# BIG BRAINS IN ARTIFICIAL CAPTIVE ENVIRONMENTS

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**Morgan**, an orca held captive at Loro Parque Zoo in Spain. She was captured off the Dutch coast in 2010 under a "rescue, rehabilitation and release" permit. In 2018, she gave birth to a calf named Ula. Morgan engages in stereotypies, including repeatedly banging her head against a metal gate. Image credit: Free Morgan Foundation.

## THE BRAIN IN CAPTIVITY

Considerable empirical evidence demonstrates that large-brained mammals, such as cetaceans and elephants, experience poor mental and physical welfare in confinement. Diminished well-being in confined, large-brained, social mammals is related to the well-understood effects of chronic stress on neural development and architecture. In cetaceans (e.g., bottlenose dolphins, belugas, and orcas), captivity and isolation in environmentally impoverished tanks may have deleterious effects on cortical and subcortical structures such as the hippocampus, the basal ganglia, and the amygdala [1].

### Impoverished environments and the cerebral cortex

Cortical neurons in environmentally impoverished, captive animals, compared to animals in enriched natural environments are:

- **Less complex**
- **Receive less metabolic support**
- **Process information less efficiently**

The negative consequences of a captive, impoverished environment include a thinner cerebral cortex, decreased blood supply, smaller neuronal cells bodies with few glial cells, decreased dendritic extent for synthesizing information, fewer dendritic spines (indicating fewer connections with other neurons), and smaller, less efficient synapses [2]. Studies reveal similar epigenetic-related deficiencies at the molecular and neurochemical level throughout the brain.

**Orcas:** In the natural environment, orcas spend their days traveling up to 100 miles a day in close family groups held together by strong emotional and cultural bonds, hunting acoustically, playing with other animals and objects in the environment, and generally making choices about who to spend time with, what to do, and where to go. When these opportunities are lacking, as they are in tanks, their absence becomes a major stressor.

**Stereotypies and the basal ganglia:** Captivity and the psychosocial stress it engenders, has negative effects on complex circuitry between the basal ganglia and the cerebral cortex. Through a series of reciprocal connections, the basal ganglia select and orchestrate appropriate cortical activity for a given situation, including the two pathways involved in movement. Stereotypic behavior resulting from stress has been documented in a large number of species, and is invariably associated with an imbalance in the direct/indirect pathways. More specifically, the indirect pathway is suppressed as a result of dysregulation of two neurotransmitter systems, dopamine and serotonin [3]. Such behavioral stereotypies may represent a coping strategy as the animal attempts to mitigate the overwhelming effects of psychosocial stress.

## ORCAS: THE EFFECTS OF CHRONIC STRESS AND CONFINEMENT

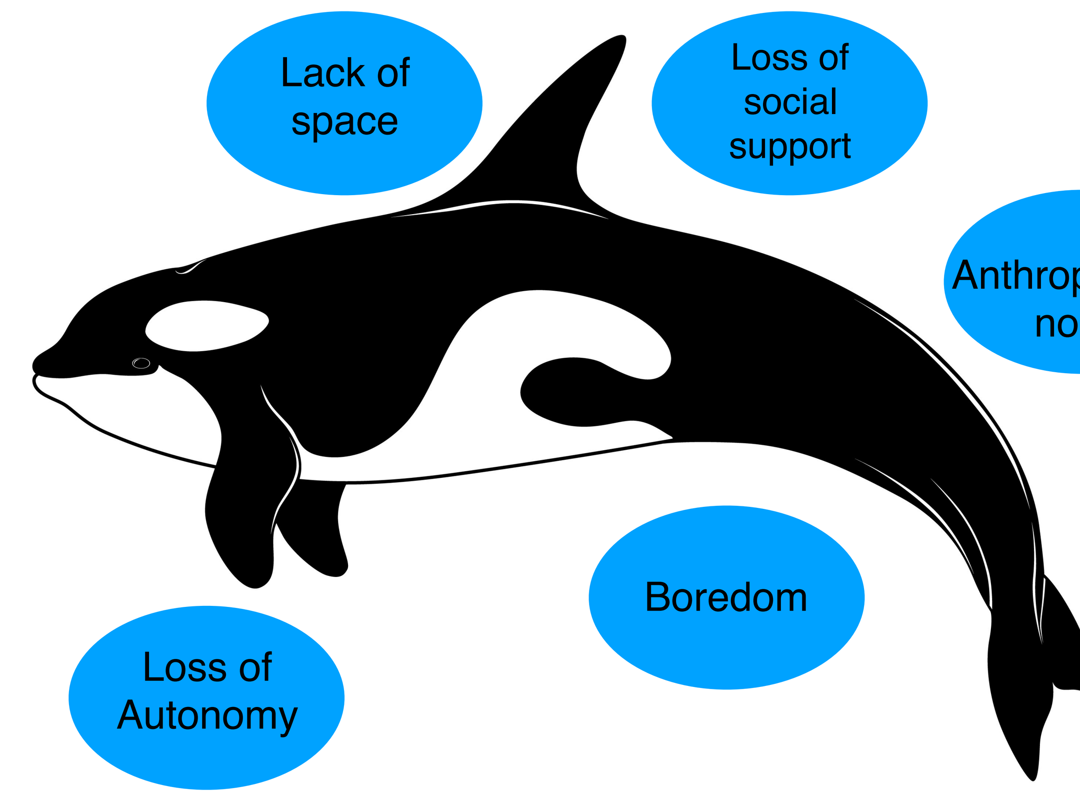
Orca brains are among the most complex and elaborated of all mammal brains, with a higher degree of cortical surface area, a higher proportion of cerebral tissue to the rest of the brain than other species (including humans), and an encephalization level indicating their brain is almost 2.5 times larger than expected for their body weight. The orca brain is well-developed in areas adjacent to the limbic system, the area of the brain which processes emotions and memories.

### Neural consequences of chronic stress

Prolonged stress results in chronically elevated levels of glucocorticoids (stress hormones), which contribute to neurodegeneration, particularly in the hippocampus, involved primarily in declarative and spatial memory formation, and the amygdala, involved in emotional processing [4]. Animals who lack control over their environment develop learned helplessness (associated with amygdala dysregulation). **Under similar conditions, stress in humans is associated with anxiety/mood disorders, major depression, and post-traumatic stress disorder (PTSD).** Due to the highly conserved nature of neural structures, the large, complex brains of orcas react similarly to a severely stressful environment, with well-documented behavioral and physiological evidence.

Right: Skull of free-ranging orca showing normal teeth. Left: One particularly notable behavioral abnormality in captive orcas is the grating of the teeth on hard surfaces until they are broken or worn down close to the gum. A recent study (Jett, J., Visser, I.N., Ventre, J., Waltz, J. and Loch, C., 2017. Tooth damage in captive orcas (Orcinus orca). *Archives of Oral Biology*, 84:151-160.) found that over 60% of captive orcas in the USA and Spain have fractured mandibular teeth and 24% exhibited "major" to "extreme" mandibular coronal tooth wear down to the gingiva. This condition increases vulnerability to systemic infections and the teeth must be drilled out and regularly flushed. (Left photo credit: I. N. Visser, Orca Research Trust. Right photo credit: The Orca Project)

## FIVE MAJOR CHRONIC STRESSORS IN ORCAS CONFINED TO TANKS




## NEUROETHICS AND ANIMAL WELL-BEING

Much of the neuroethical focus on nonhuman animals has been on animals used in neuroscientific research – the ethics of neuroscience. The deleterious effect of captivity on animal well-being and brain development is both **a scientific and an ethical concern.** The effects of confining and environmentally impoverished forms of captivity on the brain in animals, including the confinement of cetaceans in zoos and marine parks, have been neglected as neuroethical issues. Understanding the effects of captivity on animals in a way that is attentive to how captivity itself frustrates the fulfillment of important needs, alters behavior, and **alters the brain** is a relevant focus of neuroethics. It can and should inform our ethical, social, and legal thinking about captivity for these and other species, including humans [5]. Similarly, what we know about **institutionalization and environmental deprivation** in humans should inform the way we view the captivity of nonhuman animals in various settings, especially those animals who are most like us – highly intelligent, big-brained, social mammals who share our vulnerabilities to isolation and confinement in artificial environments.

**References**

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**DECLARATIONS: None**

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