Why do polar bears and other captive carnivores perform stereotypic behavior?

Professor Georgia Mason
Canada Research Chair in Animal Welfare, University of Guelph, Ontario, Canada

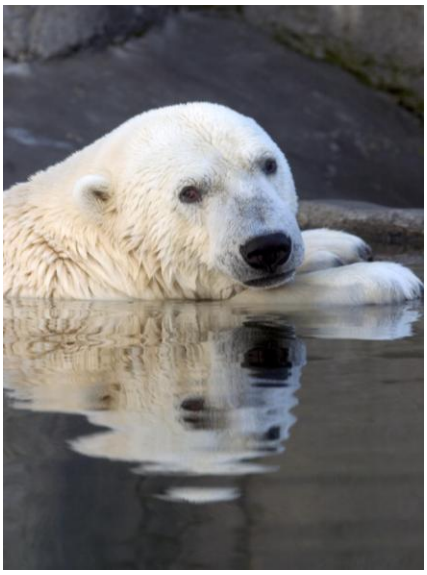
Polar bears in zoos often pace in predictable, stereotypic ways. Some 85% of North American polar bears do it, devoting nearly a quarter of their "active day" (i.e. the time they spend alert and moving) to this behavior (1). It is such a global phenomenon that the Dutch even use it as a verb – '*ijsberen*', literally, 'to polar bear' – when describing pacing, restless people. So, where does this behavior come from, and what does it mean for animal welfare? This leaflet summarizes the current scientific understanding of stereotypic behavior, pulling together findings from laboratory and farm species as well as zoo animals.

"Stereotypic behaviours" (SBs) are defined as repetitive activities induced by frustration, repeated attempts to cope, and/or CNS dysfunction (2). In other words, SBs are repetitive behaviours caused by an underlying problem (and so not all repetitive behaviors are SBs: a purring cat kneading on your lap is not showing a SB, for instance). Several pieces of evidence confirm that pacing, head-swaying, and related behaviors in captive polar bears meet this definition. First, these activities are most frequent in unstimulating environments, and reduced by environmental enrichment (with more diverse enrichments being most effective) (1). Second, they are associated with elevated cortisol in this species, and possibly less bold or exploratory personalities, both suggesting reduced wellbeing (1). Third, in other captive Carnivora (other bears, plus felids, canids and mustelids), which also tend to perform pacing and other whole-body movements (3), barren enclosures, food deprivation, disturbance by visitors and other aversive, frustrating situations all exacerbate these behaviors (4). Fourth, in American mink, a semi-wild carnivore which can be studied in controlled experiments, the small barren cages that reliably induce pacing and similar behaviors cause evidence of altered brain development in the form of elevated "perseveration": generalized tendencies to form routines and pointlessly reiterate actions that can be detected in behavioral tests (5).

The biology of SBs, and why polar bears are so prone to them

One partial explanation for SBs is that animals are so highly motivated to perform certain natural behaviors that they cannot help trying to act them out. For example, pacing in carnivores has often been described as repeated attempts to enact hunting, an idea suggested by the way it typically peaks just before feeding (4,5). Others argue instead that pacing reflects repeated escape attempts (4): an idea suggested by the way that carnivores often pace at enclosure boundaries, and also by the diverse factors that increase this behavior: not just those related to feeding, or that make enclosures aversive, but also by

internal factors making animals motivated to roam such as seasonal changes in sexual hormones (6). Whatever the case, results from mink suggest that stereotypic carnivores are highly motivated to pace: mink given running wheels redirect all their pacing into running in these, and if then required to work to access the wheels (e.g. by pulling a chain), they will do so (7).



The concept that SBs reflect intensely-repeated, highly motivated normal activities is very plausible. For example in poultry, evidence for this idea includes that stereotypic feather-pecking involves pecks that are identical in form to those used in normal foraging; while in laboratory mice, stereotypic mouthing of the bars of their cages focuses at any location where there is an exit: good evidence that this rodent SB derives from escape attempts (5). There is no equivalent information for any carnivore, but in principle this does suggest that stereotypic polar bears could thus be expressing high motivations, for example to hunt, to roam, or to escape.

This motivational view is not the whole story, however. For a start, many SBs, including some in polar bears, look very odd. Some are unlike any normal or natural activity in form, and the way they persist day after day, week after week, also makes it unlikely that they are purely escape attempts (intelligent animals like bears are surely capable of rapidly learning that escape is impossible). Furthermore, SBs are often influenced by early experience in ways that are hard to explain in terms of motivations to perform normal behaviors. Social deprivation in infancy, being raised to in captivity instead of the wild, or in barren environments instead of enriched ones, all tend to predispose animals to SB (the best evidence coming from rodents and primates: 8,9,10). Naturalistic early starts to life, in contrast, tend to protect animals from SB, even if they are later placed in barren environments that must motivate foraging and/or escape attempts (and where, at least in rodents, such individuals are inactive instead of being stereotypic: 7). A final problem for the "natural motivations" idea is that animals like these, who do not show SB despite living in frustrating, impoverished environments, seem just as stressed, sometimes even more so, than stereotypic individuals (9,10,11). If SBs were just about expressing high motivations, you would expect that in identical barren environments, the individuals displaying the most SB are those who are most frustrated, with low-SB animals being relatively 'laid back' and relaxed about the confined housing – and yet, as a rule, this is not what we find.

The explanation for these paradoxes is that being highly active and perseverative – not just highly motivated to perform normal activities – often predisposes animals to SB (2,5,9). So far, links between perseveration (high tendencies to repeat responses) and SB have been found in every species tested (over a dozen, including three carnivores – two bear species as well as mink; 5), although not in all forms of SB (e.g. in mink, perseveration is involved in very predictable SBs but not in "loose", variable ones; 5). One factor causing abnormal perseveration is impaired brain development caused by unnatural rearing environments (5,9,12,13). This helps explain why early experience can be a risk or protective factor for the emergence of SB. Perseveration can also be caused by high levels of stress (2). Poor welfare is not the only influence, however: differences in activity levels and tendencies to perseverate are also simply part of normal individual variation or personality (2,5). Overall, it seems that SBs result from a combination of high motivations to perform specific activities, along with tendencies to be active and perseverative (the relative contributions of these factors varying from one SB to another).

As for why polar bears are so prone to SB, we know that across the Carnivora, natural home range size predicts the severity of SB in captivity (14). With their vast natural ranges, polar bears are thus inherently vulnerable. However, we do not yet know whether this is because wide-ranging carnivores are highly motivated to escape and roam; they are naturally active and perseverative – with this being just part of their normal personality; or instead whether they are particularly prone to being rendered abnormally perseverative by captive conditions (15).

SB, animal wellbeing, and environmental enrichment

An animal with SB has not had a good life, and may have welfare problems still. Early rearing conditions that predispose animals to later SB are typically non-naturalistic, as we have seen, and so probably reduce wellbeing (8,10). Furthermore, in laboratory primates (16, 17), animals that experience many stressful events (e.g. many research procedures) over their lifetimes become more stereotypic. Ongoing conditions that increase SB are also typically poor for current wellbeing (5,11). Finally, elderly animals with SB may become hard to treat in ways that further suggest poor welfare: environmental enrichments that reduce SB in younger animals become less effective, and, at least in mice, the enrichments become less rewarding to the animals too (18). SBs thus seem to reflect cumulative poor welfare over the lifespan.

However, if you are concerned about animal wellbeing, non-stereotypers must not be overlooked, especially if they are very timid (7,14) and housed in ways that do typically cause SB. These animals may well have poor welfare too, but are just not active or perseverative enough to express it as SB.

This emerging understanding of SB helps explain why enrichments differ in impact, and are not always great at reducing SB in long-affected animals (19); it also helps yield some general principles for tackling SB with enrichment and husbandry. Good, effective enrichments should be applied early in young animals' lives, to try and normalize brain development, as well throughout life. They should tackle specific sources of frustration (e.g. reducing motivations to escape or forage), but should also seek to reduce general stress too, perhaps combined with other stress-reducing aspects of care like good keeper relationships (1, 19). Furthermore, although we typically think of enrichments as offering animals activities that they prefer to do instead of SB (3,19), enrichments that reduce overall activity (e.g. by encouraging rest) may be effective too (20). Husbandry practices that physically prevent SB should be avoided (3): the aim should be to reduce animals' motivations to perform SB, not stop them from doing it if they want to. Finally, long-established SBs may need tackling with particular care and imagination, since affected animals may be 'underwhelmed' by enrichments that would be highly positive for younger, less stereotypic individuals (3, 18).

Note: All photos by Michael Durham, Oregonzoo….with exception of last two by Amy Cutting, taken at Seneca Park Zoo.

Literature cited

1) Shepherdson et al. in press *Appl. Anim. Behav. Sci.* Individual and environmental factors associated with stereotypic behavior and fecal glucocorticoid metabolite levels in zoo housed polar bears.

2) Mason 2006. Stereotypic behaviour: fundamentals and applications to animal welfare and beyond. In: *Stereotypic Behaviour in Captive Animals: Fundamentals and Applications to Welfare* (second edition), eds. Mason & Rushen, CAB International, pp. 325-356.

3) Mason *et al.* 2007. How and why should we use enrichments to tackle stereotypic behaviour? *Appl. Anim. Behav. Sci.* 102: 163 – 188.

4) Clubb & Vickery 2006. Locomotory stereotypies in carnivores: does pacing stem from hunting, ranging or frustrated escape? In: *Stereotypic Behaviour in Captive Animals: Fundamentals and Applications to Welfare* (second edition), eds. Mason & Rushen, CAB International, pp. 58-85.

5) Campbell *et al.* 2013. Environmental enrichment reduces perseveration in the American mink, but enhances spontaneous alternation. *Behav. Brain Res.* 239: 177-187.

6) Frederick *et al.* 2010. Methods of estrus detection and correlates of the reproductive cycle in the

sun bear (*Helarctos malayanus*). *Theriogenology* 74: 1121-1135.
7) Hansen & Damgaard 2010. Running in a running wheel substitutes for stereotypies in mink (*Mustela vison*) but does it improve their welfare? *Appl. Anim. Behav. Sci.* 118: 76-83.
8) Novak *et al.* 2006. Deprived environments: Developmental insights from primatology. In: *Stereotypic Behaviour in Captive Animals: Fundamentals and Applications to Welfare* (second edition), eds. Mason & Rushen, CAB International, pp. 153-189.
9) Jones *et al.* 2011. Correlates of birth origin effects on the development of stereotypic behaviour in striped mice, *Rhabdomys*. *Anim. Behav.* 82: 149-159.
10) Jones *et al.* 2011. Early environmental enrichment protects captive-born striped mice against the later development of stereotypic behaviour. *Appl. Anim. Behav. Sci.* 135: 138-145.
11) Mason & Latham 2004. Can't stop, won't stop: Is stereotypy a reliable animal welfare indicator? *Anim. Welf.* 13: S57 – S 69.
12) Lewis & Kim 209. The pathophysiology of restricted repetitive behavior. *J. Neurodevel. Dis.* 1: 114–32.
13) Langen *et al.* 2011. The neurobiology of repetitive behavior: Of mice… *Neurosci. Biobehav. Reviews* 35: 345-355.
14) Clubb & Mason 2003. Captivity effects on wide-ranging carnivores. *Nature* 425: 473 – 474.
15) Clubb & Mason 2007. Natural behavioural biology as a risk factor in carnivore welfare: How understanding species differences could help zoos redesign enclosures. *Appl. Anim. Behav. Sci.* 102: 303 – 328.
16) Gottlieb *et al.* 2013. Risk Factors for Stereotypic Behavior and Self-Biting in Rhesus Macaques (*Macaca mulatta*): Animal's History, Current Environment, and Personality. *Am. J. Primatol.* May 2. doi: 10.1002/ajp.22161. [Epub ahead of print]
17) Lutz *et al.* 2003. Stereotypic and self-injurious behavior in rhesus macaques: A survey and retrospective analysis of environment and early experience. *Am. J. Primatol.* 60: 1-15.
18) Tilly *et al.* 2010. Too old to care? Environmental enrichment has reduced reward value for middle-aged mice with enrichment-resistant stereotypic behaviour. *Anim. Behav.* 80: 363-373.
19) Swaisgood & Shepherdson 2005. Scientific approaches to enrichment and stereotypies in zoo animals: what's been done and where should we go next? *Zoo Biol.* 24: 499–518.
20) Dallaire *et al.* 2012. Individual differences in stereotypic behaviour predict individual differences in the nature and degree of enrichment use in caged American mink. *Appl. Anim. Behav. Sci.* 142: 98-108.