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Essay

Bestial boredom: a biological perspective on animal boredom and suggestions for its scientific investigation

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Boredom is likely to have adaptive value in motivating exploration and learning, and many animals may possess the basic neurological mechanisms to support it. Chronic inescapable boredom can be extremely aversive, and understimulation can harm neural, cognitive and behavioural flexibility. Wild and domesticated animals are at particular risk in captivity, which is often spatially and temporally monotonous. Yet biological research into boredom has barely begun, despite having important implications for animal welfare, the evolution of motivation and cognition, and for human dysfunction at individual and societal levels. Here I aim to facilitate hypotheses about how monotony affects behaviour and physiology, so that boredom can be objectively studied by ethologists and other scientists. I cover valence (pleasantness) and arousal (wakefulness) qualities of boredom, because both can be measured, and I suggest boredom includes suboptimal arousal and aversion to monotony. Because the suboptimal arousal during boredom is aversive, individuals will resist low arousal. Thus, behavioural indicators of boredom will, seemingly paradoxically, include signs of increasing drowsiness, alongside bouts of restlessness, avoidance and sensation-seeking behaviour. Valence and arousal are not, however, sufficient to fully describe boredom. For example, human boredom is further characterized by a perception that time 'drags', and this effect of monotony on time perception can too be behaviourally assayed in animals. Sleep disruption and some abnormal behaviour may also be caused by boredom. Ethological research into this emotional phenomenon will deepen understanding of its causes, development, function and evolution, and will enable evidence-based interventions to mitigate human and animal boredom.
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Chronic inescapable boredom is neither trivial nor benign. In Charles Dickens's (1853) novel *Bleak House*, where the relatively modern word 'boredom' was coined, he described chronic boredom as 'desolation', a 'malady' and a 'monster'. Boredom is an unpleasant emotion including suboptimal arousal levels and a thwarted motivation to experience almost anything different or more arousing than the behaviours and sensations currently possible (adapted from Mason & Burn, 2011, in press). It arises when we perceive that there is 'nothing to do' or are 'tired of doing the same thing' (Larson & Richards, 1991), and is accompanied by a sense of time dragging (Didier-Weil, 1990; Droit-Volet & Meck, 2007; Wahidin, 2006). Fahlman, Mercer-Lynn, Flora, and Eastwood (2013) suggested boredom includes five components they labelled as Disengagement, High Arousal, Low Arousal, Inattention and Time Perception. Boredom differs from other related states including frustration (Mason & Burn, 2011, in press), depression, stress and apathy (Goldberg, Eastwood, Laguardia, & Danckert, 2011). Inescapable boredom is highly distressing (Martin, Sadlo, & Stew, 2006), and a major torment for human prisoners (in both the U.S. and U.K.: Hunt, 2006, pp. 37–61; Wahidin, 2006). Human boredom can be triggered externally by monotonous, meaningless situations. This can cause work absenteeism, cognitive impairment, apathy (Harris, 2000), risk taking, alcoholism (Wegner & Flisher, 2009) and abnormal behaviours (such as head banging or rocking; Mendez & Mirea, 1998). Similarly, boredom proneness exists as a personality trait, predictive of addiction, aggression, depression, impulsivity, sensation seeking, dangerous driving and juvenile delinquency (Dahlen, Martin, Ragan, & Kuhlman, 2005; Harris, 2000; Mercer-Lynn, Flora, Fahlman, & Eastwood, 2013; Newberry & Duncan, 2001). Toohey (2011, page 1) suggested 'Predictability, monotony and confinement are all key' to triggering boredom. Although he was mostly writing about human boredom, these three factors typify captive life for nonhuman animals, so boredom could be a prevalent and chronic animal welfare problem (Mason & Burn, 2011; Wemelsfelder, 2005). Boredom is socially and

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economically important, and it has been studied in human sociological and psychological fields. However, investigation of its biological basis is just beginning.

Here I aim to help stimulate biological research into boredom in wild and captive animals. This paper consists of two main sections. First, I summarize the still rather scant empirical evidence and, using Tinbergen's (1963) framework, explore theoretical arguments for boredom-like states in animals. Second, to enable identification of potential behavioural and physiological indicators of boredom, I characterize boredom in terms of its likely behavioural and physiological manifestations, suggesting how it might be measured in future research. I cover the valence (pleasantness) and arousal (wakefulness) qualities of boredom, using them to predict many likely indicators of boredom. However, not every indicator fits the valence-arousal framework so I also include other likely hallmarks of boredom, such as manifestations of perceived slow passage of time, abnormal behaviour and sleep disruption. Being able to scientifically study objective indicators of boredom has wide relevance, enabling use of animal models of human boredom, research into the ethology and evolution of boredom, and scientific evaluation of the efficacy of interventions to combat human and animal boredom.

WHY MIGHT NONHUMAN ANIMALS EXPERIENCE BOREDOM?

A dog left home alone for several hours each day energetically extracts the foam from a well-chewed corner of the sofa, then whines, yawns and lies awake awhile before getting up again (Lund & Jørgensen, 1999); Alex, the African grey parrot, having shown great prowess in naming colours and quantities of numerous objects, starts to stare at the ceiling, to offer nonsensical answers to questions, repeatedly preens himself, and requests to go to his cage or be given water, food or novel treats (Pepperberg, 2013); a laboratory rat sniffs through the bars of its unenriched cage, digs briefly at the sawdust, sniffs the cage walls and nips at a passing cagemate (Abou-Ismail, Burman, Nicol, & Mendl, 2010); and a farmed pig with no substrate to chew sits and stares, then stands inactive awhile, before suddenly chewing a penmate's tail (Studnitz, Jensen, & Pedersen, 2007). To the naïve observer, the behaviour of each of these animals may be reminiscent of that of a bored human. Indeed, the little evidence to date suggests the homology may go deeper than mere superficial resemblance.

As with any emotion, boredom is private to the individual experiencing it. Therefore, we cannot be certain that other individuals, human or otherwise, experience it exactly as we ourselves do. The term 'Boredom' has historically been rather taboo in serious animal behaviour science, being labelled as 'anthropomorphic', or dismissed as trivial compared with some other welfare issues (Wemelsfelder, 2005). Moreover, boredom is sometimes assumed to be unique to humans (e.g. Anderson, 2004). Thus, it has largely been neglected despite its potential prevalence and malignance. However, there are both empirical and theoretical reasons, as well as ethical ones, to encourage biological exploration of animal boredom.

Existing Empirical Studies of Animal Boredom

The few studies explicitly aiming to investigate animal boredom include observations that propensity for behavioural diversity is significantly reduced in pigs, *Sus scrofa*, kept in impoverished environments for 5 months compared with pigs that received manipulable substrate (Wemelsfelder, Hunter, Mendl, & Lawrence, 2000). This is consistent with boredom, but also with other explanations, including apathy, depression or cognitive impairment. Taking a different approach, monotony causes many species to seek novelty, even novel stimuli they would normally avoid (reviewed in Berlyne, 1960; Kirkden, 2000; Mason et al., 2013; Stevenson, 1983). For example, despite normally shunning bright light, rats, *Rattus norvegicus*, increasingly pressed levers for flashes of light the longer they were kept in darkness (in Berlyne, 1960). Similarly, rats given only their preferred food for 3 days and then offered a choice selected a nonpreferred food, even one previously associated with sickness (Galef & Whiskin, 2003). Thus, even initially positive monotony becomes aversive with time.

More recently, clear hypotheses regarding a key hallmark of boredom, motivation for general stimulation (Meagher, Campbell, & Mason, in press; Meagher & Mason, 2012), have been tested in fur-farmed mink, *Mustela vison*. Compared with mink in environmentally enriched cages, those in standard cages were significantly more likely to approach diverse stimuli, ranging from rewarding cues to (normally) aversive ones. Standard-housed mink also consumed more snacks and spent more time lying awake inactive, as is reported in bored humans (Moynihan et al., 2015). Together, this profile of behaviours enabled Meagher and Mason (2012) to differentiate boredom from depression or apathy as explanations for the awake inactivity so prevalent in standard-housed mink.

Hypothetical Ethological Explanations for Animal Boredom

The above examples all originate from studies of captive animals, understandably as captive animals are subject to inescapable monotonous situations more than wild ones are. Yet, as captivity is a relatively recent challenge in evolutionary terms, one might ask why the ability to experience boredom would have evolved. As so few studies have explicitly investigated animal boredom, the hypothetical explanations I offer draw on indirect evidence regarding human boredom or from indirectly relevant phenomena in nonhuman animals (e.g. impulsivity, neophilia [attraction to novelty] or sensation seeking). I offer suggestions rather than answers. With this limitation acknowledged, I briefly explore how and why animals might experience boredom, using Tinbergen's (1963) four levels of explanation as a framework.

Causation of boredom

Causation refers to the immediate internal and external mechanisms that trigger individual behaviour, or in this case a behaviourally relevant emotion. Causal explanations comprise myriad mechanisms, ranging from environmental cues to endocrine, neurological and other physiological signals. As indicated earlier, a key external trigger for boredom in captive animals will be barren environments, which may be spatially and/or temporally monotonous. Boredom thus occurs when both external and internal stimulation are insufficient to maintain optimal arousal (Berlyne, 1960).

The neural mechanisms producing boredom have seemingly not been investigated even in humans, but the brain's arousal systems will be relevant. Arousal is nonunitary, instead being distributed across several different, interconnected brain structures (Calderon, Kilinc, Maritan, Banavar, & Pfaff, 2016; Jones, 2003). Within the brainstem, arousal is supported by six systems: (1) long glutaminergic nucleus gigantocellularis neurones in the reticular formation, which receive cortical and multisensory peripheral stimulation and have both ascending (cortical) and descending (autonomic, neuroendocrine and motor) projections; (2) cholinergic pontomesencephalic neurones, which facilitate awakening and REM sleep; (3) the mesolimbic dopamine pathway, which helps elicit all motivations and reward-directed behaviour; (4) the adjacent nigrostriatal dopamine system, which increases arousal and reward-directed behaviour, and is involved in time perception (Jahanshahi, Jones, Dirnberger, & Frith, 2006; Simen & Matell,

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