes. Presence to engage in non-feeding related activities occurred 30 times which covered 4 hours (7.84%) of the total observation period. An average non-feeding event lasted 19 minutes. Keeper presence had a significant effect on the male polar bear's stereotypic behaviour ($F(1.104)=4.274$; $P=0.041$). Stereotypic behaviour decreased significantly when a keeper was present. The polar bear's shifting between behaviours significantly differed during keeper presence compared to the baseline situation ($X^2=237.190$; $df=8$; $P\leq 0.001$) (Table V.18 in Appendix V). Unchanged 'stereotypic' and 'out of sight' behaviour occurred significantly less frequent during keeper presence while a strong increase is observed in unchanged 'active' behaviour, and in shifts between 'out of sight' and 'active' and vice versa. This indicates that the presence of a keeper elicits increased active walking between the bear's exhibit and his night den area.

Feeding related Activities

Keeper presence related to feeding activities did not meet Pearson's chi-square standards due to the low number of shifts that were observed (N=27) and could therefore not be compared to the baseline situation. However, it is possible to say something about the frequency of the observed shifts and how they differ from the baseline. Unchanged 'active' behaviour occurred more compared to the baseline but still less frequent than some behavioural shifts during feeding related keeper presence. Unchanged 'stereotypic' and 'out of sight' behaviour occurred less while shifting between 'out of sight' and 'active' and vice versa occurred more frequent compared to baseline (Figure 4.5). The shifting between 'out of sight' and 'active' and vice versa also represents 18 (66%) of the total number of behaviour shifts (N=27) observed during feeding related keeper presence (Table V.18 in Appendix V). Although impossible to compare to baseline data, these results do point to similar effects seen in non-feeding related activities.

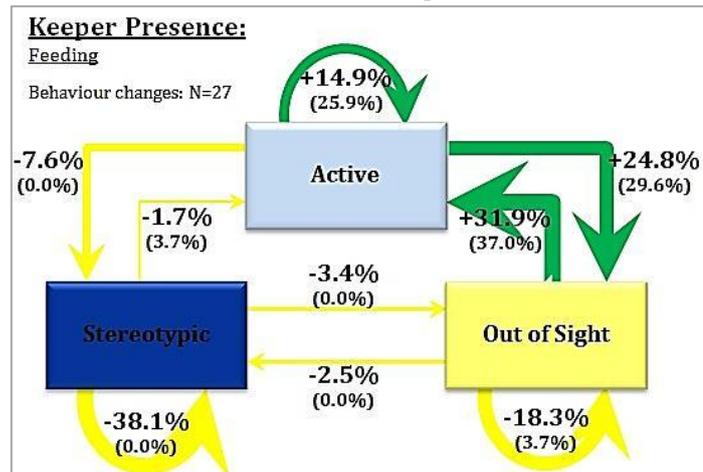


Figure 4.5: Behavioural shifts (%) between Active, Stereotypic and Out of Sight behaviour that, compared to baseline, decrease (>1%; yellow) or increase (>1%; green) during feeding related keeper presence. Thickness of arrows and large font +/- percentages represents the amount of difference.

Non-feeding related Activities

Compared to the baseline situation, significantly more shifting between behaviours was observed in the male polar bear during non-feeding related keeper presence ($X^2=229.659$; $df=8$; $P\leq 0.001$). Unchanged behaviours 'active', 'stereotypic' and 'out of sight' occurred significantly less frequent while a strong increase is observed especially in shifting between 'out of sight' and 'active' and vice versa (Figure 4.6)(Table V.18 in Appendix V). It also shows that non-feeding related keeper presence elicits more shifting between behaviours 'active' and 'stereotypic' and vice versa.

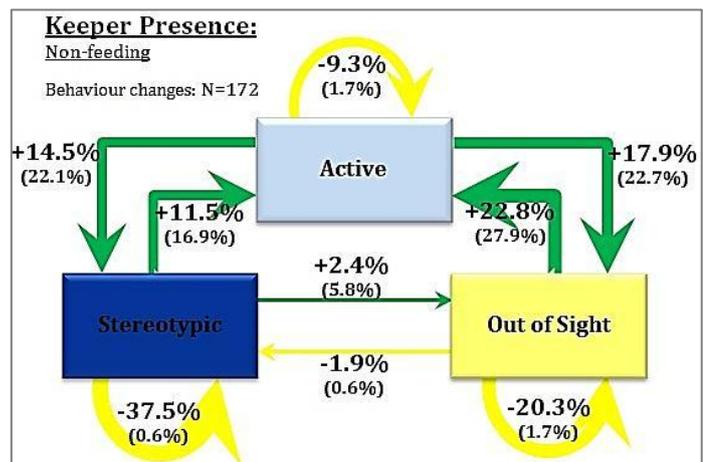


Figure 4.6: Behavioural shifts (%) between Active, Stereotypic and Out of Sight behaviour that, compared to baseline, decrease (>1%; yellow) or increase (>1%; green) during non-feeding related keeper presence. Thickness of arrows and large font +/- percentages represents the amount of difference. ($X^2=118.242$; $df=4$; $P\leq 0.001$)

Female Group Behaviour

The data collected from the female polar bear group resulted in 253 female group events of interest. Food was present in the female's exhibit 11 times (2.60%) over the total observation period, while the other 242 events indicated that a member of the female group was within the male's line of sight. This could either be in the outside exhibit ('within sight': 121 times) (13.79%) or when a member of the female group was inside the night dens ('inside': 121 times) (5.89%). An average food presence event lasted 11 minutes, while a 'within sight' and 'inside' event lasted 4 and 1.5 minutes respectively (Table V.20 of Appendix V). No tests could be done on the presence of food in the female exhibit because it did not meet Pearson's chi-square standards due to the low number of food presence events (N=11) and low number of behaviour shifts that were observed during these events (N=20).

There is a significant difference found in the polar bear's behaviour when female group events are compared to the baseline situation ($X^2=86.385$; $df=8$; $P\leq 0.001$).

Compared to the baseline situation, unchanged behaviours decrease, with the biggest change found in 'stereotypic' behaviour. During female group events increased behavioural shifts are observed between 'active' and 'stereotypic', 'active' and 'out of sight' and 'out of sight' and 'active' if compared to the baseline situation (Table V.18 in Appendix V).

Female Group Possibly within Sight

There is a significant effect found on the male polar bear's behaviour whenever the female and/or her cubs are possibly within his line of sight ($X^2=66.380$; $df=8$; $P\leq 0.001$).

Figure 4.7 shows that the male polar bear expressed significantly less unchanged 'active' and 'stereotypic' behaviour compared to the baseline (Figure 4.4). A significant increase in all behaviour shifts is observed compared to the baseline except for 'out of sight' into 'stereotypic'. (Table V.18 in Appendix V)

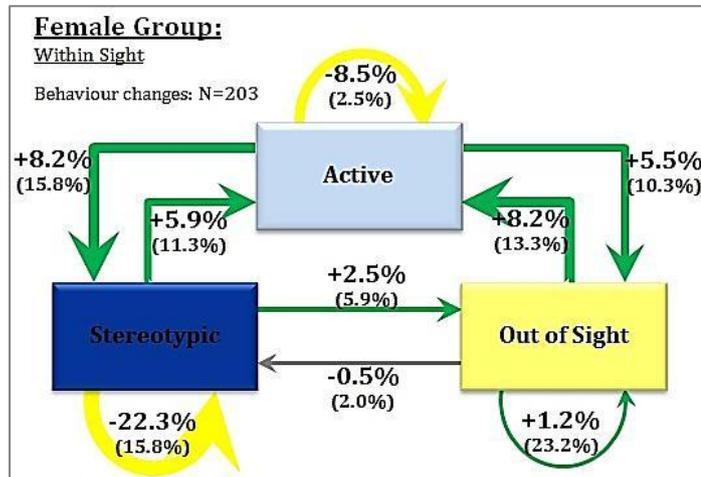


Figure 4.7: Behavioural shifts (%) between Active, Stereotypic and Out of Sight behaviour that, compared to baseline, decrease ($->1\%$; yellow) or increase ($+>1\%$; green) when a member of the female group was within sight. Thickness of arrows and large font +/- percentages represents the amount of difference. ($X^2=66.380$; $df=8$; $P\leq 0.001$)

Female Group Inside night den

The male polar bear and a member of the female group were observed to be together inside for 47 times during the observation period. Compared to the baseline situation, the male polar bear expressed significantly less 'active' behaviour when a member of the female group is inside the dens ($X^2=63.615$; $df=8$; $P\leq 0.001$). A significant decrease in 'stereotypic' behaviour is observed compared to the baseline (Table V.18 in Appendix V). However, this behaviour still occurred significantly more than other behaviours, namely 20.6% (Figure 4.8). Most of the time, the male polar bear stayed in a 'stereotypic' state during the entire event the female or her cubs were in the night den. However, due to the locations where the stereotypic behaviour occurs, the male had to be visually unaware of the presence of the female or cubs in the night dens. When the male saw that one of the female or cub's inside the night dens, behaviour shifts between 'out of sight' and 'active' and vice versa occurred significantly more than in the baseline situation, concluding that when he is aware of the presence of a member of the female group in the night den, it elicits walking between the night dens and the outside exhibit.

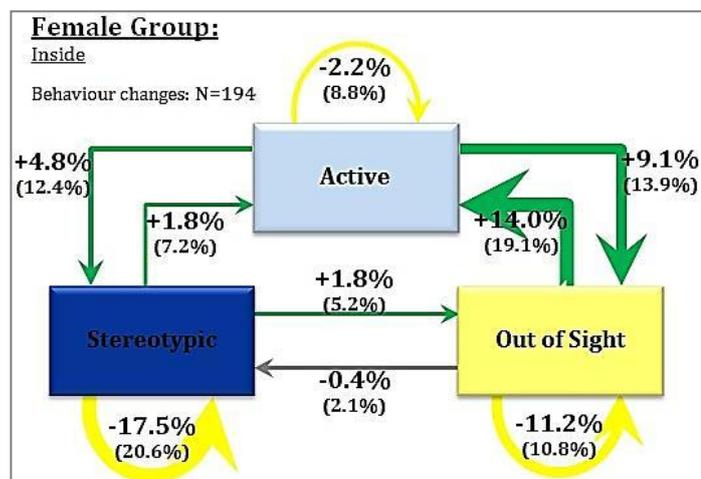


Figure 4.8: Behavioural shifts (%) between Active, Stereotypic and Out of Sight behaviour that, compared to baseline, decrease ($->1\%$; yellow) or increase ($+>1\%$; green) when a member of the female group was inside their night dens. Thickness of arrows and large font +/- percentages represents the amount of difference. ($X^2=63.615$; $df=8$; $P\leq 0.001$)

Traffic and (Construction Work) Noises

Data collected about zoo staff traffic and construction work noise was divided into 252 traffic events, 183 decibel events and 35 Traffic + Decibel combined events covering 1.38%, 3.09% and 0.57% respectively of the total observation period (Table V.21 of Appendix V). Each of these events, on average, lasted 10, 22 and 32 seconds respectively. Behaviours the male polar bear expressed during traffic and decibel events were compared to the baseline behaviours (Table V.18 in Appendix V). The low number of behaviour shifts observed (N=37) in traffic + decibel combined events could not be compared to baseline because Pearson's chi-square standards were not met.

Traffic

There is a significant effect on the polar bear's behaviour whenever traffic passes his exhibit ($\chi^2=51.213$; $df=8$; $P\leq 0.001$).

Unchanged behaviour states 'active', 'stereotypic' and 'out of sight' occurred significantly more frequent than in the baseline situation (Figure 4.9). All other behaviour shifts occurred significantly less or in equal amounts as the baseline situation (Table V.18 in Appendix V).

Increased point behaviours were also observed during traffic events (Table V.7 in Appendix V). 'Head swing' and 'Variation' were observed 16 and 15 times respectively during traffic events, while 4 and 2 were expected respectively if looked at chance and percentage of traffic event time over the total observation period (1.38%).

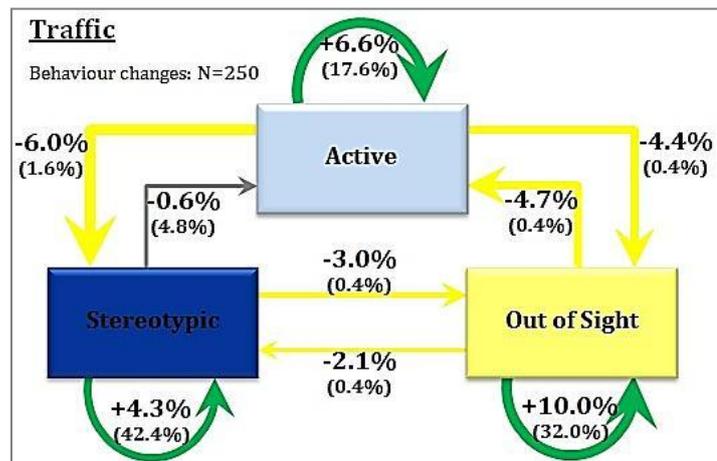


Figure 4.9: Behavioural shifts (%) between Active, Stereotypic and Out of Sight behaviour that, compared to baseline, decrease ($>1\%$; yellow) or increase ($>1\%$; green) when traffic passed the male polar bear's exhibit. Thickness of arrows and large font +/- percentages represents the amount of difference. ($\chi^2=51.213$; $df=8$; $P\leq 0.001$)

Decibel

There is a significant effect on the polar bear's behaviour whenever noises over 70dB occurred close to his exhibit ($\chi^2=18.492$; $df=8$; $P=0.018$).

During decibel events, unchanged 'stereotypic' behaviour occurred more frequent compared to the baseline situation. A reasonable decrease is found in 'out of sight' behaviour and all other behaviour shifts occurred less or in equal amounts as the baseline situation (Table V.18 in Appendix V)(Figure 4.10).

Increased point behaviours were also observed during decibel events (Table V.7 in Appendix V). 'Head swing' and 'Variation' were observed 14 and 11 times respectively during decibel events event, while 9 and 4 were expected respectively if looked at chance and percentage of traffic event time over the total observation period (3.09%).

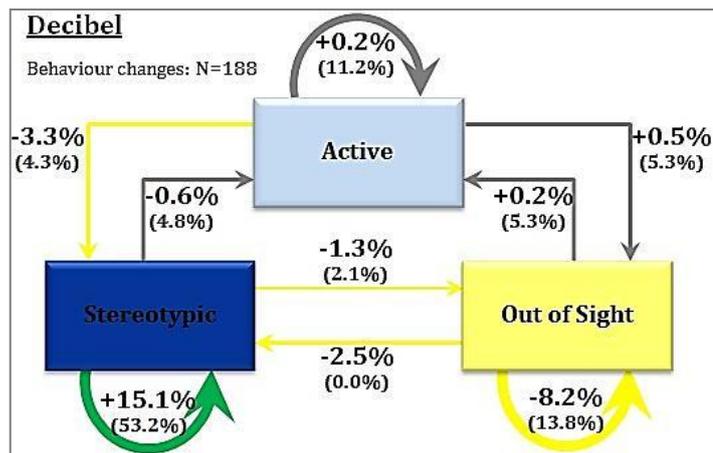


Figure 4.10: Behavioural shifts (%) between Active, Stereotypic and Out of Sight behaviour that, compared to baseline, decrease ($>1\%$; yellow) or increase ($>1\%$; green) when loud noises over 70dB occur close to his exhibit. Thickness of arrows and large font +/- percentages represents the amount of difference. ($\chi^2=18.492$; $df=8$; $P=0.018$)

5. Discussion

5.1 Food

The results show a significant relation between food presence and stereotypic behaviour. After feeding, the average percentage of stereotypic behaviour decreased from 50.35% to 39.97%. However the male polar bear is also significantly less stereotypic and more active and out of sight at the end of the day and therefore this could also explain the decrease of stereotypic behaviour at the end of the day.

The average duration of stereotypic behaviour of the male polar on non-feeding days, is 30% higher than on feeding days (69% to 39.7%). This gives a clear indication that providing food increases the level of non-stereotypic behaviours in the male polar bear. The percentage of stereotypic behaviour is lowest during observations where he is fed and remains lower for the rest of the day.

Research shows that providing food based enrichment can prolong the feeding experience and can decrease stereotypic behaviours (Carlstead *et al.*, 1991; Forthman *et al.*, 1992; Mason and Rushen, 2006; Hosey, 2009; Ames, 1994). A similar result is found in this research, as the food interaction time of the male polar bear is longer when food is provided in a more challenging way (e.g. in the water, frozen fish, etc.). Ames (1993) stated that when provided with scattered food through a mechanical feeder, the foraging behaviour of captive polar bears increases. The foraging for food in the water also takes up more time from his activity budget and is more similar to that of his wild conspecifics. Being fed in water could also trigger grooming behaviour. (Hosey, 2009)

Pre-feeding anticipation (PFA) is one of the main contributory factors influencing the development of stereotypies (Howell *et al.*, 1993). Time of feeding can influence behaviour if its predictability allows the animal to anticipate it; this can lead to stereotypic pacing (Weller and Bennett 2001). Though the male polar bear is fed at irregular times to avoid food anticipation, the level of stereotypic pacing was significantly higher on the non-feeding days, suggesting a relation between PFA and stereotypic behaviour. The male was also observed to be more 'restless' before he was fed. He significantly changed more between active and out of sight when a keeper was present. No data could be collected on keeper presence for food preparation; Therefore the exact effect is unknown.

The diet of the male polar bear should also be taken into account in this research. Since this research was conducted during winter months, the male polar bear was provided with a winter diet, which contained more fats and proteins and the food interval was longer than in summer. In summer the male is fed more often, but the amount of meat is lowered and items with more fibres (vegetables) are provided.

A significant relation between food items (meat and fish) and stereotypic behaviour was found. The male polar bear had a longer interaction time with meat than with fish and was never stereotypic during an observation when meat was provided. The results however did show that the male displayed more stereotypic behaviour after he was given meat compared to when he was provided with fish.

In contrast, the male polar bear had a shorter overall fish interaction, because fish was consumed more easily. The percentage stereotypic behaviour decreased after the provision of fish. This difference could be due to the fact that meat was given 5 out of 6 times during the first three time segments in the morning and fish was mainly provided in time segments 3 to 6 in the afternoon. Therefore no conclusions can be drawn from food items, except for the fact that the overall interaction time with meat is twice as long as the fish interaction time.

To be able to measure the exact effect of food items on the behaviour of the male polar bear, a trial should be done were both food items are presented in same amount in the morning as well as in the afternoon and evening. This would also give more information on the effect of feeding times on his behaviour.

5.2 Enrichment

Enrichment is thought to stimulate captive animals both mentally and physically. There is scientific evidence that enrichment is extremely beneficial to animals on many levels and it can improve animal welfare. (Hosey, 2009)

Many studies have been done on the effect of environmental enrichment on zoo bears, including polar bears, and they all show a significant decrease of abnormal behaviour and increase in active behaviour during enriched conditions (Carlstead *et al.*, 1991; Forthman *et al.*, 1992; Ames, 1994). The male polar bear was provided with new enrichment on 25 occasions (7 different items). There were several enrichment items (tires, barrels, buckets and branches) in the polar bear exhibit at all times, but no play behaviour was observed during the entire observation period and only 17 interactions occurred with enrichment items. Therefore the results show no relation between the stereotypic behaviour of the male polar bear and enrichment items.

Some enrichment items provided to the male polar bear were present in the enclosure for at least two months. Mainly due to the fact that the keepers were unable to access the polar bear exhibit, because of the required rest for the new-born polar bears and their mother. These items did no longer qualify as enrichment, because to be effective the item should be replaced on a daily basis (Laidlaw, 2005). Stan *et al.* (2002) stated that when a novel object is first introduced to an animal's environment, it elicits extensive attention from the animal. When the object was simply left in the animal's environment for a 60 minute period, animals become tired of the object and interacted with it less and less. This demonstrates that habituation could occur even during the first hour of a novel object's introduction. The results of the present study demonstrate that environmental enrichment programs that use objects should adopt variable schedules of object presentation in order to avoid the effects of habituation.

When given new items the male polar didn't display any play behaviour, the items provided to the male polar bear (a bucket or a box with fish) were handled with care. The polar bear took out the fish and left the bucket in his enclosure almost untouched for several days afterwards.

This does not mean the enrichment object has no effect on the polar bear's behaviour. Ames (1994) advised that for polar bears, enrichments should be persevered, even when they seem to have little impact on behaviour, because stereotypic behaviours can persist long after their initial causes have successfully been dealt with.

Although no relation was found between enrichment and the male polar bear's stereotypic behaviour, there was clearly an interaction with the new substrate provided on day 4. The male polar bear spent a substantial time inactive in the substrate, this covered 80% of the total time he was inactive during the entire observation period. This complies with research of Ames (1993; 2000) that indicates that polar bears prefer soft substrates for resting.

During the research period a large rubber tyre was placed on the polar bear's stereotypic routine path before the 3rd observation session of day 3 and was removed before the 5th observation session of day 15. This tyre was an unexpected influence on the male polar bears behaviour since it blocked his normal stereotypic routine in exhibit 1. The male polar bear was first observed to walk only half his usual routine up a small rock and back. After 3 days the male polar bear developed a new routine, where he walked around the rock in a small circle. This routine block could have a large influence on the male polar bear, but further effects of this "enrichment" are difficult to measure because at the beginning of day 5 (this is 2 days into the routine blockage period) the polar bear was provided access to a 2nd exhibit, expanding his enclosure by 150m² and offering him more concrete, some sand and grass and another moat. The pregnant female polar bear was formerly housed in this enclosure and therefore this was the first time since 3 months he gained access to it. In addition, there were too many other external factors in this same period that influenced the male polar bear. The new enclosure that was provided to him with extra space and new smells of the pregnant female, the birth of the two cubs on observation day 6 and the adjusted husbandry because of this birth.

After the tyre was removed on day 15, the male polar bear continued to walk the shorter routine around the rock for at least 8 days, before returning to his old routine. The long period it took to

get used to a new routine and later switch back to the old routine supports the fact that the male polar bear was strongly set in a routine.

5.3 Keeper Presence

Although some events of keeper presence may have been missed because not all keeper presence events were announced by the keepers, a significant effect on the polar bear's behaviour was observed when keepers were present at his enclosure. Because it is likely that several events of keeper presence were missed it is only possible to discuss the effect that the 43 recorded events had on the polar bear's behaviour. Food preparation was never recorded and cleaning and administration events occurred less than 5 times over the entire observation period. For that reason cleaning and administration were combined with check-up events to make a non-feeding related keeper presence. It is assumed that combining these cleaning (N=1) and administration (N=3) events, will not majorly affect the 26 check-up events.

The male polar bear especially expresses significantly more time switching between 'active' and 'out of sight' behaviour, as well as 'out of sight' into 'active' behaviour when a keeper is present to engage in feeding- and non-feeding related activities. This can be explained by the fact that the polar bear spots a keeper outside its enclosure and walking back and forth between its night den (where the bear is out of sight) and active behaviour in the outside exhibit. The fact that the polar bear shifts between 'active' and 'out of sight' behaviours whenever he spots a keeper indicates that there is a sign of classical conditioning and associative learning in which the polar bear learned that the presence of a keeper is related to an event (e.g. feeding) that is important to him (Hosey *et al.*, 2009; Atkinson *et al.*, 1996). Food is a strong motivator of behaviour in most animals and feeding times can influence their behaviour if predictability allows anticipation (Hosey *et al.*, 2009). The presence of a keeper seems to positively affect the male polar bear's behaviour. His stereotypic behaviour decreased and this is possibly due to the anticipation of food. This was also seen in three polar bears in Zurich Zoo (Wechsler, 1991) where the bears would calmly sit in front of their night den door prior to feeding.

In keeper presence for both feeding and non-feeding related activities, the same shifting between 'active' and 'out of sight' behaviour is observed. However due to the low number of shifts observed in feeding related activities, only non-feeding related activities showed to have a significant effect. Besides the shifting between 'active' and 'out of sight' behaviour, an additional behaviour increase is found in behaviour change 'active' into 'stereotypic' during non-feeding related activities. Since the average duration of a non-feeding related activity is longer than a feeding related activity, there is an indication that the bear's stereotypic behaviour returns after a certain amount of time. If the polar bear is not fed within a certain time of keeper presence, the effect of stimuli related to feeding, wears off even when the stimulus (i.e. keeper) is still present, suggesting habituation (Hosey *et al.*, 2009). Another thing that supports this theory is the number of stereotypic point behaviours. Although the point behaviours 'head swing', 'yawn' and 'variation' occur less whenever a keeper is present, the 33 point behaviours that were observed during overall keeper presence, all occurred during non-feeding related activities.

5.4 Geography

For this research the behaviour of the male polar bear in the three enclosures should have been measured. However because of the pregnancy of one of the female polar bears the husbandry and housing routine of the polar bears was different than usual. The male polar bear was never seen in exhibit 3, the Nose to nose exhibit, nor was he exclusively located in exhibit 2. He was only located in exhibit 1 or exhibit 1 and 2 combined. This removed the opportunity to collect data about his behaviour in exhibits 2 and 3 and limits answering the research question: 'In what way is Victor's stereotypic behaviour related to housing in the different exhibits?'. No significant relation between the exhibits and his stereotypic behaviour was found.

Because the male polar bear only had access to the two old Hagenbeck exhibits, this could have affected his behaviour in two ways. Firstly, his usual routine of being switched between the

three exhibits every two days was breached because he had to stay in the old Hagenbeck exhibits for several months. Secondly, his behaviour could have been influenced by the fact that the two old Hagenbeck exhibits combined are smaller in size, water body and different substrates than the Nose to Nose exhibit. The AZA Bear TAG, in conjunction with the Manitoba Standards, state that 1-2 bears should be given access to 501.7m² of dry land, with an additional 150m² of land for each additional polar bear. Furthermore, exhibits should be designed to allow for walking and running opportunities (PBPA, 2002).

Research suggests that the amount of stereotypic pacing that carnivorous animals express in captivity can be predicted by their home range size in the wild. Polar bears may be susceptible to the development of abnormal behaviours in captivity due to their wide-ranging territories in the wild (Clubb and Mason, 2003; Mason and Rushen, 2006).

Enclosures with complex pathways and designs help reduce stress, stereotypic behaviour, and other abnormal behaviours. The Hagenbeck exhibits, do not meet the guidelines on size, since they are an estimated 400m² combined and have limited opportunity for the male polar bear to run. Also the water bodies of the Hagenbeck exhibit do not entirely live up to the AZA polar bear guidelines. Polar bears are excellent swimmers, using their large front paws as powerful oars, and their rear paws as rudders. They may remain submerged for over a minute, which is why the AZA Bear TAG recommends large pools with an area of 70.6 m², and a deep end that is 2.75m deep or more should be incorporated into exhibits (PBPA, 2002). It is recommended that pools are irregular in shape, containing both deep and shallow areas. The bears often utilize the shallow areas for wading and play (AZA TAG, 2007). The water bodies of the Hagenbeck exhibits are moats, with a rectangular shape, no shallow areas and no floating furnishings. This makes the current water bodies of the exhibit less suitable for expressing natural behaviours.

As mentioned in chapter 3.1.2, exhibit 1 approximately consists out of 95% concrete. The results show there is a significant correlation between stereotypic behaviour and the three different substrates. The male polar bear significantly displays more stereotypic behaviour on concrete (especially concrete 4) but is never stereotypic on the other soft substrates.

The AZA polar bear guideline (2007) state that to promote species-appropriate behaviours, the landscape should be naturalistic (planted with grass, bushes and trees for shade) and functional, including as necessary elements: a pool, foliage, enclosure furniture (boulders, trees, logs), open/panoramic views, and substrate pits with various materials. The Manitoba Polar Bear Protection Act regulations also states that a polar bear exhibit must include a 125m² area that is covered by soil, straw, woodchips or another suitably soft substrate (PBPA, 2002). This is all well represented in the new 'nose to nose' exhibit but not in the old Hagenbeck exhibit.

Research shows that soft substrates are preferred by polar bears for nesting and resting (Ames, 2000) and this behaviour was also seen in the male polar bear. When he was given new soft substrate, he laid down in it to groom and to rest.

The AZA polar bear guideline also recommends providing a polar bear with elevated areas (plateaus) within the exhibit, so the bear has a long distance visibility. This should be an important element of the exhibit design (Stephan, 2006). Unfortunately exhibits 1 and 2 have no platform and during winter the glass barrier becomes dim, so there is a very limited view of the surroundings. In addition, the new gorilla exhibit that is built across from the Hagenbeck polar bear's exhibits is very high and it limits the long distance visibility of the polar bears even more.

To get a complete insight in the influence of the exhibits on the male polar bear, an additional research should be done on his (stereotypic) behaviour in the more naturalistic Nose to Nose exhibit.

5.5 Female Group

Through use of the female camera, data was collected about 5 specific behaviours of the female polar bear and her cubs in the nose to nose exhibit to see what their effect is on the male polar bear's behaviour. A significant relation was found between certain female group events and the male polar bear's behaviour. 'Active' behaviour occurs significant less, while a significant

increase is observed in 'stereotypic' and 'out of sight' behaviour states. Behaviour changes 'active' into 'stereotypic' and 'out of sight' into 'active' occur more often than expected.

A few problems arose while using the female camera that affected the data collected from the female group. The camera lens range could not record the entire nose to nose exhibit because the exhibit was too big. Also, rain and strong winds occasionally blurred the camera lens or blew the camera into a different position. Some parts of the exhibit were therefore not recorded, possibly leading to missing female behaviour events that were of interest. For this reason, defecation and vocalization were excluded from further data processing. Defecation was only observed once and since polar bears tend to defecate at set spots, some events may have occurred outside the camera's sight. Vocalizations were never observed possibly due to bad sound recordings from the female camera.

Over the 11 times food was present in the female exhibit, 'stereotypic' behaviour occurs more frequent than any other behaviour. Although this might be an indication that the effect of food presence in the female polar bear enclosure increases the male's stereotypic behaviour, when looking at the frequencies in which the different behaviours occurred, it may lead to a different conclusion. Food was present in the female exhibit 11 times over the total observation period. Spread over these 11 times, the male polar bear's behaviour changed a total of 20 times. Although 'stereotypic' behaviour occurred significantly more, of these 20 behaviour changes, the male only once was and stayed in a 'stereotypic' behaviour state. Furthermore, behaviour changes from 'active' into 'out of sight' and vice versa both occurred 6 times, summing up to 12 of the 20 behaviour changes. 'Active' behaviour, the 'active' into 'out of sight' and 'out of sight' into 'active' combined, will add up to 16 out of the total 20 observed behaviour changes observed during food presence events. The behaviour shifts observed 16 times. The theory that stereotypic behaviour actually decreases and does not occur more frequent than any other behaviour, is also supported by the number of stereotypic point behaviours during food present. Only 2 points were observed while a total of 18 were expected.

This shifting between 'active' and 'out of sight' behaviour was also observed prior to when the male polar bear himself was fed, leading to the same food anticipation behaviour through classical conditioning and associative learning as found during keeper presence (Hosey *et al.*, 2009; Atkinson *et al.*, 1996). However, in this situation it is not possible to know whether this food anticipation is related to the keeper presence or the fact that the female group was fed. It is therefore assumed that especially their keen sense of smell (Derocher and Stirling, 1990) and smelling the food that is fed (to either the male or the female group) plays a strong role in the male polar bear's food anticipating behaviour (Hosey *et al.*, 2009).

There is a significant effect on the male polar bear's behaviour whenever the female and/or her cubs are possibly within his line of sight in their outside exhibits.

The male polar bear expressed significantly less continued 'active' behaviour, while more 'out of sight' behaviour was observed. Behaviour change 'active' into 'stereotypic' also occurs more frequent. Finally, the male's 'stereotypic' behaviour increases when the female polar bear and/or her cubs are within sight. However, 'out of sight' behaviour mainly defines that the polar bear is inside his night den, making it impossible for the male to view the female group outside. 'Stereotypic' behaviour only occurs at two specific locations on concrete substrates, which are surrounded by rock walls which also limit the male polar bear from actually viewing the female and/or her cubs. The increased 'stereotypic' and 'out of sight' behaviour in this scenario therefore seems not to be caused by the females being within his sight.

With female polar bear Huggies retreating to her nursing den at the end of November and the birth of her cubs on the 1st of December 2011, the other female Freedom and her cubs did not have access to their night dens for the first two weeks of the data collection period. Despite missing two weeks of data on the female and/or cubs inside the night dens, a significant relation was found between the polar bear's behaviour and the female and/or her cubs entering the night dens. A slight increase in head swings occurred but no major difference between the expected and observed point behaviours was found. Continued 'active' behaviour occurred significantly less frequent in the male polar bear whenever the female and/or one of her cubs enter the night dens. Behaviour changes 'stereotypic' into 'active', 'stereotypic' into 'out of sight'

and vice versa also occurred less frequent, while 'active' into 'out of sight' and vice versa occurred more frequent. This indicates that the male polar bear becomes more 'restless' whenever one of the other polar bears are in the night dens and, just like with keeper presence and food presence in the female exhibit, starts actively walking back and forth between his inside den and outside exhibit. However, continued 'stereotypic' behaviour is also found to occur more frequent, suggesting that the male's 'restless' behaviour only occurs whenever he actually spotted one of the other polar bears in the night dens himself. If the male is displaying continued 'stereotypic' behaviour during an event where a member of the female group is inside, it was impossible for him to view and therefore know whether another polar bear was inside.

Having observed this response in the male polar bear suggests that if he knows a member of the female group is inside the night den, his stereotypic behaviour decreases and shifts between 'active' and 'out of sight' increase. Despite the fact that most zoos try to attain social groups that are similar to those that occur 'naturally' (Hediger, 1955; Hutchings *et al.*, 1978) and that polar bears are solitary animals (Ramsey, 1986), the male polar bear's behaviour indicates that even outside the mating season, there is a social interest towards the female group members. Although it is not possible to see whether the male's interest is focussed on the adult female or her cubs, the response observed in the male, seems to satisfy the social need for contact with conspecifics to an unknown degree. This need might come from his social learning in past experiences (Hosey *et al.*, 2009). Learning occurs at both individual and social group levels, but individuals decide how social groups develop. Therefore, social learning does not occur until individuals express the behaviours they have learned in the past. (Diduck *et al.*, 2005)

The first four years of the male's life he spent living with his mother and in breeding pairs with other females. Cognitive learning is strongly present during an animal's development to adulthood, which also includes learning about social structures (Hosey *et al.*, 2009).

According to the polar bear keepers, the male's stereotypic behaviour is near absent when he is housed together with a female during the mating season. His interest in another polar bear during this time of year can be explained by reproductive needs and increased testosterone levels in males during this period (Palmer *et al.*, 1988). However, this only covers interest during the mating season and may have nothing to do with a possible desire to live in a social environment throughout the rest of the year. Latour (1981) does describe that outside the mating season males are less aggressive and polar bears aggregate in amicable groups.

5.6 Traffic & Noise

Much is still unknown about the auditory ranges of most animal species. Morgan and Tromborg (2007) however, stated that underestimating auditory events as a risks, prevents adequate assessment of animal welfare, since the housing of animals in modern facilities are subject to relatively high levels of unnatural noises in variable frequencies which are routinely produced. Recordings of the sound pressure levels (spl) at San Francisco Zoo and Sacramento Zoo ranged from a low of 62dB (spl) to a high of 72dB (spl), with an average of 70dB (spl), and was influenced by the number of visitors, the intensity of their conversations, the presence of maintenance machinery or exhibit water features and the amplitude of sounds of surrounding urban transportation systems (Tromborg and Coss, 1995). Behavioural observations took place while a new exhibit was being built for the Western Lowland Gorilla (*Gorilla gorilla gorilla*) straight across from the polar bear's exhibit. Noise caused by the construction work site and the accompanying large vehicle traffic was therefore higher than other years. Data was collected during winter months which makes it impossible to say anything about how traffic and noise levels fluctuate per season or year and how this affects the polar bear's behaviour. Summer months quite possible have less construction work noise however, visitor numbers are higher and loud noise caused by them may be higher. In this study, similar sound levels were found as in Tromborg and Coss's (1995) study where here sound levels ranged between 55dB and 67dB throughout an average observation session. A total of 218 sound peaks were recorded that were over 70dB.

Also, studies of Gamble (1982) and Tromborg (1993) state that many of the enclosures of laboratory animals and cotton top tamarins (*Saguinus oedipus*) are extremely acoustically reflective. This is also the case in old Hagenbeck exhibit constructions where the back and sides of the exhibit consists of tall concrete walls.

Nachtigall *et al.* (2007) found that polar bears have a mean hearing threshold of 70dB and that sounds above this level are considered uncomfortable to them. This study shows that there is a significant effect on the polar bear's behaviour whenever traffic passes his exhibit or when noises over 70dB occur close to his exhibit. Continuous behaviour states 'active', 'stereotypic' and 'out of sight' occur significantly more than expected and all behaviour changes occur significantly less than expected.

The fact that the male polar bear mainly stays in the same state behaviour may suggest that he is either habituated to these traffic or noise events or that these events have no effect on his behavioural state and with that, his stereotypic behaviour. However, when looking at the different stereotypic point behaviours, 'head swings' and 'variations' in particular, occurred more frequent than expected within these short time periods.

Hosey *et al.* (2009) explains that there is little research done on the effects of disturbance caused by humans in a zoo setting despite the fact that there are many forms of human disturbance in zoos (e.g. visitors, keepers, construction work, maintenance, delivery work). He described three studies that tested the effects of human disturbance on behaviour and cortisol levels in the giant pandas (*Ailuropoda melanoleuca*) at the Smithsonian National Zoological Park (Powell *et al.*, 2006), two species of Hawaiian honeycreepers at Honolulu Zoo (Shepherdson *et al.*, 2004) and two groups of black-and-white ruffed lemurs (*Varecia variegata*) at Marwell Zoo (Hutchings and Mitchell, 2003). In an environment where animals were subjected to different degrees of human disturbance, these three studies showed increased 'restlessness' and cortisol excretion in giant pandas, behavioural change and higher levels of faecal corticoids in Hawaiian honeycreepers and increased sniffing, scent marking, locomotion and vigilance in black-and-white ruffed lemurs.

5.7 Visitors & employees

For this research the visitor effect on the male polar bear was measured. 1164 visitors passed the polar bear exhibit during the total observation period, with an average number of 10.3 visitors per observation. There was no significant effect found between his stereotypic behaviour and the number of visitors.

It should be taken into account that this research was conducted during winter, en visitor numbers were much lower than in summer, when more than 6000 visitors a day visit the zoo. During Christmas holiday, higher visitor numbers were observed (max. was 69 visitors in one observation) and higher levels of stereotypic behaviour were measured (70.15% during the holiday, while average stereotypic behaviour is 45.54%). Since this was only measured during one day this data is not typical and no conclusion can be drawn.

Many studies have shown however, that visitors do affect zoo animals, because they are a significant component of the zoo environment. Characteristics such as visitor presence, density, activity, size, and position are associated with animal behavioural a physiological changes.

Studies usually interpret these changes as negative (undesirable) or positive (enriching) (Davey, 2007). Most of these studies on zoo visitors have been done on primates and the evidence point to the conclusion that the effect is generally negative. Although Hediger (1965) suggested that animals might consider people to be of no significance and are just part of the background that can be ignored, the presence of zoo visitors results in the animals displaying behaviours that are usually associated with a stress response. (Hosey, 2009; Wells, 2005)

There is also a possibility that the quality of relationships that zoo animals have with their keepers influences the way in which the animal responds to visitors. Hosey (2008) suggested that the quality of the relationship with familiar people (positive or negative) relates to the response of animals to unfamiliar people. A study by 'O Donovan *et al.* (1993) at Fota Wildlife Park, Ireland, showed that there were no significant changes in behaviour of a group of cheetah

(*Acinonyx jubatus*) in response to the presence of zoo visitors. Another more recent study of six species of felid in Brookfield Zoo, Chicago, also showed no significant effect of visitors on any behaviour. Why should felids (carnivores) fail to respond while primates show such a clear response? Margulis *et al.* (2003) suggest that this may be taxon-specific.

This study indicates that visitors have no significant effect on polar bears, like felids. More research is desired, especially since the new gorilla enclosure that is built across from the polar bear exhibit will lead to higher visitor numbers in this area in the future.

A significant effect was found between the number of employees walking by the polar bear exhibit and 'variation' in the male polar bear's stereotypic behaviour. This matches up to the results of keeper presence, where the male polar bear expresses significantly more time switching between behaviours. The male polar bear was observed to vary in his stereotypic behaviour, by stopping to look at the employees that walked passed his exhibit. This can be seen as classical conditioning, where the male polar bear responds to the keeper uniforms (Hosey 2009).

5.8 Time of Day

Despite the lower number of early 9.15 observations due to public transport delays and low number of late 16.45 observations caused by the short winter days, it is still possible to conclude that time of day has a significant effect on the polar bear's behaviour. When looking at this effect, the percentages of stereotypic state- and point behaviours were highest in the early mornings between 9.15 and 11.15 and lowest in the late afternoon between 15.15 and 17.15.

A small increase in active behaviour is observed in the late morning and early afternoon, which complies with feeding events that usually occurred around this time of day. The percentage 'out of sight' on the contrary, is highest in the late afternoon and lower during the rest of the day. This suggests that the male polar bear reduces his stereotypic behaviour at the end of the day and spends more time inside his night den. Both keepers and observers do not know what the male polar bear's behaviour is like when there are no people present in the night dens. Although the keepers' knowledge of his behaviour inside the dens comes from events in which the keepers were also present, according to them, the bear is not expressing any stereotypic behaviour when he is inside and most of the time is observed to be inactive. This is similar to wild polar bears which seem to be most active in mornings and inactivity increases slowly throughout the day (Laidlaw, 2005). However, a study of Wechsler (1991) on stereotypies in three captive polar bears housed together at Zurich Zoo, found results that stereotypic behaviour in two polar bears was evenly spread over the day and that the third bear's stereotypic behaviour increased over the day.

A final note that must be taken into account is the variation in activity budgets in different seasons (Ames, 1993). Effects of longer summer days cannot be compared to the data that was collected during the winter months in which this study took place.

In conclusion of this study, it was not possible to point out a specific stressor that is causing the polar bear's stereotypic behaviour. Many different factors seem to affect the male polar bear's behaviour and cause increases and decreases in his stereotypies under certain circumstances.

A neurological cause for the male polar bear's stereotypies was already ruled out at the start of this study, however for now, it is still uncertain to say whether the polar bear's stereotypies have a motivational-frustration origin, if it is a coping mechanism or if something else is causing to his stereotypies. Motivational frustration, which is usually focussed on a single specific behaviour that cannot be completely executed, seemed to be a well-supported option at the start of this study. Now it seems to be less suitable due to the large number of factors affecting his behaviour positively and negatively. For this same reason, a coping mechanism seems more suitable because in such a mechanism, an abnormal repetitive behaviour is expressed for the release of endorphins that an animal uses to cope with continuous stressful situations. Because no specific factor or cause can be appointed at this moment, the developed recommendations are related to the different factors affecting his behaviour.

6. Conclusion

As expected, high levels of stereotypic behaviour were observed and in combination with the research done on the different husbandry-, geography- and environment-related factors surrounding the male polar bear, it was possible to answer the three research questions developed for this study.

1. What husbandry-related factors correlate with the stereotypic behaviour of the male polar bear (*Ursus maritimus*) Victor, at Ouwehands Zoo?

Except for Enrichment objects, all husbandry-related factors (i.e. Feeding times, Food items and Keeper presence) correlate significantly with the male polar bear's stereotypic behaviour. All husbandry-related factors mentioned above, cause a decrease in stereotypic behaviour, except when a keeper is present to engage in non-feeding activities. This seems to lead to an increase in stereotypic point behaviours 'head swing' and 'variation'.

2. What geography-related factors correlate with the stereotypic behaviour of the male polar bear (*Ursus maritimus*) Victor, at Ouwehands Zoo?

No significant relation was found in the polar bear's stereotypic behaviour related to housing in different exhibits. However, there is a significant correlation found between stereotypic behaviour and substrate use. Stereotypic behaviour occurs significantly more on concrete surfaces, with in this case high percentages of this behaviour was observed on concrete sections 1 and 4. Only little stereotypic behaviour was observed on concrete sections 2 and 3, as well as on soft substrates.

3. What environment-related factors correlate with the stereotypic behaviour of the male polar bear (*Ursus maritimus*) Victor, at Ouwehands Zoo?

Except for Visitor number, all environmental-related factors (i.e. Employee numbers, Female Group Events, Traffic & Noise and Time of Day) correlate significantly with the male polar bear's stereotypic behaviour. During observation sessions with increased employee numbers, more 'variation' point behaviours were observed. No significant correlation was found between female group events and the polar bear's stereotypic behaviour. However, if the male polar bear and a member of the female group were inside simultaneously, significant change occurred in his behaviour. Shifts between 'active' and 'out of sight' significantly increased during these events. Traffic and noise does not correlate with the polar bear's stereotypic state behaviour. However, increased stereotypic point behaviours 'head swing' and 'variation' was observed during traffic and/or noise events. Significantly more stereotypic behaviour is observed in early morning observations compared to those in late afternoons. On the contrary, 'out of sight' behaviour was observed less in early mornings and more in late afternoons.

Looking at the three main research questions, it can be said that husbandry, geography and environment-related factors all influence the male polar bear's behaviour. Most environment-related factors can elicit an increase in stereotypies (i.e. head swings during traffic and noise or variations when employees pass the exhibit). However, one environment-related factor (i.e. females inside the night den area) and most husbandry-related factors tend to decrease stereotypies and cause 'restless' walking between his inside and outside enclosure (i.e. feeding and non-feeding related keeper presence). The found effects can be a good indication of which factors improve the male polar bear's behaviour and which cause stereotypies to increase. The recommendations in the next chapter were developed to test what adjustments to the male polar bear's living conditions are appropriate.

7. Recommendations

Although no specific cause can be assigned to the male polar bear's stereotypic behaviour, this study did give new insights in the different factors affecting his behaviour and therefore allows explicit recommendations to be developed for the future.

This study found that many factors affect the polar bear's stereotypic behaviour in both a positive and a negative way.

No experimental phase was incorporated into this study and therefore more information and data is needed that can either support or discard findings from this study. Through experimental research, it is possible to test the stimulation of positive factors and the reduction/elimination of negative factors and their effect on the polar bear's behaviour.

It is recommended that further experimental research is used to investigate the following things in relation to the polar bear's stereotypic behaviour:

- Reducing the amount of traffic that passes the exhibit.
- Increasing (feeding) enrichment activities.
- What effect possible training has and if it can enhance play and foraging behaviour.
- Increase feeding events.
- Study seasonal variability in behaviour, visitor numbers, noise and traffic levels, etc.
- Effects of long-term housing in Exhibit 3 'Nose to Nose'.
- Effect of decreased visibility from Exhibit 1 and higher visitor numbers due to the new built Gorilla exhibit.

Stereotypic behaviour is a sign of decreased welfare and since this polar bear spends a large amount of his time expressing these behaviours it is recommended that, next to future experimental research, something also needs to happen about his current living conditions in the near future.

After this study, it is believed to be important to take a closer look at the polar bear's current living conditions and maybe consider applying new housing and husbandry strategies such as:

- Housing in a larger enclosure, such as Exhibit 3 'Nose to Nose'.
- More soft substrates, either by housing in Exhibit 3 or refurbishing the Hagenbeck exhibits to contain more soft substrates.
- Clean moats thoroughly to reduce the polar bear's current hesitance to enter the water.
- Increase enrichment circulation by removing all objects currently in his exhibit and providing one or two new objects every single day
- Consider group housing, however due to current exhibit sizes, relocation might be a better option.

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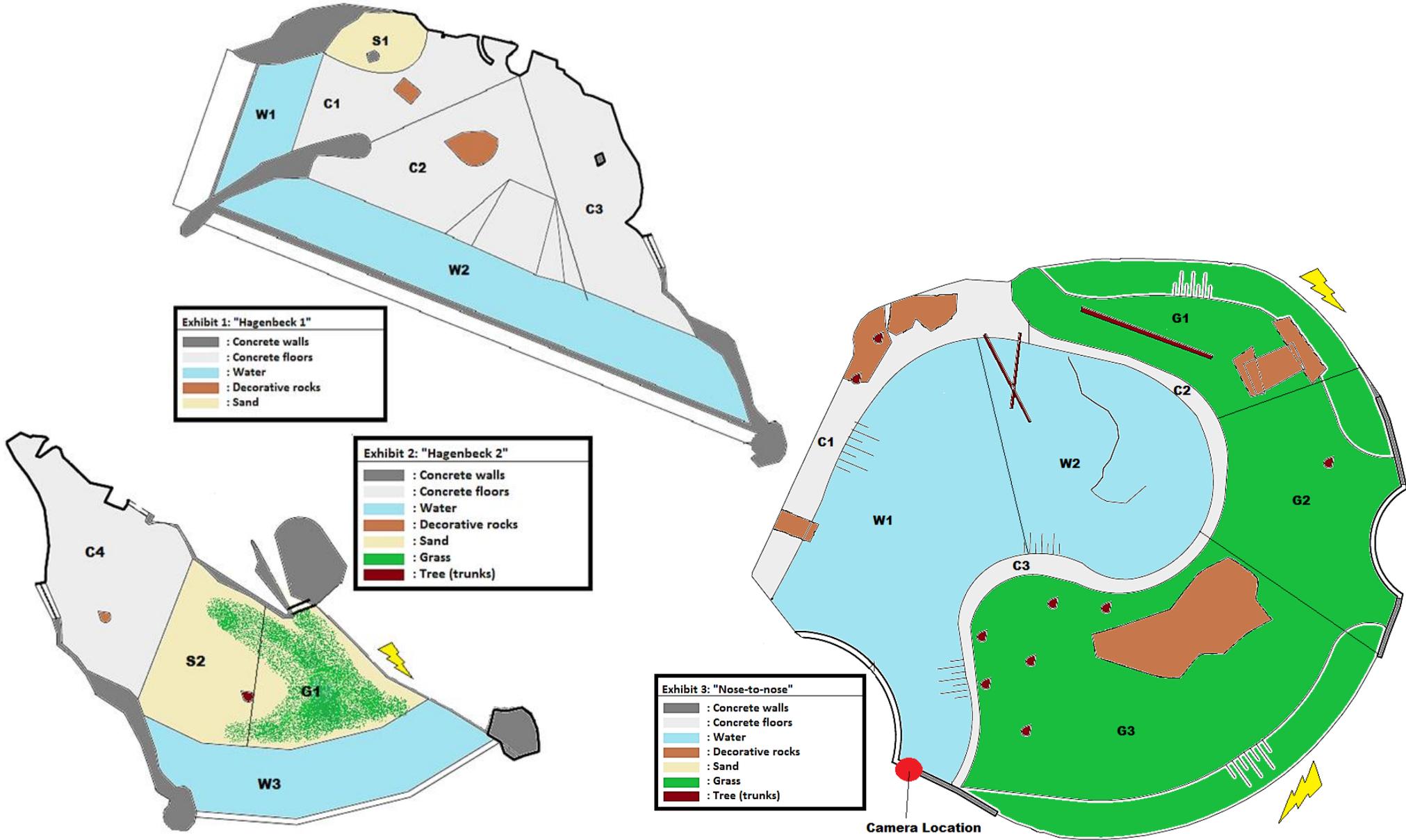
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Appendix I: Exhibit Floor Plans



Appendix II: Adult polar bear diets

The table below shows an example of two months (1 summer month and 1 winter month) of the adult polar bear diets fed at Ouwehands Zoo in 2010. Amounts are in kilograms.

June					December				
Day	Food item	Victor	Huggies	Freedom	Day	Food item	Victor	Huggies	Freedom
1	Lamb	5	5	5	1				
	Endive	5	1.5	1.5	2	Lamb	10	5	5
2					3				
3	Apples	5	1.5	1.5	4	Mackerel	30	10	10
	Eggs	2	1	1	5				
4					6	Beef fat	5	3	3
5	Lamb	5	2.5	2.5	7				
	Melon	2	1	1	8	Lamb	10	10	10
6					9				
7	Strawberries	5	1.5	1.5	10	Chicken	5	3	3
	Carrots	2	2	2	11				
8					12	Mackerel	30	5	5
9	Liver	1.5	1	1	13				
	Endive	5	2	2	14	Lamb	10	5	5
10					15				
11	Lamb	5	5	5	16	Tripe	5	3	3
	Melon	2	1.5	1.5	17				
12					18	Beef fat	5	3	3
13	Apples	5	2	2	19				
14					20	Lamb	5	5	5
15	Lamb	5	2.5	2.5	21				
	Endive	5	2	2	22	Mackerel	30	5	5
16					23				
17	Strawberries	5	2	2	24	Chicken	5	3	3
	Carrots	2	1	1	25				
18					26	Lamb	10	10	10
19	Apples	5	2	2	27				
	Eggs	2	0.5	0.5	28	Tripe	5	3	3
20					29				
21	Lamb	5	5	5	30	Lamb	5	5	5
	Melon	2	1.5	1.5	31				
22									
23	Strawberries	5	1.5	1.5					
	Carrots	2	1	1					
24									
25	Liver	1.5	1	1					
	Endive	5	2	2					
26									
27	Lamb	5	2.5	2.5					
28									
29	Apples	5	1.5	1.5					
	Strawberries	5	2	2					
30									
	Raisins	10	6	6		Raisins	6	4	4
	Walnuts	15	10	10		Walnuts	25	15	15

Appendix III: Definitions

Observation circumstances

Type:		Definition:
Observation details:	Time of day	Session number
	Weather conditions	Temperature / weather type
Husbandry Feeding:	Food present	Yes or no
	Food items fed	Type(s) of food present in enclosure
	New/Old	NEW: fed before/during current observation session OLD: already present/provided at a previous session
	Interaction time with present food items	Total time spent physically touching or consuming the present food item
Husbandry Enrichment:	Enrichment present	Yes or no (when an item has been in Victor's enclosure for over a week. it no longer counts as enrichment.)
	Types of enrichment items	Type(s) of enrichment present in enclosure
	New/Old	NEW: offered on day of current observation session OLD: already present/provided at a previous day
	Interaction time present enrichment items	Total time spent focussed on the present enrichment item (e.g. touching. smelling. stalking)
Husbandry Keepers:	Keepers present/absent	Yes or no
	Keeper presence duration	How long was a keeper present at any time of the day
Environment:	Visitor numbers (total count in 30min)	Total number of zoo visitors that pass the polar bear exhibit within a 3 meter range during an observation session
	Employee numbers (total count in 30min)	Total number of zoo employees that pass the polar bear exhibit within a 3 meter range during an observation session

Behaviours

Type:		Definition:
State behaviours	Active	All displayed behaviours involving locomotion. Playing, feeding, drinking, object manipulation, climbing, exploring, territorial behaviours, defecating, social interactions.
	Inactive	All displayed resting behaviours (e.g. passively sitting and lying awake. sleeping)
	Stereotypic	All displayed ARB's (Abnormal Repetitive Behaviours) (Pacing, head swaying, paw flicking, tongue flicking, yawning, walking backwards, swimming bouts, etc.)
	Out of sight	Subject is out of sight of the observer
Point behaviours	Head swing	Subject swings his head outside his normal routine
	Yawn	Subject Yawns
	Variation	Subject varies in his routine. Caused by a distraction or by whatever cause
Feeding interaction	Meat interaction	Total time spent physically touching or consuming the present food item
	Fish interaction	
	Other food item interaction	
Enrichment interaction	Enrich Feeding interaction	Total time spent focussed on the present enrichment item (e.g. touching. smelling. stalking)
	Enrich Toys interaction	
	Enrich Substrate interaction/use	

External factors

Type:		Definition:
Keeper activity	Cleaning	What was the reason for the keeper presence
	Check-up	
	Food prep	
	Feeding	
	Administration	
Group behaviour	Urinating/Defecating	Excretion of bodily fluids by the female and/or one of her cubs
	Vocalisation	Female and/or cubs vocalize
	Food present	There is food present in the female enclosure
	Possibly within Sight	Female and/or cubs are in nose-to-nose exhibit sections W2, C3 or G3 while Victor is in Exhibit 2
	Group inside	Female and/or cubs have entered the night dens from the nose-to-nose exhibit side
Surrounding noises	Traffic	all sounds made by traffic such as electric carts and vans that do not reach the 70dB threshold
	Decibel	all sounds producing more than 70dB during an observation session
	Traffic & Decibel combined	all sounds producing more than 70dB while traffic is passing simultaneously during an observation session

Location (see exhibit floor plans in Appendix I for locations of all sections described below)

Type:		Definition:
Exhibit	Exhibit 1	Subject is kept in Exhibit 1
	Exhibit 2	Subject is kept in Exhibit 2
	Exhibit 3	Subject is kept in Exhibit 3
	Exhibit 1 + 2	Subject has access to Exhibit 1 and 2 at the same time
Location/Substrate in Exhibit	Concrete 1	Concrete Section in Exhibit 1
	Concrete 2	Concrete Section in Exhibit 1
	Concrete 3	Concrete Section in Exhibit 1
	Concrete 4	Concrete Section in Exhibit 2
	Sand 1	Sand Section in Exhibit 1
	Sand 2	Sand Section in Exhibit 2
	Grass 1	Grass Section in Exhibit 2
	Water 1	Water body in Exhibit 1
	Water 2	Water body in Exhibit 1
	Water 3	Water body in Exhibit 2
	Inside	Access from all exhibits

Appendix V: Results

Table V.1: Daily activity budget of a male polar bear on an average observation day (N=24), calculated over the total observation period (N=116) and visible observation period (N=94)

Behaviour		Average Number	Average Duration (sec)	Per cent (%)	Std. Error	Std. Dev.
Average State Behaviour N=116	Active	-	1377.96	16.29 %	2.34	25.24
	Inactive	-	142.63	1.75 %	1.00	10.77
	Stereotypic	-	3709.54	45.54 %	3.89	41.88
	Out Of Sight	-	2915.79	35.79 %	3.87	41.65
	Total	-	8145.92	100.00 %	-	-
Average State Behaviour Visible N=94	Active	-	1377.96	26.35 %	2.34	25.24
	Inactive	-	142.63	2.73 %	1.00	10.77
	Stereotypic	-	3709.54	70.92 %	3.89	41.88
	Total	-	5230.13	100.00 %	-	-
	Average Point Behaviours N=116	Head Swing	12.17	-	57.82 %	4.31
Yawn		2.87	-	13.66 %	3.46	29.55
Variation		6.00	-	28.52 %	3.83	32.76
Total		21.04	-	100.00 %	-	-

Table V.2: Average activity budget of a male polar bear within an average combined time segment (N=4), calculated over the total observation period (N=116)

Time Segment	Behaviour N=116	Average Number	Average Duration (sec)	Per cent (%)	Std. Error	Std. Dev.
Segment 1 (N=7) Segment 2 (N=22)	Active	-	201.00	13.49 %	4.68	25.18
	Inactive	-	4.83	0.30 %	0.30	1.63
Combined Segment 1 (N=29) (point behaviour missing values =8)	Stereotypic	-	927.76	58.84 %	7.65	41.22
	Out Of Sight	-	476.34	27.36 %	7.14	38.48
	Total	-	1609.93	100.00 %	-	-
	Head Swing	4.80	-	40.89 %	7.62	34.94
	Yawn	1.72	-	32.46 %	7.41	33.95
Segment 3 (N=22) Segment 4 (N=14) Combined Segment 2 (N=36) (point behaviour missing values =8)	Variation	1.36	-	26.65 %	5.79	26.52
	Total	7.88	-	100.00 %	-	-
	Active	-	389.17	22.19 %	3.79	22.74
	Inactive	-	15.78	0.88 %	0.88	5.25
	Stereotypic	-	900.25	51.30 %	6.14	36.82
Segment 5 (N=14) Segment 6 (N=17) Combined Segment 3 (N=31) (point behaviour missing values =12)	Out Of Sight	-	438.50	25.63 %	5.99	35.96
	Total	-	1743.70	100.00 %	-	-
	Head Swing	2.55	-	56.02 %	7.25	38.38
	Yawn	0.52	-	12.47 %	4.27	22.62
	Variation	1.61	-	31.51 %	5.94	31.44
Segment 7 (N=16) Segment 8 (N=4) Combined Segment 4 (N=20) (point behaviour missing values =15)	Total	4.68	-	100.00 %	-	-
	Active	-	333.48	19.55 %	5.28	29.38
	Inactive	-	29.55	1.64 %	1.64	9.13
	Stereotypic	-	735.90	43.50 %	7.97	44.37
	Out Of Sight	-	604.61	35.30 %	7.51	41.81
Combined Segment 3 (N=31) (point behaviour missing values =12)	Total	-	1703.54	100.00 %	-	-
	Head Swing	1.38	-	39.83 %	8.15	35.52
	Yawn	0.35	-	14.41 %	7.43	32.39
	Variation	1.62	-	45.76 %	8.11	35.36
	Total	3.35	-	100.00 %	-	-
Segment 7 (N=16) Segment 8 (N=4) Combined Segment 4 (N=20) (point behaviour missing values =15)	Active	-	144.70	8.79 %	4.77	21.34
	Inactive	-	89.95	5.00 %	5.00	22.36
	Stereotypic	-	345.10	22.18 %	8.93	39.92
	Out Of Sight	-	1081.80	64.03 %	10.09	45.11
	Total	-	1661.55	100.00 %	-	-
Combined Segment 4 (N=20) (point behaviour missing values =15)	Head Swing	5.20	-	63.33 %	17.45	39.02
	Yawn	0.00	-	0.00 %	0.00	0.00
	Variation	1.50	-	36.67 %	17.45	39.02
	Total	6.70	-	100.00 %	-	-

Point behaviours

Table V.3: Point behaviours in total number and per cent over the total observation period and within the modifier period

	Total observation period	Modifier period	Per cent of total observation period (%)	Per cent of modifier period (%)
Head Swing	292	126	100.00 %	43.15 %
Yawn	69	27	100.00 %	39.13 %
Variation	144	70	100.00 %	48.61 %
Total Point behaviours	505	223	100.00 %	44.16 %
Total Duration	195502	74129	100.00 %	37.95 %

Table V.4: Total number of point behaviours during total keeper presence and non-feeding and feeding-related events

	Total Keeper Presence	Non Food-Related Keeper presence	Food-Related Keeper presence
Head Swing	22	22	0
Yawn	2	2	0
Variation	9	9	0
Total Point behaviours	33	33	0

Table V.5: Total number of point behaviours over the total Female Group behaviour events, as well as whenever there was food present in the female exhibit, when the group is within line of sight and when the group was inside their night den

	Total Group Behaviour	Food Present in Female Exhibit	Group Within line of Sight	Group Inside night den
Head Swing	73	0	50	23
Yawn	19	1	16	2
Variation	30	1	22	7
Total Point behaviours	122	2	88	32

Table V.6: Total number of point behaviours during Traffic, Decibel and Traffic + Decibel combined events

	Traffic	Decibel	Traffic + Decibel Combined
Head Swing	16	14	1
Yawn	4	1	1
Variation	15	11	5
Total Point behaviours	35	26	7

Table V.7: Point behaviours in total number and per cent over the total observation period and within the modifier period. Observed and expected through the percentage of the total observation period.

	Modifiers			Head Swing		Yawn		Variation		Total Point Behaviours	
	Total number	Total Duration	% of Obs time	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
Traffic	252	2707	1,38	16	4	4	1	15	2	35	7
Decibel	183	6048	3,09	14	9	1	2	11	4	26	16
Traffic + Decibel	35	1114	0,57	1	2	1	0	5	1	7	3
Total Keeper Presence	43	18795	9,61	22	28	2	7	9	14	33	49
Non-feeding related	30	14484	7,41	22	22	2	5	9	11	33	37
Feeding related	13	4311	2,21	0	6	0	2	0	3	0	11
Total Female Group	253	45528	23,29	73	68	19	16	30	34	122	118
Food Present	11	7041	3,60	0	11	1	2	1	5	2	18
Within Sight	121	26969	13,79	50	40	16	10	22	20	88	70
Inside	121	11518	5,89	23	17	2	4	7	8	32	30
Total during modifiers	766	74192	37,95	126	111	27	26	70	55	223	192
Total outside modifiers	-	121310	62,05	166	181	42	43	74	89	282	313
Overall Total	766	195502	100,00	292	292	69	69	144	144	505	505

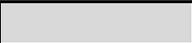
 occurs less frequent than expected
 occurs more frequent than expected

Exhibit use

Table V.8: Exhibit use per exhibit per observation.

Independent Variables		Total N=116	Total N=94
Location	Exhibit 1	21	18
	Exhibit 2	0	0
	Exhibit 3	0	0
	Exhibit 1 + 2	95	76

Table V.9: Exhibit use per exhibit, in total duration, average duration and percentage.

Location (N=116)		Total Duration Ex 1 (sec) (N=21)	Average Duration Ex 1 (sec) (N=21)	Per cent (%)	Total Duration Ex 1+2 (sec) (N=95)	Average Duration Ex 1+2 (sec) (N=95)	Per cent (%)	Number of visits	Average Duration per visit
Inside	Inside	8708	414.7	23.92 %	58884	619.8	37.02 %	156	433.47
Concrete	Concrete 1 (C1)	21648	1030.8	59.39 %	31586	332.5	19.86 %	226	235.55
	Concrete 2 (C2)	1101	52.4	3.02 %	3402	35.8	2.14 %	125	36.02
	Concrete 3 (C3)	62	2.9	0.17 %	4210	44.3	2.65 %	160	26.70
	Concrete 4 (C4)	-	-	-	48160	506.9	30.28 %	168	286.67
	Total Concrete	22811	1086.2	62.58 %	87358	919.5	54.93 %	679	584.94
Water	Water 1 (W1)	0	0	0.00 %	36	0.4	0.02 %	1	36.00
	Water 2 (W2)	404	19.2	1.10 %	2896	30.5	1.82 %	16	206.25
	Water 3 (W3)	-	-	-	21	0.2	0.01 %	1	21.00
	Total Water	404	19.2	1.10 %	2953	31.1	1.85 %	18	263.25
Soft Substrate	Sand 1 (Z1)	4527	215.6	12.42 %	631	6.6	0.40 %	16	322.38
	Sand 2 (Z2)	-	-	-	2179	22.9	1.37 %	48	45.40
	Grass 1 (G1)	-	-	-	7047	74.2	4.43 %	28	251.68
	Total Soft Substrate	4527	215.6	12.41 %	9857	103.7	6.20 %	92	619.46
Total Locations		36450	1735.7	100.00 %	159052	1674.2	100.00 %	945	1901.12
Attribute use (N=116)		Total Duration (sec)						Number of visits	Average Duration per visit
Rock		732	-	-	-	-	-	13	56.31
Tree		252	-	-	-	-	-	2	126.00
Total Attribute Use		984	-	-	-	-	-	15	182.31

Pearson's Correlation

Table V.10: Pearson correlation between percentage stereotypic behaviour during an observation session and the percentage of the time a variable was present or in use.

Variable (% of the time)		N	Pearson correlation	Sig (2-tailed)
Substrate	Concrete	94	0.685**	0.000
	Water	94	-0.253*	0.014
	Soft	94	-0.476**	0.000
Concrete	C1	94	0.086	0.412
	C2	94	-0.387**	0.000
	C3	94	-0.245*	0.017
	C4	94	0.426**	0.000
Traffic	X	116	-0.112	0.230
Decibel	X	116	0.095	0.309
Traffic Decibel	X	116	-0.021	0.823
Group behaviour		116	-0.048	0.608
	Within Sight	116	0.024	0.798
	Inside	116	-0.013	0.886
Keeper presence		116	-0.018	0.845
	Feeding	116	-0.173	0.063
	Non-feeding	116	-0.074	0.428

*Sig at the level 0.05 (2-tailed)

**Sig at the 0.01 level (2-tailed)

Weather conditions

Table V.11: Observed weather types and temperatures during observations (N=116).

Independent Variables		Total	Min	Max	Average	Std. Error	Std. Dev.
Temperature		-	1°C	11°C	5.16°C	0.259	2.785
Weather Conditions	1: Blue/Dry	16	-	-	-	-	-
	2: Blue/Wet	0					
	3: Cloudy/Dry	30					
	4: Cloudy/Wet	1					
	5: Grey/Dry	43					
	6: Grey/Wet	26					

Visitors and Employees

Table V.12: Total Visitor and Employee count over total observation time (N=116).

Independent Variables	Total	Min	Max	Average	Std. Error	Std. Dev.
Employees	579	0	18	4.99	0.349	3.764
Visitors	1164	0	69	10.3	1.090	11.742

Feeding Times

Table V.13: Duration stereotypic behaviour per Food item, before, during and after feeding (sec and %).

Food item	Duration S Before Feeding (sec)	% S Before Feeding	Duration S During Feeding (sec)	% S During Feeding	Duration S After Feeding (sec)	% S After feeding	Obs	Duration feeding day (sec)
Fish	21204 (N=22)	13,81%	5213 (N=11)	3,39%	10389 (N=13)	6,76%	N=46	77080
Meat	3653 (N=9)	2,38%	38 (N=6)	0,025	8073 (N=10)	5,26%	N=35	57760
Meat + Fish	x x		0 (N=1)	0%	4571 (N=5)	2,98%	N=6	9705
Other	1745 (N=1)	1,14%	1387 (N=1)	0,9	4689 (N=3)	3,05%	N=5	9011
Total	26602	17,33%	6638	4,32%	27722	18,05%	92	153556
Average per observation	831,32 (N=32)	50,35%	349,37 (N=19)	21,16%	660,05 (N=42)	39,97%	93	1651,1

Food Interaction

Table V.14: Total count independent Variables; Food, Food type

Independent Variables		Total N=116	Total N=94		
Food presence	New Food	19	18		
	Old Food	24	19		
	No Food	73	57		
Food Item	Meat	18	15		
	Fish	13	13		
	Meat and Fish	6	4		
	Other item	6	5		
	No Item	73	57		
Interaction		Total Duration (sec)	Per cent of total observation time (%) N=94	Number of interactions	Average duration per interaction
Food Interaction	Meat	5108	2.61 %	35	145.94
	Fish	5098	2.61 %	13	392.15
	Total Food Interaction	10206	5.22 %	48	538.09

Enrichment interaction

Table V.15: Percentage Food - and Enrichment interaction time

Independent Variables		Total N=116	Total N=94		
Enrichment present	New Enrichment	25	18		
	Old Enrichment	54	47		
	No Enrichment	37	29		
Enrichment Item	Feeding Enrichment	6	4		
	Toy Enrichment	49	39		
	Substrate Enrichment	4	4		
	Multiple old Enrichment	20	18		
	No Enrichment	37	29		
Interaction		Total Duration (sec)	Per cent of total observation time (%)	Number of interactions	Average duration per interaction
Enrichment Interaction	Food-based	506	0.26 %	3	168.67
	Toy-based	1054	0.54 %	3	351.33
	Substrate-based	4537	2.32 %	11	412.45
	Total Enrichment Interaction	6073	3.12 %	17	932.45

GLM model

Table V.16: General Linear Model of significant changes in stereotypic behaviour affected by different variables

Behaviour	N	Variable	Parameter est	Mean	Std. Error of mean	Sig F	R Squared	
(Arsin) Stereotyp	94	Food	New food:	-0.689 ^a	25.1 %	±7.35	F(2.88)=10,920; P=0.001	0.263
			Old food:	-0.131 ^b	65.5 %	±9.33		
			No Food:	0 ^b	75.9 %	±4.37		
(Arsin) Stereotyp	94	Food type	Meat:	-0.717 ^a	33.6 %	±10.92	F(3.88)=3,070; P=0.032	0.263
			Fish:	-0.638 ^a	36.0 %	±9.60		
			Meat + Fish:	-0.209 ^{ab}	71.4 %	±23.83		
			Other:	0 ^b	87.9 %	±3.26		
			No Item:	-0.135 ^b	75.9 %	±4.04		
(Arsin) Stereotyp	116	Time of day	Segment 1:	0.545 ^a	66.0%	±7.62	F(3.104)=5.358; P=0.002	0.274
			Segment 2:	0.402 ^{ab}	55.9%	±6.30		
			Segment 3:	0.304 ^{ab}	49.4%	±8.26		
			Segment 4:	0 ^b	28.4%	±9.97		
(Arsin) Active	116	Food	New food:	-0.389 ^a	25.1 %	±7.35	F(2.113)=28,356; P=<0.001	0.322
			Old food:	-0.101 ^b	65.5 %	±9.33		
			No Food:	0 ^b	75.9 %	±4.37		
(Arsin) Out of Sight	116	Time of day	Segment 1:	-0.523 ^a	27.36%	±7.14	F(3.112) =4,591; P=0.005	0.086
			Segment 2:	-0.547 ^{ab}	25.63%	±5.99		
			Segment 3:	-0.425 ^{ab}	35.30%	±7.51		
			Segment 4:	0 ^b	64.03%	±10.09		
Yawn	94	Food	New food:	-0.886 ^b	0.17	±0.09	F(2.91)=3.333; P=0.040	0.048
			Old food:	-0.737 ^b	0.32	±0.26		
			No Food:	0 ^b	1.05	±0.23		
Yawn	116	Time of day	Segment 1:	1.483 ^a	1.48	±0.41	F(3.112) =6.399; P=<0.001	0.123
			Segment 2:	0.472 ^b	0.47	±0.16		
			Segment 3:	0.290 ^b	0.29	±0.17		
			Segment 4:	0 ^b	0.00	±0.00		
Variation	116	Employers	0.107	x	x	F(1.114)=5.330; P=0.023	0.036	
Variation	94	Food	New food:	-1.447 ^a	0.05	±0.28	F(2.91) =4.006; P=0.022	0.061
			Old food:	-0.668 ^{ab}	1.26	±0.36		
			No Food:	0 ^b	1.95	±0.29		
Variation	94	Enrichment type	Food En.:	-0.694 ^{ab}	0.25	±0.25	F(4.89)=3.661 P=0.008	0.103
			Toys En.:	1.440 ^a	2.38	±0.36		
			Substrate En.:	0.806 ^{ab}	1.75	±0.85		
			Multiple En.:	0 ^{ab}	0.94	±0.392		
			No En.:	-0.048 ^b	0.90	±0.291		

Table V. 17: Complete General Linear Model of stereotypic behaviour affected by different variables

Variable		Stereotyp N=116			Stereotyp N=94		
		Parameter estimate	Mean	Significant F	Parameter estimates	Mean	Significant F
Visitors		-0.002	x	F(1.114)=0.097; P=0.756	-0.003	x	F(1.92)=0.503; P=0.480
Employers		0.003	x	F(1.114) =0.032; P=0.858	0.002	x	F(1.92)=0.503; P=0.480
Keepers	Yes:	-0.075 ^b	55.4 %	F (1.104)=4.274; P=0.041	x	x	x
	No:	0 ^b	50.4 %				
Food	New food:	-0.471 ^a	23.8%	F (2.104)=8,473;P=<0.001	-0.689 ^a	25.1 %	F(2.88)=10,920; P=0.001
	Old food:	-0.092 ^{ab}	51.9%		-0.131 ^{ab}	65.5 %	
	No Food:	0 ^b	59.3%		0 ^b	75.9 %	
Food type	Meat:	-0.598 ^b	28.0%	F (4.111)=2.387; P=0.055	-0.717 ^a	33.6 %	F(3.88)=3,070; P=0.032
	Fish:	-0.433 ^b	35.9%		-0.638 ^a	36.0 %	
	Meat + Fish:	-0.344 ^b	47.6%		-0.209 ^{ab}	71.4 %	
	Other:	0 ^b	73.3%		0 ^b	87.9 %	
	No Item:	-0.170 ^b	59.3%		-0.135 ^b	75.9 %	
Enrichment	New:	0.074 ^b	52.1%	F (2.113)=0.440; P=0.645	0.180 ^b	72.3 %	F(2.91)=0.588; P=0.557
	Old:	0.124 ^b	56.3%		0.056 ^b	64.6 %	
	No:	0 ^b	45.6%		0 ^b	58.1 %	
Enrichment type	Food En.:	-0.078 ^b	47.6%	F (4.104)=3,480; P=0.010	0.177 ^b	71.4 %	F (4.89)=0.707; P=0.589
	Toys En.:	0.021 ^b	53.4%		0.137 ^b	67.0 %	
	Substrate En.:	-0.530 ^b	90.7%		0.446 ^b	90.7 %	
	Multiple En:	0 ^b	53.8%		0 ^b	59.8 %	
	No En.:	-0.074 ^b	45.6%		0.030 ^b	58.1 %	
Exhibit	Exhibit 1:	0.082 ^b	57.6%	F(1.114)=0.298; P=0.586	0.033 ^b	67.2%	F (1.92)=0.053; P=0.819
	Exhibit 1+2:	0 ^b	50.7%		0 ^b	63.4%	
Time of day	Segment 1:	0.545 ^a	66.0%	F (3.104)=5.358; P=0.002	0.284 ^b	76.6%	F (3.90)=1.245; P=0.289
	Segment 2:	0.402 ^{ab}	55.9%		0.062 ^b	61.0%	
	Segment 3:	0.304 ^{ab}	49.4%		0.027 ^b	58.9%	
	Segment 4:	0 ^b	28.4%		0 ^b	56.7%	

Shifting between behaviours

Table V.18: Cross tabulation of the different behavioural increases and decreases expressed during the baseline compared to modifier situations

		Behaviour									Total	
		S - S	S - A	S - OOS	A - S	A - A	A - OOS	OOS - S	OOS - A	OOS - OOS		
Baseline	Count	135	19	12	27	39	17	9	18	78	354	
	Expected Count	87.1	31.4	14.1	41.6	31.4	41.0	6.4	48.7	52.5	354.0	
	% within Modifier	38.1%	5.4%	3.4%	7.6%	11.0%	4.8%	2.5%	5.1%	22.0%	100.0%	
Modifier*	Total keeper presence ¹	Count	1	30	10	38	10	47	1	58	4	199
		Expected Count	48.9	17.6	7.9	23.4	17.6	23.0	3.6	27.3	29.5	199.0
		% within Modifier	.5%	15.1%	5.0%	19.1%	5.0%	23.6%	.5%	29.1%	2.0%	100.0%
	Non-feeding keeper ²	Count	1	29	10	38	3	39	1	48	3	172
		Expected Count	44.5	15.7	7.2	21.3	13.7	18.3	3.3	21.6	26.5	172.0
		% within Modifier	.6%	16.9%	5.8%	22.1%	1.7%	22.7%	.6%	27.9%	1.7%	100.0%
	Feeding keeper	Count	0	1	0	0	7	8	0	10	1	27
		Expected Count	9.6	1.4	.9	1.9	3.3	1.8	.6	2.0	5.6	27.0
		% within Modifier	.0%	3.7%	.0%	.0%	25.9%	29.6%	.0%	37.0%	3.7%	100.0%
	Total group behaviour ³	Count	73	37	23	56	26	54	8	70	70	417
		Expected Count	112.5	30.3	18.9	44.9	35.2	38.4	9.2	47.6	80.0	417.0
		% within Modifier	17.5%	8.9%	5.5%	13.4%	6.2%	12.9%	1.9%	16.8%	16.8%	100.0%
	Food present	Count	1	0	1	0	4	6	0	6	2	20
		Expected Count	7.3	1.0	.7	1.4	2.3	1.2	.5	1.3	4.3	20.0
		% within Modifier	5.0%	.0%	5.0%	.0%	20.0%	30.0%	.0%	30.0%	10.0%	100.0%
	Within sight ⁴	Count	32	23	12	32	5	21	4	27	47	203
		Expected Count	60.9	15.3	8.7	21.5	16.0	13.8	4.7	16.4	45.6	203.0
		% within Modifier	15.8%	11.3%	5.9%	15.8%	2.5%	10.3%	2.0%	13.3%	23.2%	100.0%
	Inside ⁵	Count	40	14	10	24	17	27	4	37	21	194
		Expected Count	62.0	11.7	7.8	18.1	19.8	15.6	4.6	19.5	35.0	194.0
		% within Modifier	20.6%	7.2%	5.2%	12.4%	8.8%	13.9%	2.1%	19.1%	10.8%	100.0%
	Traffic ⁶	Count	106	12	1	4	44	1	1	1	80	250
		Expected Count	99.8	12.8	5.4	12.8	34.4	7.5	4.1	7.9	65.4	250.0
		% within Modifier	42.4%	4.8%	.4%	1.6%	17.6%	.4%	.4%	.4%	32.0%	100.0%
Decibel ⁷	Count	100	9	4	8	21	10	0	10	26	188	
	Expected Count	81.5	9.7	5.5	12.1	20.8	9.4	3.1	9.7	36.1	188.0	
	% within Modifier	53.2%	4.8%	2.1%	4.3%	11.2%	5.3%	.0%	5.3%	13.8%	100.0%	
Traffic & Decibel combined	Count	14	4	0	2	5	1	0	1	10	37	
	Expected Count	14.1	2.2	1.1	2.7	4.2	1.7	.9	1.8	8.3	37.0	
	% within Modifier	37.8%	10.8%	.0%	5.4%	13.5%	2.7%	.0%	2.7%	27.0%	100.0%	

*Significant differences found compared to baseline: 1. ($X^2=237.190$; $df=8$; $P\leq 0.001$), 2. ($X^2=229.659$; $df=8$; $P\leq 0.001$), 3. ($X^2=86.385$; $df=8$; $P\leq 0.001$), 4. ($X^2=66.380$; $df=8$; $P\leq 0.001$), 5. ($X^2=63.615$; $df=8$; $P\leq 0.001$), 6. ($X^2=51.213$; $df=8$; $P\leq 0.001$), 7. ($X^2=18.492$; $df=8$; $P=0.018$).

Keeper Presence

Table V.19: Different modifiers related to keeper presence expressed in number of occurrence, total duration and per cent

Modifier		Number	Duration (sec)	Per cent (%)	Std. Error	Std. Dev.
Keeper presence	Feeding	13	4311	2.34 %	18.08	194.76
	Cleaning	1	311	0.17 %	2.68	28.88
	Food Preparation*	0	0	0.00 %	0.00	0.00
	Check-up	26	13269	7.19 %	31.5	339.38
	Administration	3	904	0.48 %	4.62	49.76
	Food-related	13	4311	2.34 %	18.08	194.76
	Non Food-related**	30	14484	7.84 %	32.39	348.84
Total		43	18795	10.18 %	36.10	388.83

* Food preparation was not observed and therefore excluded from scientific analysis.

** Cleaning, Check-up and Administration combined.

Female Group Behaviour

Table V.20: Different modifiers related to behavioural events of the female and/or her cubs, expressed in number of occurrence, total duration and per cent.

Modifier		Number	Duration (sec)	Per cent (%)	Std. Error	Std. Dev.
Group behaviour	Defecate*	1	30	0.02 %	.259	2.785
	Vocalize*	0	0	0.00 %	0.00	0.00
	Food Present	11	7041	3.81 %	24.46	263.47
	Possibly within Sight	121	26969	14.61 %	35.98	387.46
	Group Inside	121	11518	6.24 %	23.23	250.14
	Total	254	45558	24.68 %	45.87	493.99

* Female group defecations only occurred once and female group vocalizations did not occur at all. For that reason these two modifiers were excluded from scientific analysis.

Traffic and (Construction Work) Noises

Table V.21: Different modifiers related to environmental events and construction work noises, expressed in number of occurrence, total duration and per cent.

Modifier		Number	Duration (sec)	Per cent (%)	Std. Error	Std. Dev.
Environment	Traffic	252	2707	1.47 %	4.49	48.32
	Decibel	183	6048	3.28 %	9.70	104.48
	Traffic + Decibel	35	1114	0.60 %	2.68	28.91
	Routine Block*	64	110365	59.79 %	81.29	875.55
	Total	534	120234	65.14 %	83.64	900.88

*Routine Blockage is not related to construction work noises, but is an environmental effect.