
WARMING A COLD SHOULDER: ANIMAL ETHICS, SENTIENCE, AND PREFERENCES FOR HUMAN INTERACTION IN ZOO-HOUSED NON-AVIAN REPTILES

Mark James Learmonth

ORCID iD: 0000-0002-2237-0665

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The University of Melbourne

Abstract

Animal welfare science has functionally only existed for a little over 50 years. The last three to four decades in particular have seen a relative boom in the rate of expansion, understanding and attention that this discipline has received. Whilst the foundations of animal welfare science mainly focused on identifying and removing *negative* welfare states in captive animals, modern scientific inquiry is now starting to understand and approach *positive* welfare states as a crucial part of any sentient being's experience of life as well. Positive welfare states may include many elements, such as an animal being fit and healthy, experiencing positive moods and affects, and being able to express natural behaviours (or instead, as this thesis will argue, behaviours that are highly motivated and/or highly rewarding). Encouraging, facilitating and maintaining positive animal welfare states in captive zoo animals are a high priority for modern, ethical zoos. However, there is currently a substantial gap in the published literature exploring positive welfare states associated with human (especially visitor) contact in zoo settings. There is limited research that suggests that human-animal interactions in zoos may potentially be rewarding for some animals that are motivated to participate in, and even 'solicit', these interactions, from both familiar husbandry providers (zookeepers) and/or unfamiliar zoo visitors.

Ethically, zoos operate under a few key theories pertaining to animal welfare, animal rights, and environmental ethics. A few such theories are: Compassionate Conservation, Conservation Welfare, and Duty of Care. These theories take inspiration from multiple philosophical discourses, and many of them co-exist within the zoological and aquaria communities, institutions and (self-regulated) associations. Many individual institutions may favour particular ethical theories over others, and not all zoos are ethically run, nor is their captivity of certain animals justified or adequate. However, many influential voices within zoological associations are creating a robust model for running 'modern, ethical zoos'. An

amalgamation of many theoretical ethical approaches is required to fully articulate why zoos should, and do, continue to exist.

The phylogenetic Class *Reptilia* (reptiles) is now more correctly termed non-avian reptiles, as recent taxonomic amendments have included all extant and extinct animals back to the clade *Diapsida*, which includes all dinosaurs, and hence all modern birds - *Aves*. This now makes reptiles a monophyletic group (i.e. with a single common ancestor). Thus, when discussing modern reptiles, such as tortoises, it is proper to distinguish between avian and non-avian reptiles. Currently, none of the non-avian reptile families have been adequately studied in terms of animal behaviour, cognition and animal welfare sciences. These families include: Sub-order *Crocodylia* – crocodiles, alligators, gharials, & caimans; Order *Lepidosauria*, which includes both *Squamata* – lizards and snakes, and Order *Rhynchocephalia* – Tuatara; and Order *Testudines* – turtles, tortoises and terrapins. Declarations of sentience (i.e. feelings) made by governments and scientific associations (such as the World Organisation for Animal Health (OIE)) often include reptiles under the assumption of “*all vertebrate animals*”, but specific declarations of sentience in reptiles are often missing, or overlooked, in scientific writing and welfare-related policies and discussions. Indeed, the historical assumption that reptiles are merely sedentary *automata* without complex cognitive and sentient capacities persist. Available cognition and sentience research, however, indicates that there is a very solid basis for assuming and declaring that non-avian reptiles do indeed display all relevant capacities to be classified as conscious, aware, and sentient beings. This means that they most likely are consciously aware of their own welfare, and hence their lives and well-being matter to them.

This thesis was designed to weave a coherent story connecting animal ethics, states of consciousness, awareness and sentience in non-avian reptiles (that are often overlooked), and experimental research that addresses whether some zoo-housed reptiles perceive human interaction as rewarding, and whether they are indeed motivated to seek these interactions. Three experiments were conducted: An Aldabran Giant Tortoise (*Aldabrachelys gigantea*)

preference test (n=2); a Leopard Tortoise (*Stigmochelys pardalis*) preference test (n=5); and a zoo visitor survey of behavioural and ethical beliefs about zoo-housed non-avian reptiles, and the acceptability of human-animal interactions and owning wildlife as pets (n=231).

Both tortoise preference tests found individual differences between subjects, and I concluded that *some* individual tortoises do indeed prefer human interaction (shell scratching and neck rubs) over other stimuli in the experimental circumstances. Whether the rewarding component for the tortoises was the interaction with the human or simply a pleasurable outcome was not determined. While these results could not be generalised to all populations of tortoises or reptiles in general, the results showed significant individual preferences amongst the sample populations, indicating that being aware of, and sensitive to, individual animals' 'wants', rather than making decisions at a species level, is warranted for zoo-housed non-avian reptiles.

The results of PCAs of visitor survey responses (n=231) found five common ethical beliefs (components) in the sample of zoo visitors, labelled: 1) Human interaction and entertainment priority component; 2) Complicated zoo ethics and animal welfare component; 3) "Wilding", natural living and anti-captivity sentiments component; 4) Ethical duty of care component; and 5) Animal agency and respect component. There were some significant differences between agreement with Component 2 and respondents' education level. Furthermore, Wilcoxon's Signed Rank tests on 3 paired questions (that were answered before and after randomly allocated positive or negative human-animal interaction statements) significantly influenced the re-rated scores to the questions in either the positive or negative direction corresponding to the information provided, showing a significant influence of education (informative statements) on zoo visitor attitudes.

Finally, drawing from relevant information of the known capacities of non-avian reptiles, and from the results of the two preference tests conducted herein that indicated some

preferences for human interactions by tortoises studied, I investigated an ethical model of human-animal interactions in zoos that may benefit the well-being and positive welfare of both animal and human participants, and proposed some recommendations for improvement of such interactions. These recommendations may be relevant to zoological institutions and their governing associations, and the results of the ethical and experimental chapters within this thesis may help inform evidence-based improvements for non-avian reptile welfare within these institutions.

Declaration

This is to certify that:

- this thesis comprises only my original work towards the PhD except where indicated in the Preface,
- due acknowledgement has been made in the text to all other materials used,
- the thesis is fewer than 100 000 words in length, exclusive of tables, maps, bibliographies, and appendices.

Mark James Learmonth

Date: 29/04/2021

Preface

The research herein was conducted through the Animal Welfare Science Centre (AWSC) at The University of Melbourne, in partnership with Zoos Victoria (ZV), and co-supervised by Dr Sally Sherwen, Director of Wildlife Conservation and Science at ZV. The ethical publications and chapters within this thesis were supervised by Professor Peter Sandøe of Copenhagen University, Denmark. The primary supervisor of all components of this thesis was Professor Paul Hemsworth, Animal Welfare Science Centre, The University of Melbourne.

Chapters 1, 2, 3, 7 and 8 of this thesis constitute my sole work; these manuscripts were written in their entirety by me. Professors Paul Hemsworth and Peter Sandøe provided academic advice, guidance, editing and comments for multiple draft revisions of these chapters, but were not listed as (and did not want to be considered as) co-authors for these original single author manuscripts.

For the experimental chapters – 4, 5 and 6 – identification of the focal animals, the development of research questions and experimental methodology, and the statistical analyses of the obtained data were achieved collaboratively with valued input and guidance from my three supervisors. The experiments and data collection were all conducted and overseen by me, with generous support from Dr Sally Sherwen and other Zoos Victoria personnel for coordination and liaising with multiple zoo departments. Data collection for each experiment was also supported by interns and research assistants from the Animal Welfare Science Centre and Zoos Victoria, and by trained zoo personnel during the animal handling components. Manuscripts for the experimental publications were written by me (to no less than 90% of each final text), with revisions and editing provided by Professor Paul Hemsworth and Dr Sally Sherwen before submission for peer-review. All relevant academic supervisors and supports were recognised in the acknowledgements section of each manuscript.

Overall, this thesis consists of no less than 90% of my own academic work.

My PhD candidature was supported by an Australian Government Research Training Program (RTP) Scholarship.

List of publications

The following is a list of the published peer-reviewed journal articles, and those currently under peer-review at the time of submission of this thesis.

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Learmonth, M.J., Sherwen, S., & Hemsworth, P.H. (2020). Assessing preferences of two zoo-housed Aldabran Giant Tortoises (*Aldabrachelys gigantea*) for three stimuli using a novel preference test. *Zoo Biology*, 40(2), 98-106. DOI: 10.1002/zoo.21585

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Academic presentations from this thesis

The following abstracts based on thesis works were presented at international conferences and research symposiums.

Conference Proceedings

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Academic Presentations

Learmonth, M.J. (2016). Human interaction as enrichment for zoo-housed animals: Opportunity for positive affective experiences? *FVAS Student Research Symposium*. The University of Melbourne, Parkville, VIC, Australia. November 2016.

Learmonth, M.J. (2017). Human interaction as enrichment for zoo-housed Giant Tortoises: A research plan update. *Zoos Victoria Research Symposium 2017*. Melbourne Zoo, VIC, Australia. September 2017.

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First and foremost, I would like to acknowledge and thank the immeasurable support of my three supervisors: Professor Paul Hemsworth, Dr Sally Sherwen, and Professor Peter Sandøe. Thank you, all of you. My primary supervisor, Paul Hemsworth, has been an extraordinary supervisor since I undertook my Masters research in 2015. He has been immediately and unequivocally available to help me progress through each stage of my PhD, has challenged my ideas, and given me countless opportunities to grow, both within and without academia. He has been so sensitive, compassionate and accepting of the almost insurmountable health and well-being challenges that I have personally faced during the course of my PhD. He has accommodated and helped me to perform beyond anyone's expectations (including my own) in the face of significant health problems. I am incredibly grateful for everything he has done. Likewise, Sally Sherwen and Peter Sandøe have been just as accepting and accommodating of my unique challenges and ailments. They have helped me to craft the very best version of this thesis possible, and have challenged me to reconsider and evolve my thoughts and reasoning on a great number of issues and topics that I chose to explore in this thesis. They have never let me rest on my laurels, nor lose my direction and commitment to this PhD.

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been invaluable in all aspects concerning formulation, continuation and completion of my thesis. He has been an immeasurable support for meeting all of my academic requirements and guiding me to suitable options for finishing my PhD under difficult circumstances. I am also immensely grateful to Dr Jenny Gray for all of her valuable time spent providing me with feedback on methodologies and ethical discourse, challenging me to improve my logic and arguments for and against issues that arise in zoo captivity, just as Peter Sandøe has also done. I would also like to acknowledge and thank Dr Jean-Loup Rault for his time and guidance as my original advisory chair before he departed Melbourne for Vienna, and his continued support from the other side of the world for all these years after his departure. In addition, thank you to Dr Rebecca Doyle for her key advice and mentorship, especially early on in my PhD journey.

My involvement with the Animal Welfare Science Centre since my Master of Animal Science degree in 2015 has been a remarkable introduction to academia. The academic connections and networks that I have forged within, and through, the centre will prove to be invaluable in my academic career; and being part of such a globally-renowned, progressive centre that produces such innovative and high-quality science has been an immense privilege. The academic and personal friendships that I have formed through the centre will forever be cherished. Thank you to Jeremy Skuse, Lauren Hemsworth, Andrew Fisher, Sam Borg, and Tracie Storey especially.

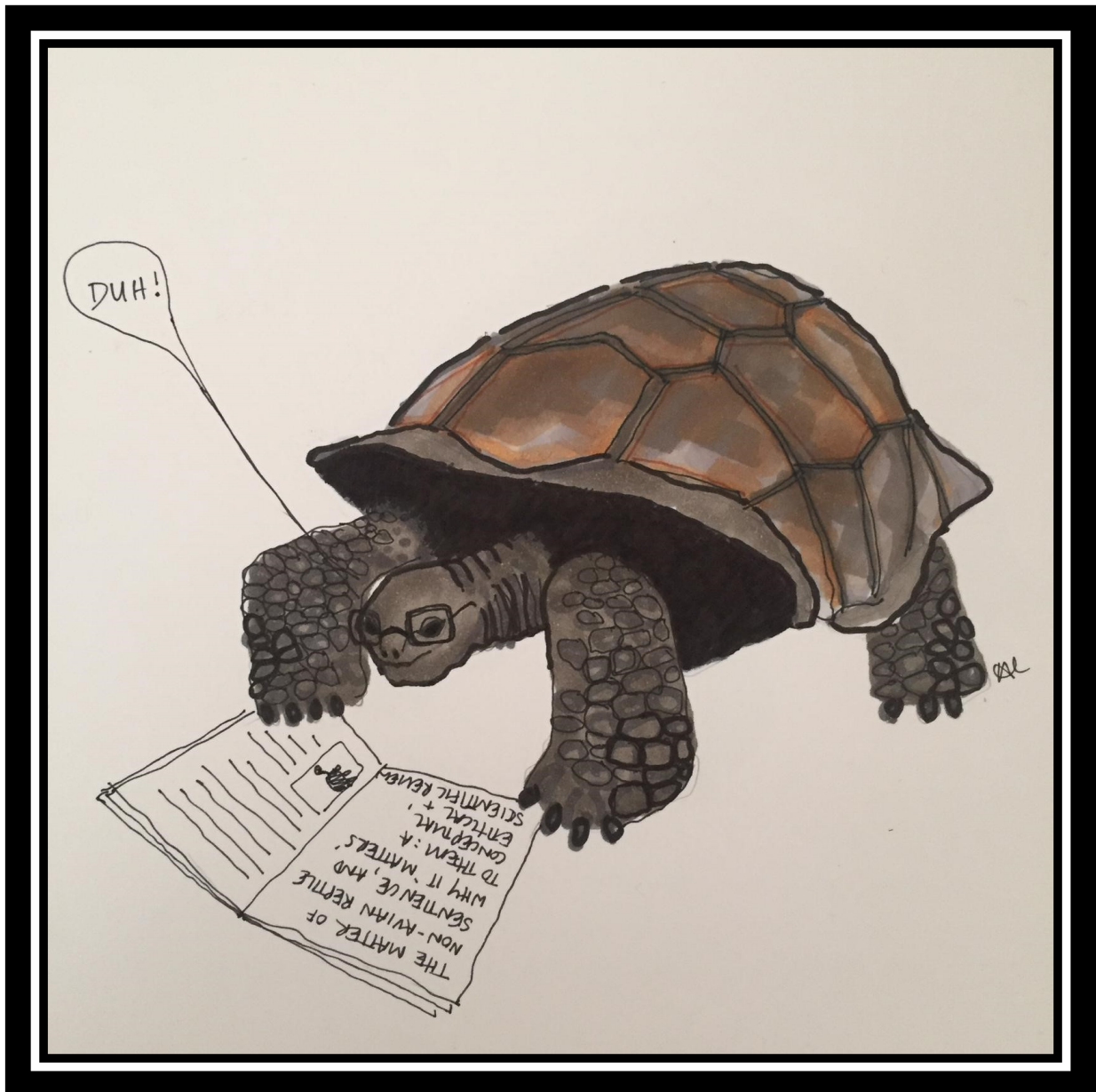
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Finally, I must acknowledge all of the tortoises who participated in the experiments herein, and all of the animals in zoos around the world. I hope that we can start bringing about some real, progressive changes to captive reptile husbandry and welfare to make yours and future reptiles' lives "worth living" in captivity for the rest of human history.



Artwork by Amy Learmonth (2020).

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CHAPTER 1: SIGNIFICANCE, AIMS, AND A REVIEW OF THE LITERATURE

As many of the published chapters of this thesis include comprehensive literature reviews of their own, this chapter will frame the journey that led to the melding of theoretical ethical work and practical experimental welfare works. It shall signpost the salient points of my research, and detail some areas of the history of animal welfare science that were not thoroughly explored in the published chapters. Breaking from thesis tradition, I present the justification for this thesis and my specific aims up-front, so the reader may more effectively follow and understand the narrative journey ahead.

Significance of research

Animal welfare, both at a species level and at the level of each individual, is now one of the highest priorities of modern, ethical zoos (Gray, 2017). Research to date has examined how raising minimum standards for species across all captive industries (including agriculture, laboratories and teaching, companion animals, and zoos) may increase welfare, and some standards in some industries have been consistently updated accordingly (Fraser, 2008; Rose & Grant, 2013; Hemsworth, *et al.* 2015; Mellor, 2015a; 2015b; 2015c; 2019; Gray, 2017). Much of the recent zoo-specific animal welfare research has focused on ‘naturalising the zoo environment’, to make it more reflective of an animals’ native habitat, which has also been suggested to provide more opportunities for “*natural behaviours*” to occur (Maple & Perdue, 2013; Ward & Sherwen, 2018). While this is of salient interest for improving overall zoo animal welfare, many zoological institutions and staff have misconstrued the concept of ‘natural living’, possibly to the detriment of optimal welfare.

It has been suggested that, as it is a very prominent part of the lives of captive zoo animals, human-animal interactions (HAIs) may be either beneficial or detrimental (often both) to the

overall welfare of these animals (Hemsworth, Sherwen & Coleman, 2018; Sherwen, Hemsworth, Beausoleil, Embury, & Mellor, 2018; D’Cruze, *et al.* 2019; Godinez & Fernandez, 2019; Sherwen & Hemsworth, 2019). Likewise, zoo visitors often report as wanting to “connect” with animals as a prime motivation for visiting zoos – to many this means wanting to physically interact with zoo animals (D’Cruze, *et al.* 2019; Howell, McLeod & Coleman, 2019). Pioneering research is now focusing the wealth of available behavioural, physiological and psychological knowledge (collected from all captive settings) on increasing opportunities for captive animals to engage in “positive affective experiences” (Mellor, 2015a; 2019). Increasing positive affective experiences of animals may be achieved in some circumstances by increasing opportunities for interaction between animals and humans, especially for animals that are initiating or soliciting these interactions. These interactions likely also contribute to improved visitor experience and engagement, based on the suggestions from ‘visitor attraction models’ (Moss & Esson, 2010; Howell, *et al.* 2019).

Compared to large, charismatic, and small, cute, fluffy mammals, *non-avian reptiles* (as well as birds and fish) have been comparatively ignored or understudied in scientific literature for many of the last decades. This thesis deliberately chose to investigate some of the capacities of reptiles that are often overlooked, and attempts to answer questions around whether this class of animals can make choices and have preferences similar to most other vertebrate animals. This thesis is a novel, innovative combination of theoretical ethical chapters exploring concepts of ‘natural living’ in zoos (and how this has often been misconstrued), sentience in non-avian reptiles, and the ethics of human-animal interactions; as well as practical experimental chapters focusing on the preferences of two species of zoo-housed tortoises, and a survey of visitor beliefs and attitudes about reptiles and human-animal interactions.

Aims

This experimental and ethical research thesis aimed to:

1. Investigate whether zoo-housed animals are motivated to solicit human-animal interactions, whether natural or unnatural (and if these interactions may improve their well-being and welfare).
2. Review research evidence that suggests non-avian reptiles are conscious, sentient beings, capable of thinking and feeling in many meaningful ways, just like all other vertebrates (and possibly invertebrates).
3. Examine preferences for human interaction in two species of long-living, zoo-housed reptiles – specifically Aldabran Giant Tortoises (*Aldabrachelys gigantea*) and Leopard Tortoises (*Stigmochelys pardalis*), located at Melbourne Zoo, and Werribee Open Range Zoo, respectively.
4. Examine zoo visitor beliefs and attitudes towards tortoises and other reptiles, and investigate ethical beliefs around interacting with captive animals and wildlife.
5. Propose a model of ethical human-animal interactions in zoos that prioritise the animal's experience of the interaction, and avoid unintended behavioural consequences in human participants (when they are in other, inappropriate settings – such as in “nature”).

A brief history of animal welfare science

The last few decades have seen a boom in the science of animal welfare, as humane treatment and animal rights issues are being pressed in academic literature, scientific research communities, and especially in (and by) the general public, via popular media, advertising, activism and social media (Goulart, *et al.* 2009; Whitham & Wielebnowski, 2013; Sherwen, *et al.* 2018). Public awareness of the issue of captive animal welfare – in zoos, production industries, laboratories and companion animals – has increased dramatically over this period, meaning many zoos (and other animal sectors) must adapt and improve, or change focus, to survive (Clayton, *et al.* 2008; Hemsworth & Coleman, 2011; Whitham & Wielebnowski, 2013; Gray, 2017; Sherwen, *et al.* 2018). Many zoos are now championing captive breeding of endangered animals, committed to saving species from extinction; but also committed to treating all animals in their care with *compassion* and *respect* (Zoos Victoria, 2015) and attending to their individual needs, so that they all might have “*a life worth living*” (Yeates, 2011; Mellor, *et al.* 2015; Gray, 2017).

Animal welfare, as a science, owes much of its inception to Ruth Harrison’s seminal text, *Animal Machines* (1964), that uncovered the hidden processes and practices (and indeed the abuses) of animals that were occurring under a rapidly expanding ‘factory farming’, or intensive systems, network (itself borne of post-WWII era progress in the automation, manufacturing, commercialisation, expansion and efficiency of many agricultural practices). This book was the impetus for the Brambell Committee report (1965) to be commissioned, and from it came the invention of the Farm Animal Welfare Council’s “*five freedoms of animal welfare*”. More recently, three key conceptual frameworks have been commonly accepted by experts as a good basis for animal welfare science: 1. Biological functioning, 2. Affective states, and 3. Natural living (Hemsworth, Mellor, Cronin, & Tilbrook, 2015; Veasey, 2017).

From the historical “five freedoms” of animal welfare to more recent definitions, considerations of animal welfare were primarily focused on the first conceptual framework – biological functioning (Broom, 1996; Fraser, 2008). This framework posited that an animal’s ability to cope with its environment derived from empirically measurable biological states, such as health and reproduction measures (Broom, 1996), and that the minimisation or elimination of negative physical and physiological states or experiences (such as hunger or pain) would be sufficient to increase animal production outputs, as negative conditions may lead to impaired biological functioning (Keeling, Rushen, & Duncan, 2011; Hemsworth, *et al.* 2015). It was often regarded that this was the only objective way to measure animals’ welfare, as talk of affective states in non-human animals was seen as an erroneous anthropomorphic endeavour (Webster, 2011; Mellor, 2019). However, modern definitions of animal welfare acknowledge not only the complexity of animals’ biological functioning, but also that these animals do indeed have *needs, likes* and *wants* (Yeates & Main, 2008), and emotional experiences that can create, prolong and modulate their experiences of (at a minimum) pleasure and pain, and of suffering (Yeates & Main, 2008; Broom, 2014; Hemsworth, *et al.* 2015; Veasey, 2017; Mellor, 2015a; Mellor, 2019). In addition, the absolute elimination of *all* negative experiences can actually reduce an animals overall fitness, and hence welfare (Keeling, *et al.* 2011; Špinka & Wemelsfelder, 2011; Mellor, 2015a). Part of the subjective experience of life, for all animals, includes experiencing some (not frequent) negative circumstances, negative sensations (such as nociception) and related emotions (affective states such as pain). It is especially important that animals encounter some negative circumstances that are linked to experience of ‘survival-critical’ behaviours during their lifetime – experiences of acute, short-term nociception or pain are important to allow an animal to learn to avoid noxious stimuli (Viñuela-Fernández, *et al.* 2011). The experience of challenging environments to be overcome may lead to increased stress resilience and cognitive engagement (Špinka and Wemelsfelder, 2011; 2018; Špinka, 2019). Yet, repeated or frequent exposure to negative states such as pain

or to challenging environments that are unable to be overcome (because of physical or cognitive incapacities) will lead to a decline in fitness, functioning and welfare (Hemsworth & Coleman, 2011). Overall welfare not only includes the physical or environmental aspects of wellbeing, but also the animal's own psychological experience of its environment, its health and its welfare state (Maple & Perdue, 2013; Mellor & Beausoleil, 2015; Mellor, 2019). Welfare states are not fixed; instead, they exist along a continuum, being highly dependent upon context and individual variation (Mellor, 2012). Whereas historical considerations of welfare often focused on the absence (or elimination) of negative welfare states, current research acknowledges that the experience of positive welfare states (physical and psychological), and "positive affective engagement" (Mellor, 2015a), are paramount to overall good animal welfare, but good welfare does not mean absolute elimination of all negative experiences (Mellor, 2012; 2015a; Mellor & Beausoleil, 2015; Hemsworth, *et al.* 2015; Veasey, 2017). It is, therefore, crucial that captive animal industries, such as zoos, provide suitable conditions for animals to avoid frequent or chronic negative affective experiences, but also provide opportunities for them to experience positive affective states in a species-specific (or individual) manner, through what are considered good evidence-based husbandry practices, enrichment, and appropriate contact with humans (Mellor, *et al.* 2015; Gray, 2017; Sherwen, *et al.* 2018; Sherwen & Hemsworth, 2019).

The third conceptual framework – natural living – is mainly about providing captive animals with 'natural environments', and allowing them to perform 'natural behaviours'. However, definitions of 'natural' are usually inadequate, and can become problematic if this framework is the sole focus for applied welfare improvements (Hemsworth, *et al.* 2015; Yeates, 2018). Still, the conceptual framework has been a useful tool for attending to what is perhaps 'meaningful' for captive animals' welfare (Weary & Robbins, 2019), but there are also many dangers and logical pitfalls associated with *only* attending to, or providing animals with, that which is *natural* (Yeates, 2018). Chapter 2 of this thesis outlines some dilemmas the natural living

framework has encountered in zoological institutions, and how often this concept becomes misconstrued as what has been termed “*wilding*” of captive animals.

The Five Domains model

The original and revised Five Domains Model (Mellor & Reid, 1994; Mellor & Beausoleil, 2015, respectively) are an ever-evolving reflection of this (oft-overwhelming) conglomerate of factors that influence animal welfare in all captive settings. The original five domains model was developed to assess compromised welfare of ‘sentient’ animals in a research, teaching and testing (laboratory) setting. It has since been applied to all captive animal industries, as a more up to date model than the five freedoms model, and is used extensively as an applied model by modern zoos and associations (Mellor, *et al.* 2015). The Five Domains Model easily categorises and simplifies many factors which may affect animal welfare, into a practical and pragmatic figure that can be easily adapted and co-opted by various animal husbandry fields and workers. Mellor himself refers to the model as a practical guide – that it does not necessarily matter which category a welfare concern is conceptually placed under, but it should always lead to positive outcomes for the animal if applied correctly. Zoological institutions and associations worldwide have been quick to adopt and promote the Five Domains model as central to zoo animal welfare understanding, monitoring, and management (Mellor, *et al.* 2015).

Zoo animal welfare, and ‘modern’ zoos’ raison d’être

Zoo animal welfare is very similar to other captive animal welfare, except the targets of welfare are most often non-farmed and ‘undomesticated’ wildlife. Zoo animal welfare has previously been defined as the overall wellbeing of an animal, achieved through meeting its physical, environmental, nutritional, behavioural and social needs (Goulart, *et al.* 2009). There are a myriad of factors that influence zoo animal welfare both positively and negatively, including husbandry practices (Zwart, 2001; Balcombe, *et al.* 2004; Melfi, 2009; 2013), enclosure

design (Appleby, 1997; Morgan & Tromborg, 2007; Fernandez, *et al.* 2009), environmental enrichment (Bashaw, *et al.* 2003; Claxton, 2005; Hosey, 2005) and exposure to visitors (Carder & Semple, 2008; Davey, 2007; Morgan & Tromborg, 2007; Carlstead, 2009; Fernandez, *et al.* 2009; Farrand, *et al.* 2014; Sherwen & Hemsworth, 2019). Many of these factors will be explored in sections ahead.

In the last few decades, animal welfare has become one of the leading priorities of what have been termed ‘modern’ or ‘ethical’ zoos (Maple & Purdue, 2013; Gray, 2017). The World Association of Zoos and Aquariums (WAZA), in all policy documents since 2015, have reasoned that, globally, zoos’ core *purpose* is conservation, but their core *activity* is animal welfare (Mellor, *et al.* 2015; WAZA, 2015). That is, zoos exist to contribute practically and meaningfully to *in-situ* and *ex-situ* conservation, but positive animal welfare must be a priority for all animals under a zoo’s direct care (which should include sick and injured wildlife, ‘pest’ species living on the property, etc.).

Historically, zoos (and, before zoos, animal menageries) were simply a venue for human entertainment and awe, primarily visited as a leisure activity (and a symbol of wealth, status and dominion of individuals, communities or cities since at least Ancient Egypt) (Tribe & Booth, 2003; Reading & Miller, 2007; Carr & Cohen, 2011; Gray, 2017). However, 21st Century ‘modern, ethical zoos’ are positioning themselves as *ex-situ* and *in-situ* biodiversity conservation organisations, which also promote the highest standards of welfare for the animals in their captive care (Moss & Esson, 2010; Mellor, *et al.* 2015; Gray, 2017). They also attempt to act as providers of conservation expertise, wildlife and environmental advocacy, and general education (Swanagan, 2000; Ballantyne, *et al.* 2007; Falk, *et al.* 2007; 2008; Randler, *et al.* 2007; Moss & Esson, 2010; Mellish, *et al.* 2019), and, many visitors do indeed view zoos as educational destinations (Packer & Ballantyne, 2002; Briseno-Garzon, *et al.* 2007; Falk, *et al.* 2008). It has been estimated that at least 700 million visitors attend zoos and aquariums annually around the world (Gusset & Dick, 2011; Moss, *et al.* 2014).

Difficulties of experimentation in a zoo environment

Numerous difficulties arise during attempts to deploy effective experiments within a zoo environment. Examining the effects that visitors may have upon zoo animals (especially positive effects) has proven quite difficult, as the context and circumstances of HAIs in this setting may be confounded by a number of extraneous variables that cannot be easily controlled. Designing robust experiments with sufficient sample size and sufficient replication, that are conducted over a sufficient period (and with proper consideration of predictable confounds), are all hallmarks of good outdoor agricultural and ecological experimentation. Many factors can be adequately controlled for in seemingly unpredictable, confounded environments if the methodology is reasonable. Conversely, studies within zoo environments are often harder to control than large-scale agricultural experiments, and often have very limited availability for data collection periods, due to other animal husbandry requirements, ethical requirements, and institutional business concerns, especially for experiments that require exclusion of visitors from certain areas for extended periods. Thus, the experiments designed for this PhD thesis were all conducted within traditional zoo enclosures/environments, without necessitating the exclusion of visitors from the viewing areas, or from witnessing the experimentation. The two animal species chosen for the preference experiments conducted herein were both reptiles, specifically tortoises: 1. Aldabran Giant Tortoises (*Aldabrachelys gigantea*), and 2. Leopard Tortoises (*Stigmochelys pardalis*).

Non-avian Reptilia

Recently, the class *Reptilia* of the phylogenetic tree has been altered to include *all* animals in the clade *Diapsids*, which includes all extant bird species (and the extinct *parareptilia*) (Modesto, *et al.* 2004; Pincheira-Donoso, *et al.* 2013), creating a monophyletic group back to the clade *Sauropsida*. This is largely just a semantic difference in scientific nomenclature, but it

begets some unity in our long-standing taxonomic classification system. As such, when referring to “*reptiles*” in this thesis, it is taken to mean the proper *non-avian reptiles* in all cases except where specifically marked otherwise.

Non-avian Reptilia comprises an astounding 10,793 species (Uetz, Freed, & Hošek, 2019). It has been calculated that less than 1% of all non-avian reptile species have been studied in animal cognition, sentience and animal welfare research (Lambert, Carder & D’Cruze, 2019). However, from this substantial yet limited research, many general inferences may be concluded presently. A number of related species in each taxonomic order of non-avian reptiles (*Rhynchocephalia*; *Squamata*; *Testudines*; and *Crocodylia*) often display similar capacities, abilities, and personality traits. For example, many reptiles show very similar preferences for colours, and closely aligned visual acuity (Moskovits & Bjørndal, 1990; Wilkinson & Huber, 2012; Matsubara, Deeming, & Wilkinson, 2017; Bridgeman & Tattersall, 2019); similar domain-general learning abilities (Yori, 1978; Day, Crews, & Wilczynski, 1999; Day, Ismail, & Wilczynski, 2003; LaDage, Riggs, Sinervo, & Pravosudov, 2009; Gaalema, 2011; Mueller, Wilkinson, & Huber, 2011; LaDage, *et al.* 2012; Mueller-Paul, *et al.* 2012; Wilkinson & Huber, 2012; LaDage, *et al.* 2013; Mueller-Paul, *et al.* 2014; Emer, Mora, Harvey, & Grace, 2015; Qi, Noble, Fu, & Whiting, 2018; Bridgeman & Tattersall, 2019); social learning (Wilkinson, Kuenstner, Mueller, & Huber, 2010a; Wilkinson, Mandl, Bugnyar, & Huber, 2010b; Davis & Burghardt, 2011); and evidence of individual personalities and preferences (Carter, Goldizen, & Tromp, 2010; Mehrkam & Dorey, 2014; Goulet, Thompson, & Chapple, 2017; Waters, Bowers & Burghardt, 2017; Kashon & Carlson, 2018).

Management of and captive conditions for reptiles are currently inadequate in many parts of the world, due to a misunderstanding of their needs, or dismissal of their cognitive and emotional complexity (Victoria State Government, 2002; Burghardt, 2013; Wilkinson, 2015; Warwick, Arena & Steedman, 2018; Citizen team, 2020). Inadequate conditions are often normalised and propagated through “*folklore husbandry*” (Warwick, Arena and Steedman,

2018), a pervasive system of anecdotal information sharing (now easily shared through social media) between zookeepers, hobbyist collectors and private citizens. One of the largest inadequacies found in reptile keeping (both professional and hobbyist alike) is a significant lack of space, and lack of complexity of that space, for the animals residing within these enclosures (e.g. snakes not being able to extend their full body length within a traditional and usual 'snake rack') (Warwick, Arena and Steedman, 2018; Howell, Warwick & Bennett, 2020).

In zoos, it has been observed that visitors typically spend less than 10 seconds viewing reptile enclosures (Marcellini & Jenssen, 1988; Alba, *et al.* 2017). However, Alba *et al.* (2017) reported that a “*cognitive research demonstration*” conducted within an eastern box turtle (*Terrapene carolina carolina*) exhibit increased visitor viewing times significantly, and also increased reported attention and engagement with the tortoises; as well as stronger keeper-animal “bonds” reported by those keepers who conducted the demonstrations with the animals.

As mentioned above, the experimental components of this PhD were preference tests conducted with two species of zoo-housed tortoises: Aldabran Giant Tortoises (*Aldabrachelys gigantea*) and Leopard Tortoises (*Stigmochelys pardalis*). These species were chosen due to their longevity, their commonality/ubiquity in zoological collections in many regions, and their relative under-representation in the zoo animal welfare research to date. Multiple experimental studies on tortoise species were used to inform and develop the preference tests conducted for this PhD thesis (Evans & Quaranta, 1949; Moskovits & Bjorndal, 1990; Mattis, 1994; Weiss & Wilson, 2003; Gaalema & Benboe, 2008; Pellitteri-Rosa, *et al.*, 2010; Wilkinson, *et al.*, 2010a; 2010b; Gaalema, 2011; Gerlach, *et al.*, 2013; Wilkinson, *et al.*, 2013; Mehrkam & Dorey, 2014; Mueller-Paul, *et al.*, 2014; Passos, *et al.*, 2014; Alba, *et al.*, 2017; Kashon & Carlson, 2018; Tetzlaff, *et al.*, 2018; Gutnick, Weissenbacher & Kuba, 2019).

Human-animal interactions

Human-animal interactions (HAIs) encompass any direct or perceived interaction between an animal and a human in a captive/farm/domestic setting. Prolonged and/or frequent HAIs with the same individual participants over time have been suggested to lead to the establishment of a human-animal relationship (HAR) in zoo animals (Hosey, 2000; Hosey & Melfi, 2014; 2015). These interactions and relationships have been extensively researched in production animals (Waiblinger, *et al.* 2006; Hemsworth & Coleman, 2011), and have been a focus of some of the welfare studies based in zoos (Hosey, 2000; Hosey & Melfi, 2015; D’Cruze, *et al.* 2019). In companion animals, strong positive HARs are often referred to as human-animal bonds (HABs), and many anecdotal accounts of relationships between zookeepers and their animals may be reported as such (Hosey & Melfi, 2012; 2014). Not all HAIs and HARs between zoo animals and zookeepers are necessarily positive, and some neutral or negative relationships may be overlooked (Hosey & Melfi, 2015). However, dedicated zoo professionals should be working to maximise the positive HAR that they have with their animals (Hosey & Melfi, 2012). Figure 1 below shows a proposed model of the interplay of factors that contribute to human-animal interactions in zoo animals, created by Hosey (2013), based on the Hemsworth-Coleman human-livestock model (2011).

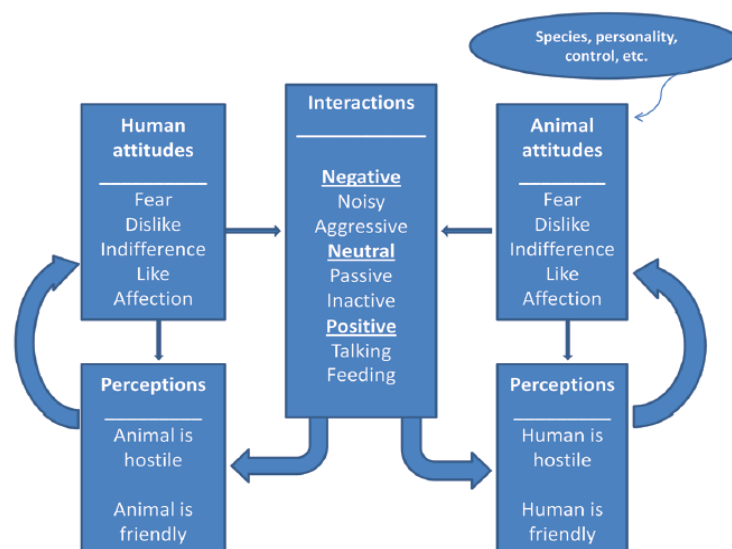


Figure 1: Zoo human-animal interaction model from Hosey (2013), based on the Hemsworth-Coleman human-livestock interaction model (2011).

While this model takes into account many of the factors that may affect human-animal interactions in zoos, and the interplay and feedback loops inherent between factors, newly proposed models aim to make these relationships in HAIs more clear. Figure 2 represents a model of reasoned action and planned behaviour adapted by Hemsworth and Coleman (2011) from Albarracín *et al.* (2005). This model of human behaviour attempts to illustrate the complexity of human psychology that leads to expressed behaviours, and the feedback loops inherent in decision-making or the expression of certain behaviours. From this adapted model of planned behaviour, a hypothesised model specific to visitor-animal interactions and relationships (VAIs/VARs) in zoos has been proposed (Figure 3). This more comprehensive VAI model is proposed to replace the Hosey model, accounting for more antecedents and variables for expressed behaviours and eventual outcomes. It was adapted from the Hemsworth-Coleman “human-livestock model” (2011), and is similar to the general human-animal relationship model published by Hemsworth, Sherwen and Coleman (2018).

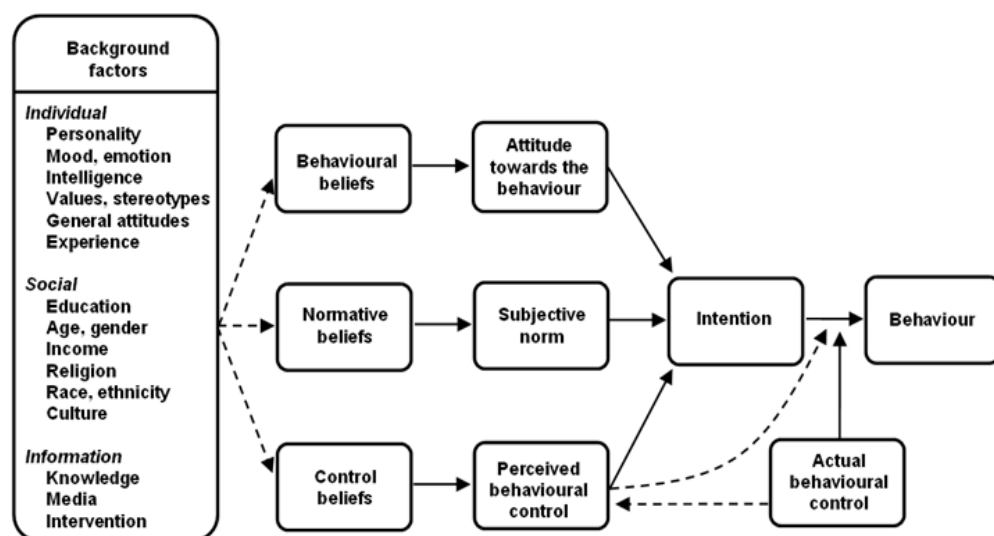


Figure 2: A model of theories of reasoned action and planned behaviour (adapted by Hemsworth and Coleman, 2011, from Albarracín, *et al.* 2005).

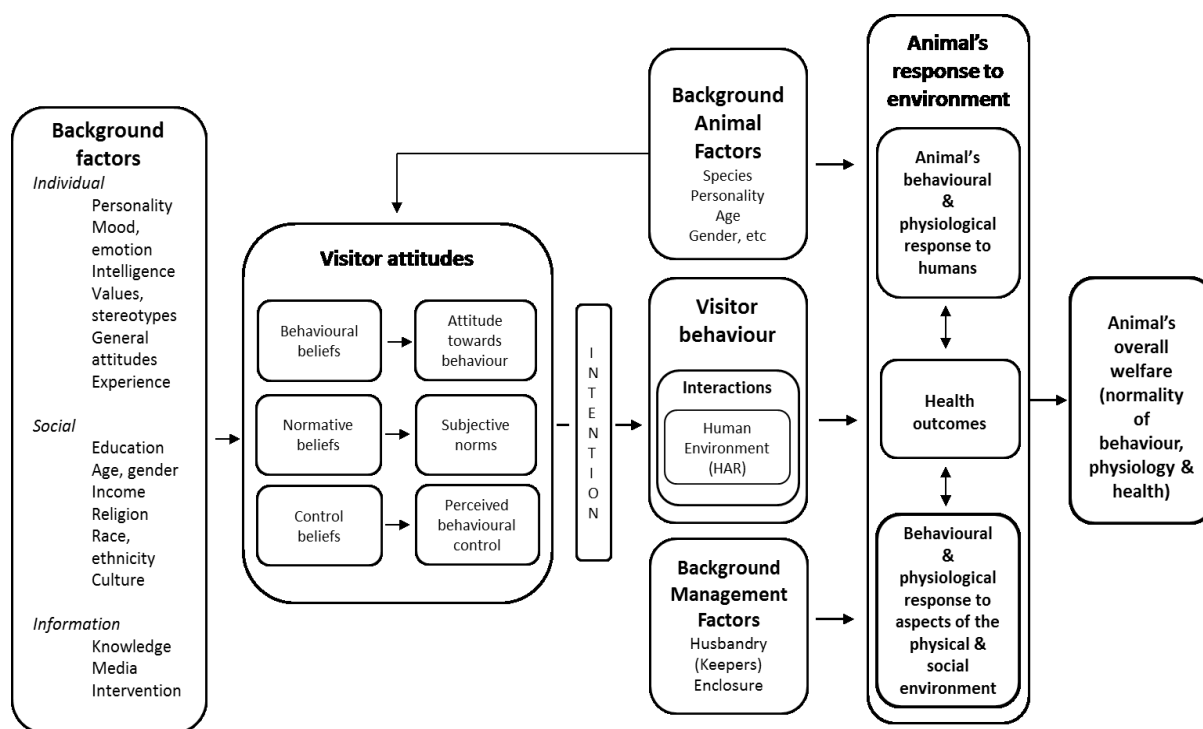


Figure 3: Zoo visitor-animal interaction model (adapted from the Hemsworth & Coleman model (2011) by S. Chiew and L. Hemsworth, personal communications).

Animal behavioural indicators to HAIs

Fear responses and avoidance behaviours

Fear is a negative affective experience (Forkman, *et al.* 2007; Mellor, 2012), and is an undesirable state of suffering (Jones & Waddington, 1992; Dawkins, 2004; Forkman, *et al.* 2007); however fear is also an adaptive response to aversive stimuli (Gray, 1987; Mellor, 2012; Hemsworth, *et al.* 2015). Gray (1987) described five categories for a stimulus that may elicit a strong fear response: intensity, novelty, special evolutionary danger, social interaction with conspecifics and conditioned fear stimuli. Novel environmental stimuli of high intensity may elicit the strongest initial fear response, and repeated encounters with noxious or aversive stimuli may lead to a conditioned fear response (plus the development of an overall negative HAR if humans are involved with the stimulus). Furthermore, frequent or prolonged fear responses lead to persistent or chronic stress, which is known to have negative implications on overall health and welfare (Hemsworth & Coleman, 2011; Keeling, *et al.* 2011). Fearfulness of the stockperson in livestock can lead to markedly decreased production rates and

compromised reproductive success (Hemsworth & Coleman, 2011). Fear and avoidance responses towards stockpersons can validate and reinforce beliefs held by the stockperson that the animal is increasingly difficult to work with, and can elicit even stronger fear-provoking behaviours displayed by the stockperson towards these animals in subsequent interactions (Hemsworth & Coleman, 2011).

Avoidance behaviours (avoidance of humans, avoidance of conspecifics) have been widely used as an indicator of fear and stress in animals (Gray, 1987; Waiblinger, *et al.* 2006; Forkman, *et al.* 2007; Hemsworth & Coleman, 2011; Sherwen, *et al.* 2015a; 2015b; 2015c; Learmonth, *et al.* 2018). Avoidance behaviours can be observed in an agricultural setting when animals are fearful of certain individual or general stockpersons. Avoidance behaviours by zoo animals towards zookeepers may not be as common as in an agricultural setting, however very few empirical studies have assessed the actual nature of these HARs (Hosey & Melfi, 2015; Ward & Melfi, 2015). What has been suggested, however, is that strong avoidance responses may be evident in zoo animals when exposed to unfamiliar visitors, or specific fear-provoking visitor behaviours. Avoidance behaviours in zoo animals in the presence of human visitors may arise from interactions that the animal perceives as mostly negative, potentially leading to an established negative relationship towards humans, that may be generalised across all encounters (including with familiar humans), or to a more discriminatory category of ‘unfamiliar humans’ (that excludes keepers and familiar humans) (Hosey, 2008; 2013; Hosey & Melfi, 2015). Persistent avoidance behaviours have been used as a measure indicative of compromised welfare, as the behaviours are most often linked to the experience of heightened stress and fear levels (and elevated, persistent stress hormone (cortisol) release) due to the animals’ perceptions and predictions of these (and of future) interactions (Morgan & Tromborg, 2007; Hosey, 2008; Carlstead, 2009). Persistent avoidance behaviours in captive animals are undesirable, and effective amelioration of the causal stressor(s) should be a high priority. Avoidance behaviour may also affect visitor experience, and indeed zoo visitors have

been observed to display a range of negatively-aligned behaviours when no animals are immediately visible or active - behaviours such as banging on glass, shouting, waving, or throwing objects to elicit some response (Sherwen, *et al.* 2014; 2015a).

Positive affective experiences

A considerable amount of recent literature now acknowledges the significant impact positive affective experiences can have on animals in all captive settings (Boissy, *et al.* 2007; Yeates & Main, 2008; Mellor, 2012; Kagan, Carter & Allard, 2015; Mellor, 2015a; Mellor, 2016). In a three-part article series, Mellor (2015a; 2015b; 2015c) discusses the need for “*positive affective engagement*” (i.e. opportunities for positive affective experiences in animals) in all captive animal fields, through a considered and cautioned review of the current behavioural-observation and neuroscience-supported evidence of affective states, motivations and goal-directed behaviour in animals (especially mammals, and birds). One of Mellor’s (2015a) main conclusions was that “*providing animals kept in restrictive conditions with situation-related positive affects [positive affective experiences] ... would enhance their welfare, and, furthermore, that this could involve devising and applying additional demonstrably beneficial environmental enrichments and opportunities for companionship*”. He also noted that this companionship could be with either conspecifics or other animals (heterospecifics; including humans) (Mellor, 2015a).

Boissy *et al.* (2007) in their (then current) review of the state of positive emotions in animal welfare, concluded that much future research and funding should be allocated to exploring the possibilities of positive affective states. Now a decade later, published experimental research has advanced somewhat, with many authors steadily investigating positive affective states throughout this period, as demonstrated by Mellor’s review (2015a). It may be that the philosophical and ethical discourse, which underpins all experimental research in this emergent field of ‘positive welfare’, is still contentious in some way, or to some groups, so a solid basis of reasoning must be established before a large dedication of research funding is

viable. Exploring the extent of these opportunities for positive affective experiences in zoo animals, linked to their exposure and control over contact with visitors in or around their enclosures, is a novel area of study, and is related to the objective of this PhD research.

Positive affective experiences, or (at least), circumstances that provide opportunities for positive affective experiences, are critical for creating a captive environment in which an animal can *thrive*, as opposed to just survive (Kagan, *et al.* 2015; Mellor, 2016). Some important factors for creating these opportunities include variable environments that allow for predictable and unpredictable events (which may contribute to positive experiences of *eustress*); variability in available resources (food, enrichment) especially with variable complexity of acquisition, allowing animals to perform exploratory and complex, cognitive problem-solving behaviours; provision of opportunities for animals to express choices in their environments, and hence express agency or some perceived control; provision of opportunities that promotes play behaviour; and providing circumstances for animals to engage in bonding and bond affirming activities, and other appropriate affiliative activities with conspecifics or heterospecifics (Mellor, 2016). This is by no means an exhaustive list of possibilities for promoting positive affect in captive zoo animals.

Špinka and Wemelsfelder (2011; 2018) describe various research regarding the importance of agency and competence in animals for their overall welfare. Exploration of variably challenging environments is often a key indicator of a positive welfare state in animals, especially exploration that is of an inquisitive as opposed to inspective nature. Inspective exploration is a functional behaviour aimed at gathering information: identifying aspects of an environment for memory or recall at a later period, such as typical locations of food, fresh water or shelter. Inspective exploration is also engaged in periodically to check for changes to the environment. Inquisitive exploration is an act usually performed when an animal is searching for cognitive stimulation, that is, exploration out of a sense of ‘curiosity’ to learn more about an environment, or simply exploration for the sake of exploration. Therefore,

inquisitive exploration has its own motivation, and is intrinsically rewarding (Špinka and Wemelsfelder, 2011). This may be an animal's attempt at exerting some behavioural control over its environment, be indicative of a motivation to search for cognitive stimulation to keep the animal engaged, and thus avoid boredom. Whitham and Wielebnowski (2013) propose that these positive affective experiences for zoo animals may be promoted through: 1) offering these variable environments and circumstances that allow expressions of agency and competence; or 2) through engaging, positive keeper-animal interactions. Unfamiliar zoo visitors may be able to provide similar positive interactions in controlled, or at least supervised, interactions. Furthermore, positive affective experiences may be modulated by the animal's unique, internal, subjective feelings – variably referred to as their 'coping style', 'behavioural syndrome', 'temperament' or 'personality' (MacKay & Haskell, 2015).

Coping styles, temperament and animal 'personality'

Individual *personality* and *coping style* in animals are now considered of rather high importance for understanding the holistic picture of their mental well-being and overall welfare (Mellor, 2015a; Waters, *et al.* 2017). Before the acceptance of personality as applicable to non-human animals, coping styles' (towards stressors) were the major focus of behavioural pattern research (Øverli, *et al.*, 2007; de Boer, *et al.* 2017). Coping styles are still relevant, terminologically, when discussing behavioural responses to stressors, but are not inclusive of all of the elements of behaviour, affective states and cognition (especially in positive circumstances) that make up individual 'personality' or temperament.

There are two main coping style responses to stressors – proactive (fight-flight) and reactive (conservation-withdrawal), and the dominant of these response patterns can modulate whether an animal is “*resilient*” or “*susceptible*” (Øverli, *et al.* 2007). Proactive coping is characterised by low HPA axis responsiveness, and “*high levels of active avoidance, aggression, and other actions indicating attempts to counteract the stressful stimulus*” (Koolhaas, *et al.* 1999;

Øverli, *et al.* 2007). Reactive coping is oppositely characterised by high HPA axis activity, and involves low activity, to the point of immobility, and low levels of aggression (Koolhaas, *et al.* 1999; Øverli, *et al.* 2007). Proactive coping is generally considered better, physiologically, for the animal's ability to cope with acute stressors; and an animal displaying a reactive coping style is possibly coping poorly, and likely suffering from extended HPA activity (prolonged glucocorticoid release), and therefore chronically stressed (de Boer, *et al.* 2017). Whilst it is labelled "*reactive*", due to the heightened physiological reactions to stress that the animal's body is producing, the behavioural expression of a reactive coping style is anything but "*reactive*" – usually, the afflicted animal's behaviours "*shut down*", and the animal becomes withdrawn, depressed, unreactive and torpid, especially when suffering from protracted, chronic stressors.

In the scientific literature, individual changes and variation in patterns of behaviour have been labelled as "*animal personality*", "*behavioural syndromes*", or "*temperament*" interchangeably (MacKay & Haskell, 2015). The label personality in non-human animals has been of much contention in scientific paradigms because of the values and human attributes that are loaded into the term (MacKay & Haskell, 2015; Mellor, 2015a), however, academic acceptance of personality as a label for non-human animals becoming more positive, and is often found warranted (Sih, Bell & Johnson, 2004; Kashon & Carlson, 2008; Sih & Bell, 2008; Wolf & Weissing, 2010; 2012; Sih, *et al.* 2012; MacKay & Haskell, 2015; Sih, *et al.* 2015; Waters, Powers, & Burghardt, 2017). Waters *et al.* (2017) compiled a book chapter on research into individual variation in personality in non-avian reptiles, and concluded that there is sufficient evidence for attributing the label to this class of animals. Further scientific acceptance of the existence of individual temperaments or personalities in non-human animals is imperative, as personality factors may be important contributors towards, or modifiers of, the preferences of and choices made by these animals. Discussions of animal personality as it pertains to

sentience (feelings) in animals, and how this may affect HAIs, are forthcoming in Chapters 3, 6 and 7 of this thesis.

Visitor effects and visitor interests

In the literature addressing the effects of visitors on zoo animal welfare, many areas remain poorly understood (Davey, 2007; Sherwen & Hemsworth, 2019). Much of the inconsistency has been attributed to limited sample sizes, between-species (and within-species, individual) variation, or flaws in interpretation (Morgan & Tromborg, 2007; Mason, 2010). In 2009, it was calculated that around 76% of the literature addressing human effects in zoos was based on studies of mammalian species (Goulart, *et al.* 2009). Of this literature, the number of studies of differing mammalian taxa is very highly biased towards primates (Hosey, 2005; Davey, 2007; Hosey & Melfi, 2014). This may be due to the close evolutionary relation between humans and other apes or primates, and the ‘human-like’ interactivity they offer. It may be that it is easier to interpret similar behaviours between humans and these species, since we are all (including humans) categorically primates, and express ‘primate-like’ behaviours. After primates, many studies focus on felids, canids and ungulates, with very few studies focusing on birds, reptiles, rodents or marsupials (Davey, 2007; Hosey & Melfi, 2014). The bias towards certain taxonomic groups may simply be due to the general scarcity of research and prioritisation of limited funding, or in many cases, the bias towards primates may be due to actual identified issues affecting the welfare of those animals.

Many of the limited number of HAI studies on zoo animals have taken an observational, correlational approach. This may be due to limitations to experimental manipulation of animals in their exhibits, and ethical implications of imposing certain ‘treatments’ on captive animals. For example, a positive association between the number of visitors viewing gorillas and the duration of self-scratching and visual monitoring has been reported (Carder & Semple, 2008) and increased visitor numbers have been associated with higher aggression and

abnormal behaviours in gorillas (Wells, 2005). These two correlational studies have shown an association between variables, but cannot demonstrate causation. Whilst these results may make intuitive sense to researchers in the welfare field, they may reflect other unrelated causal factors. However, non-invasive correlational studies may be appropriate for a wide range of cases in captive zoo animal studies, especially in pioneering research trying to establish some form of relationship between human and animal variables in captive environments. Correlational studies are often the first step towards understanding the human-animal relationship, and act as a rationale for further experimental manipulations.

Positive, negative, or innocuous visitor interactions

Research has shown that exposure to zoo visitors can widely influence the behaviour and welfare of zoo animals (Davey, 2007; Sherwen & Hemsworth, 2019). Across studies of many different captive species, visitor interactions have been interpreted as stressful (Hosey, 2000; Birke, 2002; Davis, *et al.* 2005; Mason, 2010; Sherwen, *et al.* 2015a; 2015c; Learmonth, Sherwen, & Hemsworth, 2018; Chiew, *et al.* 2019; D'Cruze, *et al.* 2019), enriching (Manna, *et al.* 2007; Claxton, 2011; Hosey, 2013; Jones, *et al.* 2016), or innocuous (Choo, *et al.* 2011; Sherwen, *et al.* 2014; 2015a; 2015b; Hosey & Melfi, 2015). Mixed responses are very common, depending on species and/or individuals (Collins & Marples, 2015). Much of the inconsistency in animal responses to visitors may be specific to individuals, due to differences in animal genetics, experiential conditions (subjective experiences), social learning and facilitation, enclosure design and behaviour of visitors; and may vary greatly within a species or any one population (Maple & Purdue, 2013; Sherwen & Hemsworth, 2019). It may also reflect different animals' abilities and mechanisms for coping with what may be considered stressful environments, and their ability and opportunities to express self-determined 'agency' (Špinka, 2019).

Research on human-animal relationships in agriculture (Hemsworth & Coleman, 2011) has shown that the history of a stockperson's interactions with a farm animal leads to the

development of learned fear responses (both physiological and behavioural) in the animal towards that stockperson, and often generalised to all humans that it encounters. Furthermore, the stockperson's direct and indirect experiences with their animals, including the animals' behavioural responses to the stockperson, are influential determinants of the stockperson's attitudes and future behaviour towards their animals. Hosey (2013) has suggested that the nature of the effects of visitor interaction on animal welfare may vary from negative to neutral to positive. Thus visitor behaviours, particularly those perceived as negative by the animal, may be fear provoking (Sherwen *et al.* 2015a; 2015b; Learmonth, *et al.* 2018; Sherwen & Hemsworth, 2019). Conversely, some visitor behaviours may be rewarding in nature for zoo animals, leading to positive affective states and "*positive affective engagement*" in these animals (Bloomfield, *et al.* 2015; Mellor, 2015a; 2015b; 2019). Thus, as is seen in stockpeople (Hemsworth & Coleman, 2011), the way that a visitor interacts – in terms of the proximity, amount of verbal or physical activity and their intention to repeat this type of interaction in the future – may be a product of the attitudes that they hold about such interactions and their effect(s) on the animal, and indeed the perceived response of the animal to these behaviours may reinforce the attitude of the visitor that such behaviours are rewarding (for the visitor themselves) and acceptable (Sherwen & Hemsworth, 2019). Margulis *et al.* (2003) have suggested that the relationship between visitor interest (and overall visitor experience) and zoo animal behaviour is bi-directional, whereby visitors influence animal behaviour, and the animal's behaviour influences zoo visitors' interest and perception of the animal's welfare. Such interaction feedback loops exist on a continuum from extremely negative to extremely positive, however relationships may be highly dependent upon species (or individuals within a species or group), and dependent upon the particular inter- and intra-species interactions occurring.

Close-contact opportunities

Often zoos attempt to engage visitors through close-contact animal experiences to enhance visitor experience and learning outcomes, ultimately to contribute to conservation goals (de Mori, *et al.* 2019a; de Mori, *et al.* 2019b; Godinez & Fernandez, 2019; D'Cruze, *et al.* 2019; Jensen, Moss, & Gusset, 2017; Clayton, *et al.* 2008; Skibins & Powell, 2013; Sherwen & Hemsworth, 2019). Zoos may encourage visitor-animal interactions through the offering of animal presentations, behind-the-scenes or close-contact experiences with certain animals (often for extra donations or purchases), or by building modern walk-through exhibits with free-ranging animals (D'Cruze, *et al.* 2019; Morgan & Tromborg, 2007; Sherwen, *et al.* 2015c; Godinez & Fernandez, 2019; Sherwen & Hemsworth, 2019). Walk-through exhibits are often typified by minimal physical barriers between visitors and animals (Hosey, *et al.* 2009; Moss, *et al.* 2008; Sherwen, *et al.* 2015c; Learmonth, *et al.* 2018).

Sherwen *et al.* (2015c) found an increase in vigilance in free-ranging kangaroos in two walk-through zoo exhibits during periods of high visitor numbers; but no difference in the kangaroos' distance from visitor paths was found between high or low visitor number periods. The behavioural responses of the kangaroos did not indicate compromised welfare states in the study animals. This may be due to the relative size of kangaroos compared to people, as other research has found smaller macropods in a walk-through exhibit to be moderately fearful of humans (Quokkas; Learmonth, *et al.* 2018). It has been suggested that walk-through exhibits may allow animals more freedom of movement, choice and control over interactions with humans, which may play a major role in how an animal copes in its captive enclosure (Morgan & Tromborg, 2007; Sherwen, *et al.* 2015b), and so these designs (if adequate) have the capacity to improve overall welfare. Access to adequate retreat areas for avoiding human interaction may help reduce overall fearful behaviours, even if the animals are not actively using the areas (Hosey, 2005; Morgan and Tromborg, 2007; Fernandez *et al.* 2009; Choo, *et al.* 2011).

Zoos vary considerably amongst their offerings of close-contact experiences. ‘Visitor attraction models’ are increasingly being used to study zoo visitation and what interests and engages visitors whilst on-site, with direct interaction and close-contact experiences being high on visitors’ priority lists (Margulis *et al.* 2003; Moss & Esson, 2010; Howell, *et al.* 2019). It is easier to promote learning, both in adults and children, through subject matter for which the learner has a personal interest (Rennie & Johnston, 2004) or emotional affinity (Ballantyne & Packer, 2005), such as charismatic zoo animals (Moss & Esson, 2010). Indeed, many zoo visitors report wanting to “connect” with wildlife as being a top priority for attending, but what ‘connecting’ actually means varies between respondents (Howell, *et al.* 2019). Globally, animal-visitor interactions (AVIs) are often advertised to increase visitation and revenue, with patting of charismatic mammalian species being the most frequently advertised experiences, but many of the most common daily experiences involve handled reptiles (D’Cruze, *et al.* 2019).

The PhD research conducted here focused on traditional display enclosures that had close-contact visitor-animal areas (e.g. windows, shared fences) to eliminate many of the possibly confounding factors and difficulties of studying preferences in walk-through exhibits. However, the experimental methods utilised herein may be readily adaptable to popular walk-through enclosures and/or close-contact handling experiences in the future.

Animal ethics

An area of increasing importance is animal ethics. Currently, few scientific researchers, zoo personnel, and public figures are willing or motivated to engage with the deeper intellectual or philosophical reasoning for the existence of zoological institutions, nor have they yet adequately addressed the harms and benefits of captivity to all participants (including the wider biotic community) (Gray, 2017). It is imperative that all stakeholders start to engage more with captive animal philosophy and ethics; for example, an intellectual understanding

of our behaviour, and sound reasoning of the harms and benefits of zoos (and which parties are accruing which outcomes), as well as philosophical discussions of what constitutes an adequate or good life for captive animals. This intellectual reasoning and discussion will ultimately shape society's decisions for the future of animal use and guardianship of the type that zoos aim to provide.

Ethical implications of visitor-animal interactions

Of course, any human-animal interaction should be subject to ethical scrutiny. All of the animal experiments that occur in 'modern zoos' (that are members of WAZA and their regional associations) should have been approved by a relevant ethics committee, to ensure animal wellbeing during the proposed experimentation and to protect the animals from dubious practices and mistreatment (Mellor, *et al.* 2015). However, day-to-day visitor-animal interactions may often be overlooked, or not be discussed in great depth ethically or empirically (Hosey & Melfi, 2015). It is imperative that we study these interactions scientifically, to identify both negative and positive effects on the animal that may arise from these situations, and to create new evidence-based husbandry and welfare practices (Sherwen, *et al.* 2018; Ward, Sherwen & Clark, 2018). Yet we must also consider how to best approach or adapt these circumstances from a moral and ethical standpoint, and consider the positive and negative effects on the humans involved as well. Are zoos still to be considered morally equal to other animal industries (such as circuses, "roadside zoos" or intensive farms)? Alternatively, have zoos adapted enough to occupy the so-called 'moral high ground'? Irrespective of these questions, what are the fundamental ethical implications of human-animal interactions? Moreover, why do we bother assessing interactions at an individual level, rather than by population or species? Should the conservation of species outweigh an individual's needs in captivity? Some of these questions will be explored in Chapter 7 of this thesis.

Zoos' ethical codes and welfare values

Major rifts often exist between countries, cultures and individual institutions regarding what constitutes adequate (and then positive) welfare conditions for zoo-housed animals (WAP, 2020). Whilst all zoological facilities should be bound by their country's legislation on prevention of animal cruelty, and most facilities now have documented policies on minimum welfare standards, many (or most) institutions still lack specific documented policies in regards to achieving positive, or 'good' welfare for the animals in their collections (Palmer, *et al.* 2018; WAP, 2020). Depending on the accepted practices and policies, good care and the best intentions of husbandry staff do not always translate to good welfare in captive industries, including zoos (Grandin, 2015). Zoos have taken it upon themselves to form associations that provide accreditation, and develop guidelines, plans and strategies concerning both minimum acceptable standards (which may be different to the relevant government legislation acts) and ideal or target standards (Mellor, *et al.* 2015). These associations comprise member zoos and individuals, with the impetus of providing some sort of self-regulation.

Palmer *et al.* (2018) investigated the ethics behind policies of three main associations- the World Association of Zoos and Aquariums (WAZA); America's Association of zoos and Aquariums (AZA); and the European Association of Zoos and Aquariums (EAZA). They investigated how the actions taken by member institutions align with conservation, education and welfare policies, through collection species planning and measurable conservation outcomes, and how relevant welfare policies are either adhered to or contradicted by the overarching aims of both individual institutions and the different levels of associations. As mentioned previously, published WAZA documents describe conservation as zoos' core *purpose*, but their core *activity* is fostering positive welfare (WAZA, 2015; Mellor, *et al.* 2015). Obviously, WAZA (as the global association) should be the association with the most relevant, collaborative and peer-accepted policies, as it is an organisation set up to regulate zoos and aquariums globally rather than regionally. However, many differing cultural and societal

challenges are present when trying to form and enact global standards for the keeping of animals in zoos (WAP, 2020). These issues and considerations may be comparable to those of other organisations that focus on other captive animal fields (such as farms or laboratories), like the World Organisation for Animal Health (OIE). The policies accepted and produced by WAZA itself may be dominated by specific cultural views (i.e. those of 'Western' ideologies such as AZA or EAZA); the board of directors and association officials may be biased towards certain cultural norms or values; and there may be very little actual scrutiny of WAZA member institutions in terms of day-to-day adherence to the policies. Two other associations of considerable influence and significance are the British and Irish Association of Zoos and Aquariums (BIAZA), and especially (for this thesis) Australia and New Zealand's Zoo and Aquariums Association (ZAA), both of which are accredited associations of WAZA.

The accreditation process for member institutions is quite rigorous in many parts of the world, by both WAZA and regional associations (Mellor, *et al.* 2015; WAZA, 2015). However, the slow rate of formation and acceptance of specific policies regarding the emergent field of positive animal welfare needs to be redressed, both at an association guideline level, and at the institutional level. These policy updates should also include provisions being amended into each institutions code of ethics, as well as the code of ethics prescribed by the associations (by which all accredited member institutions are ultimately bound).

Compassionate Conservation

Compassionate Conservation has become an explicit ethical alignment within the code of ethics of some zoos, such as Zoos Victoria (2018), although the framework as used in a pro-zoo manner (Gray, 2017) differs from the original Compassionate Conservation approach (Bekoff, 2013) that is generally aligned to anti-captivity principles on the treatment of animals. A core principle of Compassionate Conservation, and many other animal ethics theories, is generally an uncontroversial one: "*that it is wrong to cause unnecessary harm or suffering to*

animals" (Beausoleil, 2020), including wild animals (Bekoff, 2013; Gray, 2017). Over the last decade, Compassionate Conservation has been described and refined by various proponents as ascribing most to a virtue ethic (the virtue of Compassion), a deontological ethic (Animal Rights theories), or consequentialist ethics (the greatest good for the most number of animals) (Beausoleil, 2020). What is obvious, though, is that it is a pluralistic approach that is focused on the wellbeing of individual wild animals as well as larger populations and ecosystems. Animal Rights theory principles of the inherent value of animals (that cannot be 'traded-off' for the greater good) and their "*right to life*" are reflected in Compassionate Conservations core tenets. The four core tenets of Compassionate Conservation are: (1) First, do no harm; (2) Individuals matter; (3) Inclusivity; and (4) Peaceful co-existence (Beausoleil, 2020). The tenets are predicated upon the most virtuous actions of an agent being those of *compassion for all other morally-relevant creatures*, however, these tenets have also been criticised for a lack of clarity on how they can specifically be applied to novel or complex dilemmas, such as individual suffering for the benefit of populations or ecosystems (Beausoleil, 2020). Furthermore, some proponents of Compassionate Conservation suggest that the 'right' action is the (consequentialist) one, which causes the *least* suffering, or *minimises* harm to wildlife – though this violates the first tenet, do *no* harm (Beausoleil, 2020). For a full analysis and explanation of Compassionate Conservation, see Beausoleil (2020) (and Bekoff, 2013; and Gray, 2017). A new ethic, *Conservation Welfare*, has been proposed as a more legitimate and pragmatic framework, based on Singer's utilitarianism (allowing the causation of some harms for the greatest good) for zoos, aquariums and other captive animal conservation organisations to become adherents of (Beausoleil, 2020).

Conservation Welfare

Conservation Welfare is the recent application of Animal Welfare ethics (and principles of Conservation and Environmental ethics) to conservation practices for non-captive wild animals (Beausoleil, 2020). Like Compassionate Conservation, it differs from most

Environmental ethics as it is largely focused on the wellbeing of *individual* animals, not just whole populations, species or ecosystems. Animal welfare ethics is mainly aligned to Consequentialist ethics, using a Singer Utilitarianism model of right action being that of the greatest good for the greatest number of morally-relevant beings. This ethic, like AR and Compassionate Conservation, asserts an inherent value of animals, meaning they are indeed morally relevant, though the difference here is that this inherent value does not preclude the possibility of individual suffering or death, if it is for the ‘greatest good’ (i.e. it can be ‘traded-off’). The animal welfare ethic always endeavours to *minimise* pain and suffering in individual animals, however. Thus, as applied to *in situ* and *ex situ* conservation practices, a Conservation Welfare ethic is more pragmatic than Compassionate Conservation, in that the direct imposition of some suffering on some individuals is acceptable (and this will not violate any tenets) as long as this suffering is *necessary* and *justified*. Although, what is deemed necessary, just suffering is still somewhat ambiguous (Beausoleil, 2020).

Duty of Care

A Duty of Care ethical framework (which was initially a humanistic ethical framework for humans caring for humans, then companion animals, and then other domesticated animals) is often an implicitly nurtured approach within zoos, distributed amongst the new generation of animal care managers and husbandry staff, as this ethical framework also promotes a duty to provide positive welfare conditions to captive animals which aligns with modern zoos’ goals. That is, as guardians of captive animals, we have a moral duty to provide all levels of care to those animals (Glanville, Hemsworth & Coleman, 2020), including the provision of opportunities for animals to have “*a life worth living*” or to be able to *thrive* in captivity (Yeates, 2011; Mellor, 2015a; Gray, 2017). The duty of care ethic is a reasonable melding of two ethics – a deontological ‘duty-based’ ethic (a moral obligation towards another), and a virtue-based ‘care’ ethic (both active provision of care to others, and internally ‘caring about’ [i.e. consideration for] others) (Engster, 2007; Glanville, *et al.* 2020). Duty of care as a concept

reaches far beyond simply an ethical framework, with “*currency in legal, philosophical, ethical, and general animal protection discourse*” (Glanville, *et al.* 2020).

Philosophical interpretations of animal welfare science

Aside from policies and codes of ethics, the scientific measurement of animal welfare also differs significantly between and within institutions across the world (Ward, *et al.* 2018). As mentioned earlier, the three main scientific concepts of animal welfare are: 1. Biological functioning; 2. Affective state; and 3. Natural living. In decades past, the first concept was the only scientifically justifiable way of approaching animal welfare (Hemsworth, *et al.* 2015). More recently, in production animal industries then zoological institutions, natural living had been positioned as most important in the triumvirate of welfare concepts. It is only very recently that scientific thought has managed to grapple with how to measure affective states in animals objectively.

The natural living dilemma

Although it has been a very useful conceptual framework for many instances, *natural living* as a tool for welfare improvement is also fraught with peril, as often the concept can be misinterpreted or misused (Hemsworth, *et al.* 2015; Yeates, 2018). For an alternate perspective on how natural living has been very useful for improving captive animal welfare, see Weary & Robbins (2019). The importance of this one framework, though, when compared to biological functioning and affective states, may have been somewhat overemphasised in some captive animal domains recently. Some zoos, in some regions, use natural living as the most important factor for day-to-day animal welfare (in terms of achievable daily animal husbandry, feeding, social grouping, natural environment, etc.). However, misinterpretation of the natural living concept into what I have termed “*wilding*” has become apparent in many zoos, and in the beliefs of many zoo employees. As mentioned earlier in this chapter, often these beliefs are spread through zookeepers, hobbyists and other animal care professionals by

pervasive “*folklore husbandry*” (Warwick, Arena & Steedman, 2018). These stories, methods and training techniques, once spread, often present an ‘anti-science’ educational barrier within animal-keeping communities, who become distrustful of objective scientific study, and beliefs about ‘folklore’ practices become resistant to change, even when faced with evidence-based alternatives. This dilemma is explored in depth in Chapter 2 of this thesis.

Shifting ethical perspectives

What immediately follows here is a small philosophical discourse that has been argued from a distinct moral position (which should be apparent from the writing), that has not been incorporated into ethical writings that were published in journals for this PhD. Instead, this short discourse aims to show some philosophical and critical ability for the chapters to come. This writing is quite determinedly argued from the perspective of animal rights and respect for nature ethical frameworks, but some of these themes are relevant to more ‘moderate’, utilitarian perspectives as well. This piece does not necessarily reflect my own point of view, but instead was an exercise for walking in another’s proverbial shoes, if only for a moment. The published ethics articles (Chapters 2 and 3) attempted to remain somewhat more neutral, to remain rational and applicable in a pragmatic way.

Too long in the realms of politics, industry and cultural norms has the predominant (oft theologically based) view of humans’ right to use animals however we wish prevailed (Bekoff, 2013; Singer, 1975; Regan, 1983). It has been extensively argued that this desire/need for humanity to subjugate and exploit “lesser creatures” has propagated the ideology that other animals are in fact lesser than humans are (psychologically, culturally, physically, and metaphysically). Thus, it has followed that the burden of proof has fallen on the animals themselves, or their advocates (both folk and scientific) to show that these “animals” are more than automata, and are beings with inner lives. However, especially since the 1990’s, such a wealth of literature, supported by the behavioural, neurophysiological and neuropsychological observations mentioned above, has asserted the capacity and capabilities of many animals to have subjective affective experiences (Mellor, 2015a; 2015b). What I would propose is that the prevailing system needs desperately to be inverted- the burden of proof should now fall upon those critics who wish to continue to exploit animals that these subjective experiences do not/should not

afford these animals some kind of moral considerability, or at least a consideration of (some of) their interests (to life; to not suffer; to experience positive emotions; etc.). Indeed, on providing opportunities for positive affective experiences, Mellor (2015a) writes, “the increasing understanding of the underlying neurophysiological mechanisms suggests that critics of this proposition should now be challenged to demonstrate that such welfare benefits do not exist. This would be in direct contrast to the previous demands by the critics that the advocates of the proposition should be required to demonstrate that welfare benefits of this type do exist”.

Whilst it would be ideal to completely invert the system as it were, in reality this would cause insurmountable resistance from industries, governments, businesses, workers and other large proportions of the global human population. Practically, what might suffice is for all parties to abandon the extremes, and move to a more central position- i.e. we may know, or we may not know, that all beings of Earth are equal (in right to existence). From this position, it could then be argued that, as an aspiring compassionate species, we should choose to err on the side of caution, and afford all beings some consideration of interests.

Three salient points may guide the way to a new ethical paradigm for the operation of “good, ethical zoos*” (Gray, 2017), that is considered warranted and quite necessary for future operations:

1. That it is morally and ethically imperative that we reason WHY animals deserve opportunity for positive affective experiences;
2. That human interaction could provide these opportunities, but we must empirically demonstrate HOW they provide this; and
3. We must demonstrate how these interactions in “good zoos” would differ from human-animal interactions in substandard zoos and other animal use fields, such as circuses and animal tourism ventures.

*Good zoos refer to those “best practice, conservation and welfare-focused” zoos as defined by J. H. Gray (2017) in her book “Zoo Ethics”.

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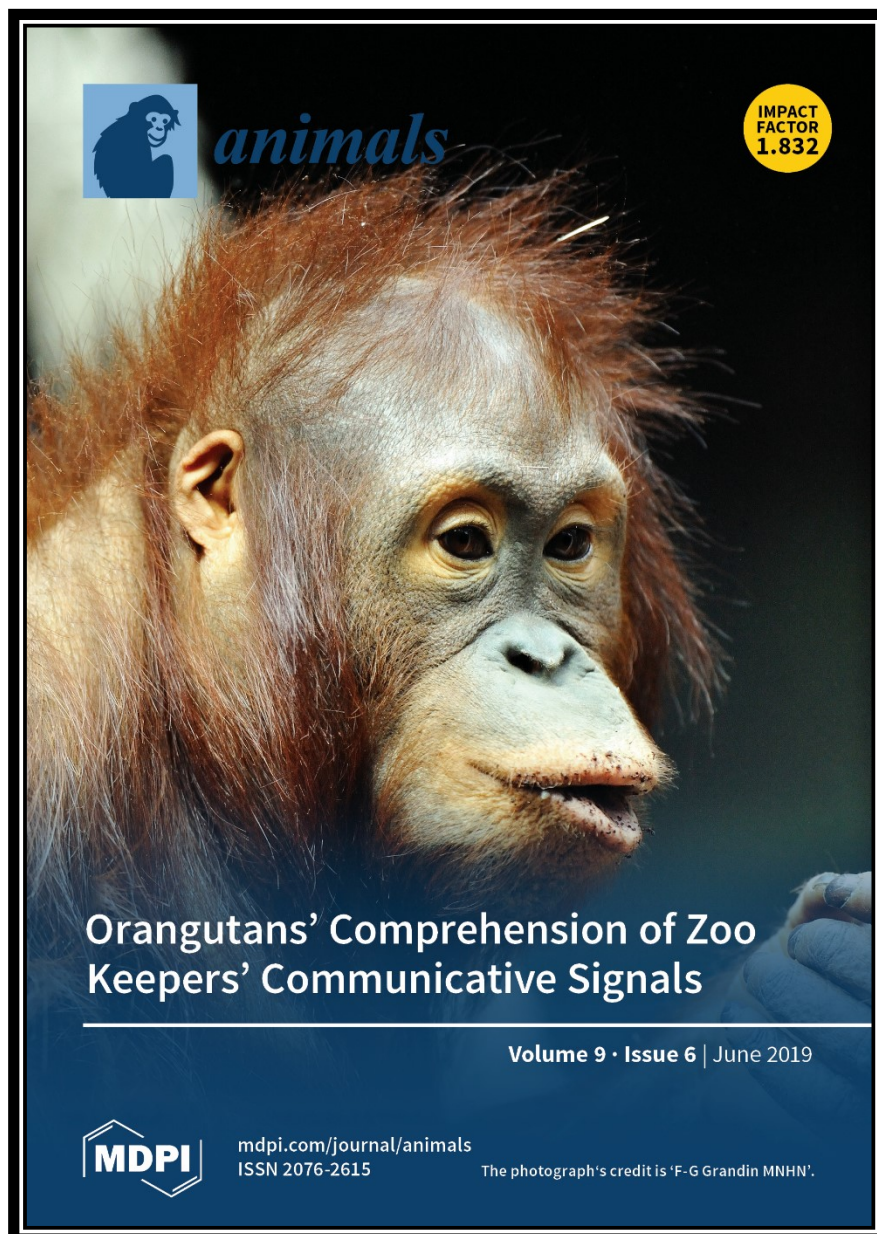
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CHAPTER 2: ANIMAL ETHICS #1

Dilemmas for natural living concepts of zoo animal welfare

Mark James Learmonth

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Commentary

Dilemmas for Natural Living Concepts of Zoo Animal Welfare

Mark James Learmonth 

Animal Welfare Science Centre, The University of Melbourne, Parkville 3010, VIC, Australia;
mlearmonth@student.unimelb.edu.au

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Simple Summary: This ethical discourse specifically deals with dilemmas encountered within zoological institutions, namely for the concept of *natural living*, and a new term—*wilding*. *Wilding* refers to extrapolation of the natural living concept to *treating an animal as wild, residing in a wild habitat*. The problems associated with *wilding* are detailed. Complexities of natural living versus natural aesthetics as judged by humans, as well as the possibility of innate preference for naturalness within animals are examined. It is argued that unintended and unavoidable genetic and epigenetic drift favouring adaptations for life in a captive environment may still occur, despite zoos best efforts to prevent this from occurring. This article further discusses the blurred lines between *natural* and *unnatural* behaviours, and the overlaps with more important *highly-motivated behaviours*, which may be better predictors of positive affective states in captive animals, and thus, better predictors of positive well-being and welfare. Finally, as we are now in the *Anthropocene* era, it is suggested that human-animal interactions could actually be considered natural in a way, and notwithstanding, be very important to animals that initiate these interactions, especially for “a life worth living”.

Abstract

This ethical discourse specifically deals with dilemmas encountered within zoological institutions, namely for the concept of *natural living*, and a new term—*wilding*. It is agreed by some that zoos are not ethically wrong *in principle*, but there are currently some contradictions and ethical concerns for zoos *in practice*. Natural living is a complicated concept, facing multiple criticisms. Not all natural behaviours, nor natural environments, are to the benefit of animals in a captive setting, and practical application of the natural living concept has flaws. Expression of natural behaviours does not necessarily indicate positive well-being of an animal. Herein it is suggested that *highly-motivated behaviours* may be a better term to properly explain behaviours of more significance to captive animals. *Wilding* refers to extrapolation of the natural living concept to *treating an animal as wild, residing in a wild habitat*. This definition is intrinsically problematic, as quite literally by definition, captivity is *not*

a wild nor natural environment. Treating a captive animal *exactly the same as a wild counterpart* is practically impossible for many species in a few ways. This article discusses complexities of natural living versus natural aesthetics as judged by humans, as well as the possibility of innate preference for naturalness within animals. Zoos nobly strive to keep wild animals as natural and undomesticated as possible. Here it is argued that unintended and unavoidable genetic and epigenetic drift favouring adaptations for life in a captive environment may still occur, despite our best efforts to prevent this from occurring. This article further discusses the blurred lines between *natural* and *unnatural* behaviours, and the overlaps with more important *highly-motivated behaviours*, which may be better predictors of positive affective states in captive animals, and thus, better predictors of positive well-being and welfare. Finally, as we are now in the *Anthropocene* era, it is suggested that human-animal interactions could actually be considered natural in a way, and notwithstanding, be very important to animals that initiate these interactions, especially for “a life worth living”.

Keywords: animal ethics; natural living; wilding; zoo animals; human-animal interactions; animal welfare

1. Introduction

To preface this article, I would acknowledge and address the implicit assumptions about animal welfare science and philosophy that have brought us to the ethical position herein. I would refer the readers to other published articles which explore the history of animal welfare and ethics in much depth, as these are used as a basis for our understanding and arguments [1–10]. This article specifically deals with competing ideals of optimal animal welfare within zoological institutions, namely concepts of *natural living*, and a new term – *wilding*. This discourse does not necessarily apply to other captive animal industries such as farms or laboratories.

As other ethicists have written, I agree that zoos are not ethically wrong *in principle*, but there are currently some contradictions and ethical concerns for zoos *in practice* [5]. It should be understood that I am a supporter of zoological institutions and their betterment, although I may disagree with some zoo practices, and between myself and other researchers in ethical views of the specific dilemmas herein. It is also acknowledged that zoos are not going away any time soon (see [5]), so it is the pragmatic duty of researchers and philosophers to work

with zoos constructively. I would also like to acknowledge the positions of other researchers in the field, such as Weary and Robbins [9], and Yeates [10]. This article is not intended as a refutation of these other recent articles about natural living and holistic welfare, but rather to present an alternate conception of one part of overall animal welfare that may have been misconstrued in certain zoo environments, leading to in practice incongruence and dilemmas. I acknowledge that my arguments are formulated from my moral and ethical position that humans have an *obligation for special protection of captive animals*, especially zoo animals, and I subscribe to many (but not all) elements of *compassionate conservation* ethical theory of contemporary philosophers such as Bekoff [11] and Gray [12] over purely utilitarian or consequentialist approaches. At the moment *compassionate conservation* remains very anti-zoo in its position, however, as Gray [12] posits, there is much merit in using this ethic to work *with* zoos constructively, to enhance zoos' ethics and practices. I acknowledge the currently accepted academic focus on the three conceptual frameworks (orientations) of animal welfare: biological functioning, affective states, and natural living [2,13]. This is how the *science* of animal welfare is commonly taught to undergraduate and postgraduate learners in our discipline. It is acknowledged, however, that this not the only way to conceptualise the entire picture of captive animal welfare [3,9], and that these three conceptual frameworks do not encompass all relevant information in all situations. I acknowledge that a predominant model for characterising and assessing good welfare, especially within zoos, is the Five Domains Model of Mellor and Reid [14] and Mellor and Beausoleil [15]. Whilst incorporating pluralistic scientific elements of welfare, at its core the Five Domains Model assumes a hedonistic priority of animal welfare, that is, what the animal feels about its life and environment is the most important factor in holistic welfare. In this article a pluralistic basis of welfare is acknowledged, though for the sake of argument a hedonistic basis is prioritised. It is understood, however, that a hedonistic priority also misses some of the whole picture [3]; hedonism-based welfare conceptions are not dogma.

The two scientific concepts of biological functioning and affective states will only be touched on in this article, as my primary focus is to shine a light on how the concept of *natural living* may have been pushed past its useful bounds in zoo situations.

It should be stated that whilst hedonistic conceptions of welfare are mostly concerned with “how the lives of sentient animals are going, for the sake of, and from the perspective of, the animals themselves” [6], it is strongly suggested here that (as written by Weary and Robbins [9]) *relationships matter*. That is, not only are the self-derived internal states of the individual highly important, but also those emotion-inducing relationships that are important to the individual—such as relationships to conspecifics, other animals, and humans including carers and visitors—and some relationships that *others* have *with* that individual may also be important to welfare outcomes (for example, the specific values and attitudes a person holds will affect their relationship with an individual animal, and reinforcers to this relationship create a bi-directional, perpetual feedback loop). These relationships may then be *reflected* by the internal affective states of both (or all) agents in that interaction [16,17]. This has been characterised by the general Hemsworth-Coleman model of human-animal interactions [18,19]. The general model has been specifically adapted for zoo visitor-animal relationships [20], pictured below (Figure 1). A very similar model has been proposed for zookeeper-animal interactions as well [20]. Human values and attitudes towards animals, and the relationships formed between them, can strongly influence subjective (hedonistic) experiences of welfare.

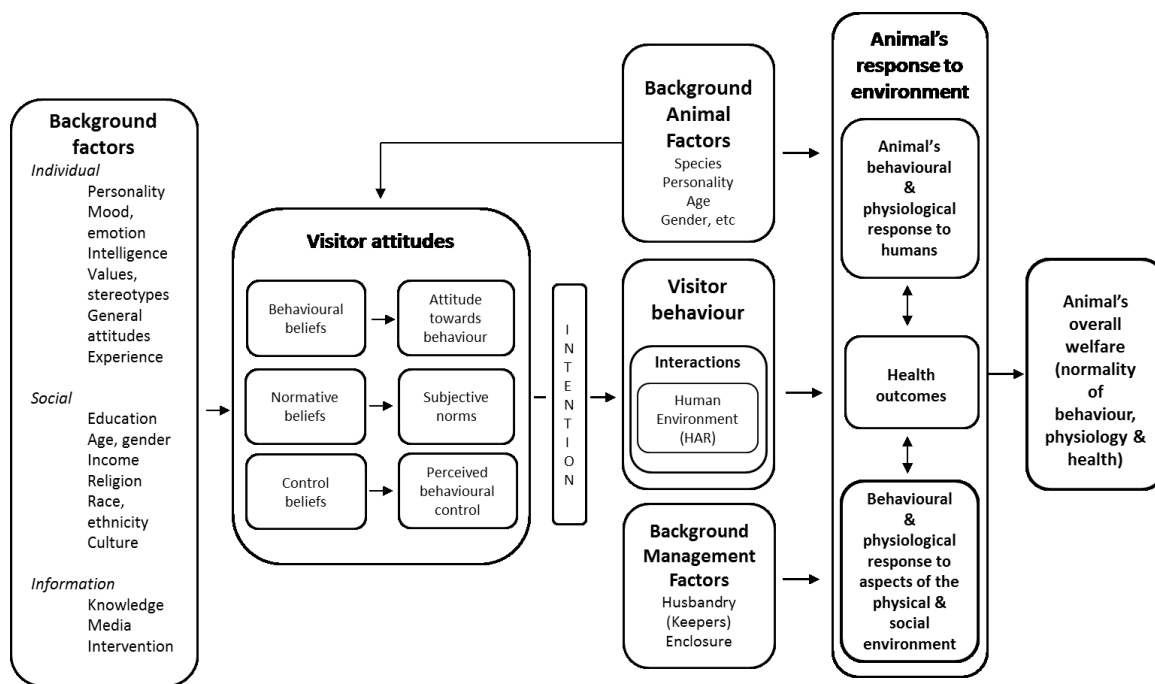


Figure 1. Proposed visitor-animal interaction model (adapted from Hemsworth-Coleman model (2011) by S. Chiew and L. Hemsworth, pers. comms., 2016) [20].

2. Natural Living

Natural living is a (sometimes) useful key concept in the assessment of animal welfare, often defined as "providing opportunities for animals to engage in natural, species-specific behaviours" [1,2,10]. As a concept, it suggests that animals' well-being may be considerably improved if they are *able to perform species-specific behaviours from their natural repertoire*, especially innate behaviours. In practice, this has often been achieved by removing restrictions to these behaviours (whether they are physical or environmental restrictions) and by providing appropriate objects, resources or enclosures with/in which to perform the behaviour(s). Often, definitions of the concept also include phrases about housing animals in *natural environments*. However, not all natural behaviours, nor natural environments, are to the benefit of animals in a captive setting, and practical application of the concept has many flaws. A main criticism of the use of natural living has been that "*the concept of natural is usually too poorly defined to provide a sound basis for animal welfare assessment, and thus when applied uncritically it may lead to poorer welfare instead of an improvement*" [21]. This criticism has

been expressed quite commonly in the past few decades [1,2,10,19,22].

Articulation of the concept, and its transposition to practical application in many captive settings have somewhat missed the point entirely. *Natural behaviour*, *natural living* and *naturalness* are poorly-defined key terms that are too often conflated with other concepts and measures of an animal's overall well-being, such as feelings (affective state) or function (biological functioning) [10]. Expression of natural behaviours does not necessarily indicate positive well-being of an animal; likewise absence of some natural behaviours does not necessarily indicate suffering [23,24]. Nor should the term *natural behaviour* be used when actually referring to other conceptual types of behaviours, such as *highly-motivated behaviours*, which may be natural or unnatural, however there is often significant overlap between these two terms. Herein I will suggest that *highly-motivated behaviours* may be a better term to properly explain behaviours of more significance to captive animals, and discuss where boundaries between *harmless* and *harmful* highly-motivated behaviours may lie (as we still have an ethical obligation to protect animals from harming themselves, whether intentionally or accidentally, in captivity).

3. Wilding: The Natural Living Dilemma

Natural living has been a useful tool for improving welfare, but its practical application, especially within zoos, has been extended beyond its theoretical usefulness, and in many instances has been misinterpreted as what I will herein refer to as *wilding*. Wilding is a new term created to refer to extrapolation of the natural living concept to *treating an animal as wild, residing in a wild habitat*. Wild here refers to “living or growing in the *natural* environment; not domesticated or cultivated” [25]. From a decade of first-hand experience within the zoo industry, this *wilding* conception of natural living has been encountered often enough to be considered pervasive amongst many zoo personnel's implicit beliefs and taught knowledge about how zoos should approach animal welfare, though actual prevalence rates have not

been systematically investigated. Indeed, many welfare assessment and monitoring tools deployed by zoos focus somewhat on natural environments and natural behaviours [26]. This *wilding* conception is intrinsically problematic for any captive animal industry (especially zoos) as, quite literally by definition, captivity is *not* a wild nor natural environment [27]. To place a wild animal in an artificial environment (no matter how accurate a recreation of a natural setting) and still presume to treat it *exactly the same as a wild counterpart* is practically impossible for many animal species, in a few obvious ways.

Firstly, truly *wild* animals in nature are not *treated* by humans in a particular way- they are not under the direct care of humans, however, they may yet be influenced by humans [28]. These wild animals may be exposed to humans in multiple situations, and even have interactions with humans, but their lives are not solely dictated by humans as captors/guardians. This does not preclude the possibility of interactions (both positive and negative) or conflicts arising between humans and animals, animals venturing into “human spaces”, or encroachment of humans into an animal’s native space [28]. However, as soon as an animal is placed in captivity, no matter how wild its behaviours or instincts, its care (and indeed its survival) is then determined and controlled by those humans that placed it there. A person cannot place an animal in a captive environment then refrain from providing basic cares or resources (such as food, water and shelter), and yet expect the animal to survive, let alone to thrive. Even in a highly accurate recreation of a natural environment, those basic resources must still be provided by the controlling humans - that is, the environment has been created and curated to provide those resources for the animal, through natural or artificial structures.

Secondly, even if it were the case that humans could provide a perfect replica of an animal’s wild environment with wild conditions, would it be morally or ethically permissible? Would it be (morally) right? Forgetting for a second that this perfect replica would still have been constructed upon another natural or wild environment (thereby

destroying a natural habitat and causing displacement of many native species), if truly a replica of natural conditions, then the animals placed in this environment would be subject to both the boons and significant hardships of nature. Nature is often bountiful and has allowed the rise of an amazingly diverse array of living beings, but has also borne witness to countless extinctions and ecological changes. Wild animals often must endure very harsh conditions to survive – conditions that objectively lead to periods of very poor welfare, when measured through scientific welfare concepts (biological functioning and affective states) [10,28–30]. Inclement weather and natural disasters such as droughts, fires or floods, are all common occurrences in nature. Animals must endure a lack of shelter, food or water in many areas; they must avoid predation, injury, and disease; they may experience miscarriages, offspring mortalities or reproductive issues; they often have to compete with other animals (both of their own and other species) for access to resources; and they have to navigate oft-unfair social interactions and hierarchies. Often, living in nature leads to *prolonged suffering* and ends in *premature death* for individuals.

Many *wild-type* or *natural behaviours* are also maladaptive in a captive environment (such as fratricide or infanticide for extreme examples; to significant inbreeding in closed populations; group ostracism of certain individuals; or unfulfillable migratory behaviours/motivations) [12,30,31]. Thus, if it was indeed the objective of captive animal industries, such as zoos, to perfectly replicate natural environments so their animals may live *wildly*, it follows that all of the hardships of nature would also occur, or would have to be imposed. This is not a tenable ethical position that any zoo organisation is known to advocate. Instead, natural recreations of wild environments in zoos try to focus mainly on *positive* elements of nature, without imposition of events or states that may significantly diminish the animal's well-being [5,26,30,32]. Ethically, one will not find much (or any) opposition to this mode of treatment of the captive animals. This also provides a pro-captivity argument against some anti-captivity, *animal freedom*-based philosophies—

captivity does indeed curtail some freedom of the captive animal, but it also provides solace and shelter from significant welfare-affecting hardships, which may be especially of benefit to those animals whom are most vulnerable to suffering. Indeed, if captivity is providing all of the needs and wants of an animal (including positive affective experiences), but without liberty, then liberty is not necessarily a basic interest of the animal [5]. Zoos are often the last bastion of hope for many endangered species, as their wild homes have been irreparably damaged or overtaken by ever-expanding human populations [12,28,30,33]. This is an ever more salient point after the United Nations Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) released a 2019 report which estimates that anthropogenic influences may cause the extinction of 1 million species of animals and plants [33].

It should be noted that whilst zoos tend to focus mostly on recreating positive elements of nature and reducing *negative* circumstances, many zoos also understand the impossibility of complete elimination of all negative circumstances, events, or negative feelings within an animal. In fact, many zoos will impose slight negative circumstances if it is believed that they may be of benefit to the animals' health, fitness, or experience of life [34]. That is, *harmless* or *minimally harmful* negative circumstances are sometimes imposed to increase stress resilience and/or physiological arousal of an animal [35,36]. For example, it has been reported that reliably signalling startling husbandry events can improve stress resilience and welfare of zoo-housed capuchins (*Sapajus apella*), whilst still leading to physiological arousal within the animals [37]. However, where is the distinction drawn between harmless, minimally harmful and very harmful negatives? And who makes these categorical judgements?

Through collaborative practices shared between many zoos, a few common circumstances for imposing *minimally harmful* negative events include: rotational predator-prey housing (where predatory species and prey species are rotated into the same enclosure at separate times); predator-prey adjacent housing with visual proximity; olfactory

proximity between predator-prey species or dominant-subordinate species (sometimes in the form of “enrichment”, like adding predator bedding material to a prey enclosure); or auditory proximity between predator-prey species (such as housing prey species within earshot of vocalising predators or dominant species, or playing recorded audio of predator/dominant animal vocalisations near prey/subordinate species) [26,31]. These circumstances are thought to confer some resilience to animals through arousal of certain fear and vigilance responses, which can have a wide range of beneficial physiological effects, if not experienced for prolonged periods (acute stressors versus chronic stressors) [35,36]. Therefore, some mild harms are actually of high instrumental value within a captive environment. However, there should be a trepidation of pushing such stress responses too far in prey species, or causing inadvertent frustrations to these animals, for example in adjacent predator-prey housing where predators can visually see prey in very close proximity, but not actually reach them. Repeated frustration of consummatory outcomes may lead to development of negative affective states, as indicated by frustration-type behaviours [24,34]. More evidence is needed of the overall effects of the imposition of these stressors on individual animals, to ensure that the intended arousal and stress resilience is being achieved whilst avoiding unintended frustrations or development of negative affective states in these animals.

4. Natural Living, or Just Natural Looking?

Erstwhile, when considering and implementing positive natural enclosures, zoos may tend to focus only on those that, aesthetically, lead people to *believe* that the environment is *natural*. For example, lush plant-life (or well-designed arid/desert habitats), water features, painted backdrops or “mock-rock” walls, absence of artificial structures, and/or limiting contact with visitors (or even staff/keepers) whether the limitations are visual, tactile or proximal. Much of the time, considerations of what is aesthetically pleasing may eclipse considerations of what is functional and appropriate, with respect to evidence-based

practices [31]. More than just *looking* natural, zoo animals' enclosures must be able to provide necessary features and structures to allow animals to display a range of important behaviours, provide access to perform positive husbandry practices, and allow ease-of-access for emergency procedures to be adhered to (for both animal emergencies, and other visitor or human emergency situations which may occur). If a natural look is considered forefront, this may lead to functional inadequacies in many enclosures. Sometimes artificial structures in enclosures may be more appropriate to facilitate specific animal behaviours – whereas natural structures may weaken, deteriorate or break (such as tree branches or vines), suitable artificial replacements may provide the necessary environment for the behaviour and be a considerably more durable, sturdy or clean provision, which would require far less maintenance (and therefore monetary cost). As is becoming apparent in novel affective state research, interactions with humans may actually be beneficial and rewarding for *some* zoo-housed species in *some* situations [38–41]. If a zoo is too focused on *wilding* their animals, opportunities to truly provide the best positive welfare conditions for the captive animals may be missed or ignored. Therefore, mixed natural/artificial enclosures for animals in zoos, that consider function, aesthetics, appropriate contact with humans, and practicality, may be much more fitting than the natural-only enclosures of the recent past. Two questions we might ask ourselves of mixed natural-artificial environments are as follows:

1. Does the animal have the capacity to *know* that the environment is (partly) artificial?
2. Does the animal *care* if the environment is (partly) artificial?

These are open-ended questions that might be addressed in a separate paper, drawing from current knowledge of animal neurobiology and cognition, and their needs and wants for a “life worth living” [4,42]. There is some evidence that some species do indeed display an innate preference for naturalistic “enriched” enclosures as opposed to basic artificial

environments without many features (barren environments) (Box Turtles [43,44]; Coal tits and blue tits [45]), suggesting that some animals may indeed have a capacity to identify *natural* environments. Alternatively, perhaps they just innately prefer *non-barren*, enriched environments - perhaps these animals would be just as likely to select enriched *artificial* environments over any basic or barren environments. Utilising current animal welfare research and expert consensus a new era of evidence-based enclosure design, natural or not, which consider the animals' needs foremost, should be the next step forward for zoo institutions [46]. As will be explored later, unnatural or artificial environments can still be compatible with promoting the expression of natural behaviours.

A dilemma with *wilding*, then, is that attempts to treat captive animals as wild are partly or wholly incongruent with their actual situation. As has been said in this article before, captive animals are not, nor will they be, *wild animals living in a wild environment*. Their living environment is completely curated by humans, who must make many decisions for the animals for their best interests. This does not mean that we should attempt to treat all captive animals as we would extensively domesticated animals such as livestock or companion animals (i.e., dogs and cats). Zoos indeed strive to keep their wild animals as “undomesticated” as possible [12]. This, however, may be an unattainable ideal, due to unintended and unavoidable genetic and epigenetic drifts favouring adaptations for life in a captive environment, despite our best efforts to otherwise prevent this from occurring. Indeed, in a human-animal interaction review chapter, Hemsworth *et al.* [18] write about the possibility of unintended domestication in zoos, citing research such as Price [47,48] – “While zoo animals are generally not considered to be domestic animals, domestication can obviously occur with wild animals kept and bred in captivity, such as zoos, but the extent of the domestication process will depend on the rate of artificial selection” [18]. The chapter also highlights the distinction between domestication of a group of animals, and *taming* of an individual animal – domestication can be defined as “a process by which a population of

animals becomes adapted to man and to the captive environment by genetic changes occurring over generations and environmentally induced developmental events reoccurring during each generation” [48]; whereas taming is simply “an experiential (learning) phenomenon occurring during the lifetime of an individual animal” [47]. Domestication is a process most likely to happen to animals that are purposefully kept in captivity, and artificially bred or selected, or genetically altered, by humans. Individual taming may more frequently occur in both captive *and* wild animals that are in regular contact with humans.

To unpack this, we should consider other historical animal domestications. The domestication process has taken thousands of years for those animals that we now consider domesticated. In that time, these animals have been subject to multiple selective pressures including artificially imposed selective breeding, turning them from a “wild-variant” into domesticated animals, specifically chosen for their desirable adaptations. A strong argument against the concept of natural living for these domesticated animals, therefore, is that these animals don’t actually represent or reflect any animal which may be found in the *wild* or in *nature* [10]. They have transformed into animals that don’t fill any natural ecological niche, whose existence is solely reliant upon human intervention and care, and their persistence is reliant upon humans’ continual propagation of that lineage. Of course, if all human interference or interaction were to cease, these “unnatural” animals are still a part of the *biotic community* of Earth, and they would be able to freely breed and propagate themselves. Yet still they would not be a part of the current *natural ecosystem*, they still would not have a natural ecological niche, and many cases of free-living livestock or pets (feral animals) in many inappropriate locations have led to irreparable habitat degradation or even ecosystem collapse [28,30].

Many researchers posit the co-evolution of wolves and humans, rather than the one-way domestication of the animal [49]. Both species adapted to working with each other (for the benefit of both) over tens or hundreds of thousands of years. Wolf-human co-evolution is

now suggested to have happened at multiple historical intervals in different geographical regions, leading to the rise of an entire species (or sub-species), dogs (*Canis familiaris*, or *Canis lupus familiaris*), and a multitude of breeds [49]. This co-evolution theory may plausibly explain the domestication process of most modern livestock and pets. Novel research also suggests that the co-evolution of humans and many of our domestic species may have been modulated and propagated by the shared experience of bonding, through the ubiquitous neurotransmitter *oxytocin* [50,51]. While general consensus would not consider zoo-housed animals as domesticated, we must consider that humans have unintentionally started these animals down a similar domestication pathway, as we now approach the third century of keeping animals in zoos, with many captive animal lineages able to be traced back over 100 years in captivity [12]. This generational captive breeding (including artificial selection of mates) will certainly have profound effects on the prevalent adaptations of these captive animals – adaptations to life in a captive environment and in close proximity with humans. Speculatively, it is possible that close contact with humans may be activating oxytocin pathways in many captive zoo species, leading to positive affiliative (or bonding) human-animal interactions. Indeed, some researchers are starting to focus on reported keeper-animal bonds in zoos [52,53]. However, 300 years is still a shorter timespan than the domestication process for most other animals we keep today (with exception for some farmed species, such as rapidly “domesticated” mink and foxes), and most animals displayed in zoos still resemble and behave like their wild counterparts far more than any newly bred type of domesticated animal.

One of the core tenets of zoos is to display *wild* animals that have, and will retain, a certain *wildness* to visitors, not to breed new types of domesticated animals [12]. Therefore, many practices and safeguards are employed by zoos to try to maintain this *wildness*. However, the efficacy of our attempts to retain wildness may eventually be mooted by uncontrollable selective pressures of generational life in captivity. If zoos exist 1000 years from now, zoo

animals may have significantly drifted from true representations of their wild counterparts (many of which will be extinct in the wild). But, zoos will still strive to maintain wildness. And for many animals, zoos' careful management will at least succeed in *slowing* the rate of domestication, but inevitably some genetic or epigenetic drift (mitochondrial drift), or even morphological drift, might still occur regardless of our procedures and safeguards. Thus, these captive animals that still resemble wild species must have specific requirements for care and housing that may differ from common practices for domesticated animals. This is the care that zoos should, and do, provide. But zoos must also make many ethical judgements and decisions which will benefit the animal for a full and rich life in captivity, whether wild or domesticated or somewhere in-between.

There is significant pressure on zoos to exist to advance both animal welfare and wildlife conservation priorities. Indeed, the World Association of Zoos and Aquariums (WAZA) cite conservation as zoos' core *purpose*, but fostering positive animal welfare is their core *activity* [32]. However, this animal welfare strategy document also quite plainly acknowledges that often conservation priorities may compromise optimal welfare, but zoos should always endeavour to minimise welfare-reducing conditions [32]. A strong priority of zoos is to avoid genetic drift towards domestication of their captive held *wild* animals, but, as explained above, there is still a risk that time will change these animals in unknowable ways. This is not written intentionally as an inflammatory argument against genetic selection and diversity processes utilised by zoos, but merely as an acknowledgement of the inherent entropy of many natural systems, and an acknowledgement that humans do not have absolute control of natural processes. But, we do our best with the science and technology that we have available. This ethical *wildness* dilemma has been explored in context of other arguments, such as human-controlled *facilitated adaptation* to climate change impacts [29]. It should also be considered that there may be negative impacts of zoos maintaining *wildness* in their non-releasable captive animals, especially in species known to have low behavioural

plasticity [30]. For example, some wild animals may be very prone to negative welfare states due to captivity, manifesting in fear or anxiety responses and behavioural patterns [24,30], whereas domesticated or semi-domesticated species (or wild species with high behavioural plasticity) may potentially cope better in captive environments [30].

5. (Un)Natural Behaviours

Part of the *natural living* concept is a focus on *allowing animals to express natural behaviours*. As has been pointed out by many, however, the definition of *natural behaviour* is problematic, especially when referring to domesticated species with no *natural* or *wild* equivalent animal, and therefore, no known *natural* behaviours (for review, see [10]). Again, *wilding* runs into problematic territory here, by over-emphasising or reinforcing only those *natural* behaviours that are generally displayed by the species in the *wild*. Academics have suggested multiple alternative terms for *natural behaviour* that may better define what is intended, such as *normal behaviours* or *species-typical behaviours* [1,10,18,34]. However, these terms still struggle to articulate which behaviours are definitely included as natural, and behaviours classified in this way may be adaptive or maladaptive for a captive environment. For example, migratory behaviour would be considered *normal* or *typical* for a migratory bird species, but is maladaptive in captivity as the animal cannot fulfil that motivation [30]. Many behaviours that are displayed by a species in nature have no function or purpose in a captive setting. Simply because a natural behaviour is *not* displayed in captivity does not infer that the animal is in a state of distress or suffering. If a natural behaviour serves no purpose for the animal in its captive environment, the motivation to perform the behaviour may be very low or non-existent [19,23,24,34].

Therefore, more important measures of welfare-positive behaviours for captive animals are *highly-motivated behaviours*, and *highly-rewarding behaviours*. These behaviours may be part of a natural repertoire, or wholly *unnatural* – only displayed in captivity. So-called unnatural

behaviours may be the most adaptive for the animal's captive environment, and may be important for positive affective experiences for that animal. *Unnatural behaviours* do not fit with the ethos of the concept of *natural living* or *wilding*, and attempts may be made to extinguish these behaviours. However, this may actually be of more harm to the animal than benefit—if the behaviour is highly motivated, frustration of that motivation may lead to a negative affective state, and possibly a negative welfare state [24]. Restricting an animal's behaviours to only those which are considered natural may also significantly reduce that animal's ability to make choices (reducing self-determined agency), which in turn leads to a perceived lack of control over their situation, which is known to negatively affect coping efforts and welfare of captive animals [31,54–56].

Another curiosity of *nature* is what I will term *unexpected natural behaviours*. These are behaviours that will be performed by wild animals in specific unnatural situations, such as interacting with artificial running wheels or mirrors placed in wild environments. Quite a few “popular science” documentaries and online videos show the effects of placing these sorts of objects in nature. Often animals in these videos will run in the artificial wheel, or stare at their reflection for long periods [57]. These are wholly *wild* animals that are interacting *naturally* with artificial (*unnatural*) objects. Following from this, many behaviours in captive animals may be incorrectly classified as *unnatural*, as they are behaviours that are also displayed by wild animals with access to the same or similar unnatural objects.

To increase well-being and assist positive welfare outcomes for captive animals, focus needs to shift from a fixation on what are considered *natural behaviours* to those behaviours which the animal appears *highly-motivated* to perform. Thus, rather than focus on *treating animals as though they were wild*, it would be more pertinent to focus on *allowing animals to express highly-motivated behaviours*, particularly if deprivation or frustration of these behaviours results in significant stress, reduced fitness and/or a negative affective state [24].

Expressing highly-motivated behaviours may also afford the animals more agency and choice within their environments [54], which should be allowed within reasonable limits – the allowed behaviours must not compromise the safety or health of the individual performing the behaviours, or of the other animal(s) or human(s) involved (i.e., allowing a predator to hunt for live prey does not consider the ethical obligations for the safety of the intended prey animal). This may be categorised into *harmless* and *harmful wants* of an animal. *Harmless wants* may include highly-motivated behaviours such as foraging, climbing, playing or resting. *Harmful wants* may include highly-motivated behaviours such as feeding, hunting or fighting *without restriction*. The important factor here is that *harmful wants without restriction* can lead to *harmful consequences* (negative, self-injurious or self-destructive outcomes) for the individual performing the behaviour, or for individuals that are the target of the behaviours. A classic example is allowing Labradors access to food *ad libitum* will often result in excessive overeating causing multiple long-term health problems, such as obesity and other related conditions. These limits need to be examined carefully and thoroughly, as they will be very species- and individual-specific behavioural limitations. Many zoos are already doing this, however consensus for an ethical and practical realignment towards promoting *highly-motivated behaviours* instead of *natural behaviours* needs to be agreed to and endorsed by zoological institutions, associations, workers and allies.

6. Are Human-Animal Interactions Natural?

Whether zoos focus on natural behaviours or highly-motivated behaviours, both of these may still include direct interactions with humans. It is often supposed or assumed that human-animal interactions in zoos are an unnatural phenomenon, however, there is one clear way to counter this presumption. In nature, wild animals encounter many other species around them, to which they must adapt, and often interact with, in positive, negative and neutral ways (from symbiotic relationships to parasitic or predatory relationships). Most wild animals now have to adapt not only to their historically natural ecosystem conspecifics,

but also to a multitude of invasive species that were previously unknown to them or their ancestors [28,30]. Also, as we now live in the *Anthropocene* era, wild animals increasingly have to adapt to the ever-growing and ever-encroaching human population, in an increasingly human-affected world [28,30,33]. In captivity, then, are not humans one of those species to adapt to, and to interact with? Humanity often assumes some removal of our species from the rest of nature, that we are somehow a step apart from other animals. It is doubtful that this is how other animals view humans, however. Often one of the great curiosities of the natural world is how competing animal species may form symbiotic balances that benefit all, and actively help each other in interactions. These would be deemed *natural behaviours*. Therefore, if many species actively interact with other species as a mode of adaptation to their environment, would it not follow that human-animal interactions in zoos could actually be considered quite *natural* adaptations? And if those interactions are highly-motivated in the animal, should we encourage them?

Whether these interactions are deemed *natural* or *unnatural*, allowing for positive human-animal interactions may be one avenue of increasing positive affective experiences for animals, especially if those animals are highly motivated to interact with humans (whether it be zookeepers or zoo visitors) [39]. These interactions must be subject to rigorous safety evaluations for all participants, of course. However, the current status quo of *wilding* frameworks often view these interactions as undesirable in any and all situations, regardless of the animal's motivations behind the intended behaviours. Again, frustration of these motivations may actually be detracting from an animal's well-being. If an animal is *highly motivated* to interact with humans in or around its environment, and if those interactions are considered *safe* for all participants, then those interactions should be allowed to occur, or even promoted (through *supervised* offerings of such interactions). Obviously some interactions are exempt from these stipulations, when considering an animal's overall health or best interests (such as veterinary procedures or restraint for medical treatment), though

positive reinforcement training schedules can often remove some of the harshest penalties to the animals these situation might present (such as training for quick, mildly-aversive hand-injections, blood sampling, or “crate training” for restraint and transport) [37,58].

An animal’s motivation to engage in positive human-interactions may vary from day-to-day, based on other internal and external factors, but the animal should never be confined to, or negatively coerced into, an interaction scenario. The choice to interact should always be on an animal’s own terms. This may not be the case for all human-animal interactions currently deployed by zoos across the world. Often, many “encounter” or “interaction” animals are not afforded a choice of whether to participate or not, or are housed in inadequate areas that may increase their desire to escape that area, even if it means having to interact when they are unwilling [59,60]. Most industry-accredited zoos have their own welfare charter, and have processes and policies implemented to safeguard encounter animal well-being, and to try to offer as much choice as possible to the animals before being handled for interactions. Indeed, the guidelines published by WAZA [32] state that: *“Interactive experiences should be non-invasive, safe and non-stressful for animals. Monitoring of all animals involved in interactions must be ongoing and have professional oversight. Risks to animal welfare should be minimised by carefully considering whether interactive experiences are appropriate, and if they are, by accommodating the animals’ particular needs”* (p. 74).

7. Conclusions

Natural living may be a useful concept for developing robust measures of holistic zoo animal welfare, but care must be taken to avoid the pitfalls and dilemmas explored in this article. Specifically, *wilding* is a concept that may not truly be providing zoo personnel with an appropriate ethical or conceptual basis for optimizing evidence-based animal welfare. Zoos will continue existing well into the future, and so more appropriate measures of *what is important to an animal* for a “life worth living” in captivity should tend towards *highly-*

motivated behaviours rather than just *natural behaviours*. *Human-animal interactions* in zoos are a source of debate and controversy, however, if implemented appropriately, they may significantly enhance animal well-being and holistic animal welfare (which may still be distinctly different concepts, even though the words are now often used interchangeably [10]), as they are often relationships of great importance to captive animals. Further exploration of what might constitute positive human-animal interactions, both scientifically and ethically, as well as ways of implementing such interactions without leading to unintended or "undesirable" human behavioural patterns emerging (such as an increased desire to "own" exotic wildlife) shall be forthcoming as a follow-up to this article.

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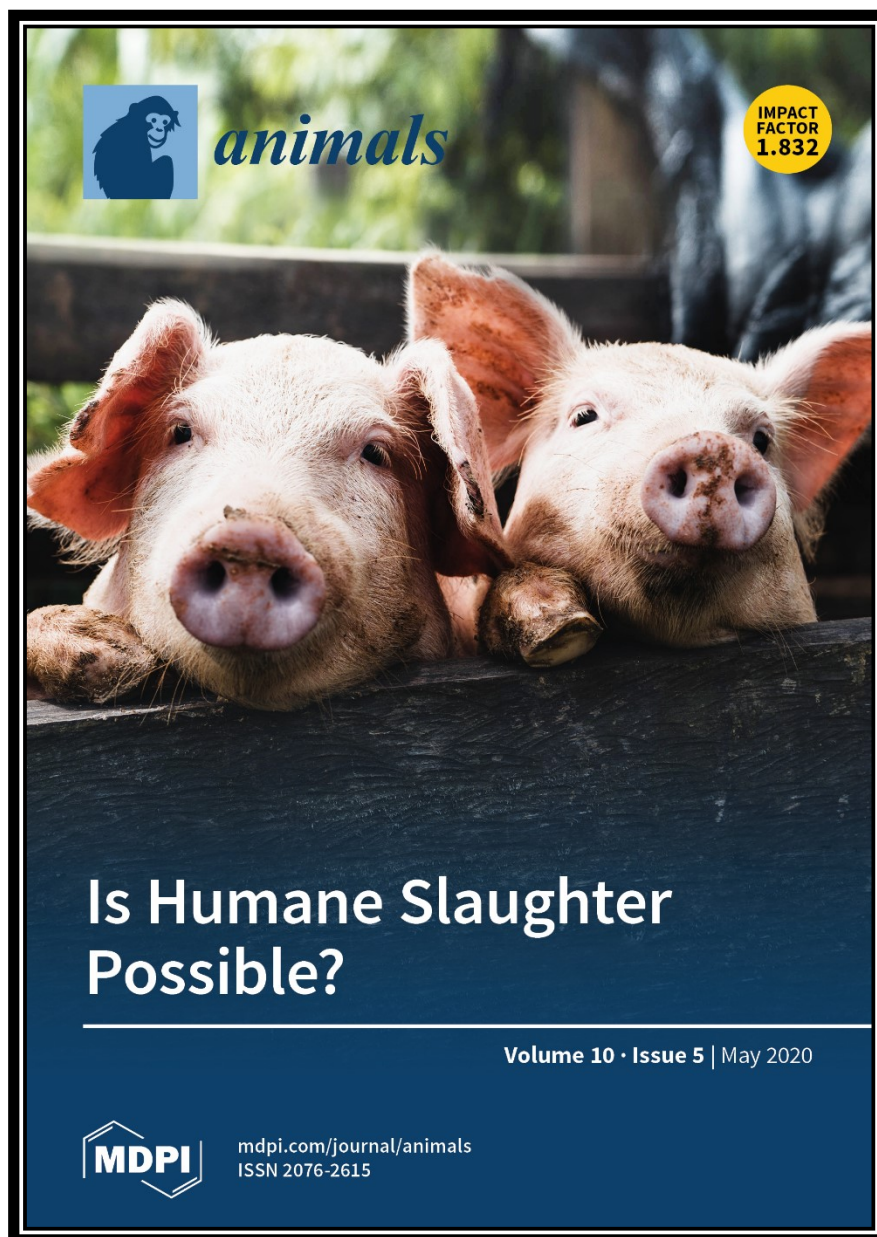
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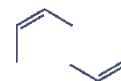
CHAPTER 3: ANIMAL ETHICS #2

The matter of non-avian reptile sentience, and why it “matters” to them: A conceptual, ethical and scientific review.

Mark James Learmonth

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Commentary

The Matter of Non-Avian Reptile Sentience, and Why It "Matters" to Them: A Conceptual, Ethical and Scientific Review

Mark James Learmonth

Animal Welfare Science Centre, The University of Melbourne, Parkville 3010, Victoria, Australia;
mlearmonth@student.unimelb.edu.au

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Simple Summary: Sentience is a complex and contentious concept, especially when attributing the label to non-human animals. Non-avian reptiles are often overlooked in many scientific, ethical and layperson discussions of sentience, awareness and consciousness in animals. Most modern declarations of sentience include all vertebrate animals, and some invertebrates, which automatically includes reptiles and fish. However, specific declarations often ignore the "lower" classes of non-human animals. This paper specifically focuses reviewing the concepts and definitions of consciousness, awareness and sentience; and then reviews research which provides solid evidence for sentience in non-avian reptiles. It is concluded that non-avian reptiles indeed possess all of the necessary capacities to be classified as sentient beings.

Abstract

The concept of sentience, how it is characterised and which non-human animals possess it have long been of contention in academic and intellectual debates. Many have argued that there is no way to empirically know that animals have conscious experiences. Yet others argue that consciousness, awareness and sentience in non-human animals can be quite obvious, and can indeed be measured empirically. Most modern declarations of animal sentience from official organisations and governments now include *all vertebrate animals* as sentient beings, including reptiles and fish. Some declarations also include *some invertebrate species*. This conceptual, ethical and scientific review first focuses on conceptual components and definitions of consciousness, awareness and sentience. It then specifically discusses how cognitive, neurobiological, ethological and comparative psychological research in *non-avian reptiles* over the last century has evidenced many capacities that historically were denied to this class of animals. Non-avian reptiles do indeed possess all of the necessary capacities to be declared as sentient beings, at least in the small proportion of reptile species that have actually been empirically investigated so far. It is suggested that much innovative future research will continue to uncover evidence of capabilities linked to sentience within a wide range of species, including non-

avian reptiles, fish and invertebrates.

Keywords: reptile sentience; animal ethics; sentience review; non-avian reptiles; consciousness; awareness; sentience

1. Introduction

The concept of sentience, how it is characterised and which non-human animals possess it have long been contentious topics for ethologists, biologists, cognitive psychologists, neuroscientists and philosophers alike. Conflating *animal sentience* with *anthropomorphism*, many scientists that adhere to traditional principles (such as Cartesians) would often argue that there is no way for us to actually *know* that (inside their heads) non-human animals are anything more than mere *automata* (biological "clockwork" or machines—Descartes, [1]; discussed in [2,3]). Yet others would argue that we can indeed perceive consciousness and sentience in other creatures merely through common sense, and that this need not be an erroneous anthropomorphic endeavour [3–5]. Three key issues have been proposed as the core of any animal sentience debate: "(i) *whether they are aware of what is happening around them*; (ii) *whether they are capable of cognitive processing*; and (iii) *whether they can have feelings such as pain*" [5]. Discussions and attributions of the label of sentience to non-human animals historically only attended to issue (iii) above; that is, whether they can feel pain or not [3]. However, more recently, and in many scientific disciplines, definitions of sentience have become increasingly complex and comprehensive, meaning much more than just sensations of pleasure or pain in animals [4,5]. The present acceptance of most *vertebrate* animal taxa (including *fish*) as sentient beings may reflect "*the most recent oscillation in the balance of thinking between scepticism and confidence on this matter expressed by philosophers, scientists and other professionals over the last 300 years*" [4]. However, even sceptics now often acknowledge that the breadth of behavioural, neurobiological and neurophysiological evidence gathered points to the existence of consciousness, awareness and sentience in the majority of vertebrate animals, and possibly in many *invertebrates* as well [2–6]. Labels of *sentient* versus

non-sentient may have profound implications for how humans treat animals that we use, care for and sometimes exploit, as this label is often used as a conceptual point at which we assign "moral status"—the line past which their lives and our treatment of them "matters" [7]. Political and legislative decisions made using this "line" of moral status have far reaching consequences for practical animal welfare on farms, in laboratories, with household pets and in other captive settings, like zoos [4,5,8]; and, importantly, these laws may change in the future, to recognise and assign non-human animal moral and/or legal rights [9].

Many countries have ratified declarations of *animal sentience* and some jurisdictions have enshrined these declarations in legislative changes. As outlined by Mellor [4], experts from the 180 member countries of the World Organisation of Animal Health (OIE) adopted a statement of animal sentience in the "OIE Global Animal Welfare Strategy 2017"; 46 countries (most of which are also OIE members) supported a proposal for a UN Declaration on Animal Welfare; the European Union established the Treaty of Lisbon (2008); and declarations were made directly via laws in France (2014), New Zealand (2015 amendment to the NZ "Animal Welfare Act 1999"), Quebec (province of Canada; 2015 amendment to their Civil Code) and Colombia (2016) (for a recent summary of legal status changes, see [4,10]). These declarations mostly include *all vertebrate taxa* (including fish), and some have included "*complex invertebrates*, such as cephalopods (octopuses, squid and cuttlefish) and sometimes a few decapods (crabs, lobsters, crayfish). However, in many robust discussions and acknowledgements for and against non-human animal sentience, one particular class is often overlooked or forgotten—*Reptilia*, or now, to be distinct—*non-avian Reptilia*. Because some living reptiles are more closely related to birds than to other reptiles, the traditional taxonomic class *Reptilia* has been modified to include the clade *Diapsids*, which creates a monophyletic group (a group with a common ancestor) back to the clade *Sauropsida* (all living reptiles and birds, and the extinct *parareptilia*), and is in line with the other monophyletic groups of the animal kingdom [11,12]. This is largely a semantic difference in

scientific nomenclature, but begets some unity in our long-standing classification system. Therefore, when referring to those animals that were previously considered *reptiles*, the distinction must be made whether the discussion is inclusive of birds or not (hence, non-avian Reptilia). Herein, if referring simply to reptiles, the proper "*non-avian reptiles*" is inferred.

Long-standing beliefs around "behavioural sedentarism" and lack of complex brain anatomy have often shaped perceptions and understanding of non-avian reptiles and amphibians as animals that probably "matter less," as they were long thought to be incapable of complex thought or emotion [2], and hence incapable of meaningful suffering. World Animal Protection's (WAP) "Animal Protection Index" is a very valuable resource for checking the current status of animal protections per country (where data is available and has been compiled), and WAP lists "animal sentience recognition" as the most important indicator for good animal protections [13]. In the Australian Capital Territory (ACT), an "Animal Welfare Legislation Amendment Bill" was passed in 2019, changing multiple acts and codes, prominently featuring explicit changes to reflect that: "*(a) Animals are sentient beings that are able to subjectively feel and perceive the world around them; and (b) animals have intrinsic value and deserve to be treated with compassion and have a quality of life that reflects their intrinsic value*" [14]. This was the first Australian jurisdiction to explicitly add a non-human animal sentience statement to legislation. However, the definitions of "animal" throughout the amendments and the multiple codes are not always identical—they broadly list all vertebrates, but some specific classes may be exempt or missing from some of the acts or codes [15]. Additionally, where there are other state or national animal use "codes of practice" in place "*animal industry practices that might otherwise be considered animal cruelty are exempted from the requirements of the legislation*" [15]. The definitions of sentience that these declarations and legislation are based upon may also vary extensively, and some of these definitions may be too reductive or simplistic to capture the meaningful capacities that a

sentient animal possesses. This paper discusses multiple definitions of and justifications for consciousness, awareness and sentience in a range of non-human animals, and then focuses on the under-acknowledged reptilian vertebrates. It shall build upon the recent reptile sentience review published by Lambert *et al.* [8], by interrogating much of the relevant behavioural, cognitive, biological, physiological and psychological research in reptile species that may provide evidence for commonly prescribed elements of sentience.

2. Definitions of Sentience

There are a few different definitions of sentience that are currently adopted by differing sectors of scientific, philosophical and layperson communities. It is important to consider how each sector may view sentience (and aligned concepts), as, depending on the definitions used, practical changes, policies and legislation that are implemented may inadvertently be inadequate, or become too technically confusing to be actionable or enforceable. Sentience was first introduced into the English language around 1603 C.E. (from Latin *sentire* – *to feel*) to describe the philosophical distinction between thinking (reason) and feeling (sentience) [16]. A few dictionary definitions of sentient and/or sentience are: "*responsive to or conscious of sense impressions; aware; or finely sensitive in perception or feeling*" [17]; "*the quality of being able to experience feelings*" [18]; and "*being able to exercise the senses and respond to sensory stimuli*" [19]. These dictionary definitions differ somewhat significantly – and are each somewhat reductive – but all would imply that a sentient being has some degree of *awareness* (since awareness is probably necessary to *experience* feelings or sensations). The former two of these definitions indicate that the "feelings" linked to sentience are more than merely having *sensations*; they may more accurately mean "emotions" that are *consciously experienced*. The third definition, however, merely requires a being to respond to sensory stimuli (i.e., to have sensations) to be labelled sentient, which is arguably achievable by many plants just as well as animals [20]. However, we would not usually attribute consciousness or sentience to any organisms outside of the animal kingdom (yet). Thus, it would seem that all of these

dictionary definitions are too simplistic, or in some way inadequate at describing quite what constitutes the *entire* concept of sentience. On the Wikipedia entry for sentience, the definition given is: "*The capacity to feel, perceive, or experience subjectively*" [21], citing the Merriam-Webster dictionary definition given above. Mellor [4] expands on this to mention that, logically, "*for something to be **perceived** or **experienced** the animal must be conscious.*" Thus, attention to these simple and (mostly) non-technical definitions of sentience may not be adequate to encapsulate *all* of the components required for, and leading to, sentience in non-human animals.

From an ethological/animal welfare science perspective, Broom [5] defines a sentient being as: "*One that has some ability: (i) to evaluate the actions of others in relation to itself and third parties; (ii) to remember some of its own actions and their consequences; (iii) to assess risks and benefits; (iv) to have some feelings; and (v) to have some degree of awareness*" (p. 5). Awareness, in Broom's book [5], has been defined as: "*A state during which concepts of environment, of self, and of self in relation to environment result from complex brain analysis of sensory stimuli or constructs based on memory*"(p. 73). Finally, Mellor [4]—also from an animal welfare science perspective—offers a new definition, for a slightly different type of sentience, termed "welfare-aligned sentience": "*Welfare-aligned sentience*" *confers a capacity to consciously perceive negative and/or positive sensations, feelings, emotions, or other subjective experiences which **matter to the animal.***" These latter definitions are more comprehensive than the dictionary definitions given earlier.

Turning to animal ethics and philosophy, these definitions (especially welfare-aligned sentience) overlap significantly with what Tom Regan best described as the criteria for a being that is the "*subject-of-a-life*" [9], which would further mean that they have "inherent value," like each and every human being. That is, sentient animals *experience* their own lives, but that experience does not have to be exactly the same as humans' experience to matter morally and ethically. While this may intuitively seem to "set the bar" quite high for some

animals to reach, as the evidence discussed below should show, this use of the concept of sentience (as *more* than only experiencing the sensation of pain or physiological "feeling" of pleasure) may elevate many animals to a higher "moral standing." Moral standing is inherently important for influencing and informing various protections for non-human animals (and indeed humans) against abuse and exploitation. Indeed, the ACT legislation mentioned above includes Regan's argument for the "inherent value" each animal possesses in the key definition amendments [14]. The concept of *welfare-aligned sentience* is particularly useful in deciding what exactly researchers and policy makers should attend to, to make meaningful declarations and changes that are in the best interests of non-human animals. Regan's "*subject-of-a-life*" arguments have been useful in animal welfare science in progressing the notions of "quality-of-life" [22], and particularly the Farm Animal Welfare Council's [23] "*a good life*," and "*a life-worth-living*" for captive animals, whether in farms, laboratories or zoos/living museums [23–27]. That is, animals that humans keep for use or display should still have lives that they enjoy living, with appropriate protection from harm, and access to multiple opportunities for pleasure, joy and "*positive affective engagement*" [26,27]. This review aims to argue that consciousness, awareness and sentience (all up, thinking and feeling) are complementary and intertwined processes, and that the emergence of one likely precipitates the emergence of some degree of the others in *all* animals, including invertebrates. The review explores much of the accumulated evidence that satisfies the common conditions given in the Mellor [4] and Broom [5] definitions – particularly evidence of consciousness, awareness, cognition and affect – that may solidify the case for attributing sentience to non-avian reptiles, with some limited discussion of amphibian, fish and invertebrate capacities too.

3. Consciousness, Brain Size and Brain Power

Consciousness has been defined as "*the quality or state of being aware especially of something within oneself; the state or fact of being conscious of an external object, state, or fact; or the totality of*

conscious states of an individual" [28], amongst numerous other definitions. Conscious, then, is defined simply as being "*awake*"; that is, "*having mental faculties that are not dulled by sleep, faintness, or stupor*" [29]. The Cambridge Online Dictionary [30] defines consciousness as "*the state of being awake, aware of what is around you, and able to think*." Most definitions of consciousness are somewhat circular with definitions of awareness—they reference each other as states that describe each other. Many, then, use the terms consciousness and awareness interchangeably [5] (p. 72). The threshold for "basic" consciousness might simply be any animal that is observed to be "*awake*" (i.e., not sleeping). But would we say that a sleeping adult lacks consciousness? What about a sleeping newborn baby, or a sleeping pet? In this sense, we would usually agree that consciousness is probably a state that does not fully cease to exist (not in all its meanings at least) while we are "*unconscious*," but that we are not *aware* during unconsciousness, and that consciousness will indeed return upon waking. This may also be a case of inferring the wrong use of a multiply-defined word—merely an artefact of our convoluted languages. Therefore, using awareness as a more useful alternative concept in debates of consciousness is warranted.

Delving deeper into consciousness, would we describe an animal that is merely reactive to stimuli through its senses as conscious? If an animal avoids touching an aversive surface after initial sensation (e.g., reacting to pain and withdrawing—like a mollusc withdrawing from touching salt or boiling water), is that animal *conscious*, or even *aware*? Initially, basic reactivity was not classified as "consciousness" at all, it was merely an autonomous response [2]. Some physical processes and responses are indeed automatic or autonomous, like breathing, but they are necessary processes that keep the conscious being alive. The majority of normal human foetuses are, by the third trimester, able to react to sensations and to suck their own thumbs, and they have autonomous heartbeats amongst other capabilities, but many scientists and medical professionals would not usually classify foetuses as *gaining consciousness* until they emerge from the womb, and take their first breath [5] (p. 109).

However, there are others that would argue that human fetuses *are* conscious, but highly subdued or sedated, in the womb by the third trimester of pregnancy, as they are able to partially respond to touch, light and sound from within the womb. Although they are not usually considered (fully) conscious in the womb, we still regard fetuses as *going to possess consciousness* in the future (once oxygenation rises when breathing begins post-birth—an evolutionary technique designed to suppress in utero risks such as damage to the mother's organs, or spontaneous foetal abortion due to agitated movements by the foetus [5]). There are some abnormal fetuses that we would regard as *never* experiencing consciousness, even when oxygenation rises after birth—abnormalities such as babies born with anencephaly (i.e., born without the majority of their brain). These babies may survive for a limited time after birth without intervention (they may breathe naturally for some hours after birth), but presently die, without ever gaining what we would describe as consciousness. These abnormalities are unusual cases, but they exist for a percentage of births in *all* animal species. Next, what of oviparous species' babies that must forcibly "birth" (hatch) themselves from eggs (i.e., birds, reptiles, monotremes, fish, amphibians and many invertebrates)? Surely a complex series of brain processes is required to coordinate movements of their body parts to break out of a shell, and these processes would meet the criteria for consciousness at very least. There is also evidence of these animals being able to respond to sound, touch and light from several days *before* hatching from their eggs, and even evidence of "pipping" communication between unhatched eggs that allows synchronisation of hatching in some species [5] (p. 109). So when exactly has consciousness started in those animals—sometime *before*, or sometime *after* hatching? If they are communicating with each other, is there some sort of *conscious awareness* of that communication within the egg?

As Broom [5] describes, consciousness and awareness have often been used interchangeably, but instead should be explained as distinct, separate processes. Herein it is suggested that they are probably successive in nature—that is, consciousness evolved before

awareness, and is necessary to bring about awareness. Others have used consciousness to refer to "*executive awareness*" [31]; however, this again leads to one or both of consciousness and awareness becoming conflated and redundant. Many centuries of investigation, both scientific and philosophical, have sought to find the root of consciousness in the anatomy of the brain [1,2]. Brain size varies dramatically amongst vertebrate animals, from the minuscule brains of some amphibians and fishes, to the massive brains of elephants and whales. Iwaniuk and Wylie [32] describe the "brain mass to body mass ratio" of many vertebrate classes, which shows that many birds and mammals have a relatively larger brain to body masses than reptiles, fishes and amphibians (pp. 502–503). It has long been assumed that the increase in brain mass to body mass infers greater *encephalization* [33] meaning more mass to a brain equals more processing power [5,32,34]. The degree of encephalization above or below the expected "standard" is referred to as the encephalization quotient (EQ) [33,35]. For some mammal examples: *Homo sapiens* have an EQ of 7.8, dolphins 5.3, chimpanzees 2.5, elephants 1.3, cats 1.0 and rabbits 0.4 [35] (p. 244). But how do we calculate an expected, "standard" EQ for birds, reptiles or fish? What is the basis for our standardisation? Even more complex, how would we calculate an EQ for invertebrates with no centralised brain? This EQ concept, then, is not necessarily always the best, nor the only measure of total capacity for intelligence.

It is also a long-standing neuroscientific principle that increased *gyrification*, or cortical folding, is a better indicator of cognitive and "conscious" sophistication, at least in mammals [2], [34] (pp.723–724). Sir Charles Darwin's famous statement on cognition, that "*the difference in mind between man and the higher animals, great as it is, certainly is one of degree not of kind*" [35] (p. 238) is pertinent here, though it is now obvious that differences in mind between humans and *all* vertebrate animals may be of degree, not kind. It has been known at least since the experiments of Bailey and Davis [36,37] that when the sub-cortical periaqueductal grey (PAG) matter in the mid-brains of cats and primates is completely destroyed, they become

vegetative—they lose all indications of consciousness and never recover. All documented human patients with near-complete damage to the PAG region have remained in comas until death [38] (p. 476). Panksepp [38] describes this evolutionarily primordial brain region as the most emotionally enriched region of the brain: *"It has the highest density of primary-process neural emotional-autonomic systems within the brain, which suggests the importance that the ancestral affective system – a primary form of consciousness – may have for the construction of higher forms of consciousness"* (p. 476). That is, the capacity to have conscious experience—or *qualia*, as Panksepp and others refer to it—derives from the PAG brain region (present or homologous in probably all vertebrates), which may essentially be foundational and necessary for all "higher" forms of consciousness (and, this higher consciousness is what we would now better describe as awareness and sentience). However, this still discounts the possibility that many *invertebrates* may possess consciousness due to their lack of anything remotely homologous to a centralised vertebrate brain or central nervous system—although we have recently discovered that many invertebrates do possess neurons much like ours, but with a few differences (such as lacking a myelin sheathe) [39].

Even though differences in brain anatomy between vertebrates and invertebrates are *"of kind,"* this does not exclude the latter from possessing cognitive complexity, consciousness, awareness and sentience. Indeed, many comparisons between brains of minuscule invertebrates and comparatively larger vertebrate animals have found that the invertebrate species do not necessarily have less neurons—for example, a species of salamander has a reported 240,000 neurons, while the honeybee has 960,000 [5] (p. 37). Recently it has been reported that bumblebees are able to be operantly trained to perform a resource acquisition task, and then socially communicate the effective solution to other bumblebees, both when the reward is linked directly to a string-pulling task (the reward is at the end of the string [40]), and indirectly to rolling a ball into a hole (the reward is offered separately after the ball enters the hole [41]). These are both learning and communication-type tasks that some

vertebrates have been unsuccessful at achieving, albeit in different experimental settings and using different, species-relevant tasks. Cephalopods such as octopuses, squid and cuttlefish are known to possess even more complex forms of cognition than bumblebees – they display learning and memory in experimental studies that is at least as good as mammals such as pigs, and crucially, they can modify previous learning with new knowledge, use tools and even "*carry out behaviour that leads to deception*" [5] (pp. 48–49).

Most theories and experiments on brain capacity and function, from a neuroscientific perspective, also deem consciousness, awareness and sentience to be hierarchical in nature, and whilst most now agree non-human animals do possess "basic" consciousness, many are still sceptical of whether they possess *awareness* or *sentience* (as these were historically regarded as indicators of the uniqueness of human beings). Three points that may typify the commonly accepted hierarchy are: (i) "higher" processes are only achieved with "higher" (meaning more human-like) brain size, brain mass to body mass ratio, EQ, gyrification, processing power and neuronal complexity/inter-connectivity; (ii) that this is a step-wise process that we have characterised based on human development and capacities; and (iii) *only* those animals that possess homologous brain structures to humans may experience the same awareness or emotions as us. Undoubtedly humans do possess a very complex and evolutionarily-advanced brain when compared to those of many other animals, but this *anthropocentric* view of "the best brain to have" for consciousness and cognitive sophistication may be over-stating and/or over-valuing certain brain and neural morphologies; sensory organs; capacities and acuity; and behavioural expressions that are comparatively irrelevant to other species, their environments, their abilities and their complexities. This anthropocentric "best brain" assumption has been integrated into many evolutionary neuroscience hypotheses, such as the *social-brain hypothesis* of Dunbar and colleagues [34] (pp. 723–724), [5] (p. 38), which states that complex social cognitive capacities co-evolved with "larger" brain mass, and so essentially social-living species, like humans, are more cognitively

complex by virtue of living socially. This may indeed be true—that a higher degree of complexity in frontal cortex "social-processing" regions of brains develops from living socially—however, many solitary-living animals have been shown to also be able learn tasks socially, despite lacking these "larger, social-living" brains. Evidence of social learning in non-social reptiles is forthcoming later in this review.

Lastly, the *anthropocentric approach* of the "gold-standard" human brain and sensory experience in comparative animal cognition and neurobiological research may be excluding many sensory capacities or perceptions that certain animals possess that are different or superior to the senses that humans possess. For example, dogs (and many other animals) have far better olfactory senses than humans; some birds and sea turtles are able to navigate using magnetoreception—the ability to see the Earth's magnetic field in their vision [42,43]; many pythons and snakes locate prey using specialised heat-sensing organs; and sharks, rays and platypuses (among others) have evolved electroreceptors to sense the minute electrical charges given off by other living beings, sometimes at great distances. All of these capacities are linked to sensory organs or receptors that are not possessed by humans, and these are often reflected in certain enlarged brain structures that process these sensations in these animals, as sensations have to be cognitively processed (even if autonomously) to be meaningful [5]. This alternate approach—looking at which experiences are most relevant for each unique species—is called the *ecological approach* [35]. Recently, a *combined approach* has provided the ability to test supposedly unique aspects of human cognition, such as "theory of mind" and "mental time-travel" [35]. Through the combined approach, it has often been uncovered that these supposed uniquely human elements of cognition, consciousness and awareness are not actually unique to humans at all. Therefore, when we are evaluating consciousness and the extent of awareness in non-human animals, we must "*take account of the world as **they** perceive it*" [5] (p. 39).

4. Awareness

Awareness is a state within an animal that allows it to perceive its environment, perceive itself and have a concept of itself in relation to that environment. It is supposed that awareness developed after "basic" consciousness, and it involves more cognitive processes than does being "conscious." For instance, the threshold for "basic" awareness would be satisfied by any animal that can use memory and multiple sensory inputs to modify its behaviour in response to a repeatedly presented environmental stimulus, such as seeking a shaded area once they perceive that they are too hot. Common sense and direct observations tell us that many animals are capable of these behaviours. Many long-standing animal training or conditioning paradigms, such as classical and operant conditioning, rely on an animal's ability to evaluate its own behaviour, and learn how to respond to both predictable and unpredictable stimuli, to gain the most desirable outcome over a series of repeated trials. They have to learn and adapt over time to continue to be successful, which is reliant on them being *aware*, to learn and remember effectively. There are many types of awareness, from "basic" awareness of a change in the environment, such as weather conditions changing from sunny to raining; through to self-awareness; and then awareness of another animals' awareness. As previously mentioned in the section on consciousness, awareness is usually (logically) deemed to be hierarchical, with many chronological "levels" of awareness that appeared successively in conjunction with increasing evolutionary "complexity" [5] (p. 73). However, these "levels" of awareness may not all necessarily be hierarchical – different kinds of processing may appear or develop in different ways, at different times, in different orders and in different or in multiple areas of the brain concurrently (just like "convergent evolution" of animal types) [5] (p. 73). Therefore, the proposition of Broom [5] will be followed, that "levels" of awareness will instead be referred to as "categories." Many types of awareness may also be contingent upon having strong internal reinforcers for learning and memory – reinforcers like feelings, emotions or moods associated with, and modulated by,

external stimuli or behaviours.

Some psychologists, philosophers and neuroscientists have assumed that it is only mammals (particularly only "higher-order" mammals) that possess the capacities for awareness. Panksepp [2] (p. 35) posited that (from neuroanatomical analyses) awareness originated within mammals, with "reflexive" behaviour starting in reptiles and birds, and fish and invertebrates possess nothing of the kind—their "behaviours" are all preconscious and automatic. This idea was prominent in the scientific writings of Descartes [1] on the comparative abilities of "God-made," rational *Homo sapiens* versus the soulless, non-rational animal "automata." In turn, these views reflected those of some Aristotelian philosophers before them [44]. Now, the idea of only preconscious, automatic behaviour in living beings (i.e., biological machines) has been categorically proven inaccurate [35]. Fish, and even some invertebrates, are now generally accepted to have some degree of consciousness and awareness, though many still dispute whether they possess sentience [4–6,45]. Additionally, there is still much contention around whether many "lesser" invertebrate species possess even "basic" consciousness [6,46]—take earthworms, or the mollusc example from the section above. What then, of awareness in such animals as sea cucumbers, sea sponges and coral? Arguments for or against consciousness and awareness in these types of animals is beyond the scope of this article, but are still prescient issues that should be acknowledged and addressed forthwith.

Broom [5] discusses five categories that may describe the types of awareness: "*Unaware, perceptual awareness, cognitive awareness, assessment awareness, and executive awareness.*" A review of these categories can be found in Broom's book, "*Sentience and Animal Welfare*" [5]. For the sake of simplicity, here we will discuss relevant types of awareness in three categories: "basic" awareness, "self-awareness" (including "future-self"), and "theory of mind" awareness (ToM awareness). Importantly, "sentience" would likely already be attributed to any animal that shows evidence of the latter two categories of awareness discussed here.

That is, animals that are found to be self-aware, or display traits of possessing their own theory of mind, should have already far surpassed the concomitant "hurdle" of having subjective sensations, feelings, emotions and moods. These awareness categories will still be considered, as they are important to the discussion of the capacities of non-human animals, and will assist in later arguments for the subjective experience of emotions (and the understanding that others may also have these emotions) in non-human animals.

4.1. Basic Awareness (Perceptual Awareness)

"Basic" awareness is now something that is usually afforded to most vertebrate species [4], and there is limited (and increasing) evidence of basic awareness in many invertebrate species as well [6,46]. Most (unimpaired) animals, that have been observed scientifically, are able to modify behaviours and adapt to environmental changes in a way that indicates that they are aware of their surroundings, and this behavioural variation within and between species is described as *"the raw substrate for evolutionary change"*—it can both enhance or constrain evolution [47,48]. Thus, it stands to reason that basic awareness evolved to enable animals to use this awareness as one of a suite of tools to continue surviving and evolving. More than mere *consciousness*, basic awareness, as in the awareness definitions given previously, requires an animal to *"perceive"* environmental changes (which would involve a series of cognitive functions) rather than merely being able to *"detect"* changes [5] (p. 76). Just as we now consider most non-human animals to indeed be conscious (including many invertebrates), so too would most of these animals, if not all, be considered to have basic awareness. Simply by looking at a non-human animal, most of us would perceive that there is something similar to our awareness going on behind that animal's eyes, and this has been established as legitimately beyond an anthropomorphic fallacy [3,4,49,50].

4.2. Self-Awareness

The category of self-awareness is one that was long deemed to be unique to *Homo sapiens*

[35]. However, many species (both vertebrate and invertebrate) have quite successfully and repeatedly shown the capacity for self-awareness—such as the recognition of self in mirror reflections, the evaluation of their own actions, the understanding of consequences of their own actions and planning for future actions [5] (pp. 77–78, 80–82). One such moment of self-realisation that has been studied in a number of species is termed the "*eureka effect*"—that animals, such as cows, show behavioural and physiological signs of excitement and pleasure at the exact moment of learning how to complete a task, and this excitement is not shown by matched control animals that cannot control the task outcome [5,51]. Similarly, in many contra-free-loading studies of animals' preferences, it has been shown that many species will "work" to gain access to a resource that is also freely available to them, indicating that they value learning and effort, and the physiological (and presumably psychological) pleasure they experience from solving or completing a task [52]. To be physiologically aroused by the completion of a task, when linked to performance of emotional, excitement-type behaviours as well, gives a good indication that the animal is indeed aware of itself, and that its own actions are leading to a rewarding or desirable outcome. This again indicates that these animals have internal pleasure states and other feelings and emotions linked to motivation and for rewarding outcomes (i.e., sentience). Two areas that are still of contention in many animal awareness studies, however, are the abilities for "future-planning" and for "mirror self-recognition" (MSR) [5] (pp. 78–82).

Many animals have been reported as either able or unable (or, confoundingly, both) to recognise themselves in a mirror, though only a few have passed all "levels" of the test, including Amsterdam's seminal self-recognition "mark test" or "rouge test" from 1972 (for a review, see [53] pp. 745–764). Those animals that have reportedly "passed" all levels of MSR are all social-living species with high EQs, and often display evidence for empathy and perspective-taking for conspecifics or even other familiar individuals of unrelated species [53] (p. 748). These species, specifically, are: *Homo sapiens* and the other four great apes—

chimpanzees (*Pan troglodytes*), orangutans (*Pongo spp.*), bonobos (*Pan paniscus*) and gorillas (*Gorilla gorilla gorilla*) (though Gorillas have lower success than all other apes); and a few non-primate species: bottlenose dolphins (*Tursiops truncatus*), Asiatic elephants (*Elephas maximus*) and Eurasian magpies (*Pica pica*). Recently, it has been reported that the classic MSR tests have also been passed by species such as orcas (*Orcinus orca*) [54], and possibly cleaner wrasse fish (*Labroides dimidiatus*), though the results were ambiguous [55]. Other successful mirror awareness tasks have been completed by pigs (locating food after visual discovery through a mirror reflection [56]), and investigated in corvids, parrots, dogs and octopuses, with varying success. Many other tested animals have failed the classic MSR tasks; however, the anthropocentric nature of the tests and the human evaluation of observed mirror-directed behaviours have been criticised for over-valuing the visual senses and not taking into account the animals' own perceptions of reality ([5], pp. 80–82). The "mark" test may also often report "false-negatives"—many of the animals tested may indeed have perceived their own reflection, and simply have not cared to (or not needed to) visually and/or physically explore the marks visible on their bodies in the reflection [55,57].

Having internal concepts of the future, and abilities for future-planning, are most likely very important parts of self-awareness. Many animals that possess "basic" awareness (i.e., that can respond directly to perceived environmental changes) can just as well have *predictions* about what is likely to occur after those changes [5] (p. 78). For example, many animals that are fed at routine times display anticipatory behaviours in the period before usual feedings [5,58–61], and the act of anticipation means that these animals possess an internal concept of imminent (but still future) satiety, even in the absence of reliable precursory signals (though reliable signalling will indeed increase "positive" anticipatory behaviours and reduce "startle" responses) [61–64]. It has also been well established that a farm animal's previous experiences with stock-handlers has a long-lasting influence over their future interactions with other handlers, and their ease of management and productivity

will decline with exposure to "negative," fear-provoking and/or painful stockperson behaviours [65]. These predictions of future events in animals can be measured through overt behavioural changes, and through a multitude of reliable physiological responses [5,65]. "Mental time travel," as described by Mendl and Paul [66], is an ability frequently engaged by humans, to imagine future scenarios and ourselves in those scenarios. There is much inferential evidence that many non-human animals rely on similar mental time travel concepts to function and survive [5,66–68], from studies with a diverse range of species, such as primates, corvids, rodents, magpies, arachnids and cuttlefish [5,68]. For a review of mental time travel abilities in animals, see Clayton [68].

4.3. "Theory of Mind" Awareness

Theory of mind refers to the ability of an animal to comprehend that another animal apart from oneself also has internal mental states [34] (p. 723). In terms of the "complexity" of awareness required, this category of awareness may indeed be the highest "level," as it requires far more brain processing to achieve this kind of awareness. It also involves an ability for "*meta-cognition*"; that is, *knowing what you know, and how you know it* [69]. Any animals that can indeed show evidence of ToM awareness should surely already be included under the umbrella of "sentient beings". However, old questions about what we can actually *know* about the minds and internal experience of non-human animals without self-reporting abilities, arise again [1,2]. How can we actually definitively know that a non-human animal is aware of other animals' mental states? In the absence of self-reporting of mental states in an intelligible common language, research in this domain relies heavily upon innovative paradigms that may allow us to infer an animal's understanding of others' mental states, through careful and cautious analysis and interpretation of the focal animal's behavioural outputs [34] (p. 723). Some of these innovative paradigms have given rise to a number of very popular and intuitive theories, such as the *Machiavellian intelligence hypothesis* of Whiten and Byrne [70,71], and especially the *social-brain hypothesis* of Barton and Dunbar [72]. These

are both *anthropocentric* hypotheses, but have allowed us to infer a great deal about ToM awareness in animals, through a comparative approach to experimentation (that is, can animals achieve the same or similar "thresholds" of behaviour that human adults or children can, when we know that humans must engage ToM awareness when behaving in that certain way?).

Two such comparative behaviour approaches are research into attention reading and gaze following in non-human animals. Gaze-following is an important human-to-human "*social cognitive*" behaviour that allows us to gather more information or knowledge about our environment, as we are able to understand that if another human is looking in a direction, the object of their gaze or of their attention, might be important for us to assess ourselves [34] (pp. 724–729). Attention reading is a very similar process to gaze-following, and is a part of gaze-following, in that the animal is *aware* of the direction of another animals' attention, whether through gaze or other "attentive" behaviours displayed by the latter animal. For instance, it has been shown that all four non-human great ape species will modify their gestural communication for the attention of human watchers. That is, they will increase visual physical gestures (e.g., pointing) when they are aware that the human's eyes are attentive to them, or increase other non-visual attention seeking gestures (e.g., clapping) when they are out-of-sight, or are not holding the human's gaze/visual attention [34] (p. 727). Gaze-following is a developmental behaviour that is important from an early age in humans (and in the other great apes), before they are able to verbally report why they are attentive in this way, and comparatively, many animals have shown similar ability to understand another animals' attention [34] (p. 724–729). Being attentive to another animals' attention has been shown to be important for advantage and survival, but may be especially important for social-living species that are sensitive to "eye-shaped stimuli" (and hence, again may over-value certain sensory priorities, such as visual perception). Eye-shaped patterns and colours are an evolutionary advantage and predatory avoidance adaptation

that has evolved independently of conscious experience, and are very prevalent across the animal kingdom [34] (p. 726). Surely, then, this prevalence can be assumed to be related to the relative importance of visual stimuli across a wide range of animals in nature, not just humans.

Gaze-following research is usually conducted in two ways: the first assesses whether non-human animals are able to follow the gaze of conspecifics, to gain information about their environment, or discover items that other conspecifics might value; and the second assesses whether non-human animals can follow the gaze of other, unrelated species (such as humans), or modify their behaviours when they are aware that another animal's gaze or attention is directed towards them (attention reading). For a full review of gaze-following in animals, see Kaminski [34]. A brief list of animals that are attentive to others' gaze is as follows: almost all primates (apes, monkeys and prosimians), dolphins, seals, goats, dogs, wolves, ravens, rooks and (importantly for this argument) *red-footed tortoises* [73]. There is some doubt as to whether gaze-following is sufficient evidence for ToM in non-human animals, as it could be simply reflecting an animal's understanding of spatial relationships – not necessarily an understanding that the animal's gaze that they are following also means that this other animal has its own perception or understanding. However, there is further evidence in a range of species for abilities of understanding another's perspective (perspective-taking), understanding another's past visual access (knowledge attribution) and understanding others' goals, intentions or desires [34]. A summary table of the species tested (so far) and the main findings of that research can be found in Kaminski [34] (p. 737). One ToM ability that is displayed by humans but has not yet been detected in non-human animals is that of understanding another's false beliefs. Many animals can indeed hold their *own* false beliefs, but cannot quite comprehend that other animals similarly may have false beliefs. This seems to require a degree of cognition that is still unique to humans, as it requires an understanding that others' beliefs may be true or false, like one's own, but also

that others' beliefs may be contrary to one's own beliefs, and even contradictory to objective reality, despite evidence of that reality [34] (p. 736).

5. Sentience

After awareness, the next categorical "step" in our understanding of non-human animals is the concept of *sentience*. This may be the most important concept to empirically show as existing within animals' minds, as animals that are sentient can, at a minimum, experience pleasure and pain, and (at least by comprehensive definitions) they can also *consciously experience* life, and are (to some degree) *aware*—aware of their own sensations and feelings, and probably aware of their own lives. If this is true, and sentient beings are also aware, their survival, internal well-being and overall welfare (including internal and external factors) will also *matter* to them, in a consciously-perceived way. In our broadly "utilitarian" ethical society, animals that have been afforded the title of "*sentient*" have been elevated to a conceptual status above "*biological machines*," and this then matters in a moral and ethical way to human beings, as we ought to reassess the ways in which we currently use, utilise or exploit animals as resources [9]. However, cultural and political acceptance, and practical implementation of animal protections quite often lag far behind the evidence for complex capacities in these animals, as there are many broad economical, societal and personal financial ramifications to changing the status quo of animal uses for human benefits [9,74]. Most current animal protection laws or codes still only attend to sentience as indicating whether an animal can experience "*feelings such as pain*" [75], and this is the commonly understood way in which sentience is used meaningfully as a label or descriptor of a characteristic [3]. That is, a *vertebrate* animal (often lab mammals, such as mice or rats, are in mind in these scenarios) should be reasonably expected to feel pain in any situation where a human would also be expected to feel pain [74,75]. Whether these same "reasonable expectations" perspicaciously carry across to considerations about birds, reptiles, amphibians and/or fish is debatable, and these expectations are almost non-existent for

considerations of invertebrates [3]. However, as described above, many scientists and philosophers in many disciplines have expanded the definitions of sentience to include more meaningful feelings and capacities beyond merely feeling pain [4,5]. This may turn sentience into a spectrum or a gradient, rather than an on/off type capacity. Of course we should always avoid unnecessary animal pain and suffering, but we should also start attending to minimum requirements for giving animals the appropriate spaces and resources to feel pleasure and other positive affects, as a part of meaningful sentience declarations, and codes or legislation that are borne of those declarations [4].

Returning to the definitions of sentience, an animal that could be regarded as sentient is one that *"Has some ability: (i) to evaluate the actions of others in relation to itself and third parties; (ii) to remember some of its own actions and their consequences; (iii) to assess risks and benefits; (iv) to have some feelings; and (v) to have some degree of awareness"* [5] (p. 5), and that these *"subjective experiences matter to the animal"* [4]. So far, the majority of beings within the animal kingdom (both vertebrate and invertebrate) are now classified as conscious, or of possessing consciousness [4]. Above, much evidence of types of awareness, at least to the category of "self-awareness," spans almost the entire vertebrate animal kingdom as well (including reptiles and fish, but still with much contention about many orders of invertebrates). Those animals that display capacities for "self-awareness," and especially those animals listed above in "theory of mind awareness," have satisfied the abilities (i), (ii), (iii) and (v) of Broom's definition of sentience. The decisive factor, then, between attributing labels of *sentience* or *non-sentience* in many animals may come down to an ability or capacity that is not necessarily included as a type of awareness—the capacity to have *feelings*, to have *emotions* and to have *moods*—usually referred to collectively as *affective states* in psychological and animal welfare research [76].

5.1. Animal Welfare Science and Affective States

The second conceptual framework of animal welfare is that of affective states [76]. That is, *"the welfare of an animal derives from its capacity for affective experiences"* [76,77], and so, the overall welfare state of an animal will likely be negative when the predominant affective experiences of the animal are negative or aversive, or positive if the predominant affective experiences are likewise positive or pleasant [76]. The *"subjective experience of life,"* however, is always a mix of positive and negative affective experiences, and a life devoid of any negative experiences may be "boring" or unfulfilling [26,76]. There is some discrepancy as to which term attends to which components of the experience of feelings, emotions and moods [5] (pp. 57–58). Each have been used both to describe one another interchangeably, or as distinct entities when attempting to describe the holistic picture of all of the "emotional" components of the experience of "feelings." The length of time that they are present within the animal is another discrepancy amongst usage of the terms. Even when trying to describe the separateness of these terms, it is difficult not to use the same words circularly to express the meaning of each other word. Here, it shall simply be said that feelings, emotions and mood are all inter-linked: they may be components of each other, some may be necessary to elicit others and all may be measured in both subjective and objective ways. The other statement made here is that, after decades of innovative and ground-breaking research, we can definitively state that some non-human animals, especially vertebrates, have the relevant capacities to experience feelings, emotions and moods, and these will all affect their behaviours and mental states [2,26,27,76]. The term "affective state" when used to describe phenomena in non-human animals largely refers to "mood" [5] (p. 59), but recently has also been utilised to replace the terms "emotion" and "feeling" in animal science. It is quite possibly much easier to sell the term "affective state" to sceptics as an objective, empirical scientific measurement than it has been to publish terms such as animal "emotions," "feelings" or *"personality."* Affective states, like moods, are usually conceptualised as long-

lasting, they can have multiple effects on an animal's physiological functioning and behaviour, and the *valence* (positive/negative) and *intensity* (weak/strong) of these affective states have profound impacts on their subjective experience of life (if they are conscious and aware) [45,78]. Previous experience of affective states can lead to anticipation of future states as well, and current or past affective states can influence attention and judgement biases and decision-making in animals [45].

The majority of early animal affective state research, in regards to political declarations of what harms humans (intentionally or unintentionally) do to animals, focused primarily on non-human animals' capacities to feel fear or distress (as these are closely aligned with the sensation of pain), and whether our actions upon them would lead to suffering, which could be objectively measured through biological and physiological examinations, and later, objective behavioural observations [5,76,79,80]. Many of these pioneering researchers logically posited that: if an animal can *suffer*, it is probably *sentient*; and if it is *sentient*, then we have many more moral and ethical obligations towards them, pertaining to how we treat them and how we use them. Philosophers at least as far back as Jeremy Bentham [81] have singled out suffering as one of the base universal indicators for where moral consideration might (and should) begin, and that alone is sufficient reason for us to treat them in a considerate manner (i.e., not make them suffer unnecessarily). Others, however, would argue that suffering alone is insufficient evidence for sentience, but suffering is indeed one of the many capacities that a sentient animal possesses [2,5] (pp. 59–60). While initial investigations of animal affective states primarily focused on negative states (such as fear and distress), it is now widely acknowledged that animals have many capacities for positive states and experiences, which can dramatically enhance well-being and welfare [26,27,45,50,76].

6. Why Does Reptile Sentience Matter?

An animal's capacity to have affective states is (scientifically) the convincing factor in the

attribution and recognition of the label of sentient [4,8], and while most declarations of animal sentience now include "*all vertebrate animals*" [4], in legislation, policy and intellectual discussions surrounding sentient animal protection, non-avian reptiles are often accidentally overlooked (or sometimes deliberately dismissed) [8]. Many robust codes do now *explicitly* state "animal" to include *all* relevant types (that have been given moral consideration so far), such as the "Australian code for the care and use of animals for scientific purposes" [75]: "*Animal: any live non-human vertebrate (that is, fish, amphibians, reptiles, birds and mammals, encompassing domestic animals, purpose-bred animals, livestock, wildlife) and cephalopods.*" However, many policies and codes around the world may still neglect to explicitly mention classes like reptiles and amphibians [13]. Long-standing popular beliefs of "behavioural sedentarism" and "lack of brain complexity" in reptiles, when compared to mammals and birds, are exaggerated and inaccurate [8], but, because of these beliefs, many current standards for reptile housing and enrichments are less than ideal for promoting optimal, positive welfare states [8,82,83]. In fact, many current standards for pet reptile keeping, and for private or public museums or zoological collections, may be inadequate – many probably causing prolonged frustration, distress and suffering in these animals [8,82,84]. Adding to this is the dilemma of "*folklore husbandry*" – a belief system that is based on "*typically unscientific, often anecdotal information communicated via keeper-to-keeper, hobbyist forums and magazines, trade and amateur herpetological groups, and 'care sheets' developed by vested interests*" [84], and, worryingly, "*scientific evidence and high-level objective data and opinion are frequently overlooked, disfavored, or disregarded by commercial and private snake keepers where it is inconsistent with folklore husbandry*" [84]. For instance, it is very common practice to keep many snake species in quite barren boxes or plastic tub "enclosures" (often with multiple tubs stacked on racks), with just a heat lamp, a clean water source, a sloughing aid (a rough-surfaced object of any size) and "easily-cleaned" plastic or paper-lined flooring [84,85]. Often these enclosures are of such small sizes that the snake cannot extend its full body length

without "lining" its body along the inner walls of the box – leading to quite severe musculo-skeletal problems in many cases, and negative affective states [84]. These inadequate enclosures still fall under the acceptable standards outlined in many UK, USA and Australian codes for keeping of reptiles [84]. For example, the "Victorian Code of Practice for the Welfare of Animals – Private Keeping of Reptiles" states that the minimum requirement for a terrestrial snake enclosure, with two individuals, only has to be 40% of the length of the longest specimen in box length and width dimensions [85]. Auditing, enforcement and prosecution of violations of appropriate codes and standards for reptile keeping (in regions where these codes do exist) may be lax or non-existent [13], and likewise, criminal penalties and sentences laid for illegal reptile collection and trafficking out of Australia often result in minimal, non-detering punishments being imposed [86].

Some new research does still support the idea of behavioural sedentarism in at least some species of amphibians, which are classified as taxonomically similar to reptiles. Balázs, Lewarne and Herczeg [87] reported that in a capture-mark-recapture study conducted over 8 years, the long-living (estimated 100+ year lifespan), underwater-cave-dwelling, salamander-like olm (*Proteus anguinus*), were extremely sedentary, with one of the 27 studied individuals reportedly not moving position for 2,569 days. However, individuals were only observed every 100 days or longer, and the study was not designed to detect daily movement or behaviours, but rather was to understand site or "home-range" fidelity, which was extremely high for all individuals studied over the 8 year period. In laboratory studies with olms, it has been shown that they are able to recognise their own scent-marked substrates and discriminate these from the scent-markings of conspecifics, even after various relocations of the substrate, and have been observed performing gregarious behaviour when placed in unfamiliar environments, possibly attributed to group anti-predatory or fear-alleviating behaviour in these novel environments (as reported by [87]). Therefore, even these solitary, sedentary amphibians show signs of conscious behaviour and cognitive

awareness (possibly even self-awareness, as they are able to discriminate between self and others). But would this creature meet all of the required criteria to be deemed sentient? The next sections will specifically describe the conclusions of experimentation specifically completed with non-avian reptiles that shows evidence of fulfilment of the sentience criteria of Mellor [4] and Broom [5].

7. Evidence for Reptile Awareness and Sentience

7.1. Cognitive Evidence

Many elements of cognition are involved in the processes of awareness displayed by sentient animals. Therefore, studies into reptile learning and cognition will be described herein, as they are considered inherently linked to sentience, although another recent literature review of reptile sentience research [8] has excluded such research into reptile cognition. A few review chapters of reptile cognition from last decade have each shown evidence for a multitude of cognitive capacities in reptiles previously not afforded to them [83,88,89]. Weiss and Wilson [90] have described successful classical and operant conditioning of Aldabran giant tortoises to approach targets, hold steady and then stretch and hold their necks out for (marginally painful) venepuncture procedures. Successful operant training was again shown in Aldabran giant tortoises in a 2019 study by Gutnick, Weissenbacher and Kuba [91]. As outlined in sections above, successfully training/conditioning an animal is contingent upon them having some kinds of complex awareness, and hence, some level of sentience. Other successful reptile training has been published relating to a sea turtle [92]; in Florida, red-bellied cooters (turtles) [93]; a pet Leopard tortoise [94]; wild Burmese pythons [95]; and many skink and lizard species [88,96–98]. Reptile training is very commonly undertaken in a variety of captive settings, such as in zoos or with privately-owned pets, but it is not usually systematically recorded nor published in academic journals. Therefore actual prevalence rates of reptile training or

attempted reptile training are largely unknown, though it can be assumed to be considerably common [82,84].

Learning and memory may be very important cognitive capacities tied to sentience. It has been posited that the experience of emotions during formation of particular memories help an animal (or human) to remember vividly and meaningfully, and remember accurately for a longer time than memories processed without an emotional attachment [99]. Learning from past experiences and from memory are a substantial component of conditioning and training, and also very important for spatial cognition and navigation (and remembering your surroundings). Many studies with many species of reptiles, especially *Squamata* (skinks and lizards), have investigated spatial cognition and reversal learning, with varying, but mostly successful results [88,97,98,100–108]. Often the final objective of these studies is to assess these reptiles' cognitive and behavioural plasticity or flexibility [88,100,109]. Qi *et al.* [98] have reported that some reptile species may be proficient at "*domain general learning*" as opposed to "*domain specific learning*." That is, reptile species may be proficient at a variety of cognitive tasks, rather than just an expected set of specific survival-linked cognitive tasks from one "cognitive domain." "Domain general learning" would mean that those reptiles that possess it probably have an increased degree of cognitive plasticity, and show flexibility in applying specific learning to a number of untrained novel circumstances. "Domain general learning," evolutionarily, can be more adaptive for animals that live in complex, changing environments, but it is also more energetically "costly" [98]. In contrast, most reptiles are solitary or semi-solitary, and being ectotherms they rely on more consistent, warm environments to function optimally [82,110]. Therefore, for reptiles to possess "domain general learning" does not necessarily follow the expected trend for their evolutionary life-history and expected cognitive requirements for their immediate environment, and the reasons for this generalised learning probably relate to more complex internal processes or experiences that have not been uncovered or quantified yet. However, in the Qi *et al.* study

with semi-solitary Australian eastern water skinks (*Eulamprus quoyii*), individual results between "domain-general" or "domain-specific" learning were mixed, and were possibly attributable to spatial vs. non-spatial learners [98]. They also concluded that this species displays high cognitive/behavioural flexibility across individuals, because they are competent across multiple cognitive domains and are capable of "reversal learning" (that is, "unlearning" what they have learned, and then "relearning" new information), whether spatial or non-spatial learners. Very similar results have also been reported for behavioural flexibility and reversal learning in a social-living tree skink species (*Egernia striolata*) from eastern Australia [111]. Spatial cognition, learning and awareness has also been studied in radial-arm-maze choice experiments with a few species of tortoise—red-footed tortoises [107], and very recently with Leopard tortoises (data under peer-review [112]).

Picture-object recognition is a complex cognitive process that is only fully realised by humans, and a small number of mammals and birds tested so far. It is suggested to be indicative of and controlled by "higher-order processing" in the brain—first an animal has to perceive the picture as a representation of an object, and then abstract that representation to a real-life object (e.g., a photo of food is not the food itself, but is a representation of the actual food) [113]. It stands to reason, then, that this higher-order processing is concomitant with many other abilities of awareness and consciousness, and, just like learning and memory, it is probably processed with an emotional or affective component. Fagot *et al.* [114] have proposed three distinct types of picture perception in animals, with increasing levels of cognitive processing: independence, confusion and equivalence. Independence processing is failing to recognise that a picture represents a real-life object in any way, but objects in photos may be discriminated through processing combinations of features or patterns. Confusion processing entails confusing a photographic representation of an object with the real-life object. Equivalence processing refers to the ability to perceive that a photo is a representation of a real-life object, but it is not the actual object itself. Very few non-human mammals and

birds have been shown to have representational equivalence processing, with even gorillas and baboons often confusing photographic representations of objects for the actual real-life object (i.e., confusion representational processing state [115]). Wilkinson *et al.* [116] investigated picture-object recognition in red-footed tortoises (*Geochelone carbonaria*), one of the first ever investigations into reptile photographic processing. They conducted two step-wise experiments with red-footed tortoises (the same individual tortoises from other social learning experiments by Wilkinson *et al.* [117]) to investigate whether they show representational insight of photographs of food (i.e., that a photograph of food was a representation of real-life food). The result of the first experiment, which replaced learned food stimuli with photographs of that food, found that the tortoises would all approach the correct photograph of food, suggesting that they were able to at least recognise a static photo as a representation of desired food. The second experiment sought to clarify whether the same tortoises were actually perceiving the photograph as a *representation* of the real-life object, or mistaking it for the object itself. The results of the second experiment showed that the tortoises were mistaking the photograph for the actual real-life object, suggesting the tortoises, just like gorillas and baboons, were in a confusion representational processing state. These results suggest that some reptile species can perform at least as well as "higher-order" primate species, and provide evidence that confusion representational processing states are common across the animal kingdom.

Social learning and co-operative behaviours are quite common in social-living species [34,35,72], and are often used as evidence for the "social-brain hypothesis" and for cognitive and emotional complexity in these social-living species. However, there are many examples of solitary, non-social and semi-social animals also learning from each other, and co-operating to achieve tasks or rewarding outcomes [34,35,117-119]. There are also some examples of altruistic pro-social behaviours between members of non-social species, or even between animals of completely different species (even classes), both domesticated and

wildlife, which do not follow expected behavioural patterns for the "survival of the fittest" evolutionary hypothesis in non-social species [118,119]. As far back as 1949, co-operative behaviours were observed and reported in 14 group-housed giant tortoises in a zoo, even though these animals are typically solitary beings [120]. Wilkinson *et al.* [117] investigated social learning in non-social red-footed tortoises (*Geochelone carbonaria*). These tortoises (like most tortoise species) are completely precocial after hatching from unguarded egg clutches, and do not exhibit social development in wild environments. Regardless of this, the results of the experiment found that all of the "observer" tortoises, that observed a trained "demonstrator" tortoise solve a simple detour task, were then able to solve the task themselves. None of the control group of tortoises that did not observe a demonstrator tortoise were able to solve the task through individual learning on any of the trials. What this research suggests is that social learning may actually reflect an animal's general learning ability (domain-general learning), rather than a specially-evolved social learning mechanism, which would then only be apparent in social species (social-brain hypothesis). It is also suggestive of a greater cognitive complexity in tortoise brains than previously acknowledged. These tortoises had also previously succeeded in a gaze following experiment mentioned earlier [73]. Social transmission of food acquisition behaviours and visual signalling cues have also been reported in semi-social-living red-bellied cooters [121], which indicates that these animals are aware of their conspecifics' behaviours that lead to rewarding or positive outcomes, and that imitation of the observed behaviours will usually lead to a similar rewarding outcome for themselves. These "cognitively-complex" behaviours outlined here are very good indicators for the existence of awareness in reptile species, at least to the category of "self-awareness," and possibly some features of "ToM awareness." This may further (intuitively) indicate the concomitant presence of subjective feelings and emotions in these animals. To further assess the validity of this supposition, the limited existing research into reptile affective states and personality shall be discussed next.

7.2. Affective States and Reptile Personality Research

Very few studies into non-avian reptile affective states have been conducted [8,88,89], and, of those studies conducted, many of them focused on assessing only negative affective states (such as distress [8]). For example, over-crowding can lead to behavioural expressions indicative of negative emotions such as fear, distress and anxiety in some studied reptile species, such as farmed American alligators (*Alligator mississippiensis*) and crocodiles (*Crocodylus acutus*), and increases the frequency of incidents of aggression and injurious fighting between animals that are usually quite placid towards conspecifics [82]. Affective states such as distress and anxiety have been both assumed and explored in quite a number of reptile research articles (see summary tables in [8]).

On positive affective states, some research has been conducted into play behaviour, displayed by multiple reptile species [88,89]. It is known that play behaviour can often be a response to the subjective experience of boredom [122], but it is as yet unknown whether reptiles actually have the capacity to experience boredom [88]. Play is also modulated and incited by the subjective experience of, and is the behavioural expression of, other internal feelings (affective states, such as joy or excitement [122]). A large part of play may be to facilitate social interactions in social-living species, and for young to learn how to interact with others as adults [122]. However, most reptile species (with a few exceptions) are precocial animals—they "raise" themselves and survive alone after hatching from eggs (without parental support or safety), and live solitary or semi-solitary lives in the wild. However they are often reared and housed in groups in captivity harmoniously, and they sometimes even display pro-social behaviours between conspecifics and other animals when housed together, but not when over-crowded [82]. Some of these pro-social behaviours may also be seen in wild counterparts, however, and are not necessarily unique to captivity (such as co-operative hunting and young protection in crocodilians [118]). Spontaneous play-like behaviour, directed towards inanimate objects in the absence of other animals, has been

observed and reported in an adult Nile soft-shelled turtle (*Trionyx triunguis*), and this animal spent up to 31% of its time "playing" [88]. Play behaviour has also been reported in groups of juvenile emydid turtles (*Pseudemys nelsoni*), with pre-sexual "titillation" displays performed towards conspecifics by both juvenile males and females (in a form different to the sexual courtship displays performed by adult males); and also performed towards food before ingestion, which closely matched criteria for social play (even when the behavioural target was their own food, not another animal) [88]. Play is often self-handicapping (assisting the learning of survival behaviours under duress or injury), socially-aligned, and performed in quite unique, individual ways, reminiscent of individual "personalities" [122–125].

"Animal personality," "temperament" and "behavioural syndrome" are often used interchangeably in the literature to refer to individual behavioural variation [124], and there is now a substantial volume of research which supports the attribution of labels and types of "personality" in non-human animals [123–131]. Kashon and Carlson [123] reported that in a population of wild eastern box turtles (*Terrapene carolina*), individuals that scored higher in the "boldness" personality trait (as measured by latency to re-emerge from their shell after handling or confinement) had consistently higher body temperature from more time spent basking in sunlight, and also more damage to the shell – suspected to be from more frequent predation attempts whilst basking. This result is important for advancing perceptions of "personality" traits in terrestrial ectotherms, as it suggests that bolder turtles may be less fearful of potential predators and display more risk-taking behaviours (such as basking in very exposed locations) resulting in the benefit of higher body temperature, and hence increased movement ability and fecundity [123]. Similar boldness – risk-taking – body temperature evidence has been shown in some lizard species (delicate skinks (*Lampropholis delicata*), [132]; and Namib rock agamas (*Agama planiceps*), [133]). In 2017, Waters, Bowers and Burghardt [131] compiled a book chapter of evidence for reptile personality and individuality. From their discussion, it is evident that important individual variation exists

within many populations of lizards, turtles, tortoises, snakes and crocodilians. However, as is prefaced in this section, "*The diversity in reptile behaviour, although acknowledged, was, with few exceptions, not a focus of research to the extent found with fishes, birds, and mammals. This relative degree of neglect was true whether the research focused on ethology, comparative psychology, natural history, or laboratory experimentation*" [131]. However, many researchers and workers with captive reptiles very often anecdotally describe individual "personality" differences within the animals in their care [131]. These personality differences are very often expressed in "folklore husbandry" circles as well [84]. More robust, scientific research into personality traits in non-avian reptiles is definitely warranted.

7.3. Preference Research

Preference research is often conducted when it is assumed (or has been specifically investigated) that animals can experience pleasurable states, and subsequently choose pleasurable or rewarding outcomes over neutral or aversive outcomes [76,134,135]. To have preferences, an animal must be sentient (i.e., it must be able to experience positive and negative feelings, and must be aware of these feelings) [4,26,76]. A few species of tortoises (Aldabran giant tortoises (*Aldabrachelys gigantea*); Hermann's tortoises (*Testudo hermanni*); and yellow-footed tortoises (*Chelonoidis denticulata*)) have been shown to be able to identify and prefer colours between red and yellow, which align with flowering and fruiting bodies in their environments. These three species are vastly geographically separated – Hermann's from southern Europe [136]; yellow-footed from the Amazon rainforest in Brazil [137]; and Aldabran giant tortoises from the Aldabran Atoll in the Indian Ocean [138,139], yet still show similar preferences for colours. Therefore, this may be a commonality amongst many, or all, tortoise species (to be able to visually find the most desirable food), and has been reported numerous times in the small amount of vision and preference research in reptiles [88,100,140]. Paradis and Cabanac [141] conducted a study to investigate whether a few species of *Squamata* – the brown basilisk (*Basiliscus vittatus*), the common basilisk (*Basiliscus*

basiliscus), Schneider's skink (*Eumeces schneiderii*) and the many-lined sun skink (*Eutropis multifasciata*)—showed flavour aversion learning, and concluded that these species can experience taste sensory pleasure as well as diminishment of that pleasure by aversive additive flavours [141].

Mehrkam and Dorey [142] conducted preference tests with three Galapagos giant tortoises (*Geochelone nigra*), to establish their preferences for different types of environmental enrichment—human interaction with familiar keepers, a water sprinkler enrichment or a "boomer ball" enrichment. The level of attraction or motivation to interact with certain environmental enrichments has been suggested to be positively correlated with improved welfare, as an animal may be more motivated to interact with enrichments that are more rewarding for them individually [143]. The results of the preference test found that for all three subjects, human interaction with familiar zookeepers was the most preferred enrichment, but there were individual differences recorded in the form of this interaction—two of the tortoises preferred neck rubs, and one preferred shell scrubbing. Similar independent research into the preferences of two Aldabran giant tortoises (*Aldabrachelys gigantea*) [144] found individual differences between the preferred enrichments—one tortoise highly preferred neck and shell rubs from the experimenter over food and a "boomer ball" enrichment; but the other tortoise preferred food primarily, and then the "boomer ball" enrichment, while completely avoiding the human stimulus on all trials. Both of these tortoises had been reported in preliminary observations to approach the fence line of their enclosure to "solicit" interactions from zoo visitors, at least once daily, which was a catalyst for the preference testing to be conducted [144]. The individual differences observed in this study were suggested to be possibly attributable to the anecdotal "personalities" displayed by these two individual tortoises. Further preference testing research has been conducted with a group of five Leopard tortoises (*Stigmochelys pardalis*), again resulting in highly-individual differences between preferred stimuli, suggested to be attributable to differing personality

traits [112].

8. Are Reptiles Sentient?

Of the known 10,793 species of non-avian reptile [145], Lambert *et al.* [8] found results for only 50 species in their literature review, constituting less than 1% of all known reptiles. Even when including personality and cognitive research (which was excluded from the Lambert and colleagues review), the total number of reptile species studied is likely still less than 1% of the diversity of species. However, from this substantial yet limited research, many general inferences may be concluded presently. As has been discussed in all sections above, a number of related species in each taxonomic order of non-avian reptiles (*Rhynchocephalia*; *Squamata*; *Testudines*; and *Crocodylia*) often display similar capacities, abilities and personality traits. For example, many of them show very similar preferences for colours, and closely aligned visual acuity [88,100,140]; similar domain-general learning abilities [88,97, 98,100–108]; social learning [117,121]; and evidence of individual "personalities" and preferences [112, 123,131–133,142,144]. Therefore, from the existing research into non-avian reptile sentience, we can confidently assert that sentience probably does exist within many of those species that have been studied, and cautiously assert that it does exist within the rest of those Orders of reptiles even if the particular species has not been studied. As has been discussed previously, most current declarations of animal sentience recognise *all vertebrate animals*, and hence, non-avian reptiles are automatically included. However, it is important to make the explicit statement that non-avian reptiles are sentient beings included under that umbrella (as are all fish). The evidence above has attempted to satisfy criteria for sentience as outlined by Broom [5]: that individual reptiles have some ability "(i) to evaluate the actions of others in relation to themselves and third parties; (ii) to remember some of their own actions and their consequences; (iii) to assess risks and benefits; (iv) to have some feelings; and (v) to have some degree of awareness" (p. 5). Most importantly, these capabilities mean that these reptiles can consciously experience life (including pleasure and pain), and hence their welfare probably

"matters to them" [4]. Much of the research into reptiles is currently sparse, with reptiles having received little of the attention that has been dominated by mammals thus far; however, academic interest in reptile species (and many other non-mammal species) is increasing. Hopefully, future research shall further uncover hidden talents and capacities in non-human animals that allow them greater access to "moral status," in the same way that humans have, which may further safeguard them from human exploitation.

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CHAPTER 4: EXPERIMENT #1

Assessing preferences of two zoo-housed Aldabran Giant Tortoises (*Aldabrachelys gigantea*) for three stimuli using a novel preference test

Mark James Learmonth, Sally Sherwen & Paul H. Hemsworth

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Assessing preferences of two zoo-housed Aldabran Giant Tortoises (*Aldabrachelys gigantea*) for three stimuli using a novel preference test

Mark James Learmonth¹, Sally Sherwen² and Paul H. Hemsworth¹

¹Animal Welfare Science Centre, The University of Melbourne, Parkville 3010, Victoria, Australia.

²Wildlife Conservation and Science, Zoos Victoria, Melbourne Zoo, Parkville 3052, Victoria, Australia.

Corresponding author:

Mark James Learmonth

mlearmonth@student.unimelb.edu.au

Animal Welfare Science Centre | The University of Melbourne

Parkville | VIC 3010 | Australia

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Abstract

Recent research has uncovered many complex cognitive traits and affective processes in many reptile species, such as the ability to make choices that are rewarding or pleasurable. The investigation herein was initiated after many years of anecdotal reports, and preliminary observations, that the two male Aldabran Giant Tortoises (*Aldabrachelys gigantea*), Wilbur and Little John, at Melbourne Zoo (Melbourne, Australia) would approach the fence-line of their enclosure, sometimes multiple times daily, to 'solicit' interactions from zoo visitors and/or zoo staff. Following other research with Galapagos Giant Tortoises (*Geochelone nigra*), this experiment was a novel preference test with two male Aldabran Giant Tortoises to assess their individual preferences for three stimuli: 1) Human interaction (shell and neck rubs provided using hands); 2) Food (highly-palatable carrot pieces); and 3) an 'enrichment' ball (a red

‘boomer ball’). The results found that Wilbur highly preferred human interaction and food over the ball; whereas Little John preferred food, and showed some initial interest in the ball, but did not approach the human on any of his 13 human interaction trials. These results reflect previous published findings, that human interaction is a preferred “enrichment”, but is dependent upon a multitude of other contextual factors, and is not preferred at all times by all individuals. Individual variation may be very important to understand to have greater positive effect on the welfare-related needs of each giant tortoise housed in captivity. Further research is clearly required to enhance the welfare and well-being of many types of zoo-housed reptiles.

Introduction

Currently, achieving positive welfare states for zoo-housed animals has become a top priority for well-run, ethical zoos (Gray, 2017; Mellor, *et al.* 2015). The World Association of Zoos and Aquariums (WAZA) cites conservation as zoos’ *core purpose*, and animal welfare is their *core activity* (Mellor, *et al.* 2015). Public opinion and perception of animal rights and animal welfare-related issues in zoos has increased rapidly in the last decades (Whitham & Wielebnowski, 2013), pressuring zoos worldwide to improve and justify welfare practices. To correctly identify welfare issues affecting the wellbeing of zoo-housed animals, we must consider what it is that the animals actually want, and make sure we are being honest and explicit about the way we are asking the animals to “answer” (and how we are scientifically interpreting that answer) (Franks, 2019). There are many ways to assess needs and wants of animals; preference testing has for decades been praised and criticized for its varying efficacy and implicit assumptions (Browne, *et al.* 2011; Franks, 2019; Hemsworth, *et al.* 2011; Kirkden & Pajor, 2006; Mehrkam & Dorey, 2014). Preference testing is currently considered as a good way to assess an animal’s affective state and motivations for rewarding and pleasurable stimuli (Kirkden & Pajor, 2006). Put simply, preference testing may allow us to ask an animal what it actually wants, at any given time, within a constrained group of stimuli. However, an

animal's preferences may change rapidly, or over time, depending upon other conditions, circumstances and experiences of each individual animal, or may actually be false preferences (or wrongly identified preferences) based on what we have given them or what we have not (Franks, 2019). Notwithstanding, simplistic preference testing with easily accessible options, that the animals only have to work minimally for, is considered the first step in determining whether these animals may learn and comply with these forms of training and testing at all. Acknowledging cautions and caveats, simple preference testing is still one of the best methods currently devised to attempt to ask an animal what it wants (Hemsworth, *et al.* 2015; Kirkden & Pajor, 2006).

Furthermore, there are individual differences in preferences and in behavioral expressions of affective states which may be modulated by distinct temperament traits within non-human animals. There is a burgeoning body of validated research that concludes that non-human animals (indeed even non-avian reptiles) do possess the relevant capacities for cognition and sentience, and vary considerably amongst their individual behavioral responses, to be described as having individual “temperaments” (also often referred to as individual “personality” and/or “behavioural syndromes”) (Carter, Goldizen & Tromp, 2010; Kashon & Carlson, 2018; Lambert, *et al.* 2019; Learmonth, 2020; MacKay & Haskell, 2015; Sih, Bell & Johnson, 2004; Sih, *et al.* 2012; Sih, *et al.* 2015; Vonk, Weiss & Kuczaj, 2017; Waters, Bowers & Burghardt, 2017; Wilkinson, 2015; Wolf & Weissing, 2010; 2012).

Reptile preferences

Reptilia (now *non-avian reptiles*) are very under-researched within the animal welfare, ethology, comparative psychology and zoo-animal fields (Goulart, *et al.* 2009; Hosey & Melfi, 2014), possibly due to lack of funding, lack of interest in, or lack of understanding of these classes of animals (Lambert, *et al.* 2019). Still, there is a small amount of relevant published research on turtles and tortoises, that has been conducted in zoos, other captive settings, and

the wild, which may be drawn upon here (Alba, *et al.* 2017; Gaalema & Benboe, 2008; Gerlach, *et al.* 2013; Gutnick, Weissenbacher & Kuba, 2019; Kashon & Carlson, 2018; Mehrkam & Dorey, 2014; Mueller-Paul, *et al.* 2014; Passos, *et al.* 2014; Pellitteri-Rosa, *et al.* 2010; Tetzlaff, *et al.* 2018; Weiss & Wilson, 2003; Wilkinson, *et al.* 2010; Wilkinson, *et al.* 2013; Wilkinson, 2015). Similarly, some reference books on the wild ecology of Aldabra and the Galapagos Islands may provide relevant insights into the life-history and some expected behavioural characteristics of the tortoises, i.e. behaviour that tortoises have been observed performing in the wild (Stoddart & Westoll, 1979; Pritchard, 1996). Successful operant training of an animal is contingent upon them having some kind of *awareness*, and hence, some level of *sentience* (for a review of reptile sentience see Lambert, *et al.* 2019; and Learmonth, 2020). Thus, having preferences (likes and dislikes) is contingent upon having awareness and sentience as well (Broom, 2014).

In a preference study, Mehrkam and Dorey (2014) investigated the choices of three Galapagos Giant Tortoises (*Geochelone nigra*) for different ‘environmental enrichments’ - shell scrubs or neck rubs by familiar zookeepers, a ‘boomer ball’ enrichment, or a water sprinkler. The level of attraction or motivation to interact with certain environmental enrichments has been suggested to be positively correlated with improved welfare, as an animal may be more motivated to interact with enrichments that are more rewarding for them individually (Mason, *et al.* 2007). The results of the preference test found that for all three subjects, human interaction with familiar zookeepers was the most preferred ‘enrichment’ (stimulus), but there were individual differences recorded in the form of this interaction – two of the tortoises preferred neck rubs, and one preferred shell scrubbing. The authors concluded that future research should attempt to replicate these findings and evaluate the efficacy of these preferences as enrichment strategies in other individuals of the same or similar tortoise species.

Aim

Preliminary observations of the two Aldabran giant tortoises at Melbourne Zoo, Australia revealed that the tortoises at least daily approached zoo visitors at the fence-line of their enclosure and allowed their shell and neck to be rubbed. Therefore the aim of the present study was to investigate the relative preferences of these two Aldabran giant tortoises for a highly desirable food, human interaction and a novel object. Understanding these preferences (especially if preferences exist for interaction with humans) may be used to inform future enrichment implementations for improving opportunities for positive affective experiences, and hence positive welfare states, in the tortoises (Mellor, 2015a; 2015b), as, in scientific commentaries on animal sentience and cognitive capacities, tortoises (and reptiles in general) are often excluded (Panksepp, 2012) and thus their needs for effective enrichment and positive welfare strategies are often deemed less important (Learmonth, 2020).

Materials and Methods

Study Site and Animals

This study was conducted at Melbourne Zoo, Victoria, Australia, in a Giant Tortoise enclosure. Two male Aldabran Giant Tortoises (*Aldabrachelys gigantea*) were studied in this experiment. Wilbur – estimated to be between 90 to 110 years old, was originally caught from the wild in the Seychelles in 1929, arriving at Melbourne Zoo in 1965 (gifted to MZ from the Seychelles government). Little John (LJ) – recorded as being 80 years old, was born in 1939 by a private breeder in the USA, and then transferred to Melbourne Zoo in 1995. The enclosure used in this study was first constructed in 1980, and has remained largely unchanged since that time, though some garden and fence features have been modified in the last 5 years. The perimeter of the enclosure was made of large wooden logs approximately 1.2m high. The ground area of the enclosure was 774.7m², also containing a climate-regulated (20-26°C) ‘den’

building of 29.3m². This research received approval from the Zoos Victoria Animal Ethics Committee (ZV16014). The study was conducted between December 2017 and March 2018.

Novel Preference Test

In their preference study of three Galapagos Giant Tortoises, Mehrkam and Dorey (2014) used a competitive paired-stimulus test in which the tortoises were individually introduced to a testing facility where they had the opportunity to choose one of two paired stimuli (one pair per trial) in an ABA design that tested three stimuli overall: shell scrubs or neck rubs by familiar zookeepers, a ‘boomer ball’ enrichment, or a water sprinkler. Due to concerns about human and animal safety with the giant tortoises’ size, weight (150 – 200 kg), ease of handling and mobility, the preference test conducted in the present study had no traditional walled structure commonly used in preference tests such as Y-maze or behavioural demand testing. Furthermore, this preference test was not a competitive test but a single stimulus “diversion” test, since only one stimulus was presented in each individual trial. Artificial and natural structures in the enclosure prevented the opportunity to position test stimuli on either side of each of the main pathways to study preference in a competitive paired-stimulus test. The preference test was conducted by the primary researcher in the tortoise enclosure on a few “commonly-used” tortoise walking routes around the enclosure. “Commonly-used” routes were identified through a short set of preliminary observations. This preference test was designed to assess the willingness of the giant tortoises to deviate from their intended route when presented with one of the three test stimuli – regarded as making a choice – in a series of these trials, to understand each tortoise’s relative preference for each of the three stimuli. This novel preference testing method was developed to account for all necessary aspects of safe operating procedures and practicality when conducting experimentation within the current tortoise enclosure at Melbourne Zoo.

Preference trials were conducted within a 4-h period on each study day (12:00 – 16:00h). This period had been previously identified as a higher activity period for the giant tortoises. Study days were on Tuesdays, Wednesdays and Thursdays from November – December 2017, and February – March 2018. Trials were run on a total of 12 study days, with many other planned days cancelled due to inclement weather, ‘extreme’ summer temperatures, and an end-of-year summer-break period (as visitation at the zoo and foot traffic around the tortoise enclosure are markedly increased at this time of year). Trials were only conducted on days between 15°C - 32°C, as temperatures above and below this range make it much harder for ectotherms to thermoregulate, and hence their movement and activity are significantly reduced. Optimal temperature conditions for Aldabran Giant Tortoises have been reported as between 17°C - 31°C (Highfield, 1996).

The three stimuli used for the trials were: (1) Food (carrot pieces- a high value reward); (2) Human interaction (in which the primary researcher rubbed the shell and neck); and (3) a novel object (a red ‘boomer ball’). The food reward chosen, carrot pieces, were a high-value food of a size comparable to those used during zookeeper-led target training with the tortoises. This reward was chosen to comply with the animals’ diet restrictions; because carrot is of a color known to be preferred by tortoises (orange); and because carrot was already known to be a high-value reward for these two tortoises. A highly-preferred food, as in preference tests with other animals, was hypothesized to be the ‘gold-standard’ for choice (Fraser & Nicol, 2018). A red pet-enrichment boomer ball (“Aussie Dog Enduro” boomer ball, 24cm diameter) was chosen as a novel stimulus based on prior studies which have demonstrated that tortoise species have a preference for the colors red, orange and yellow (Gaalema & Benboe, 2008; Mehrkam & Dorey, 2014; Passos, *et al.* 2014; Pellitteri-Rosa, *et al.* 2010), and it was approved for use as an enrichment item for giant tortoises by Melbourne Zoo’s veterinary team. It was intended to be an attractive item for the tortoises to investigate, but provide no obvious reward (such as food, scent or interactivity). Three diverse species of

tortoises – Aldabran Giant Tortoises (*Aldabrachelys gigantea*) (Gaalema & Benboe, 2008; Stoddart & Westoll, 1979); Hermann’s Tortoises (*Testudo hermanni*) (Pellitteri-Rosa, *et al.*, 2010); and Yellow-footed Tortoises (*Chelonoidis denticulata*) (Passos, *et al.*, 2014) – have been reported as able to identify and prefer colors between red and yellow, which align with flowering and fruiting bodies in their environments. These three species are vastly geographically separated yet they all still show similar visual acuity and the same preferences for colors. Therefore, this is considered to be a commonality amongst many, or all, tortoise species, probably to be able to find the most desirable food. This research, plus anecdotal observations from zookeepers, were instrumental for deciding what color food and enrichment stimuli were chosen for this experiment. The researcher wore blue work coveralls during all trials, as distinct from the color of the zookeepers’ uniform (khaki). Relative to zookeepers, the tortoises were unfamiliar with the researcher, although familiarity likely increased over the experimental period.

Two trials of each stimulus were planned for each study day. Therefore, a maximum of 12 trials could be conducted per day – six per tortoise. Each trial lasted 5 min. The minimum interval between successive trials for each tortoise was 5 min, to avoid testing fatigue. Not all trials were completed each study day, as trials were highly dependent on location and movement of the tortoises, and some days were abandoned due to close-to-zero movement by the tortoises over the 4 h testing period (as expected, tortoises can remain stationary for very long periods). Trials were run with one tortoise at a time, only when the two tortoises were at least 5m apart from each other, and not moving in the same direction or along the same pathway, to avoid competition or interference from the non-focal tortoise during that trial. Trials with the alternate tortoise were often conducted during the 5 min break interval for the first tortoise.

A research assistant placed a camcorder on a tripod at a suitable fence-line position to record the trial, capturing the focal animal and the researcher in a wide-angle frame. The primary

researcher delivering the trial stimulus recorded the approach and focal animal behaviour with a chest mounted GoPro Hero3 HD camera (GoPro, Inc., USA). Trials were initiated once the focal tortoise was moving along one of their commonly-used pathways and had been moving for at least 5 s without stopping. After the 5 s of tortoise movement, the researcher positioned himself directly in front of the tortoise's current route at an approximated distance of 5m, then approached the focal tortoise at approximately 1 step/s. At approximately 1m from the tortoise, the researcher stepped away perpendicular to the pathway at an angle of approximately 45° to the left or right of the tortoise and placed the test stimulus (or stood in place as the human stimulus) slightly off the tortoise's initial intended route. All distance and speed measurements were approximated judgements made by the primary researcher, and only the primary researcher delivered all trials, to maintain consistency. Stimulus placements on either the left or right for each tortoise were randomly assigned to trials and balanced *a priori*, but physical features or obstacles in the enclosure (such as sloped ground, or large rock features) sometimes changed the actual left or right placement for that specific trial. Once the test stimulus was placed, the researcher retreated to at least 5m away from the focal animal and out of their immediate line of sight, unless the stimulus was human interaction. Interactions with the non-human stimuli were recorded as commencing once the head of the tortoise was approximately 10cm from the stimulus (as this was the minimum distance that was clearly discernable from the video recordings for the smaller two stimuli). In human interaction trials, the researcher stood at the stimulus point and waited for the focal tortoise to approach. Once the tortoise had approached to approximately 30cm from the researcher's position, the researcher would crouch down and to the side of the tortoise, then initiate the stimulus interaction with the tortoise - a shell and neck rub using his hands. To comply with safe operating procedures when interacting with the ~200kg animals, the researcher would always move to the side of the tortoise (instead of crouching directly in front) before initiating any interactions. The increased "interaction threshold" distance for the human stimulus

compared to the other two stimuli (30cm as opposed to 10cm) was to ensure the safety of participants (as this was the necessary distance for the human to begin safely pivoting to the side of the tortoise).

Data Collection

Choice (to divert or not) and outcome (interaction or not) were both recorded for each trial. A choice was specifically recorded as occurring if the focal tortoise oriented towards and then diverted towards (i.e. took at least one step in the direction of) the stimulus. If the focal tortoise diverted towards the stimulus it was marked as a successful trial; if not it was marked as unsuccessful. The key time measurements taken for each trial were: latency of orientation to stimulus (head clearly oriented towards placement of stimulus at the delivery position); latency of diversion to stimulus (time between orientation to stimulus placement and the first step towards that stimulus direction); and duration of interaction with stimulus (head within 10cm of stimulus and attention directed towards stimulus, e.g. eating food). All stimulus interactions had a maximum of 60 s, after which the stimulus was removed from the area (i.e. ball, uneaten food or human stimulus), or in the case of food, less than 60 s if it had been fully consumed. Furthermore, trials were terminated before 60 s if the tortoise had moved more than 2m away from the stimulus. The stimulus was then removed and the trial was ended. During video playback, the moment that the tortoise stopped engaging with the stimulus (i.e. oriented away from the stimulus and began moving away) the timer was stopped and the interaction time measurement for that trial was recorded. Whether trials were run or abandoned before completion were also recorded. Abandonments were due to agonistic behaviors – i.e. mouth open for mock or actual bite attempts, breathing heavily (audible), tall posture and fast gait towards researcher; or due to changes in tortoise positioning in relation to enclosure obstacles and/or proximity to their conspecific. Abandoned trials were discounted from the data as they were not successful nor complete trials, so no relevant time measures were recorded.

Data Analysis

Video analysis was used to collect key measurements from each trial. Videos were analysed using a VLC media player with a timecode function (VideoLAN Organization, France). Fisher's Exact Probability tests were used to compare the proportions of successful diversion towards each stimulus for each tortoise independently, and the specific differences were identified with Bonferroni-corrected multiple comparisons. Kruskal-Wallis tests were used to compare the differences between the three stimuli for variables: latency of orientation to stimulus (aware); latency to diversion (choice); and time spent interacting with stimulus (interaction). Latency to diversion and time spent interacting were only analysed on trials where tortoises actually diverted (i.e. made a choice), not just oriented towards the stimulus. LSD multiple comparisons were conducted to identify the differences between significant Kruskal-Wallis test measures. All statistical analyses were performed using IBM SPSS Statistics Version 25.

Results

Little John

For Little John, 31 trials were conducted: 8 with stimulus Ball; 10 with Food; and 13 with Human. LJ chose (diverted towards) Ball on 63% of trials (5/8); Food on 80% of trials (8/10); and Human on 0% of trials (0/13) (Fig 1). A Fisher's Exact Probability test found significant differences between the proportional choice (diversion rate) per stimulus ($p < 0.001$). Bonferroni-corrected comparisons indicated choice for both Ball and Food were significantly higher than the choice for Human ($p < 0.001$ for both), but there was no significant difference for choice between Ball and Food ($p = 0.912$).

Kruskal-Wallis tests found that for LJ, latency of orientation towards stimulus was not significantly different between stimuli (Fig 2) (means: Human = 27.75s; Food = 13.30s; Ball = 18.16s; $p = 0.43$). The latency to diversion towards stimulus was significantly different between

stimuli (Fig 3), with diversion to Food fastest, then Ball, and Human slowest (means: Human= 60.00s (i.e. no diversion by the tortoise from the pathway); Food= 14.09s; Ball= 25.95s; $p= 0.002$). Post-hoc tests found significant differences between the comparisons Human-Food ($p < 0.001$) and Human-Ball ($p= 0.039$), but not between Food-Ball ($p= 0.265$). Time spent interacting with stimulus was significantly different between stimuli (Fig 4) with interaction with Food longest, Ball intermediate, and Human was not interacted with at all (means: Human= 0.00s; Food= 48.00s; Ball= 20.91s; $p < 0.001$). Post-hoc differences were significant for the comparisons Human-Food ($p < 0.001$) and Human-Ball ($p= 0.009$), but not between Food-Ball ($p= 0.265$).

Wilbur

For Wilbur, 35 trials were conducted: 10 with stimulus Ball; 11 with Food; and 10 with Human; plus 4 Human trials that were abandoned due to agonistic approach (data removed from analysis). Wilbur chose (diverted towards) Ball on 30% of trials (3/10); Food on 81.8% of trials (9/11); and Human on 90% of trials (9/10) (Fig 1). A Fisher's Exact Probability test found that proportional choice (diversion rate) per stimulus was significantly different ($p= 0.014$). Bonferroni-corrected comparisons found the choice for Ball to be significantly lower than Human ($p= 0.008$) and Food ($p= 0.021$); but choice for Human and for Food did not differ significantly ($p= 1.000$).

For Wilbur, latency of orientation towards stimulus was significantly different between stimuli (Fig 2), with orientation towards Human fastest, Food intermediate, and Ball slowest (means: Human= 0.05s; Food= 3.17s; Ball= 6.44s; $p < 0.001$). Post-hoc differences were significant for comparisons Human-Food and Human-Ball (both $p < 0.001$), but not for Food-Ball ($p= 0.422$). Latency to diversion towards stimulus was significantly different between stimuli (Fig 3), with diversion to human fastest, then Food, and Ball slowest (means: Human= 3.03s; Food= 13.31s; Ball= 34.48s; $p < 0.001$). Post-hoc tests found significant differences

between the comparisons Human-Food ($p= 0.020$) and Human-Ball ($p <0.001$), but not between Food-Ball ($p= 0.079$). Time spent interacting with each stimulus was significantly different between stimuli (Fig 4), with interaction with Human longest, Food intermediate, and Ball shortest (means: Human= 54.00s; Food= 49.09s; Ball= 5.64s; $p <0.001$). Post-hoc differences were significant for the comparisons Human-Ball ($p <0.001$) and Food-Ball ($p <0.001$), but not between Human-Food ($p= 0.69$).

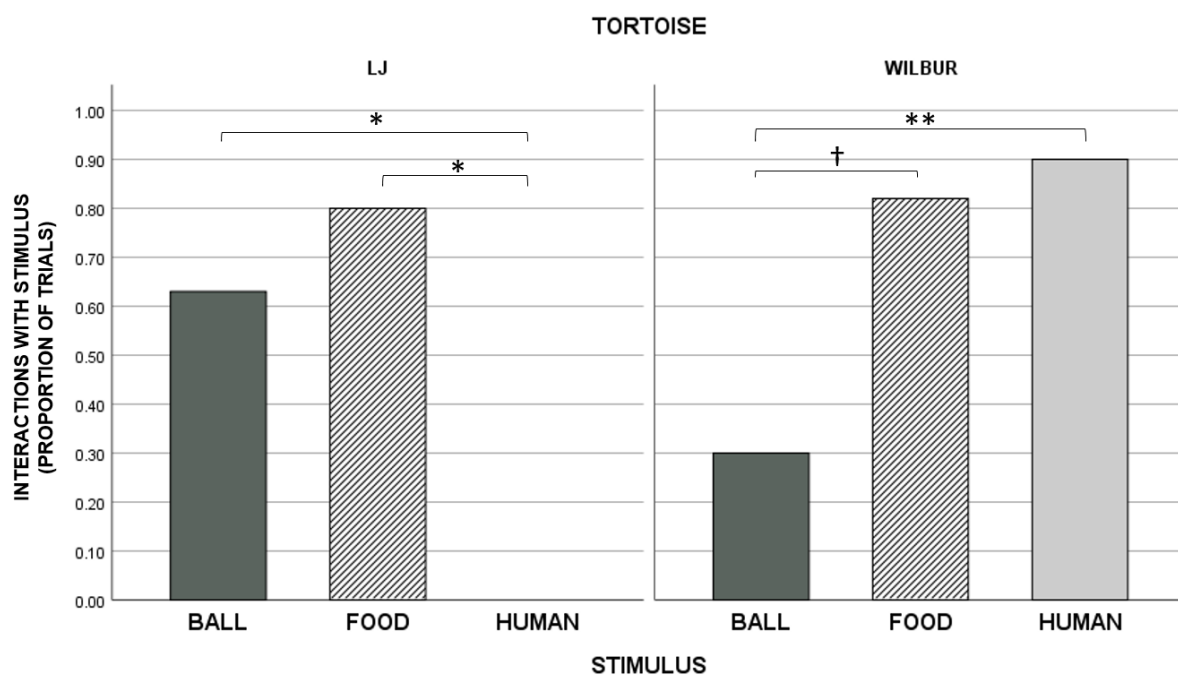


Figure 4: Proportion of successful trials per stimulus for each tortoise. Little John approached Ball and Food on a statistically similar proportion of trials ($p=0.912$), but did not approach Human on any of the trials (0%). Wilbur approached Food and Human on a statistically similar proportion of trials ($p=1.000$), and both were statistically higher than his proportion of Ball approaches. * $p<0.001$; ** $p=0.008$; † $p=0.021$.

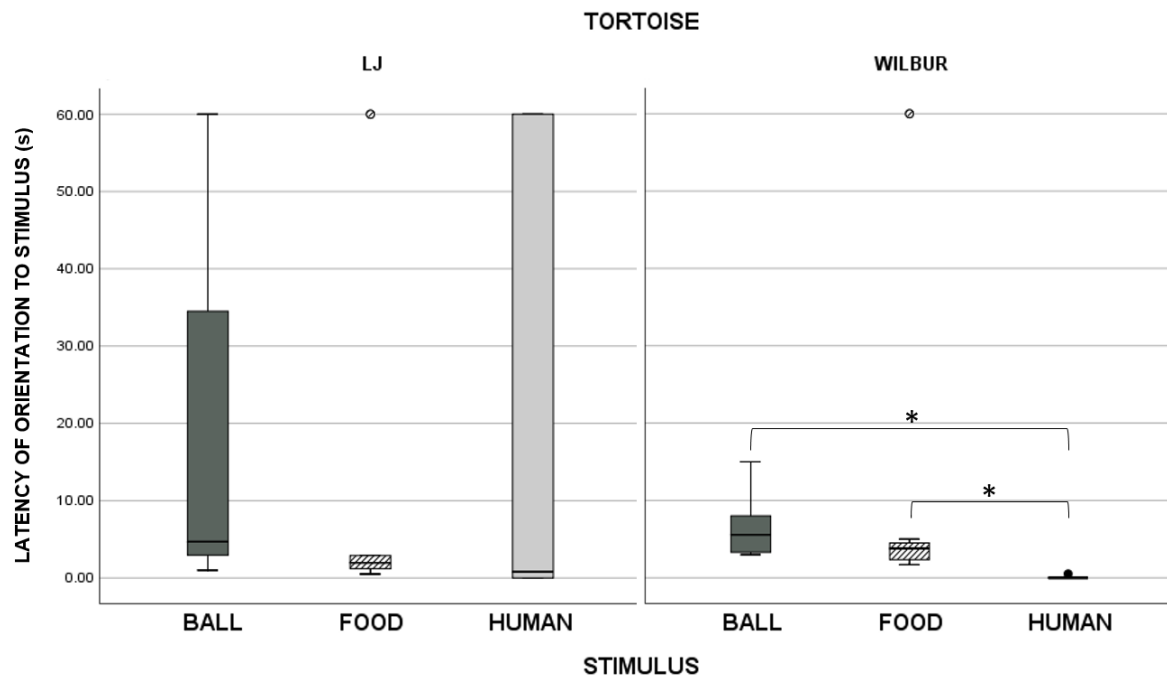


Figure 5: Differences in latency of orientation to stimuli for each giant tortoise. Horizontal lines in boxes represent medians, not means. Circles represent single outliers in the data. For Wilbur, the box for Human is a thick line at 0.00s, as the box has a median, mode and all except one data points of 0.00s (mean: 0.05s). *: For Wilbur, significant differences were found between Human and Food and Human and Ball (both $p < 0.001$). No significant differences were found between Food and Ball $p = 0.422$). Differences in orientation to stimuli for LJ were all NS ($p = 0.430$).

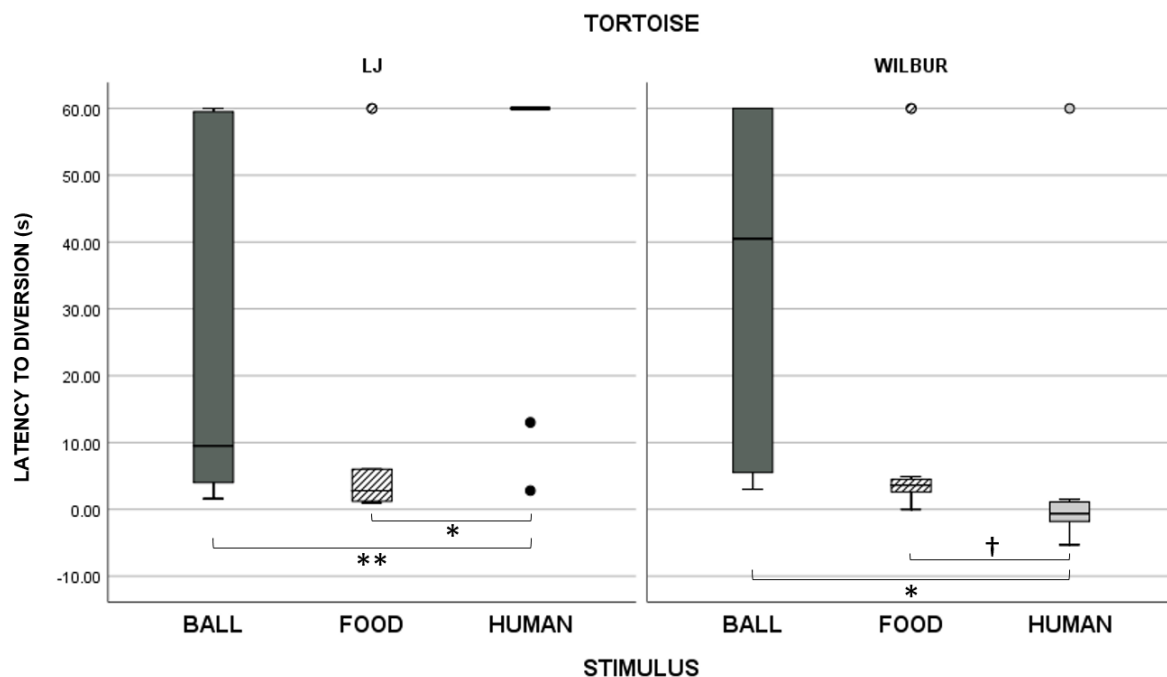


Figure 6: Differences in latency to diversion to stimuli for each giant tortoise. Horizontal lines in boxes represent medians, not means. Negative values indicate movement towards stimulus before it was at the stimulus delivery position. Circles represent single outliers in the data. For LJ, the box for Human is a thick line at 60.00s, as the box has a median and all percentiles (excluding outliers) of 60.00s. Significant multiple comparisons: * $p < 0.001$; ** $p = 0.039$; † $p = 0.020$.

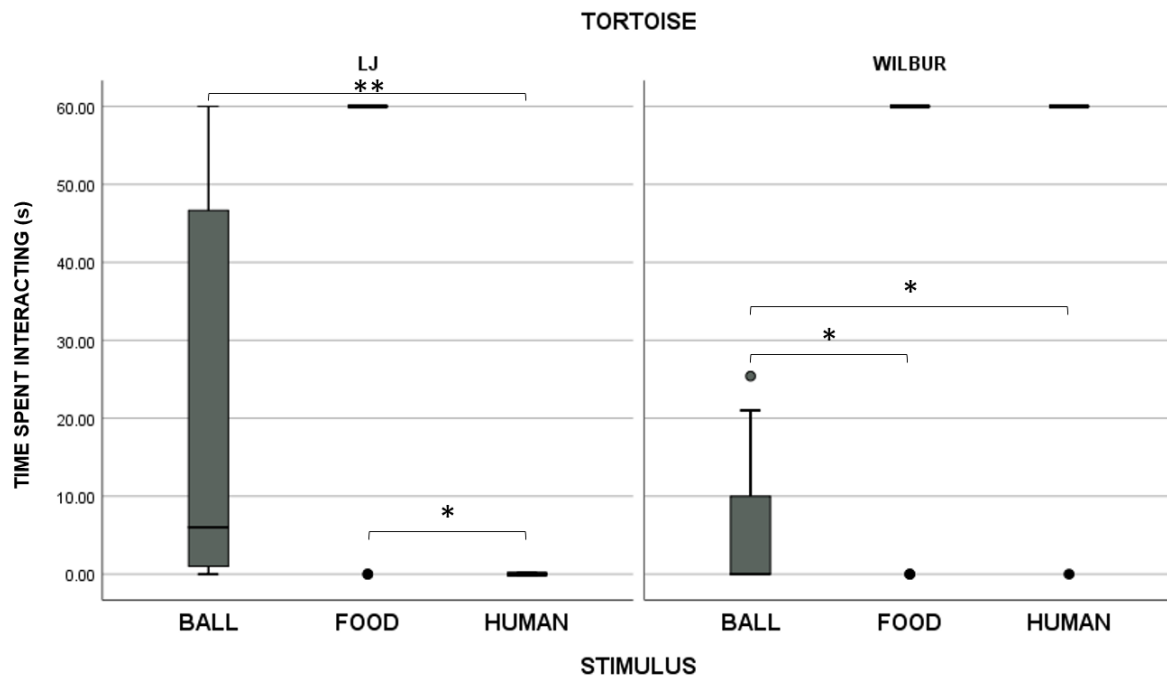


Figure 7: Differences in time spent interacting with stimuli for each giant tortoise. Horizontal lines in boxes represent medians, not means. Circles represent single outliers in the data. Thick lines at the 60.00s maximum or 0.00s minimum indicate medians and all percentiles (excluding outliers) are equal to 60.00s or 0.00s for those stimuli. Significant multiple comparisons: * $p < 0.001$; ** $p = 0.009$.

Discussion

Both giant tortoises approached and interacted with food more than the boomer ball (LJ: 80% of food trials vs 63% of ball trials; Wilbur: 82% of food trials vs 30% of ball trials). After initial inspection of the ball on the first trials, diversion latency increased towards maximum (60 s), and interaction time diminished to near zero seconds on each trial. Factors such as habituation to the stimulus, positioning of the stimulus, time of day, or weather may have affected when and where the tortoises approached and interacted with the ball or not, however it may likely have been due to general disinterest for the inert object after initial exploration (and hence it is likely the ball was an ineffective enrichment item). Wilbur interacted with food and the human stimulus for a similar amount of time, though the averaged human interaction time was slightly longer than food. Little John interacted with food on most of his trials until it was fully consumed (the maximum possible interaction), while his interaction time with the

human stimulus was zero (no interaction). The results found here are very individual specific, and cannot be generalized to a species level for Aldabran Giant Tortoises. However, Wilbur's results did reflect the findings of Mehrkam & Dorey (2014) with their group of Galapagos Giant Tortoises, in that some tortoises will select human interaction over other enrichments, possibly when they perceive that they have control over initiation of the interaction (i.e. they have a choice to interact or not).

Both tortoises oriented towards the researcher often before the researcher had reached the stimulus delivery position. This shows that both of the tortoises were *aware* of the researcher's presence. Wilbur oriented towards food faster than the enrichment ball, after the researcher had retreated from the experimental space, but Little John was equally as fast to orient towards both non-human stimuli. Wilbur oriented towards and approached the researcher on almost every trial regardless of the stimulus placed (until the researcher retreated from the immediate area); whereas Little John stopped moving on all trials, and sometimes "actively avoided" contact with the researcher (i.e. started to move in a direction away from the researcher), but then approached and interacted with the ball or ate the food once the researcher had retreated from the immediate vicinity.

Wilbur approached and interacted with the human stimulus on all but one of the human interaction trials. Little John did not interact with the human stimulus on any of the 13 human interaction trials. Before this study commenced, and also during the study, Little John was observed interacting with visitors at the fence-line in the same manner as Wilbur, indicating that perhaps Little John's perceived level of control over the timing, location and outcome of an interaction with a human was a motivating factor for his choice to not approach the human stimulus in the trials. Little John's choice to not approach or interact with the researcher may have reflected his expression of agency when the experimenter had entered the enclosure: his ability to choose when to interact with humans (and possibly the security of the perimeter fence) was lost with the close approach of the experimenter near his intended path (that is,

avoidance of the human was a way of regaining some control over his environment), whereas interacting at the fence-line was a deliberate choice directly under his control and with perceived physical separation (Mellor, 2016; Špinka & Wemelsfelder, 2018; Špinka, 2019). Conversely, Wilbur's approach towards the researcher on almost every trial may have reflected his reported temperament (from his captive life history records) as being the more dominant or "bolder" tortoise of the enclosure, moving to inspect objects or assert dominance over conspecifics and heterospecifics within his space. Or, perhaps his ability to understand the outcome of an approach would be rewarding (pleasurable shell and neck rubs) was the motivation for approaching the researcher. Four human interaction trials with Wilbur were abandoned due to agonistic approach. This response may be to assert dominance, a response to a threat or fear-provoking stimulus, or potentially to regain some control of his environment. This is a behaviour that Wilbur is known to perform towards a number of the zookeeping staff at Melbourne Zoo.

Animal agency, choice and control are now believed to be important for positive affective experiences (Franks, 2019; Meagher, 2019; Špinka and Wemelsfelder, 2011; Špinka, 2019; Weary & Robbins, 2019). Špinka (2019) defines animal agency as "*inner-motivated behavioural engagement with the environment*", which may encompass animals' choices and perceived environmental "*control*". In animal training and husbandry, the phrase *choice and control* is now commonly used, as these two responses can be practically achieved by providing animals with diverse stimulation, opportunities and environments so that they may *choose* to engage or not, and can have considerable impact upon improving welfare states (Franks, 2019; Mellor, *et al.* 2015; Mellor, 2016). Control over environment can be very hard to provide to zoo-housed captive animals, as it requires significant resources and often complete redesign of enclosures to achieve, and may not be possible to provide for every individual of a group-housed species. Choice, on the other hand, is simple and effective to provide to zoo-housed animals, and may contribute greatly to a sense of environmental control, as choice itself is a form of controlled

action that leads to a response or environmental change. The different choices made by the two giant tortoises may reflect different levels of motivation for human interaction, due to the tortoises' individual valuation of such interactions. Having a choice itself may be the motivating factor for the tortoises to interact or not, as it gives them a sense of greater control over their environment.

Variation in zoo animals' responses to humans may be the result of differences in genetics, past experiences, coping styles and/or temperaments (Hemsworth & Coleman, 2011; Keeling, *et al.* 2011; MacKay & Haskell, 2015; Maple & Purdue, 2013; Sherwen & Hemsworth, 2019). Wilbur is known by zoo staff to more readily approach humans in the tortoise enclosure than Little John (Wilbur is considered to have a more dominant or "bold" temperament). Therefore, Wilbur often chooses to interact during a "Giant Tortoise encounter" (offered to the public for a fee), much more frequently than Little John, although both tortoises are given the option to interact with the keepers and guests, and are rewarded with food upon approach. This observation was reflected in the findings here, as Wilbur approached the researcher regardless of the stimulus presented. Little John, as mentioned previously, stopped his movement and even 'actively avoided' interacting with the researcher. These differences may reflect the differing early life experiences of each tortoise, such as where they were born and reared, and their previous experiences with humans across multiple decades (and multiple human generations) may have caused the tortoises to form generalized responses to all humans (Hemsworth & Coleman, 2011), although the zoo's observational records do report the tortoises having individual preferences for some zookeepers over others.

Conclusion

Both tortoises exhibited agency and individual choices for the stimuli that they were offered during this novel preference test. Preliminary observations found that both tortoises regularly approach visitors at the enclosure boundary (daily approach by both tortoises to visitors at

the fence-line has been witnessed). It was interpreted that this is a deliberate choice for a pleasurable or rewarding outcome, and therefore it is likely a positively-rewarding, self-reinforced behaviour (Dawkins, 2008). However, when the option to interact is within their enclosure's boundary (and so in a situation where "control" over the interaction's location has been lost), Little John clearly expressed a choice to avoid interactions with the researcher, whilst Wilbur clearly chose to interact (both affiliatively, and agonistically on occasion). Non-avian reptiles remain somewhat understudied in the vertebrate welfare literature for a number of reasons, one of the most pertinent being that often there is a lack of regard for the intelligence of reptiles by the broader population, and hence the necessity of allocating resources to investigate the welfare of reptiles is questioned, by both general public and some scientists alike. This perhaps stems from the persistent idea that reptiles are not capable of complex emotion or thought, and hence lack sentience. There has, however, been a recent increase in the amount of academic interest in this class of animals, and on promoting awareness of the cognitive and emotional complexity and capabilities of reptiles (Lambert, *et al.*, 2019; Learmonth, 2020). Further research is clearly required on non-avian reptiles to uncover evidence of their abilities for agency and choice. Further research is also required to simply increase our understanding of this diverse group of long-living vertebrate beings, and improve their welfare standards and conditions in a range of captive settings.

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CHAPTER 5: EXPERIMENT #2

Assessing choice ability and preferences of five Leopard Tortoises (*Stigmochelys pardalis*) for three stimuli through a novel two-phase preference test

Mark James Learmonth, Sally Sherwen & Paul H. Hemsworth

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Assessing choice ability and preferences of five Leopard Tortoises (*Stigmochelys pardalis*) for three stimuli through a novel two-phase preference test

Mark James Learmonth¹, Sally Sherwen² and Paul H. Hemsworth¹

¹Animal Welfare Science Centre, The University of Melbourne, Parkville 3010, Victoria, Australia.

²Wildlife Conservation and Science, Zoos Victoria, Melbourne Zoo, Parkville 3052, Victoria, Australia.

Corresponding author:

Mark James Learmonth

markjameslearmonth@gmail.com

Animal Welfare Science Centre | Faculty of Veterinary and Agricultural Sciences | The University of Melbourne | Parkville | VIC 3010 | Australia.

Keywords: Reptile behaviour; animal welfare; preference testing; zoo animals; leopard tortoise

Abstract

Preference testing has long been used in ethology and animal welfare science to assess the preferences that animals have for different resources and stimuli. The study conducted herein assessed the choice-making ability of five Leopard Tortoises (*Stigmochelys pardalis*) in a novel two-phase preference test. Phase 1 was a discrete choice test in a y-maze with two options: food in one arm, the other arm left empty, with positions fixed per tortoise, but randomised across tortoises. Multivariate ANOVA were performed on three dependent variables of time taken to make a choice in both phases. In Phase 1, four of the five tortoises clearly chose the food arm more than the empty arm. One tortoise chose the food arm and empty

arm equally (50/50). Phase 2 involved opening an additional arm on the maze and offering each tortoise 3 choices: food (the same as Phase 1); human interaction (shell scratches and rubs using hands); or an empty arm. Positions were again fixed per tortoise but randomised across tortoises. In Phase, 2 tortoise choices were more varied. Two tortoises chose human interaction more than the other two maze arms; another 2 chose the food maze arm most; and 1 did not seem to show a strong preference for any particular arm. These results suggested that some individuals of this species of tortoise may possibly prefer this form of human interaction (shell scratches and rubs) over other stimuli in certain conditions, however, further research is necessary to improve the confidence of the conclusions presented herein.

Introduction

Globally, approximately 700 million visitors attend zoos annually (Gusset & Dick, 2011). Awareness of animal welfare-related issues and captive animal wellbeing have rapidly changed in the general public in the last few decades (Whitham & Wielebnowski, 2013), motivating zoos worldwide to improve many practices, to transform into ‘ethical zoos’ (Gray, 2017; Mellor, Hunt, & Gusset, 2015). However, many visitors still attend zoos purely for their own entertainment or for socialising, rather than for ethical reasons (Carr & Cohen, 2011; Gray, 2017; Reading & Miller, 2007; Tribe & Booth, 2003). Many visitors also report attending zoos to “connect” with animals (Howell, McLeod & Coleman, 2019). Animal-visitor interactions (AVIs), especially close-contact or ‘hands-on’ experiences, are often reported as a major drawcard to attend zoos, and almost all zoos regularly advertise these sorts of experiences to their potential guests (D’Cruze, *et al.*, 2019). Many animal welfare issues can arise in zoo environments (especially concerning AVIs or other human-animal interactions (HAIs)), and many solutions may involve ‘asking’ the animal what it wants (Franks, 2019), or

as some authors say, endeavouring to ‘listen’ to animals’ attempts to express agency or make choices (Špinka & Wemelsfelder, 2011; 2018; Špinka, 2019). However, the way in which we ‘ask’ animals what they want; whether we even ‘ask’ them at all; and how we interpret the animals’ ‘answers’, may all affect our decisions regarding captive animal management, for better or for worse (Franks, 2019; Špinka, 2019). One solution to the conundrum of ‘how to ask animals what they want’ may be competitive preference testing.

Preference testing is a long-standing experimental methodology used to investigate what an animal might want or value, within a limited set of options, though the efficacy and usefulness of these tests have been both praised and criticised (Browne, *et al.*, 2011; Franks, 2019; Hemsworth, *et al.*, 2011; Kirkden & Pajor, 2006; Mehrkam & Dorey, 2014). Animals’ preferences may change rapidly or over time; can be highly dependent upon other conditions, circumstances, and experiences specific to each individual animal; and concurrent preferences can conflict with each other and become incommensurate (Franks, 2019). Also, we may end up concluding false preferences based on what stimuli the animals have been given to choose between and those they have not, and simple preference testing may not actually capture the animal’s level of motivation for the particular resource (Franks, 2019; Fraser & Nicol, 2018). Despite these concerns, classical competitive-choice preference tests, such as the tests used herein, are considered a first step when initiating preference testing in a new species of animal (Fraser & Nicol, 2018). Acknowledging cautions, preference tests are still some of the best methods available for assessing animals’ preferences for a constrained set of options, and if the options are chosen well, the observed preferences may be very meaningful for an individual’s overall welfare. Understanding animals’ preferences may lead to more effective housing and enrichment strategies (that can be tailored for individual animals) in practice in zoo environments.

Non-avian reptiles, amphibians, fish and birds are very often overlooked in the published academic literature (Hosey & Melfi, 2014; Lambert, Carder & D’Cruze, 2019), with an

estimated 76% of zoo animal welfare research solely focusing on mammals, especially primates (Goulart, *et al.*, 2009; Hosey & Melfi, 2014 respectively). The experiments conducted herein focused on five Leopard tortoises (*Stigmochelys pardalis*) housed at a zoo in Melbourne, Australia. A captive husbandry manual was used for general background information about the keeping of Leopard tortoises (Highfield, 1996). Previous preference tests and operant conditioning studies, conducted in similar circumstances with other tortoise species, were used to inform the experimental design employed here (Alba, *et al.*, 2017; Gaalema & Benboe, 2008; Gutnick, Weissenbacher & Kuba, 2019; Learmonth, Sherwen & Hemsworth, 2020; Mattis, 1994; Mehrkam & Dorey, 2014; Passos, *et al.*, 2014; Tetzlaff, *et al.*, 2018; Weiss & Wilson, 2003). Understanding whether preferences for human interaction, food, or exploration exist within the studied Leopard tortoises may be used for informing and improving husbandry, enrichment and housing of this particular group of animals, who are frequently used for visitor education and engagement activities. If some animals indeed prefer human interaction, this may be an easy and effective avenue for zoos to improve both animal welfare and visitor engagement, by offering safe, interactive experiences with animals that are known to enjoy this form of enrichment.

Aim

In this study, we tested Leopard tortoises' preferences in two phases. Phase 1 investigated whether Leopard tortoises (*Stigmochelys pardalis*) were able to make a simple choice between food or nothing. Phase 2 tested the preferences of each Leopard tortoise for three stimuli – food, human interaction, or nothing. It was hypothesised that some of the tortoises may prefer human interaction even over food, depending on each individual's immediate level of hunger and taste preference for the offered food item, and other internal motivations at the time of testing.

Materials and Methods

Study Site and Animals

This study was conducted at Zoos Victoria's Werribee Open Range Zoo (WORZ; Werribee, Victoria, Australia) and was approved by the Zoos Victoria Animal Ethics Committee (ZV18003). The study subjects were five 13-year-old male Leopard tortoises hatched from the same clutch, hereafter labelled LT1 - LT5. Leopard tortoises are a medium-sized land tortoise, the second largest tortoise from mainland Africa (Highfield, 1996). The tortoise enclosure was built in and around (split indoor/outdoor enclosure) the 'Ranger Kids' classroom and child-play building at WORZ, tailored for play-learning between young children and their parents (or early-childhood teachers). 'Ranger Kids' was a climate-controlled building with a consistent temperature of 24°C, optimal for the few reptile species housed in separate enclosures around the room (the Leopard tortoises, a snake, and a few skinks). All testing was conducted indoors, adjacent to the indoor section of the tortoises' enclosure, with the maze positioned so that the 'decision arms' (arms 2, 3 and 4; see Fig. 1 below) were facing towards the glass front of the home enclosure. These five tortoises were classified as "education" animals, and were regularly handled by trained personnel for educational experiences both within and outside of their enclosure, which included regular contact with visitors in the form of shell scratches and rubs.

Testing was conducted between December 2018 and August 2019. All trials were performed on 'reduced feeding days.' Reduced feeding days consisted of small scatter feeds of lettuces and leafy greens. Fresh pawpaw (papaya) fruit segments, each approximately 3x2x2cm in size, were selected as the food stimulus for all trials. Pawpaw was considered a high-value food for the tortoises, and was a colour (orange) understood to be highly attractive to multiple tortoise species (Gaalema & Benboe, 2008; Passos, *et al.*, 2014; Pellitteri-Rosa, *et al.*, 2010; Stoddart & Westoll, 1979). Pawpaw was not a standard part of the tortoises' weekly diet; instead, it was sometimes used as a training or motivation food due to its perceived high value

by the tortoises. The nutrient and energy content of these fruit pieces were incorporated into the regular weekly diet of the tortoises and only offered during the experimental trials. Tortoises were only tested when they were awake, alert, and compliant for being handled (i.e. not 'resisting' by flattening plastron to ground to inhibit handling) and moved to the testing arena (Y-maze), following Zoos Victoria's existing protocols for animal use for "visitor encounters". Resting or sleeping individuals were not tested on that day, unless they awoke and/or became active within the testing hours. All trials in all phases were conducted with one tortoise at a time.

Y-maze construction

The experiment was conducted within a 4-arm maze structure placed on tarps on the floor in the 'Ranger Kids' building. The maze was modular, made of lightweight foamed-PVC panels with plastic guiding rails (plastic skeleton) above and below for structural integrity and was erected and dismantled on each testing day (fabrication by *Alternative Engineering*, Melbourne, Victoria, Australia). Figure 1 depicts the maze plans and a photograph of the completed structure on the floor tarps (magnetic 'doors' for each arm not visible in photograph).

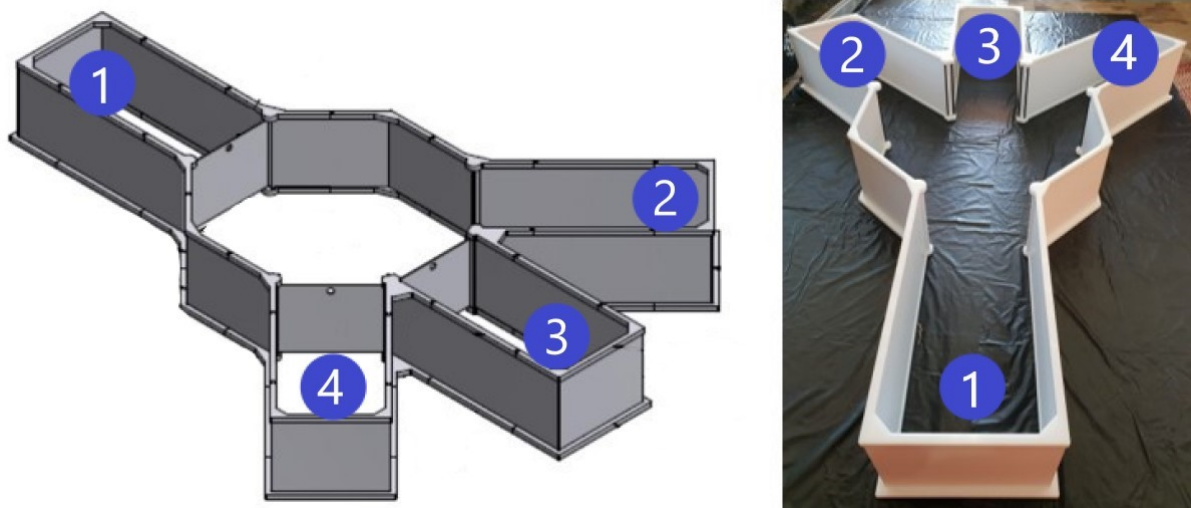


Figure 1: Design plan and photograph of foamed PVC 4-arm 'maze' used for preference tests with Leopard Tortoises. Fabrication by *Alternative Engineering*, Melbourne, Victoria, Australia.

Arm 1 was always the ‘starting chamber’ where tortoises were first placed. Tarps (that the tortoises were already familiar with) were placed underneath the maze for hygiene and ease of cleaning. Tortoises were acclimatised to the maze by placing them in arm 1 with no doors attached (as in Fig. 1 photograph) and allowed to explore for 5 min before being returned to their enclosure. Each tortoise was given four introductions to the open maze structure over two separate days (2 per day, 20 min total). Tarps and maze walls were spot-cleaned between all trials with “F10 SC Veterinary Disinfectant” solution to avoid contamination or odour residue from previous trials affecting future trial outcomes.

Preference test phase 1: Dichotomous choice

The first phase of preference testing was a simple dichotomous choice test, using only two of the three decision arms of the maze (arms 2 and 4). The choice was between an arm containing food, and one that remained empty (no stimulus). This discrete choice was designed to test the tortoises’ ability to make a choice for an obvious reward over nothing, but also to test the preference of the tortoises for the chosen food stimulus, based on latency to choice and the relative number of each choice. To assist learning, the assignment of each stimulus to an arm was fixed for each tortoise but randomised across tortoises. The assignment of stimulus sides is shown in Table 1.

Table 1. Randomised assignment of stimuli to arms for each tortoise in phase 1 and phase 2.

<i>TORTOISE</i>	<i>PHASE 1</i>		<i>PHASE 2</i>		
	Arm 2 (Left)	Arm 4 (Right)	Arm 2 (Left)	Arm 3 (Mid)	Arm 4 (Right)
<i>LT1</i>	Empty	Food	Human	Food	Empty
<i>LT2</i>	Empty	Food	Human	Empty	Food
<i>LT3</i>	Food	Empty	Food	Human	Empty
<i>LT4</i>	Food	Empty	Food	Empty	Human
<i>LT5</i>	Food	Empty	Empty	Food	Human

Training

A training period was conducted to allow tortoises to learn which arm would contain food and which arm would be empty. Each training trial consisted of two 'steps'. Tortoises were placed in the start arm (Arm 1) with the magnetic door closed. After 10 s, the door was removed allowing the tortoise to access the main chamber (decision chamber) as well as either arm 2 or arm 4 (one decision arm open per training step),. Tortoises were given 2 min to exit the start arm, as sometimes commencement of movement would be quite slow. Once the tortoise had fully entered the decision chamber, the start arm was closed with the magnetic door behind them. If they did not move from the start arm within 2 min, they were returned to their enclosure, and an extra training trial was attempted later the same day if the tortoise was still compliant. This protocol was the same for all phases and trials.

If the tortoises entered the decision chamber, they were given 1 min to explore the chamber and the open stimulus arm. If food was present, they could consume it. Once the tortoise had explored the arm or consumed the food, they were 'reset' into arm 1 again with the magnetic door closed (for step 2), and the alternate arm was then opened (i.e. if arm 2 was open first, arm 4 was then opened and arm 2 was closed). After 10 s, the tortoise was again given access to the decision chamber and to the alternate arm for 1 min or until food was consumed. After encountering each open stimulus arm (a 2-step process), the tortoise was removed from the maze and placed back in their enclosure. Two successful training trials could be conducted per tortoise per day. Each tortoise received six training trials over a period of one week (two trials per testing day). Again, this protocol was the same for all phases and trials. Based on previous research featuring training and position discrimination in tortoise species (Gutnick, et al. 2019; Mueller-Paul, et al. 2014; Passos, et al. 2014; Pellitteri-Rosa, et al. 2010; Wilkinson, et al. 2010; 2013), all five tortoises were reasonably assumed to have learned the positions of each stimulus by the end of the training period. LT3 and LT4 investigated and ate (or attempted to eat) the pawpaw on the first few training trials, but subsequently did not try to

consume the food at all in any further training or trials, indicating a moderate-to-strong ‘dislike’ of the offered food.

Choice trials

Once the training was completed, dichotomous choice trials commenced. Tortoises were placed in the start arm with the door closed. After 10 sec, the door was lifted, and tortoises could enter the decision chamber with arms 2 and 4 both open. Tortoises were given 2 min to make a decision (i.e. move beyond the threshold of one of the two open stimulus arms). Once tortoises had moved their whole body past the stimulus arm threshold, a magnetic door was placed behind them. Tortoises were given a maximum of 1 min in the chosen arm, then removed and placed back in their enclosure. Tortoises were removed from the arm before 1 min if they turned around and attempted to leave the arm by nudging or walking into the magnetic door that had closed behind them (a signal that they were choosing to try to leave the arm). Choice and latencies were still recorded for these trials. Tortoises were individually tested up to twice per day, with an interval of at least 30 min between first and second trials per tortoise to prevent testing fatigue. Each tortoise completed six to eight trials over four experimental days.

Preference test phase 2: 3-way competitive preference test

The three stimuli for the competitive preference test were labelled ‘Human Interaction’ – scratches and rubs on the shell by hands; ‘Food’ – fresh pawpaw fruit segments (the same as phase 1); and an ‘Empty’ arm. In the Human Interaction arm, the interactor was positioned kneeling at the end of the relevant arm, with hands extended just inside the maze arm, palm-side up and low to or resting on the floor.

Training

Phase 2 began with training trials as in phase 1. Stimuli positions were again randomised between tortoises, but fixed for each individual for the duration of testing (Table 1). Training

was consistent with the previous procedure – tortoises would be placed in start arm then allowed access to the decision chamber and one arm at a time. After entering and the arm, approaching the stimulus and interacting with it (including consuming the food, or receiving shell scratches and rubs from the human interactor for up to 1 min in the relevant arms), the tortoise would be immediately placed back into the start arm, then given access to the next arm (next stimulus), and so forth. Arm openings were randomised across training trials, so they did not always complete the same pattern of openings during training. Each tortoise completed at least six training trials – LT1 and LT3 completed seven. All five tortoises were again reasonably assumed to have learned the locations of each stimulus by the end of the training period.

Choice trials

Tortoises were placed in the start arm, then after 10 s were given access to the decision chamber with all three choice arms open. Tortoises were given 2 min to move from the start arm into the decision chamber, and once in the decision chamber, the start arm door was closed behind them. Once in the decision chamber, tortoises were given 2 min to make a choice, by fully entering one of the three choice arms. As long as their whole body had not entered the choice arm, tortoises were allowed to retreat and return into the decision chamber to make another choice (this was counted as inspection or exploration of certain arms, but not a full choice). When tortoises were fully past the threshold of a choice arm, a magnetic door was placed behind them, and their choice was then recorded. Tortoises were allowed up to 30 s to approach the stimulus, then given 1 min to interact with the stimulus, after which they were returned to their enclosure. On trials that the human interaction was chosen, the interactor would wait for the tortoise to approach to within 15 cm of their hands, then move their hands slowly and calmly to scratch and rub the tortoise on the shell, for up to 1 min. This process was repeated twice per day per tortoise, with a break of at least 30 min between first and second trials per tortoise to prevent testing fatigue.

Data Analysis

Video analysis was used to record key time measurements in each trial, using VLC media player with a timecode function. Key time measurements were: time spent in the decision chamber (i.e. latency to make a choice) – ‘Latency to Choice’ variable; time taken to approach stimulus (head within 10cm of stimulus) – ‘Latency to Stimulus’ variable; and the combined total of these first two variables, labelled ‘Total Choice Time’ variable. All measurements were recorded in seconds and milliseconds.

Data were analysed using IBM SPSS Statistics Version 26. Natural log and square root transformations were used to normalise the distribution of the data and the residual variances. Multivariate ANOVA were performed on transformed data, including Latency to Choice, Latency to Stimulus, and Total Choice time as dependent variables; and Tortoise, Choice, and Tortoise by Choice (the interaction term between Tortoise and Choice) as fixed factors. Non-parametric Fisher’s Exact Tests were also used on variables that violated assumptions of normality or with non-normal variance distributions even after attempted transformation.

Results

Phase 1: Dichotomous choice

In phase 1, tortoises completed at least six choice trials. Four of the five tortoises displayed a clear preference for the food arm; however, LT4 selected the food arm and the no stimulus (empty) arm 4 times each (Table 2).

Table 2. Choice behaviour per tortoise in each phase of the preference test.

TORTOISE	CHOICE (number of trials)				
	Phase 1		Phase 2		
	Food	Empty	Food	Human	Empty
LT1	7	0	9	1	0
LT2	6	1	3	5	3
LT3	7	1	4	9	0
LT4	4	4	6	2	2
LT5	8	0	7	1	6

Multivariate ANOVA (Table 3) indicated that the factor Tortoise affected Latency to Choice ($p = 0.010$) and Total Choice Time ($p = 0.002$), but there were no effects of Choice and Tortoise by Choice on these two variables (Choice: $p = 0.328$, and $p = 0.710$, respectively; Tortoise by Choice: $p = 0.103$, and $p = 0.211$, respectively). LSD pairwise comparisons showed that, for both dependent variables, LT3 was slower than all other tortoises ($p \leq 0.030$). There were no differences between each of the other 4 tortoises. Choice affected Latency to Stimulus ($p = 0.048$), but no effects of Tortoise or Tortoise by Choice on Latency to Stimulus and Total Choice time ($p = 0.406$, and $p = 0.252$, respectively). Observations indicated that LT3 and LT4 did not consume the food on any of the test trials that they chose to enter the Food arm. LT1, LT2 and LT5 consumed the entire food portion on all trials that they chose the Food arm.

Table 3. Phase 1: Effect of tortoise and choice on the three choice behaviour variables measured, latency to choice, latency to stimulus, and total choice time.

<i>Choice behaviour variable</i>	<i>Tortoise</i>					<i>Choice</i>		<i>s.e.d.</i> ¹	<i>p-value</i> ²		
	LT1	LT2	LT3	LT4	LT5	Food	Empty		Tortoise (4,29)	Choice (1,29)	Tortoise x Choice (2,29)
<i>Latency to choice (s)</i> ³	3.12^a (22.06)	3.22^a (24.05)	3.90^b (40.40)	2.98^a (19.46)	3.05^a (20.63)	3.19 (23.39)	3.48 (29.57)	0.12	0.010	0.328	0.103
<i>Latency to stimulus (s)</i> ³	2.52 (12.29)	2.40 (10.85)	2.68 (14.57)	2.39 (10.66)	2.57 (12.98)	2.61^a (13.61)	2.32^b (9.86)	0.09	0.406	0.048	0.252
<i>Total choice time (s)</i> ³	3.54^a (31.00)	3.56^a (31.65)	4.22^b (49.96)	3.39^a (27.69)	3.51^a (30.24)	3.62 (33.12)	3.76 (36.50)	0.10	0.002	0.710	0.211

¹s.e.d. denotes standard error of difference.

²*p*-values were calculated using F tests, df are presented in parentheses under each factor.

³natural logarithmic transformation and (back-transformed) means presented.

^{a,b}denote LSD post-hoc groupings (unrelated groupings across variables).

Phase 2: Competitive preference test

In phase 2, tortoises completed 10 to 14 trials. Three trials were abandoned (2 for LT3 and 1 for LT4) because the tortoises did not move from the start box within the 2-min time limit.

Multivariate ANOVA (Table 4) indicated that the factor Tortoise significantly affected Latency to Choice ($p = 0.025$) but not Latency to Stimulus ($p = 0.157$) nor Total Choice Time ($p = 0.079$). For Latency to Choice, LSD pairwise comparisons showed LT4 was faster than LT3 and LT5 ($p = 0.006$ and $p = 0.018$, respectively), but all other tortoises did not significantly differ from each other. Choice and Tortoise by Choice did not affect Latency to Choice ($p = 0.144$ and 0.260 , respectively). Choice significantly affected Latency to Stimulus ($p < 0.001$), and Total Choice Time ($p = 0.039$), however, there was also a significant Tortoise by Choice for Latency to Stimulus ($p = 0.020$). LSD comparisons for Total Choice Time indicated that the choice for Food was significantly faster than for Human ($p = 0.021$), but no other choice comparisons were significantly different. Tortoise by Choice did not affect Total Choice Time ($p = 0.206$).

A test for Simple Main Effects (the interaction effects) using Fisher's LSD for the dependent variable Latency to Stimulus indicated that the effect of Choice at the level of each Tortoise was significant for only one tortoise: LT1 chose Food faster than Human (mean difference - 20.71s, $p < 0.001$). The Simple Main Effects of Tortoise at the level of each Choice for Latency to Stimulus were: for Food - LT1 was faster to Food than LT2 (mean difference - 2.15s, $p = 0.033$); and for Human - LT1 was slower to Human than all other tortoises (mean differences - LT2: 4.92s, $p = 0.048$; LT3: 12.64s, $p = 0.002$; LT4: 7.17s, $p = 0.034$; and LT5: 8.13s, $p = 0.049$), and LT2 was slower to Human than LT3 (mean difference - 1.78s, $p = 0.021$). No other Simple Main Effect comparisons were significant ($p > 0.05$).

Table 4. Phase 2: Effect of tortoise and choice on the three choice behaviour variables measured, latency to choice, latency to stimulus, and total choice time.

<i>Choice behaviour variable</i>	<i>Tortoise</i>					<i>Choice</i>			<i>s.e.d.</i> ¹	<i>p-value</i> ²		
	LT1	LT2	LT3	LT4	LT5	Food	Human	Empty		Tortoise (4,45)	Choice (2,45)	Tortoise x Choice (6,45)
<i>Latency to choice (s)</i>	59.55^{a,b}	69.45^{a,b}	92.15^a	36.90^b	89.39^{a,b}	55.66	73.88	80.98	8.46	0.025	0.144	0.260
<i>Latency to stimulus (s)</i> ³	5.35 (28.61)	4.58 (20.98)	4.02 (16.18)	4.02 (16.14)	4.06 (16.50)	3.74^a (14.00)	5.42^b (29.35)	3.64^a (13.26)	0.22	0.157	<0.001	0.020
<i>Total choice time (s)</i> ⁴	4.36 (54.60)	4.42 (56.74)	4.55 (61.40)	3.89 (40.09)	4.50 (59.58)	4.07^a (45.34)	4.56^b (61.99)	4.35^b (54.50)	0.11	0.079	0.039	0.206

¹s.e.d. denotes standard error of difference.

²p-values were calculated using F tests, df are presented in parentheses under each factor.

³square root transformation and (back-transformed) means presented.

⁴natural logarithmic transformation and (back-transformed) means presented.

^{a,b}denote LSD post-hoc groupings (unrelated groupings across variables).

As in Phase 1, LT3 and LT4 did not consume food in any of the trials that they chose to enter the Food arm (6 and 4 respectively). LT1, LT2 and LT5 mostly consumed the food portion on each independent choice for the Food arm, though there were a few trials that it was only partially consumed for each.

Discussion

The results of Phase 1 suggest that four of the tortoises had a clear preference for food over the empty arm, although LT4 made 50% of his choices each way, and hence, his choices were possibly random (not greater than chance). There were significant differences in the latencies of the tortoises, with LT3 slower than all other tortoises to make a choice, while each of the others had similar latencies. During initial training trials, both LT3 and LT4 tasted the food stimulus (pawpaw) but showed a clear disinterest in consuming it after the training trials, and neither consumed food in any of the test trials in both phases. LT5 and LT1, on the other hand, displayed a strong preference for the food. This suggests a very clear taste preference between the tortoises. LT5 is larger than the other tortoises by both weight and shell length. Zookeepers regarded LT5 as highly food-motivated, commenting that he ate for longer periods and consumed more food than his brothers (they were fed communally). LT2 showed a moderate-to-strong taste preference for the food. There is only limited research on taste preferences in reptiles, but there is evidence that taste preferences do vary between individuals, and that they can experience sensory taste pleasure and displeasure, inferred through flavour aversion learning tests (Paradis & Cabanac, 2004). In all instances of food choice in Phase 1, LT1, LT2, and LT5 (who had a positive preference for the pawpaw) consumed all their food when the food arm was chosen.

Although LT3 was disinterested in consuming the food, he still chose the food arm on 7 out of 8 of his trials in Phase 1. There are multiple reasons why this tortoise may have chosen the non-preferred food over the empty arm, such as this tortoise having a possible side preference,

or for inspective exploration (simply to check that nothing had changed) or inquisitive exploration (in which choice for either arm would itself be rewarding) (Boissy *et al.*, 2007; Keller, *et al.*, 1994; Wood-Gush & Vestergaard, 1989). Inquisitive exploration is what is often termed ‘curiosity’ in animals, and termed ‘affective exploration’ in human psychology (Keller, *et al.*, 1994). It is akin to a ‘like’, in that it is not to discover new survival-critical information, and it is not motivated by fear nor to reduce anxiety, but instead it is its own motivator and reward – the behaviour of inquisitive exploration satisfies the animal’s curiosity, which is hedonically rewarding – and has been linked to the release of pleasure-inducing neurotransmitters and hormones in some species (Inglis *et al.*, 2001; Boissy *et al.*, 2007; Keller, *et al.*, 1994; Wood-Gush & Vestergaard, 1989).

LT4 split his trials evenly between food and empty arms, and his disinterest in consuming the food carried over successive trials. LT4 was also anecdotally considered by zookeepers and the primary observer to be ‘bolder’ than the others and more ‘curious’ – i.e. more interested in inspective and/or inquisitive exploration in most circumstances, such as when the zookeepers would take the tortoises outside to roam on grass lawns nearby their enclosure space. This inquisitive (curious) pattern of behaviour may explain LT4’s consistent choice for the empty arm across both experimental phases. It may also have been attributable to attempts to escape the maze, although behaviours indicative of escape attempts (such as climbing or pushing over maze walls) were not observed.

In Phase 2, choices were far more varied between the tortoises. However, LT1 chose food in 9 out of 10 trials, and LT3 chose human interaction in 9 out of 13 trials, indicative of a clear preference directed towards one stimulus. On average, LT1 spent almost double the amount of time in the decision chamber (Latency to Choice) when his choice was for the human interaction as compared to the food arm. A similar latency pattern for arm selection occurred for other tortoises. For LT2, the average latency to select the empty arm was almost double

that of selecting the food and human interaction arms. For LT3, the average latency to select the food arm was almost double that of selecting the human interaction arm. For LT5, the average latency to select the human interaction arm and the empty arm were almost triple and double (respectively) that of selecting the food arm. LT4, in contrast to the others, spent a comparable amount of time in the decision chamber no matter which stimulus arm ended up being chosen, and none of LT4's average latencies were over 1 min.

In human interaction choice trials, each tortoise, except LT1, moved as close as possible to the human (right to the end of the arm) and then remained motionless, some also wiggled the rear of their shells to facilitate better scratching and rubbing, possibly indicating that these four tortoises considered the shell scratching and rubbing pleasurable and positively rewarding. LT1 only chose the human interaction arm once, but was hesitant to approach the human at the end of the arm, as shown by his near maximum approach latency for that single trial. In contrast, LT2 and LT3 showed a preference for the human interaction arm and displayed both close approach and shell wiggling behaviours. Alba *et al.* (2017) found that during a cognitive training task run by zookeepers, the Eastern box turtles (*Terrapene carolina carolina*) in their study were somewhat motivated to approach and interact with the keepers during the task. This led to the keepers reporting higher degrees of “bonding” with the tortoises, and increased visitor interest and attraction to the tortoise enclosure during the ‘on-display’ training sessions. Likewise, Mehrkam & Dorey (2014) and Learmonth, Sherwen & Hemsworth (2020) found that some individual giant tortoises were similarly highly-motivated to interact with humans during preference tests. Therefore, it seems that individuals across many species of tortoise may indeed prefer human interaction in some circumstances.

The three tortoises that entered the empty arm at least once all spent longer than 30 s exploring the arm on average. This may simply be inspective exploration; however, all of the tortoises

had previously had multiple exposures to the empty arm in both phases, so perhaps it was engaging in inquisitive exploration that was interesting or rewarding to those tortoises in an internal, imperceptible way. In any preference or behavioural demand testing, variation in the choices made by animals is expected (Duncan, 1978; Hemsworth, *et al.* 2011; Franks, 2019). Inspective exploration is an evolutionary imperative that motivates an animal to keep checking whether their environment has changed, even in the absence of obvious, dramatic changes (Boissy, *et al.* 2007; Inglis, *et al.* 2001). Hence the variation in choices by the tortoises observed here may have simply reflected the need be aware of the maze environment. The exploration choices may also be attributable to high physiological satiety or low levels of hunger at times of testing for these tortoises. Perhaps the tortoises' choices for the empty arm were also to deliberately avoid human interaction, as they weren't in a positive or affiliative state or mood. These are all extraneous factors that are difficult to control that may impact immediate choices during testing. Furthermore, the immediate level of motivation to access each of the two arms may be in conflict, causing cognitive confusion for the animal, leading it to make a less preferred choice (Franks, 2019).

One of the main limitations of this current study was the extended time period that was necessary to gather sufficient choice data. This research was conducted over a nine-month period, at every available opportunity within the zoo's operating procedures and requirements. Unfortunately, as a slow-moving species, these tortoises were tested as efficiently as possible. It is suggested that future research examining tortoise preferences may be able to adjust testing periods accordingly, to be able to gather more data (i.e. conduct more choice trials).

Conclusion

This two-phase preference test attempted to determine: 1. if Leopard tortoises could make choices; and 2. if they would prefer human interaction over other stimuli. To some degree this

aim was achieved, as indeed LT2 and LT3 chose human interaction significantly more times than the other stimuli. However, more research is needed to demonstrate the efficacy of human interaction as a positive and desirable enrichment or reward for this (and other) tortoise species. Based on preference research with other tortoise species (Learmonth, Sherwen & Hemsworth, 2020; Mehrkam & Dorey, 2014), it may be cautiously concluded that some individuals of this species of tortoise may indeed enjoy and prefer this form of human interaction over other stimuli in certain conditions. These results may assist in informing future enrichment and husbandry plans for many tortoise species, such as providing regular human-animal interaction opportunities with both zookeepers and unfamiliar zoo visitors/guests, that the tortoises may choose to participate in. However animals' individual preferences must first be observed, as these results suggest that preferences were highly individual-specific, and not all tortoises were motivated to interact with a human in this experiment.

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Conflict of Interest: The authors wish to declare no conflict of interest, while the second author, Sally Sherwen, is the Director of Wildlife Conservation and Science at Zoos Victoria, the organisation that includes Melbourne Zoo as one of its properties. The authors declare that this relationship did not affect the objectivity of the research conducted.

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CHAPTER 6: EXPERIMENT #3

A survey of ethical and behavioural beliefs of zoo visitors towards human-animal interactions and non-avian reptiles.

Mark James Learmonth, Sally Sherwen, Lauren Hemsworth & Paul H. Hemsworth

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A survey of ethical and behavioural beliefs of zoo visitors towards human-animal interactions and non-avian reptiles.

Mark James Learmonth¹, Sally L. Sherwen², Lauren Hemsworth¹ and Paul H. Hemsworth¹

¹*Animal Welfare Science Centre, The University of Melbourne, Parkville 3010, Victoria, Australia.*

²*Wildlife Conservation and Science, Zoos Victoria, Melbourne Zoo, Parkville 3052, Victoria, Australia.*

Corresponding author:

Mark James Learmonth

markjameslearmonth@gmail.com

Animal Welfare Science Centre | Faculty of Veterinary and Agricultural Sciences | The University of Melbourne | Parkville | VIC 3010 | Australia

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Abstract

Understanding zoo visitor attitudes and beliefs about keeping animals in captivity are important for modern zoos. Modern zoos attempt to contribute to practical conservation, but also act as providers of conservation and environmental advocacy and education. Zoo visitors may attend zoos for many reasons, including for entertainment or leisure, for education and/or for “connection” with animals and the natural world. Previous research has shown that visitor attitudes towards human-animal interactions may be modified after receiving positive or negative information about the interactions. The present visitor survey was conducted at two zoos in Melbourne, Victoria, Australia, to investigate ethical and behavioural beliefs about housing and interacting with reptiles in zoos; and to investigate the effects of providing positive or negative-valenced human-animal interaction statements on attitudes towards interacting or owning zoo or wild animals. Principal Component Analyses were conducted on 231 visitor responses, indicating a best

solution with 5 components – “Human interaction and entertainment priority component”; “Complicated zoo ethics and animal welfare component”; “Wilding, natural living and anti-captivity sentiments component”; “Ethical duty of care component”; and “Animal agency and respect component”. An ANOVA of the extracted components found a significant effect of respondents’ education level on agreement with the “Complicated zoo ethics and animal welfare component” ($p = 0.043$). As hypothesized, positive or negative interaction statements affected respondents’ re-scores on three paired interaction questions (using Wilcoxon’s Signed Rank Tests; $p = 0.05$ to $p < 0.001$). It is suggested that future targeted questionnaires may replicate these findings, and follow-up surveys with respondents would be beneficial for understanding long-term attitude changes in zoo visitors.

Introduction

Understanding zoo visitor behaviors, their attitudes towards and beliefs about keeping animals in captivity are important for modern zoos (Moss, Jensen & Gusset, 2015; 2017a; 2017b). Multiple frameworks, developed from psychological behaviour change principles such as the theory of planned behaviour (Ajzen, 1991) and community-based social marketing (McKenzie-Mohr, 2002), have been devised to try to enhance visitor engagement with conservation messaging, such as Zoos Victoria’s successful CUA (connect-understand-act) framework (Squires, Lowry & Banks, 2016; Zoos Victoria, 2019). It has been estimated that around 700 million people visit zoos and aquariums annually worldwide, although these figures may be a conservative underestimation (Gusset & Dick, 2011; Moss, *et al.* 2014). Historically, zoos were a venue for human entertainment, primarily visited as a leisure activity (Tribe & Booth, 2003; Reading & Miller, 2007; Carr & Cohen, 2011; Gray, 2017). However, 21st Century “modern, ethical zoos” are positioning themselves as *ex-situ* and *in-situ* biodiversity conservation organizations that also promote the highest standards of welfare for the animals in their captive care (Moss & Esson, 2010; Mellor, *et al.* 2015; Gray,

2017). As reported by the World Association of Zoos and Aquariums (WAZA), conservation is zoos' core *purpose*, but animal welfare is their core *activity* (Mellor, *et al.* 2015). Many modern zoos acknowledge that they can only continue to operate under positive "social license". That is, that they have an ethical duty to remain as long as general society continues to accept their merits and relevance for conservation, advocacy and education (Sherwen, *et al.* 2018), but social license can quickly be lost. As Godinez and Fernandez (2019) write, "*it is crucial to measure the impact of zoos' education and conservation initiatives to both indicate the extent of how these organizations are fulfilling their missions [for conservation] and continue to demonstrate the importance of the role of zoos in society despite their critics*". Mellish, Ryan, Pearson & Tuckey (2019) recently evaluated the efficacy, strength and validity of research methods and reporting practices for zoo and aquarium conservation education initiatives. They reported that, out of 48 studies, many had weak-rated quantitative methods (83.3%), and the remainder were moderate-rated (16.7%). No studies were scored as strong-rated quantitative methodologies. These reported ratings were suggested to be mostly attributable to the difficulties and barriers in conducting fully randomized, controlled trials within a zoo setting, especially when targeting human beliefs, attitudes and behaviors. However, quantitative methodologies for collecting subjective visitor experiences are improving.

Modern zoos attempt to contribute to practical conservation, but also act as providers of conservation and environmental advocacy and education (Swanagan, 2000; Ballantyne, *et al.* 2007; Falk, *et al.* 2007; Randler, *et al.* 2007; Moss & Esson, 2010; Mellish, *et al.* 2019), and, many visitors do view zoos as educational destinations (Packer & Ballantyne, 2002; Briseno-Garzon, *et al.* 2007; Falk, *et al.* 2008). It has been posited that a person's preconceived perceptions and beliefs before attending a zoo will indeed modulate their desire to engage with information and learn (or not learn) more about the animals and about conservation (Clayton, *et al.* 2009; Godinez & Fernandez, 2019), and so understanding beliefs is of importance, especially when trying to change attitudes after experiences. Indeed, it is easier to promote learning, both in

adults and children, through subject matter for which the learner has a personal interest (Rennie & Johnston, 2004) or emotional affinity (Ballantyne & Packer, 2005), such as charismatic zoo animals (Moss & Esson, 2010). Many zoos offer close-contact experiences and walk-through enclosures with free-ranging animals to try to engage visitors, and provide them with “*profound experiences*” (often physical interactions) (Gray, 2017), to foster pro-environmental attitudes, and ultimately to contribute to conservation goals (Clayton, *et al.* 2009; Moss & Esson, 2010; Skibins & Powell, 2013; Sherwen, *et al.*, 2015; Sherwen & Hemsworth, 2019). Indeed, many zoo visitors report wanting to “connect” with wildlife as being a top priority for attending, but what “connecting” actually means varies between respondents (Howell, McLeod & Coleman, 2019). Globally, animal-visitor interactions (AVIs) are often advertised to increase visitation and revenue, with patting of charismatic mammalian species being the most frequently advertised experiences (D’Cruze, *et al.* 2019). While not the most highly advertised by zoos, D’Cruze *et al.* (2019) reported that close-contact experiences with non-avian reptiles were still quite common globally.

Providing Information for Attitudinal Change

Lack of information can be a strong barrier to changing attitudes and behaviors (Shultz, 2002), but providing information alone is not necessarily sufficient for long-term behavioural or attitude change (Stern, 2002). However, persuasive communication that includes a large information component is still considered to be effective for changing some attitudes in an engaged audience (Moorhouse, *et al.* 2017). In wildlife tourism research, studies suggest that “Western” tourists “*appear to accept most uses of animals, so long as they consider the animals wellbeing to be adequately cared for*” (Moorhouse, D’Cruze & Macdonald, 2017), but “Eastern” or Asian tourists’ attitudes are relatively unstudied, though are suggested to differ significantly to “Western” attitudes (Tao, *et al.* 2004; Cong, *et al.* 2014). Indeed, studies of Chinese tourist attitudes have reported a hierarchical prioritization of human experiences

over non-human animals' experiences and wellbeing (Qingming, *et al.* 2012; Suntikul, *et al.* 2016; Moorhouse, *et al.* 2017). However, many potential wildlife tourists, globally (both Eastern and Western), are in favor of preserving natural environments and respecting wildlife (Packer, *et al.* 2014; Suntikul, *et al.* 2016).

Moorhouse *et al.* (2017) performed a study aimed at assessing potential visitor attitudes to varying (positive and negative-rated) hypothetical wildlife tourism experience advertisements, and attempted to quantify attitudinal changes towards these advertisements after suggestive priming and then again after information-giving statements about each experience's true animal welfare and conservation values, to guide them to "informed decisions". They reported that English-speaking respondents who had been primed to "think ethically" were 4.1 times less likely to indicate that they would attend "bad" wildlife tourist attractions (WTAs) than non-primed English-speaking respondents; and primed Chinese-speaking respondents were 1.5 times less likely to indicate the same. Both primed groups were more likely to indicate that they would attend "good" WTAs. After the information component (ratings of WTA effects on welfare and conservation), English-speaking respondents indicated that they were 5 to 13 times less likely to attend those WTAs; and Chinese-speaking respondents indicated they were 3 to 4 times less likely to attend these WTAs.

Non-avian reptiles, amphibians, fish and birds have often been overlooked in scientific research (Hosey & Melfi, 2014; Lambert, *et al.*, 2019), with approximately 75% of research solely focused on "charismatic" mammals, especially primates (Goulart, *et al.*, 2009; Hosey & Melfi, 2014 respectively). This may be reflective of general public attitudes and opinions of 'interesting' or charismatic animals, with reptiles often being the least enticing animals for zoo visitors, and it has been measured that many zoo visitors typically spend less than 10 s viewing reptile enclosures (Marcellini & Jenssen, 1988; Alba, *et al.* 2017). However, Alba *et al.*

(2017) report that a cognitive research demonstration conducted with eastern box turtles (*Terrapene carolina carolina*) increased visitor viewing times significantly, and increased reported attention and engagement with the tortoises, as well as stronger keeper-animal “bonds” reported by those keepers who conducted the demonstrations with the animals. While many surveys have elucidated general visitor sentiments towards zoo animals, no known research has specifically focused on assessing beliefs and attitudes around the intelligence, awareness and capacities of non-avian reptiles. The present visitor survey was designed to investigate ethical beliefs and attitudes towards housing and interacting with reptiles in zoos, and examined the attitudinal change effect of providing positive or negative-valenced human-animal interaction statements about zoo-housed and wild animals.

Materials and Methods

Surveys were collected, collated and stored on the secure “Qualtrics Online Survey Platform” (Qualtrics LLC, Utah, USA). Surveys were completed at the point-of-contact through the “Qualtrics Offline Survey App” software on digital tablets running an Android OS. Offline surveys were saved locally on the device and automatically uploaded to secure online Qualtrics servers as soon as a data network connection was available. No completed survey information could be accessed directly on the tablet, only the number of surveys completed and the number still to be uploaded to online servers could be seen.

Study Sites

Zoo visitor attitude surveys were collected at two Zoos Victoria (ZV) properties – Melbourne Zoo (MZ) and Werribee Open Range Zoo (WORZ), both in Melbourne, Victoria, Australia. More collection days were scheduled at MZ than at WORZ, due to markedly higher visitation rates at MZ. The Community Conservation department of ZV approved and scheduled survey collection days with the primary researcher, and provided research assistants (RA’s)

to collect survey responses at each zoo property. RA's were dressed in a standard zoo uniform to collect surveys from visitors between 10am and 3pm on each study day.

Survey Consent

The survey required each participant to agree to a consent form, and to confirm that they were over the age of 18 years old. If respondents chose "Under 18" for the age demographic question, the survey automatically ended, the response was recorded and no further information was collected (n = 21). The questionnaire was examined and approved by The University of Melbourne's Faculty of Veterinary and Agricultural Sciences Human Ethics Advisory Group, Ethics ID 1955324.1. The title page of the survey, shown to all potential participants, was a Plain Language Statement covering the intent of the survey and the scope of data analysis and retention. Printed copies of the PLS were available to be retained by the respondents if requested. The second page was a standard introduction, researcher contact details, and the Consent Form with 8 standardized statements to consent to, as per the human research ethics guidelines of The University of Melbourne. Once respondents answered "yes" to the consent form, the survey began. If respondents answered "no" to the consent form, the survey automatically ended at that point and a "no" response was recorded, but no other information was collected (n = 1).

Questionnaire

The questionnaire was developed based on a previous zoo visitor questionnaire (Chiew, *et al.* 2019) and refined by internal focus groups with researchers from the Animal Welfare Science Centre at the University of Melbourne. The questionnaire was composed of 56 individual response items for participants, though not all questions were shown to all participants. The full questionnaire is shown in Supplementary Materials. The breakdown of the questionnaire had:

- Demographics block:
 - 8 demographics questions (including which zoo was visited); 1 question identifying the type of experience with reptiles the respondent had before taking the survey (Close Contact (CC) or Non-Close Contact (Non-CC)), with a number of different options displayed dependent upon which zoo they had attended.
- Intelligence and awareness block:
 - 1 or 2 questions (dependent upon responses) on beliefs around reptile intelligence and awareness, each rated on a customized 6-point (0: no intelligence – 5: as smart as humans) Likert scale; and 4 questions on beliefs about how tortoises perceive visitors, rated on a standard 5-point (strongly disagree – strongly agree) Likert scale.
- Attitudes block:
 - 1 response block on human attitudes towards tortoises, stratified into close contact (CC) and non-close contact (Non-CC) experience groups from the previous experience response. 13 statements rated on a 5-point (strongly disagree – strongly agree) Likert response scale, plus added “don’t know” option. 1 out of 2 possible question sets shown, based on experience group.
- Ethics block:
 - 1 response block on animal ethics and visitor beliefs, shown to all participants. 24 statements rated on 5-point (strongly disagree – strongly agree) Likert scale, plus added “don’t know” option.
- Priming block:
 - A score-rescore block of 3 paired questions, with a randomly allocated (equal groupings) set of positive or negative human-animal interaction information statements given between initial scoring and rescoring questions, i.e. 3 uninformed question responses (UR), positive or negative human interaction statements groups (PG, NG respectively), then the same 3 questions as primed responses (PR).
- Final comments:
 - The survey concluded with an optional comment box for respondents.

Data Analysis

Collated and organized data were downloaded from the Qualtrics online platform in a format compatible for analysis using IBM SPSS Statistics 26, after removing “Under 18” and “No Consent” responses from the overall dataset ($n = 22$). Principal Component Analyses were conducted to reduce the large raw dataset down to understandable common components within the responses. Pairwise exclusions were deemed acceptable in this instance and used for cases with missing data, rather than listwise exclusions (Van Ginkel, Kroonenberg, & Kiers, 2014). After finalizing the principal components, these new variables were used in multivariate ANOVA to investigate the relationships between demographic variables and component scores. Related-Samples Wilcoxon Signed Rank Tests were performed on paired ordinal response questions from the Priming block, before and after respondents received randomly allocated positive or negative human-animal interaction statements.

Results

In total 258 responses were collected. Of these, 236 were valid responses – 206 collected at MZ; 30 collected at WORZ. Five responses were deleted prior to all analyses due to near-total missing values (30 or more unanswered questions) leaving 231 analyzable responses. Before analysis, 5 questions were removed from the Attitudes Block data due to semantic differences between CC and Non-CC question sets (Appendix 1). The PCA of questionnaire items included between 172 to 228 responses per item, using pairwise exclusions for missing values in each individual item. Listwise exclusions were deemed unsuitable, as the PCA sample size was then reduced to 109 (less than half of the total responses).

Principal Component Analysis

A total of 28 questionnaire items were included in the PCA (Table 1). Cronbach’s alpha for Scale Reliability (using $\alpha \geq 0.700$ as the criterion for acceptable reliability; Pallant, 2007) was

calculated for 37 Likert-scale questionnaire items ($\alpha = 0.722$), leading to three items being excluded from the list and subsequent analyses to improve the overall reliability value ($\alpha = 0.755$) (excluded items listed in Appendix 1). Further item exclusions did not significantly improve Cronbach's alpha reliability. A further 6 items (Appendix 1) were excluded during iterative PCAs to remove factors that did not load on any components, or had loadings below 0.40 (Stevens, 2009). The Kaiser-Meyer-Olkin Measure of Sampling Adequacy performed on the final PCA extraction was deemed "middling" and acceptable to proceed (KMO = 0.709) (Kaiser, 1974), and Bartlett's Test of Sphericity was highly significant ($p < 0.001$), meeting the initial assumptions for performing a PCA on this dataset. Observation of the Eigenvalues and Scree plot (Cattell, 1965) indicated a best solution with 5 components. A Varimax rotation was performed on the 5 extracted components, and to be conservative, coefficients smaller than 0.40 were suppressed (Stevens, 2009). Loadings above 0.71 are considered excellent measures of the component; above 0.63 are very good; above 0.55 are good; and above 0.45 are fair. Loadings between 0.40 and 0.45 are considered acceptable, but erring towards poor measures of the component (Tabachnick & Fidell, 2014). The extracted components with descriptive names and individual item loadings are shown in Table 1. "Wilding" refers to the over-extension of the natural living animal welfare framework to "*treating a captive animal as though completely wild*". For an explanation of this term and its impacts on animals in zoos, see Learmonth (2019).

Table 1: Extracted components and individual item loadings (rounded to 2 decimal places). Item loadings below “Good” (0.55) are highlighted by grey text.

Extracted Component	Items	Loadings
Human interaction and entertainment priority component	Zoo animals should be treated like pets	0.73
	Humans should be allowed to interact with ALL animals in the zoo	0.72
	Zoo animals are like pets	0.68
	The tortoises don’t mind being picked up and held by people	0.62
	I believe that it is acceptable to keep ALL types of animals in zoos	0.60
	The tortoises like being scratched on the shell	0.42
Complicated zoo ethics and animal welfare component	Animals are in zoos to educate people	0.64
	Animals are in zoos to prevent them from going extinct	0.64
	The most important aspect of animal wellbeing is the animal looking happy	0.62
	The most important aspect of animal wellbeing is displaying natural behaviors	0.61
	I believe that animals can be cared for well in zoos	0.58
	Natural settings are best for animals, but some artificial elements are fine	0.50
	Zoo animals should be treated exactly the same as their species in the wild	0.47
“Wilding”, natural living and anti-captivity sentiments component	I don’t mind seeing animals in wholly artificial environments if they look happy and well cared for	0.45
	Humans should NOT interact with ANY animals in zoos	0.70
	I believe that NO animals should be in zoos	0.69
	I believe that ONLY endangered or threatened animals should be in zoos	0.65
Ethical duty of care component	Animals are in zoos for human entertainment only	0.58
	Zoo animals should be treated differently to wild animals, but not like pets either	0.66
	Zoo animals are not wild, but not pets either	0.62
	I feel a very close connection with animals I interact with	0.61
	Interacting with an animal is the best part of my day	0.60
	Humans should be allowed to interact with only SOME animals in zoos	0.55
Animal agency and respect component	I like seeing tortoises basking in the sun or under heat lamps	0.71
	I like seeing tortoises active and engaging in lots of behaviors	0.70
	I felt a sense of connection to the tortoises	0.58
	I believe tortoises CAN make choices	0.51
	I believe that ONLY animals that can thrive in captivity should be in zoos, whether endangered or not	0.43

Analysis of Variance

The 5 extracted components were entered as dependent variables into a multivariate ANOVA, with demographics questions as fixed factors. The fixed factors used were: Visitor Type (zoo member (ZM) or non-zoo member (Non-ZM)); Zoo attended (MZ or WORZ); Type of Experience (Close Contact (CC) or Non-Close Contact (Non-CC)); Age category (9 categories, from 18-20 up to 71 and over); and Education level (8 categories). Interactions between multiple fixed factors were also investigated. The results of the multivariate ANOVA (Table 2) found that the “Complicated zoo ethics and animal welfare component” was significantly affected by respondents’ Education level ($p = 0.043$). No other significant factors or interactions were found for any components, however.

Table 2: Multivariate ANOVA and LSD pairwise comparisons highlighting significant differences.

Component	Factor	F-value (df)	Sig.
Complicated zoo ethics and animal welfare component	Education	2.57 (5,123)	0.043

LSD Pairwise Comparisons	Education level	mean difference	s.e.d	Sig.
	Secondary School vs Post-Graduate	0.71	0.29	0.020
	TAFE vs Post-Graduate	0.62	0.29	0.042

LSD pairwise multiple comparisons (Table 2) for the “Complicated zoo ethics and animal welfare component” found that visitors with Post-Graduate level qualifications were less likely to agree with this component than visitors with Secondary School ($p = 0.020$) or TAFE qualifications ($p = 0.042$).

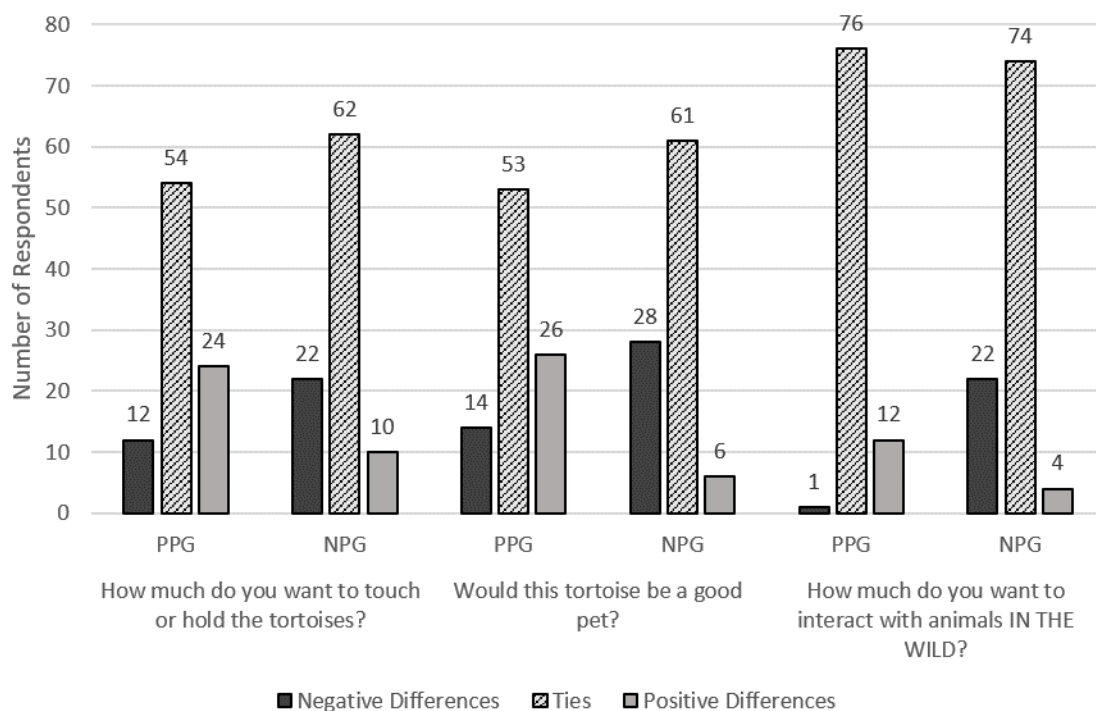
Results of Priming Information

Related-Samples Wilcoxon Signed Rank Tests were all statistically significant (Table 3). Respondents in the Negative Priming Group lowered their primed response scores compared to their unprimed scores for all 3 questions; and respondents in the Positive Priming Group raised their primed scores compared to their unprimed scores for all 3 questions. Figure 1 graphs ties and differences per question for the positive and negative priming groups (PPG; NPG).

Table 3: Wilcoxon Signed Rank Tests with Unprimed means, Primed means, and numbers of ties and differences after positive or negative priming.

Related-Samples Wilcoxon Signed Rank Tests	Unprimed Mean	Primed Mean	Ties	Positive Differences	Negative Differences	Sig.
PPG – How much do you want to touch or hold the tortoises? (n = 90)	3.1	3.3	54	24	12	0.020
NPG – How much do you want to touch or hold the tortoises? (n = 94)	3.0	2.9	62	10	22	0.015
PPG – Would this tortoise be a good pet? (n = 93)	2.7	3.1	53	26	14	0.050
NPG – Would this tortoise be a good pet? (n = 95)	2.7	2.4	61	6	28	< 0.001
PPG – How much do you want to interact with animals IN THE WILD? (n = 89)	2.8	3.0	76	12	1	0.003
NPG – How much do you want to interact with animals IN THE WILD? (n = 100)	2.8	2.6	74	4	22	< 0.001

Figure 8: Wilcoxon Signed Rank Tests for differences between respondents' initial and informed scores per question by positive priming group (PPG) or negative priming group (NPG).



Discussion

The results of this zoo visitor survey suggest several common beliefs and attitudes within this particular sample of the zoo visitor population. The first component extracted here, the “human interaction and entertainment priority component”, suggests some visitors still attend the zoo purely for entertainment or personal enjoyment and experiences, much to the chagrin of current “modern zoo” mission statements and ethical values (Carr & Cohen, 2011; Mellor, *et al.* 2015; Gray, 2017; Moss, *et al.* 2017b; Godinez & Fernandez, 2019). However, if zoos could engage and educate this subsection of visitors on-site, many perceptions may be changed towards understanding zoos’ “compassionate conservation” role in modern society (Gray, 2017; Moss, *et al.* 2017b; Godinez & Fernandez, 2019). The second, fourth and fifth components are quite similar in terms of possible underlying visitor values and core beliefs, that may be assessed and targeted for change through attitude surveys such as the one conducted here. All three of these components tend to indicate some level of understanding

of the complicated nature of zoo ethics, and of what modern zoos promote as their core values and activities (i.e. conservation and animal welfare). The second component arguably groups some contradictory statements, however, it is actually likely that respondents that rated one of these items highly would also rate the other items highly, as they all tend to engage similar ethical perceptions about the role of zoos in society and each of the statements in order offers the “next-best reason” for zoos’ existence.

The fourth component, “ethical duty of care”, may have grouped respondents that are more likely to value other “duty of care” ethical beliefs in other areas of life, such as with pets and other domesticated animals, and social or community values. The duty-of-care concept “*has currency in legal, philosophical, ethical, and general animal protection discourse*”, and has recently been conceptualized as a distinct moral motivational construct (Glanville, Hemsworth & Coleman, 2020). These types of values often align with high value of, and priority for, strong positive human-animal relationships (Glanville, *et al.* 2020). To that end, these respondents likely believe that animals in zoos should be treated as well as possible, as we have a moral duty of care towards them (since we have placed them in captivity), and that “treating them well” likely involves some human-animal interactions, that are beneficial to both carer and recipient.

The fifth component, “animal agency and respect”, has grouped questionnaire items that indicate beliefs that animals are intelligent enough to make choices and can perform a range of meaningful behaviors. The items indicate “respect for nature”-like ethical beliefs – that we should treat animals according to their *telos* (Rollin, 2012), and respect their choices to engage in behaviors that are meaningful for them. Respect for nature beliefs often coincide with beliefs that animals that do not fare well in captivity should not be housed in zoos at all, but animals that can *thrive* in captivity can be kept there ethically.

The third component, “Wilding, natural living, and anti-captivity sentiments”, is a complex ethical component, with three *prima facie* conflicting themes within the clustered questionnaire items. However, the grouped items do indeed make sense from a rational, relational ethical perspective, when again considering the “next-best reasons” for zoos’ existence. The first theme evident in the items is an anti-zoo, “no human contact with wild animals” belief type. The item “I believe that NO animals should be in zoos” is the most obvious of this theme. The strongest-loading item for this component, “Humans should NOT interact with ANY animals in zoos”, aligns with the concept of “Wilding”, or “*treating captive animals as though completely wild*” (Learmonth, 2019), and also with respect for nature and anti-captivity ethical sentiments (Rollin, 2012). The third item, “I believe that ONLY endangered or threatened animals should be in zoos”, seems to be the engagement of “next-best reason” ethical thinking, and shows that these respondents understand, at least partially, what modern zoos hope to achieve with respect to animal conservation and reducing extinction rates (Mellor, *et al.* 2015; Gray, 2017). These respondents likely understand that while they would prefer that zoos did not exist, the conservation work that they are doing is an emphatic attempt at slowing or reversing the sixth mass extinction crisis (Ceballos, *et al.* 2015). Respondents’ agreement with the final item, “animals are in zoos for human entertainment only”, at face value seems to contradict the items before it. However, it depends upon the perspective with which the question was responded to – that if respondents agreed with the statement, but did not agree with the *acceptability* of this statement, then grouping of this item with the other anti-captivity items does indeed make logical sense (i.e. animals are in captivity for human entertainment, but this is *not an acceptable reason* for keeping animals in zoos). If respondents had highly agreed with the acceptability of keeping animals for human entertainment only, this item would likely have been grouped with component 1 instead.

The “Complicated zoo ethics and animal welfare” component varied in agreement between different levels of education within our sample of respondents (Table 2), that post-graduate

educated respondents were less likely to agree with statements in this component than secondary school and TAFE educated respondents. This may be due to different levels of formal education in specific ethical or philosophical arguments, or due to the wide variety of possible TAFE and post-graduate fields/vocations. Interestingly, there were no significant differences between these reported groups and the post-doctoral and other higher education levels, indicating that “ordinally-ranked” highest-level of education was not necessarily the reason for the significant differences found here (in fact, the post-doctoral group had the highest average level of agreement with this component).

From an educational research perspective, the results of the priming component of the survey are encouraging, in that visitors alter their beliefs after being provided with relevant information about some general effects of human-animal interactions on captive and wild animals. In all paired-question sets, in both the positive information and negative information randomized groups, respondents’ changes in scores moved significantly in the hypothesized direction – that is, negative information made many respondents revise their initial ratings down upon re-rating, and *vice versa* for positive information. Interestingly, many scores also stayed the same (ties), and a few respondents re-rated items in the opposite-to-expected direction – meaning the priming effect of information did not cause those particular respondents to change their attitudes and opinions in the desired way. However, the consistent significant effect of priming for each paired question set are encouraging that a proportion of respondents did read and process the information given to them, and indeed re-rated items in a way that is ethically and logically sound with the evidence presented to them. This result confirms that information can be used as an effective tool for attitudinal change (Schultz, 2002), but the effects (and potential long-term effects) would be greater if also paired with other motivational change tools, such as priming and persuasive tools for engaging peoples’ ethical “*should selves*” over their “*want selves*” (Bazerman, *et al.* 1998; Moorhouse, *et al.* 2017). The result found here is also possibly attributable to respondents’

perception of what was being asked of them – i.e. the information components were clearly labelled positive or negative effects of interactions, and so respondents may have perceived that they were being encouraged to re-rate their answers in a particular direction. Notwithstanding, this result showed that many of the questionnaire respondents were engaged with the content, and not necessarily arbitrarily choosing responses.

While effective behavioural or attitudinal change within the short time period of engagement with zoo visitors may be difficult, it is a high priority for many modern, ethical zoos (Moss & Esson, 2010; Mellor, *et al.* 2015; Gray, 2017; Godinez & Fernandez, 2019; Howell, *et al.* 2019; Mellish, *et al.* 2019; Zoos Victoria, 2019), and is a laudable attempt at fostering pro-environmental and sustainable attitudes amongst a very broad (and large) demographic of our global population (Gusset & Dick, 2011). It is suggested that more targeted surveys to try and intimately understand visitors' pre-conceived values and beliefs before attending the zoo and the changes in attitudes visiting, and follow-up surveys to assess whether attitudinal changes were effective over time, would be beneficial for informing and developing zoos' persuasive strategies for effecting long-lasting attitude change in their visitors.

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Chapter 6: Appendix 1

List of deleted questionnaire items

Prior to analysis - Close Contact or Non-Close Contact set:

I would like to get closer to the tortoises (Non-CC);

I enjoyed being close-up to the tortoises (CC).

I would enjoy seeing the tortoises outside of their enclosure (Non-CC);

I enjoyed seeing the tortoises outside of their enclosure (CC).

I want to physically interact with the tortoises (Non-CC);

I enjoyed physically interacting with the tortoises (CC).

Touching the tortoise would make me feel good (Non-CC);

Touching the tortoise made me feel good (CC).

Touching the tortoise would make me care about it more (Non-CC);

Touching the tortoise made me care about it more (CC).

From Cronbach's Alpha for Scale Reliability:

Do you think that tortoises: Find visitors fear-provoking?

I do not like when the tortoises hide or are inactive

These tortoises are from an endangered or threatened species

During iterative PCAs:

On a scale from 0-5 how would you rate the intelligence of tortoises?

Do you think that tortoises: Are aware of visitors?

Do you think that tortoises: Find visitors interesting?

Do you think that tortoises: Are not bothered by visitors at all?

Animals in zoos should be in natural settings ONLY

Zoo animals are wild animals

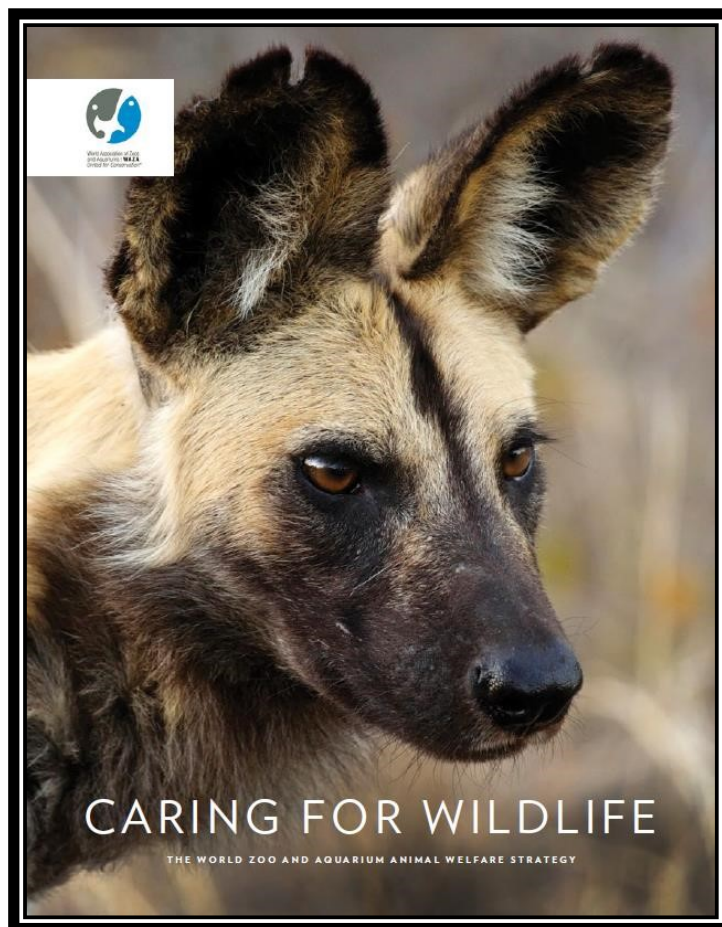
CHAPTER 7: ANIMAL ETHICS #3

Human-animal interactions in zoos: What can Compassionate Conservation, Conservation Welfare and Duty of Care tell us about the ethics of interacting, and avoiding unintended consequences?

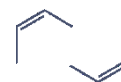
Mark James Learmonth

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(Image: WAZA Animal Welfare Strategy (2015) cover image)



Commentary

Human–Animal Interactions in Zoos: What Can Compassionate Conservation, Conservation Welfare and Duty of Care Tell Us about the Ethics of Interacting, and Avoiding Unintended Consequences?

Mark James Learmonth ^{1,*}

¹ Animal Welfare Science Centre, The University of Melbourne, Parkville 3010, Victoria, Australia;

* Correspondence: mlearmonth@student.unimelb.edu.au

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Simple Summary: This article is an examination of human–animal interactions in zoos from an ethical perspective, their benefits to both human and animal participants, and also their potential risks and ethical dilemmas. Contact with animals can be beneficial for all parties involved, and can indeed lead to pro-conservation and respect for nature behaviours being adopted by humans after so-called “profound experiences” of connecting or interacting with animals. Yet, human–animal interactions may also increase certain individuals’ desires for inappropriate wild-animal ‘pet’ ownership, and can convey a false sense of acceptability of exploiting animals for “cheap titillation”. Three ethical frameworks that may be beneficial for ethically run zoos to incorporate when considering human–animal interactions are: Compassionate Conservation, Conservation Welfare and Duty of Care. Human–animal interactions in zoos may be acceptable in many circumstances, and may be beneficial to both animal and human participants; however, they must be closely monitored through welfare tracking tools. Melding Duty of Care and the two Conservation ethical frameworks would be ideal for assessing the ethical acceptability of such interactions.

Abstract

Human–animal interactions (HAIs) in zoos can be rewarding for both humans and animals, but can also be fraught with ethical and welfare perils. Contact with animals can be beneficial for all parties involved, and can indeed lead to pro-conservation and respect for nature behaviours being adopted by humans after so-called “profound experiences” of connecting or interacting with animals. Yet, human–animal interactions may also increase certain individuals’ desires for inappropriate wild-animal ‘pet’ ownership, and can convey a false sense of acceptability of exploiting animals for “cheap titillation”. Indeed, this has been reflected in a recent research review conducted on animal–visitor interactions in zoos from a number of different countries and global regions. These are unintended consequences that “modern, ethical zoos” would try to minimise, or avoid

completely where possible, though most zoos still offer close-contact experiences with their animals. Three ethical frameworks that may be beneficial for ethically run zoos to incorporate when considering human-animal interactions are: Compassionate Conservation, Conservation Welfare and Duty of Care. These three ethical frameworks are concerned with the welfare state and outcomes for individual animals, not just the population or species. Human-animal interactions in zoos may be acceptable in many circumstances and may be beneficial to both animal and human participants; however, they must be closely monitored through welfare tracking tools. The World Association of Zoos and Aquariums (WAZA) has published guidelines for human-animal interactions that are mandatory for member institutions to adhere to, although whether these guidelines are taken as mandatory or suggestions at individual institutions is unknown. Some suggestions for relevant extensions to the guidelines are suggested herein. Melding Duty of Care and the two Conservation ethical frameworks would be ideal for assessing the ethical acceptability of such interactions as they currently occur, and for considering how they should be modified to occur (or not) into the future in zoological settings.

Keywords: human-animal interactions; animal-visitor interactions; compassionate conservation; conservation welfare; duty of care; animal ethics; zoo animals

1. Introduction

Human-animal Interactions (HAIs) are common occurrences in zoological institutions, from husbandry practices to interactions with visitors (both regulated and unregulated) [1,2]. Animal-visitor Interactions (AVIs) are often a large component of zoos' appeal to visitors, and these experiences are also a large component of zoos' operations and financial viability [1,3,4]. It has been estimated that global zoo attendance is over 700 million visitors annually [5]. Some of these zoo visitors attend purely for entertainment, and/or for direct interactions with animals (for which they are willing to pay) [4,6,7]; however, many visitors to modern zoos report considering zoos and aquaria as centres for education [8–11]. AVIs may be classified as “direct contact” (such as holding, feeding, brushing or touching experiences) or “indirect contact” (such as visually viewing, gaze-following and/or mimicking through shared enclosure windows, “scattering” food for the animals from a unique vantage point, auditory communication from traditional enclosure perimeters, or the “solving” of combined

human–animal input “puzzle walls” installed in some zoo exhibits for “cognitive enrichment” of the enclosure animals). Globally, zoos vary significantly in their offering of direct and indirect contact animal experiences, but almost all zoos surveyed in a 2019 study promoted one or more types of interaction experiences on their public websites [4]. Yet, these interactions may be at odds with many of the ethical principles upon which “modern, ethical zoos” have built their new moral foundations, and expound their virtues and “social license” [1,4,12–14], such as ensuring positive welfare of their captive animals, promoting “natural behaviours”, and being compassionate towards individuals as well as populations in their conservation efforts. This article discusses how three prominent ethical frameworks (which are often explicitly or implicitly utilised by zoos) may be used to examine and justify HAIs in zoos (examining interactions with both visitors and with zookeepers), how new guidelines for AVIs published by the World Association of Zoos and Aquariums (WAZA) [15] perform under these ethical frameworks, and whether the guidelines work in practice alongside the stated missions of some zoological associations and institutions. The three specific ethical frameworks discussed herein are: Compassionate Conservation, Conservation Welfare, and Duty of Care. These three frameworks are not mutually exclusive, although it is suggested here that a deliberate melding of elements and tenets from all three frameworks could make a robust new framework that would be of relevance to zoological institutions. Furthermore, these three frameworks are concerned with the welfare of individual animals, rather than whole populations or ecosystems as most other Conservation or Environmental ethical frameworks are. Many forms of Environmental ethics and Conservation ethics have been espoused over almost the last 100 years [16], with the collective aim of saving Earth’s last remaining wild and natural places from being paved over by human expansion/exploitation. These ethical frameworks are mostly characterised by a focus on the overall ecosystem health rather than on individual welfare outcomes [16,17]. These ethics have more recently been criticised for perpetuating the status quo of ecosystem or

population health always trumping considerations of individual animals' welfare [16] (and a lack of empathy for suffering individuals), for sidestepping problematic issues arising from our increasing knowledge of animal consciousness and sentience (and increasing knowledge of harmful anthropogenic impacts) [17], and for perpetuating the influential, anthropocentric "land ethic" attitude that species conservation is important, yet often only prioritised after human interests (especially where that land, or the animals on it, are of utility or economic benefit to humans) [18,19].

D'Cruze et al. [4] list five inter-connected goals that many modern zoos and aquaria share: 1. Conservation; 2. Education; 3. Research; 4. Animal welfare; and 5. Entertainment. While many modern facilities place major emphasis only on the first four goals, and shy away from promoting their facilities as places for human entertainment, as mentioned above, many visitors still report entertainment or leisure as their first reason for attending these places [4,6,7]. Many zoos and aquaria exist as private, for-profit enterprises, meaning a certain level of revenue is required to remain operational, and then profit is required to financially contribute to their conservation goals. WAZA report conservation as zoos' core *purpose*, but their core *activity* is animal welfare [12]. Likewise, the American Association of Zoos and Aquariums (AZA) list their mission as "*helping member institutions and animals in their care thrive, through advancing animal welfare, public engagement, and the conservation of wildlife*" [20]; and the Australasian Zoo and Aquarium Association (ZAA) list saving (conserving) wildlife by inspiring best practice in conservation and (animal) welfare with support from government and community as their strategic mission for member institutions [21]. Both of these associations detail supporting member institutions' financial and operational goals as key goals, as well as supporting and facilitating memorable visitor experiences, but they do not list "entertainment" as a key consideration in their strategic documents [20,21]. In fact, most accredited facilities oppose procuring and displaying animals for entertainment purposes, or training animals for "performances", as part of their

new “ecocentric” ethos [1,14]. It is important to note, too, that member institutions pay monetary fees and dues to continue to be members of these self-regulated associations, but the accreditation processes are independent of institutional membership. Accreditation processes with these associations are a benchmarking tool, for monitoring animal welfare standards and meaningful contributions to conservation within individual institutions [22,23]. Whilst human-animal interactions are not discouraged or banned by these associations, strict guidelines and policies around the acceptability of offering these (especially direct) interactions in accredited facilities are being written into modern documentation [13]. Here, the ethics and the welfare impacts of two types of HAIs shall be discussed: Animal-visitor Interactions; and lesser scrutinised Keeper-Animal Interactions (KAIs) and Relationships (KARs).

2. Human-Animal Interactions

HAIs have been extensively studied in the agricultural/production animal sector [24,25] and the effects of stockperson attitudes and behaviours on the behaviours and productivity of livestock have been well established, and typified in robust models, such as the Hemsworth-Coleman model [25] based on the psychological theories of reasoned action and planned behaviour [26,27]. Built upon the Hemsworth-Coleman livestock model, there are also a few models of HAIs in zoos, such as the Hosey model [28,29], and the Chiew-Hemsworth model of animal-visitor interactions (published in [30]). HAI research in zoos has steadily increased over the last few decades [14]. The results of many studies report mixed welfare effects of human interactions, from negative effects through to neutral and positive effects [4,14,31-38], and many of the results have been found to be very individual specific. Most studies of zoo HAIs to date have focused on assessing AVIs, and, so far, very few studies have assessed and quantified KAIs or KARs [32].

3. Animal–Visitor Interactions

There are now quite a few studies that have uncovered negative effects of visitor presence and interactions on captive zoo animal behaviour and welfare, especially when those interactions are in uncontrolled circumstances [4,34,37–44]. There are also many assumed detrimental (but currently unknown) effects of controlled interactions, such as in provided and promoted animal–visitor “experiences” within zoos, especially with understudied animals such as reptiles (e.g., handled snakes and lizards) [4,35,36,38]. Often, the current standards of housing conditions for these animals are also inadequate, however, and this is likely to increase or confound detrimental effects of other interactions or welfare-impacting conditions [45–47]. Although, there are also a number of studies that show that many zoo species are apparently unaffected by visitors and their behaviours, if only viewed from a distance (i.e., no direct physical interactions), and it has been supposed that these animals simply view visitors as a type of expected “environmental variation” [32,43,44,48–50].

Studies on the positive effects of AVIs are sparse [4], and are limited to very few species, such as lemurs [51,52], giant tortoises [35,53], and leopard tortoises [36]; and possible positive effects of visitors for orangutans [54,55] and meerkats [49]. Despite the dearth of research on positive AVIs, it is suggested here that, as research increases, more positive effects for some individual animals within captive groups (and possibly in some whole groups or populations) will be uncovered. This may further increase as AVIs are undertaken in a more controlled, ethical, and evidence-based manner, prioritising consideration of what the *animal* wants from the interaction, rather than the human [56]. When considering individual animal welfare as the ultimate priority for modern, ethical zoos [1,12] (especially those zoos adhering to Compassionate Conservation, Conservation Welfare and/or Duty of Care ethical frameworks), fostering positive AVIs (and positive HAIs in general) is of the utmost importance. There are countless anecdotal stories, passed between zookeeping and animal care

staff, that exemplify positive human–animal interactions with animals under their charge. Properly recording and quantifying these relationships, to provide empirical evidence that these relationships are beneficial (or that they are not, in some circumstances) is suggested to be a next step in better understanding captive animals’ wants for, or against, these interactions.

4. Ethical Frameworks

4.1. Compassionate Conservation

Compassionate Conservation is an ethical framework that has flourished in the last decade, originally conceived to deal with many “wicked problems” [1] for individual animal welfare in wildlife management, that traditional Environmental and Conservation ethics could not effectively grapple with [16,57]. This framework has become an explicit ethical alignment within the code of ethics of some zoos, such as Zoos Victoria [1,58], although the framework as used in a pro-zoo manner [1] differs from the original Compassionate Conservation approach [57], which was largely concerned with wildlife management, and was generally aligned to anti-captivity principles. While its beginnings were of an in situ wildlife conservation focus, the principles of Compassionate Conservation as applied to ex situ conservation efforts within a captive zoo environment are largely the same [1]. Compassionate Conservation, in its different iterations, has been described by various proponents as ascribing mostly to a virtue ethic (the virtue of Compassion), a deontological ethic (Animal Rights theories), or to consequentialist ethics (the greatest good for the most number of animals) [59]. It is obviously a pluralistic approach, focused on the wellbeing of individual wild animals as well as larger populations and ecosystems. The main four tenets of Compassionate Conservation are: 1. First do no harm; 2. Individuals matter; 3. Inclusivity; and 4. Peaceful co-existence (an explanation of these principles is available in [59]). However, these tenets have also been criticised for a lack of clarity on how the specifics of this ethical framework can be applied to

novel or complex dilemmas, such as individual suffering for the benefit of populations or ecosystems [59].

4.2. Conservation Welfare

A new ethic, Conservation Welfare (predicated mostly upon principles of Singer's Utilitarianism [60]), has been proposed as a more legitimate and pragmatic framework for zoos, aquariums and other captive animal conservation organisations to become adherents of [59]. Conservation Welfare is the recent application of Animal Welfare ethics (and some principles of Conservation and Environmental ethics) to conservation practices for non-captive wild animals [59]. Like Compassionate Conservation, it differs from most Environmental ethics as it is largely focused on the wellbeing of individual animals, not just whole populations, species or ecosystems. Conservation Welfare, like Animal Rights and Compassionate Conservation, asserts that animals do indeed possess inherent value, meaning they are morally relevant, though the difference in Conservation Welfare is that this inherent value does not preclude the possibility of the imposition of individual suffering or death, if it is necessary and for the "greatest good" (i.e., it can be "traded-off"). Still, this ethic always endeavours to minimise pain and suffering in individual animals. Thus, as applied to in situ and ex situ conservation practices, a Conservation Welfare ethic is more pragmatic than Compassionate Conservation, in that the direct imposition of *some* suffering on *some* individuals is deemed acceptable (and this will not violate any tenets) as long as this suffering is *necessary* and *justified*. Although, what is deemed necessary, justified suffering is still somewhat ambiguous [59].

4.3. Duty of Care

The Duty of Care ethical framework (which was initially a humanistic ethical framework for humans caring for humans, then companion animals, and then other domesticated animals) is often an implicitly nurtured approach within zoos, distributed

amongst the new generation of animal care managers and husbandry staff, as this ethical framework also promotes a duty to provide positive welfare conditions to captive animals which aligns with modern zoos' goals. That is, as guardians of captive animals, we have a moral duty to provide all levels of care to those animals [61,62], including the provision of opportunities for animals to have *"a life worth living"* or to be able to thrive in captivity [1,63,64]. The duty of care ethic is a reasonable melding of two ethics—a deontological *"duty-based"* ethic (a moral obligation towards another), and a *"virtue-based"* care ethic (both active provision of care to others, and internally *"caring about"* (i.e., consideration for) others) [61,62]. Duty of care as a concept reaches far beyond simply an ethical framework, with *"currency in legal, philosophical, ethical, and general animal protection discourse"* [62]. As opposed to Conservation and Environmental ethics at large, these three specific ethical frameworks above are all concerned with the welfare of individual animals rather than populations.

5. WAZA Guidelines for AVIs

WAZA have specifically published a set of *"Animal-Visitor Interaction Guidelines"* [15], based on their 2003 Code of Ethics [65] and their 2015 Animal Welfare Strategy [12]. There are six key recommendations for AVI's listed in the document, with further subsections devoted to recommended procedures to meet these guidelines. The six recommendations are:

1. *Avoid having animals in any interactive experience that would compromise their welfare.*
2. *Animals involved in direct contact situations should receive appropriate training for visitor interactions in order to reduce potential discomfort or stress responses.*
3. *Make no unnecessary demands on animals and assure that visitors do not provoke or create discomfort or stress responses in the animals.*

4. *Provide animals with choice of whether to participate or not in the interactions. Allow adequate rest time and assure that an animal displaying any indication that it does not want to participate is immediately removed from the interactive experience.*
5. *All walk-through habitats, touch pools and petting areas/touch paddocks where animals are in close proximity to visitors should be of a suitable size to provide for species-appropriate needs and have suitable refuge areas for the animals.*
6. *Any feeding during an interaction must be regulated so it is consistent with the animal's overall appropriate diet and health care. This food must not be the only access to food or the whole diet for the animal and the animal must have choice whether to accept this food.*

Prima facie, these guidelines are sensible and easily interpretable ways for reducing the negative impacts of AVIs on animals. However, individual institutional adherence to these “guidelines” in varying regions may be incomplete, inadequate, or altogether ignored (in favour of financial viability or human experience, for example). Likewise, the auditing of guideline adherence seems to be self-prompted by each individual institution, rather than by a broader regulatory body. Institutional adherence to WAZA and regional association guidelines is largely unknown, or at least reviews are held confidentially. Properly assessing these guidelines would also take an individualistic approach, whereas many zoo facilities often keep “encounter groups” consisting of multiple animals of the same species, and often assess their welfare collectively. Individual welfare assessments are becoming more common globally, especially with the development of specific welfare-monitoring tools (following the Five Domains model), such as WelfareTrak® (Chicago Zoological Society, Chicago, IL, USA) [14,66]. Other issues include interpretation of specific guidelines. For example, guideline 3

states, “*make no unnecessary demands on animals*”, though, what exactly necessary or unnecessary demands during human interaction encounters are is ambiguous. One of the most important guidelines is number 4—“*provide animals with choice of whether to participate or not*”. Choice and control over their immediate situation are now known to be important for an animal’s overall wellbeing and agency, which can lead to positive welfare states, and these concepts are currently being taught to new generations of zookeepers and animal husbandry professionals as crucial provisions for captive animals wherever possible and pragmatic [14,67,68]. It is also suggested that it would be pertinent to add an additional guideline here around safe interaction practices, as follows: “7. *Only interactions with non-dangerous animals should be allowed and conducted, and if there is a reasonable chance of harm (even if minimal) to either the human or the animal participants, these interactive experiences should be terminated immediately.*” That is, direct physical contact “experiences” with large predatory animals, such as Tigers, Lions, Bears or Orcas, which could potentially cause serious injury or death to the human participants, should not be offered nor conducted by modern, ethical zoological and aquarium facilities. Currently, many of these offered experiences rely on harmful or abusive training practices, physical restraint, bodily mutilations (such as declawing or teeth removal), and punishments to maintain physical and psychological “control” over these large dangerous animals [69]. This does not preclude the possibility of beneficial positive HAIs between keepers and these animals, nor in fact between unfamiliar visitors and these animals, but direct contact in these situations is always of the highest risk. It should also be mentioned that most *accredited* zoological facilities have prohibited abusive and/or bodily mutilation practices in their codes of ethics [13,15,65], yet these practices still persist at many eco-tourism or unregulated destinations in many regions [69].

6. Keeper–Animal Interactions

Currently, AVIs are the focus of much research effort [4,66,70,71]. However, close examinations of keeper–animal interactions and relationships (KAIs; KARs) are sparse, with a few varying results [32,55,72–75]. Due to the persistence of many “*folklore husbandry*” practices [45], there is a strong possibility that we are currently ignoring many established negative relationships between zookeepers and animals under their charge [32]. Although, most modern zoological facilities and (nearly all) animal care professionals endeavour to minimise harmful interventions and to ameliorate possible negative HAIs *before* they become established negative HARs that would be detrimental to the animal’s overall welfare [1,75]. Furthermore, even though they are often communicated through folklore husbandry, many anecdotal stories and personal experiences (some documented in photographs or short videos) shared broadly over social media can sometimes be beneficial for improving KAIs and KARs in circumstances where objective, empirical evidence is not currently available. Folklore husbandry is a double-edged sword, however, and the established folklore is often very resistant to change even when presented with solid scientific evidence to the contrary [45,46].

To date, specific studies on positive KARs have found the following animal-focused results: increased reproductive success in small cats [76]; lower faecal glucocorticoid metabolites in clouded leopards [77], white rhinoceros [78], and Asiatic and African elephants [74]; reduced abnormal and stress-related behaviours after positive reinforcement training (PRT) in chimpanzees [79] and polar bears [80]; and increased responsiveness to husbandry cues after PRT in black rhinoceros, zebras and Sulawesi macaques [81]. Similarly, human-focused results found that zookeepers reported stronger, more positive KARs with tortoises that they conducted public-visible training sessions with [82]; another recent study found that zookeepers’ self-reported job dissatisfaction rose when “Keeper-Elephant Bonds” were weaker [74]. Apart from Alba et al. [82], all of these KAI studies have focused on mammalian

species. Very little is known about KAIs with other classes of animal. It is strongly suggested that an increase in the empirical investigation of KAIs and KARs is necessary and warranted.

7. Are the Benefits Worth Allowing These Interactions?

As just described above, there are some reported benefits (for both humans and animals) of positive KARs in zoos. There is also marginal evidence to suggest that positive AVIs can be beneficial for the animals involved and documented evidence that these interactions do indeed improve visitor experiences, conservation caring and learning [4,70]. So, is there a good case for allowing and promoting AVIs in zoos? The answer is complicated, but yes. As with all complex dilemmas, the devil is in the details, as it were. Firstly, the guidelines as set out by WAZA, plus the suggested 7th recommendation above, should be closely adhered to, to prevent negative effects of close interactions. However, a new model for clearly identifying when these interactions are being “*asked for*” by captive animals needs to be developed (i.e., being more attentive to what animals actually “*want*”, and aware of how we interpret it [56]). Interactions that are “asked for” by animals means circumstances where animals have been observed “soliciting” interactions from people, either through glass or other barriers, or by direct contact at shared fence lines (as in the case of the Aldabran Giant Tortoises studied in [35]). Currently, many zoos have moved towards a highly “hands-off” model of animal keeping, such that most direct contact interactions between humans (both visitors and zookeepers) have been minimised, or totally abolished, and are discouraged as much as possible. Yet, this may be a counter to enhancing the overall welfare of animals in some circumstances, especially in situations where the animals are highly motivated to interact but are denied this rewarding outcome. Sufficient time should be dedicated by animal care managers to allow zookeepers or other staff qualified in animal behaviour to observe daily interaction solicitation or engagement by individual animals under their charge,

to identify more opportunities for “*positive affective engagement*” interactions that may currently be overlooked or unnoticed. Furthermore, identifying specific individuals that may benefit from positive KAIs or AVIs should be prioritised by zoos as well. These animals may not always solicit interactions, but other personality factors may be apparent that could predict higher enjoyment of these interactions were they to be offered –factors such as high levels of boldness and curiosity are suggested to be a good starting point for investigation. For human participants, provision of these so-called “*profound experiences*” [1] in safe, controlled zoo environments can indeed be very beneficial for inciting pro-environmental and pro-conservation behaviour and attitudinal change in visitors, ultimately contributing to the zoos’ conservation goals in meaningful ways [3,43,66,83,84]. “Connecting” with wildlife has been rated as a top priority by zoo visitors, although the type of “connections” that they are seeking can vary significantly [71].

8. Unintended Consequences

Although AVIs may potentially be rewarding for all parties involved in some circumstances, there are also a number of risks associated with close contact experiences offered within zoos. Obviously, there are a number of health and safety issues for both animal and human participants that are involved in these interactions (especially direct physical contact interactions), some of which have been detailed elsewhere [4,14,69]. There is also a growing worry among zoo researchers, managers, educators and behaviour change specialists that providing opportunities to directly interact with animals in zoos may “normalise” the behaviours and promote a false sense of acceptability of engaging in these same behaviours in inappropriate circumstances, such as with wild animals or at unregulated “roadside zoos” and eco-tourism destinations with very poor animal welfare standards [4,69,85,86]. Interactive experiences that present these animals as “tame” or “cute” may also increase the desire to own these types of animals as exotic pets [87], and celebrities posing

with animals at “roadside zoos” and poorly regulated eco-tourism destinations in social media posts can further normalise this problematic behaviour in unaware members of the public. There is a very real potential that “behavioural spill-over” [88] could occur after these experiences; thus, approach and interaction behaviours would be attempted by visitors in inappropriate circumstances (such as encounters with animals in the wild), especially because the interaction experienced in the zoo environment is likely to be highly rewarding emotionally and physiologically, leading to an increased motivation to engage in these types of behaviours more often [88].

Compounding these concerns, the ethical values and beliefs that certain individuals hold about interacting with wildlife may very likely increase the risks of inappropriate or ill-advised behaviours occurring. Historically, zoos were created as displays of imperial majesty – purely for elevating social/cultural status, human awe and entertainment [1,89–91]. Modern zoos are attempting to transform into ethical biodiversity conservation organisations that promote education and positive animal welfare [3,10,11,92–95], yet entertainment and leisure are still two commonly reported reasons for attending these destinations by patrons [1,89–91]. Indeed, a zoo visitor survey conducted by the author [96] found that one of the five extracted ethical alignments of visitors was labelled “*human interaction and entertainment priority*”. Visitors that aligned with this component had high agreement responses on questionnaire items such as “*humans should be allowed to interact with ALL animals in the zoo*”, “*zoo animals are like pets*”, “*zoo animals should be treated like pets*”, and “*I believe that it is acceptable to keep ALL types of animals in zoos*”. Patrons that hold these types of ethical views about interactions with wildlife are likely to be minimally concerned with the animal welfare risks associated with these interactions. They may also be less concerned with evaluating or acknowledging unsatisfactory animal handling and keeping conditions at unregulated, poor-welfare eco-tourism destinations, as their main priority in those moments is their own enjoyment (and they will engage in behaviours that are contrary to their usual moral

attitudes) [97]. To counter this problem, engaging (yet stringent) educational elements must be built into interactive animal experiences offered by zoos, to attempt to change perceptions of these interactions as being harmless enjoyable interactions for all parties involved towards a realistic understanding of how the animals may actually feel about such interactions (and why this matters).

9. What do the Ethical Frameworks Say?

From a Compassionate Conservation perspective, these types of human-animal interactions would usually be discouraged quite strongly. This is because there are many potential risks of harm to the animals involved (even though minor or non-existent in ideal settings), which would violate the first tenet. The repercussions and undesirable consequences listed above would also likely violate the tenet of peaceful co-existence, as most wild animals would be quite fearful or defensive towards humans approaching them for interactions. Whilst the controlled interactions in zoo environments could be beneficial to fostering pro-environmental attitudes if participants were educated correctly, the inherent risks of direct contact interactions are probably too great to allow. The Conservation Welfare framework would only allow these interactions to occur in very controlled circumstances, but would not completely discourage nor prohibit all of these types of direct interactions. The main principle that would have to be followed, however, is that only those interactions that are “asked” for by the captive animals (not the humans), and could be delivered in an absolutely safe and controlled manner, would be deemed acceptable. Although, uncontrolled HAIs at shared fence lines or through glass viewing windows would likely also be acceptable in circumstances where the animals were initiating or soliciting such interactions. Ergo, if the animal is “asking” for the interaction, and the interaction is deemed safe and minimal or zero risk, then this interaction could be used to increase both the individual animal’s wellbeing and welfare, and conservation caring in humans. Though Conservation Welfare would also be opposed to and

concerned about negative “behavioural spill-over” into inappropriate circumstances with wildlife or poor welfare destinations, as this is counted-productive to conservation efforts and to fostering respect for nature. Duty of Care ethics would be mostly concerned with the impacts upon the individual animals within that particular captive environment, so many more HAIs in these circumstances would be deemed acceptable. The main principle followed would be to provide that which is best for the overall welfare for individual animals, and hence allowing and facilitating HAIs and AVIs that are positive and rewarding would be best practice. These interactions would have to be assessed for risks and for safety; however, the framework would only be concerned with the participants as they are in the immediate environment, not what the humans could potentially do in other circumstances or other times outside of the interaction. Therefore, effective communication and education for pro-environmental or conservation caring behavioural change in the human participants would not be considered a priority during these allowed interactions.

10. Conclusions: Promoting Positive Interactions

There are many potential risks inherent in HAIs in all circumstances. However, in specific settings there are also many potential benefits, with the potential to greatly enhance animal welfare conditions and human attitudes towards animal (and natural habitat) conservation and environmental caring. They could potentially be a very powerful tool to increase public awareness, engagement, and support for conservation practices and for achieving the goals of many zoological institutions. However, risks to animal and human participants, as well as the risks of inciting future inappropriate behaviours need to be thoroughly assessed and appropriately mitigated, and all direct HAIs should only be conducted in strictly “very low-risk” scenarios. There is great potential to vastly improve positive affective engagement in animals that are highly motivated to engage in these interactions, providing them with more choice and control over their captive environments [64,67,98]. Welfare monitoring tools (such

as WelfareTrak®) should be utilised during all encounters, and direct behavioural observations from each and every session should be rigorously recorded, to ensure that only animals that are benefitting from interacting are continually used in “encounter programs”. Those animals that display fear, avoidance and/or defensive behaviours before, during, or after encounters should cease being used for these types of close-contact experiences. Behavioural observers must also become much more acutely aware of reptile species’ particular behaviours, as these animals’ full behavioural repertoires are still somewhat unknown [38]. Likewise, more accurate recognition of unreactive, torpid animals (that may be overwhelmed mentally and physiologically by both acute and chronic stressors) as animals that are not coping with their environments and/or handling must be treated as a priority for relevant behaviourists and animal care staff. Melding Duty of Care and the two Conservation ethical frameworks would be ideal for assessing the ethical acceptability of such interactions as they currently occur, and for considering how they should be modified to occur (or not) into the future in zoological settings.

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CHAPTER 8: GENERAL DISCUSSION AND CONCLUSIONS

Reviewing the aims of this thesis

Positive zoo animal welfare states are a high priority for modern, ethical zoos. However, there is currently a substantial gap in the published literature that explores positive welfare states associated with human (especially visitor) contact in zoo settings. This thesis was designed to weave a coherent story connecting subjects that are often overlooked, including animal ethics, evidence of awareness and sentience in animals, and experimental research that addressed whether some zoo-housed reptiles may perceive human interaction as rewarding, and whether they may indeed be motivated to seek these interactions preferentially.

The research aims of this thesis were to:

- 1. Investigate whether zoo-housed animals are motivated to solicit human-animal interactions, whether natural or unnatural (and if these interactions may improve their well-being and welfare).*
- 2. Review research evidence that suggests non-avian reptiles are conscious, sentient beings, capable of thinking and feeling in many meaningful ways, just like all other vertebrates (and possibly invertebrates).*
- 3. Examine preferences for human interaction in two species of long-living, zoo-housed reptiles – specifically Aldabran Giant Tortoises (*Aldabrachelys gigantea*) and Leopard Tortoises (*Stigmochelys pardalis*), located at Melbourne Zoo, and Werribee Open Range Zoo, respectively.*
- 4. Examine zoo visitor beliefs and attitudes towards tortoises and other reptiles, and investigate ethical beliefs around interacting with captive animals and wildlife.*
- 5. Propose a model of ethical human-animal interactions in zoos that prioritise the animal's experience of the interaction, and avoid unintended behavioural consequences in human participants (when they are in other, inappropriate settings – such as in “nature”).*

Specifically, the chapters created a combined ethical and experimental narrative by:

1. Highlighting the importance of human-animal interactions in zoos for improving the welfare of some individual animals, especially those animals that are highly-motivated to engage in these types of interactions;
2. Discussing an overlooked Class of animals – *Reptilia* (non-avian reptiles) – and their capacities for thinking and feeling that have not been explicitly acknowledged, and also how their current captive housing standards and conditions may be diminishing their overall welfare;
3. Providing experimental evidence that some individuals from two species of tortoises do indeed prefer human interaction over other stimuli;
4. Showing that many zoo visitors have complex ethical beliefs about keeping animals in captivity, and that these beliefs may be changed when provided with appropriate information; and
5. Describing how human-animal interactions can form an important component of optimal zoo animal welfare, although we must be careful to avoid unintended consequences that may arise from normalising these interactions.

Summary of research findings and key conclusions

Chapter 2: Dilemmas for natural living concepts of zoo animal welfare

Chapter 2 addressed some ethical and practical dilemmas encountered when applying the “*natural living*” framework in zoo settings, and the mistake of “*wilding*” zoo animals. “*Wilding*” was defined as “*treating an animal as wild, residing in a wild habitat*”, but this is practically incompatible with captivity. Many ‘natural’ behaviours may be maladaptive for life in captivity. In addition, many ‘unnatural’ behaviours may be improving captive welfare

conditions and improving coping in individual animals. Furthermore, zoo captivity could inadvertently be leading many wild animals down the path to domestication.

Key conclusion

This chapter highlighted the need to attend to highly-motivated and/or highly-rewarding behaviours as a better indicator of what may be important to captive wildlife, which often include interactions with other animals and humans. Further examination of these highly-motivated behaviours, at the level of individual animals, may help zoos to facilitate positive experiences for their animals, sensitive to the specific needs of each individual. As well as this, zoos must properly educate staff and visitors about the potential impacts and potential benefits that can arise from controlled, cautious human-animal interactions, especially when the animals are highly motivated to seek those interactions.

Chapter 3: The matter of non-avian reptile sentience, and why it ‘matters’ to them: A conceptual, ethical and scientific review.

Chapter 3 reviewed available research and ethical discussions that make a case for non-avian reptiles to be labelled as sentient – i.e. they have the capacity to feel (sensations/feelings/emotions/moods) and this is concomitant with complex levels of cognition and consciousness as well. Declarations of sentience (i.e. feelings) made by governments and scientific associations (such as the OIE) often include reptiles under the assumption of “*all vertebrate animals*”, but specific declarations of sentience in reptiles are often missing, or overlooked, in scientific writing and welfare-related policies and discussions. Indeed, the historical assumption that reptiles are merely sedentary *automata* without complex cognitive and sentient capacities persist. Sentience and cognitive complexity are intertwined processes, but may have evolved independently and differentially across the animal kingdom. Available cognition and sentience research indicates that there is a very solid basis for assuming and declaring that non-avian reptiles do indeed display all relevant capacities to be

classified as conscious, aware, and sentient beings. This means that they most likely are consciously aware of their own welfare state, and hence their lives and well-being matter to them. This chapter then outlined how current treatment of captive reptiles and welfare standards for housing, handling and enrichment may be diminishing their overall welfare.

Key conclusion

This chapter concluded that non-avian reptiles do indeed possess all of the necessary capacities to be acknowledged as sentient. As such, they should be entitled to a higher degree of moral consideration, and their welfare (in all circumstances) must be considered and safeguarded against abuse, exploitation and neglect.

Chapter 4: Assessing preferences of two zoo-housed Aldabran Giant Tortoises (*Aldabrachelys gigantea*) for three stimuli using a novel preference test

The first experimental chapter, this was a novel preference test with two Aldabran Giant Tortoises (*Aldabrachelys gigantea*) housed at Melbourne Zoo, Victoria, Australia. Behavioural observations recorded since the early 1980's indicated that these two tortoises would approach the fence line of their enclosure daily (sometimes multiple times) to 'solicit' interactions such as shell pats from zoo visitors. This behaviour and the outcomes were assumed to be rewarding for the tortoises, as they have persisted for a very long time. This experiment was designed to test whether the tortoises would prefer human interaction over other stimuli when offered to them inside their enclosure. The results found individual differences in the preference for human interaction between the two tortoises. Wilbur highly preferred human interactions - he moved towards the human stimulus faster than the other two stimuli (food and a boomer ball), and he spent significantly longer interacting with the human than the other two stimuli. Little John, however, avoided contact with the human stimulus on all 13 of his trials with the human. He did approach and interact with the ball and

eat the food. Little John had been observed 'soliciting' interactions with visitors at the fence line, however, so it was posited that perhaps a loss of control over the location and timing of the interactions when offered inside his enclosure during the experiment led him to choose to not interact, to regain some environmental control.

Key conclusion

This chapter concluded that human interaction may be a preferred 'enrichment' by some tortoises, but is dependent upon a multitude of other contextual factors, and interactions are not preferred at all times by all individuals. The reported individual variation in preferences may be very important to understand more fully, to have greater positive effect on the welfare-related needs of each giant tortoise housed in captivity. Further research is clearly required to enhance the welfare of many types of zoo-housed reptiles.

Chapter 5: Assessing choice ability and preferences of five Leopard Tortoises (*Stigmochelys pardalis*) for three stimuli through a novel two-phase preference test

Chapter 5 was another novel preference test, though this test was conducted in a traditional walled Y-maze. The test assessed the choice-making ability of five Leopard Tortoises (*Stigmochelys pardalis*) in two test phases. Phase 1 was a discrete choice test in a Y-maze with two options: food in one arm and the other arm left empty. Stimulus/empty positions were fixed per tortoise, but randomised across the five tortoises. Phase 2 involved opening an additional choice arm on the Y-maze, thus offering each tortoise three choices: food (the same as Phase 1); human interaction (shell scratches using hands); or an empty arm again. Positions were again fixed per tortoise, but randomised across the tortoises. Multivariate ANOVAs were performed on three dependent variables of the length of time taken to make choices in both phases. In Phase 1, four of the five tortoises (Alfred, Gilbert, Humphrey and Walter) clearly chose the food arm more than the empty arm. One tortoise (Neville) chose the food

arm and empty arm equally (50/50). In Phase, 2 tortoise choices were more varied. Two tortoises (Gilbert and Humphrey) chose human interaction more than the other two maze arms, another two (Alfred and Neville) chose the food arm most, and one (Walter) did not seem to show a strong preference for any particular arm suggesting this tortoise was perhaps confused by or did not comprehend the choice task.

Key conclusion

As in Chapter 4, the results of this Leopard Tortoise experiment suggested that some individuals of this species of tortoise do indeed prefer human interaction (shell rubbing) over other stimuli in certain conditions. However, further research is necessary to improve the confidence of this result, as many of the individual tortoises' choices were somewhat ambiguous in the current limited study.

Chapter 6: A survey of ethical and behavioural beliefs of zoo visitors towards human-animal interactions and non-avian reptiles.

Chapter 6 was a survey of zoo visitors conducted at two zoos in Melbourne, Victoria, Australia, to investigate their ethical and behavioural beliefs about housing and interacting with reptiles in zoos; and to investigate the effects of providing positive or negative-valenced human-animal interaction statements on attitudes towards interacting or owning zoo or wild animals. 258 total responses were collected in the experimental period. Principal Component Analyses were conducted on 231 valid visitor responses, indicating a best solution with 5 components, which were: 1) "Human interaction and entertainment priority component"; 2) "Complicated zoo ethics and animal welfare component"; 3) "Wilding, natural living and anti-captivity sentiments component"; 4) "Ethical duty of care component"; and 5) "Animal agency and respect component". An ANOVA of the extracted components found a significant effect of respondents' education level on agreement with the "Complicated zoo ethics and animal welfare component" ($p = 0.043$), but no other demographic variables significantly

affected any other PCA components. As hypothesized, positive or negative interaction statements affected respondents' re-scores on three paired interaction questions (using Wilcoxon's Signed Rank Tests; $p = 0.05$ to $p < 0.001$).

Key conclusion

The results of this survey confirmed previous findings, that visitor beliefs may be influenced with appropriate education (informative statements) about the impacts (both positive and negative) of human-animal interactions and private ownership of wildlife. This survey also showed the diversity of visitor beliefs about the reasons for zoos' continued existence. Thus, it is still believed that many zoo visitors simply visit for entertainment reasons – and for these individuals, serious engagement with educational and/or conservation advocacy elements of the zoo is probably a low priority. It was suggested that follow-up surveys with the same respondents would be beneficial to increase our understanding of whether targeted education and behaviour change interventions conducted on-site at zoos can affect any long-term attitudinal changes in zoo visitors.

Chapter 7: Human-animal interactions in zoos: What can Compassionate Conservation, Conservation Welfare and Duty of Care tell us about the ethics of interacting, and avoiding unintended consequences?

Human-animal interactions in zoos, especially when initiated or solicited by the animals, may be beneficial for both the animal and human participants, and contribute to positive animal welfare states. However, they are also fraught with ethical, welfare and safety perils. WAZA have specifically published a set of “*Animal-Visitor Interaction Guidelines*” (WAZA, 2020), based on their 2003 Code of Ethics (WAZA, 2003) and their 2015 Animal Welfare Strategy (Mellor, *et al.* 2015). There are six key recommendations for AVI's listed in the document, with

further subsections devoted to recommended procedures to meet these guidelines. The six recommendations are:

1. *Avoid having animals in any interactive experience that would compromise their welfare.*
2. *Animals involved in direct contact situations should receive appropriate training for visitor interactions in order to reduce potential discomfort or stress responses.*
3. *Make no unnecessary demands on animals and assure that visitors do not provoke or create discomfort or stress responses in the animals.*
4. *Provide animals with choice of whether to participate or not in the interactions. Allow adequate rest time and assure that an animal displaying any indication that it does not want to participate is immediately removed from the interactive experience.*
5. *All walk-through habitats, touch pools and petting areas/touch paddocks where animals are in close proximity to visitors should be of a suitable size to provide for species-appropriate needs and have suitable refuge areas for the animals.*
6. *Any feeding during an interaction must be regulated so it is consistent with the animal's overall appropriate diet and health care. This food must not be the only access to food or the whole diet for the animal and the animal must have choice whether to accept this food.*

Prima facie, these guidelines are sensible and easily interpretable ways for reducing the negative impacts of AVIs on animals. However, individual institutional adherence to these 'guidelines' in varying countries may be incomplete, inadequate, or altogether ignored (in favour of financial viability or human experience, for example). Likewise, auditing of guideline adherence seems to be self-prompted by each individual institution, rather than a broader regulatory body. It was suggested that it would be pertinent for WAZA to add an additional guideline around safe interaction practices, as follows:

7. *Only interactions with non-dangerous animals should be allowed and conducted, and if there is a reasonable chance of harm (even if minimal) to either the human or the animal participants, these interactive experiences should be terminated immediately.*

That is, direct physical contact ‘experiences’ with large predatory animals, such as Tigers, Lions, Bears or Orcas, which could potentially cause serious injury or death to the human participants, should not be offered nor conducted by modern, ethical zoological and aquarium facilities. Currently, many of these offered experiences rely on harmful or abusive training practices, physical restraint and punishments to maintain physical and psychological ‘control’ over these large dangerous animals (WAP, 2019). This does not preclude the possibility of beneficial positive HAIs or HARs between keepers and these animals, nor in fact between unfamiliar visitors and these animals, but direct contact in these situations is always of the highest risk.

In specific settings, and with less dangerous animals, there are also many potential benefits to HAIs. They could potentially be a very powerful tool to increase public awareness, engagement, and support for conservation practices and for achieving the goals of many zoological institutions. However, risks to individuals as well as the risks of normalising future inappropriate interaction behaviours by humans need to be thoroughly assessed and appropriately mitigated, and all direct HAIs should only be conducted in strictly ‘very low-risk’ scenarios.

Key conclusion

There is great potential to vastly improve positive affective engagement in animals that are highly motivated to engage in these interactions, providing them with more choice and control over their captive environments. Melding Duty of Care and the two Conservation ethical frameworks would be ideal for assessing the ethical acceptability of such interactions as they currently occur, and for considering how they should be modified to occur (or not) into the future in zoological settings.

Relevance of findings to the zoological industry

Currently, many policies, guidelines and husbandry manuals for non-avian reptiles do not fully appreciate these animals' capacities for thinking and feeling. Some, if not all, reptiles, should be considered as sentient beings, and indeed, they are now automatically included as sentient in some modern declarations, such as by the OIE, that "*all vertebrate animals*" possess sentience. However, there is still a massive void between ideological declarations of 'sentience' in animals and the actual, practical treatment of many of these animals in many captive conditions. Specifically, captive reptile welfare is currently often inadequate to fulfil their basic needs.

Many zoological institutions and associations have begun to implement new standards for non-avian reptile enclosures and features, to allow these animals to fully extend and move their bodies in anatomically relevant ways, and to provide naturalistic features to allow them to be immersed and comfortable in their exhibits. The research conducted in this thesis helps build a solid case for re-writing and improving non-avian reptile husbandry manuals and procedures, to ensure that their enclosures and captive lives are enriched and fulfilling, and are not inadvertently causing significant suffering. The proposed model of ethical human-animal interactions may help zoos to assess current practices and guidelines, and identify gaps and risks in current 'animal encounters' which may be exposing both animal and human participants to significant harms.

Knowledge of effective enrichments for zoo-housed non-avian reptiles is sparse, and so the results of the two preference tests conducted here may stimulate further investigations of the efficacy of the chosen stimuli. It seems apparent from the Giant Tortoise preference test that the red boomer ball was an ineffective enrichment for both tortoises, as it generally did not capture their attention for very long during any of the experimental trials.

Lastly, while AVIs may be a mechanism for promoting positive affective engagement and positive experiences for some zoo animals/reptiles, it should be noted that the experiments conducted here found only limited evidence that these interactions are preferred (and probably rewarding) for only a few of the studied individuals, not all. It was concluded that preferences for HAIs, or AVIs, are highly based on factors of the individual animal, such as individual temperament or personality and prior experiences.

Should zoos still offer AVIs?

This is a difficult question to address directly. There are many ethical and practical risks associated with AVIs, especially in poorly monitored or poorly managed situations. However, when run in a considered, cautious and controlled manner, these encounters may enhance the experience of both the captive animal and the zoo visitor. As a first step, all of the zoos currently engaging in AVIs must ensure they are adhering to the current WAZA guidelines for safe, positive interactions. Furthermore, the proposed “7th guideline” herein must be considered as well. AVIs in zoos do not necessarily need to be inherently negative or unethical. However, the onus on zoos for ensuring positive welfare is experienced by each individual captive animal will mean that, in many circumstances, some individual animals should *not* be used in any AVIs, as these animals may judge these interactions as fear-provoking or otherwise negative or unwanted (in terms of an animal’s agency). Forcing these animals to participate in AVIs may compromise those particular individual’s well-being, and hence compromise their overall welfare. Zoos must make particular effort to avoid this from occurring when offering interactive experiences to visitors. Monitoring animal behaviours and identifying individuals that seem highly-motivated to approach and engage with keepers and/or visitors may be important for classification as ‘interaction-positive’ or ‘interaction-negative’ animals.

Finally, zoos and zoo staff that are facilitating these AVIs must make all efforts to properly educate and advise zoo visitors of the potential risks involved with these interactions, and of the very limited circumstances where engaging in these interactions are appropriate (i.e. at accredited, ethical zoos). Zoo visitors attend for a myriad of reasons, such as simply for entertainment, to socialise with other humans, or to somehow “*connect*” with wildlife. Thus, effective education in a zoo environment is fraught with barriers, difficulties and perils. However, adamant and deliberate factual communication by zoo personnel to zoo visitors about the seriousness of well-controlled, cautious AVIs (as opposed to framing them as simply casual, ‘fun’ experiences), their potential ethical pitfalls, their safety risks, and the potential of unintended consequences may be sufficient to engage the majority of these ‘interaction-seeking’ visitors to make informed, ethical choices in the future.

Methodological approach: Innovations and limitations

This thesis was an innovative blend of theoretical ethical writing and practical experimental preference tests and a visitor attitudes survey. Many of the initial ethical writings led to an experimental focus on an under-represented class of animals – non-avian reptiles. This diverse class of vertebrates are very often overlooked in intellectual discussions, research and practical welfare settings. As mentioned previously, many currently captive situations for reptiles (such as zoos, hobbyist collections and even farms) are persistently inadequate, in terms of space allowances, enclosure features and provided enrichment. I hope that this thesis can contribute to the pioneering work of other animal welfare researchers in this area, to improve the moral standing and captive conditions for this class of vertebrates.

There were quite a few limitations encountered during the experimental phases of this PhD. Not least of all is gaining access to sufficient numbers of animals to perform robust, controlled experiments. This is a known limitation of most zoo-based research. Fortunately, many innovative statistical techniques allow modern researchers to still conduct meaningful

research at the level of individual animals. Replication of research findings at different zoos with different animals is often warranted, and is encouraged to solidify the findings of limited sample size research. Understanding individual preferences is paramount for ethical zoos, to be able to provide the best level of care and welfare to each animal in their collection.

Another common limitation of zoo research encountered during this PhD thesis was negotiating sufficient data collection time. Often zoos have to balance multiple considerations when approving research at their locations, such as impacts upon the research animals, staff time and level of involvement, and the impact upon visitor experience. The limitations of my research timeframes for collecting sufficient data (during preference trials) were exacerbated by studying very slow-moving ectotherms. Inclement weather and temperatures were also a significant limitation to the amount of activity that the tortoises performed day-to-day, and although these factors were accounted for in the timing of my research schedules, often-unpredictable weather effects had significant impacts upon the research animals on the day.

Future directions

Firstly, it would be pertinent to attempt to replicate the preference tests conducted herein with other groups of Aldabran Giant Tortoises and Leopard Tortoises housed at zoos in other regions. This would help to improve the confidence and validity of the conclusions that were drawn, as well as discover a wider spectrum of individual preferences within these species. Secondly, future research should prioritise understanding visitor attitudes and perceptions during 'close-up' or 'hands-on' reptile encounters, such as holding or patting tortoises, snakes or lizards, which commonly occur at zoos globally. Some recent research has started investigating the welfare states of 'encounter' reptiles, and this research should continue and increase.

Moving forward, it is hoped that many zoological facilities will continue to engage with relevant animal welfare and zoological researchers from academic institutions and increase

engagement with philosophers and animal ethicists, for the betterment of all captive wildlife housed for educational and conservation purposes, and continue to be compassionate and attentive to individual animals' needs that are under their care.

FIN.

APPENDIX 1: FULL VISITOR SURVEY FROM CHAPTER 6



Plain Language Statement

Animal Welfare Science Centre (AWSC), Faculty of Veterinary and Agricultural Sciences

Project: Zoo visitor perceptions of animal welfare and ethics

Mr Mark Learmonth, PhD Candidate (Student Researcher)
Email: mlearmonth@student.unimelb.edu.au

Professor Paul Hemsworth, AWSC (Supervisor; Responsible Researcher)
Email: phh@unimelb.edu.au

Dr Sally Sherwen, Zoos Victoria (Co-supervisor)
Email: ssherwen@zoo.org.au



**Animal Welfare
Science Centre**

Introduction

Thank you for your interest in participating in this research project. The following few pages will provide you with further information about the project, so that you can decide if you would like to take part in this research. Please take the time to read this information carefully. You may ask questions about anything you don't understand or want to know more about. Your participation is voluntary. If you don't wish to take part, you don't have to. If you begin participating, you can also stop at any time.

What is this research about?

The aim of this project is to identify and understand zoo visitor attitudes and beliefs about human-animal interactions, and about ethical questions regarding how animals live in zoo environments.

What will I be asked to do?

Should you agree to participate you will be given a tablet to complete a short (10 -12 minute) survey, asking you to answer questions about your beliefs and attitudes towards questions related to animal welfare and ethics, for some zoo animals.

What are the possible benefits?

Completing this survey will help us understand public attitudes and perceptions of animals living in zoos, and about specific ethical conundrums around human-animal interactions within zoo settings. This will help advance critical understanding of what zoos may do in future to evolve and improve, and contribute positively to animal welfare.

What are the possible risks?

There are very minimal risks associated with this research, as no personally identifiable information will be asked or collected during the survey. Participation is voluntary, and you may withdraw your consent at any time. Adding an email address at completion of the survey to be informed of the results of the study is entirely optional.

Do I have to take part?

No. Participation is completely voluntary. You are able to withdraw at any time, incomplete surveys and data already entered will be deleted. If you withdraw after completion, completed survey data will be deleted based on the timestamp of survey completion (as no personally identifiable information will be stored in your responses).

Will I hear about the results of this project?

If you choose to record your email address at the end of the survey, results will be sent to you after completion of the study. Entering an email address is entirely optional. Survey results will be used in a chapter of the student researcher's PhD thesis, and are expected to be published in a peer-reviewed academic journal.

What will happen to information about me?

No personally identifiable information (such as name or email address) will be linked to any answers given in the survey. General, non-personally identifiable demographics questions which are answered, plus survey question responses will be stored on the survey system servers (Qualtrics®) under the University of Melbourne's research accounts. Stored survey data will be retained for 10 years, and will be available for analysis by registered researchers in the fields of animal welfare and ethics, solely for the purpose of understanding public attitudes to questions of animal ethics and animal welfare.

Who is funding this project?

The primary researcher is funded by an Australian Government Research Training Program (RTP) scholarship.

Where can I get further information?

If you would like more information about the project, please contact the student researcher.

Mr Mark Learmonth, PhD Candidate, mlearmonth@student.unimelb.edu.au

Who can I contact if I have any concerns about the project?

This research project has been approved by the Human Research Ethics Committee of The University of Melbourne. If you have any concerns or complaints about the conduct of this research project, which you do not wish to discuss with the research team, you should contact the **Manager, Human Research Ethics, Research Ethics and Integrity, University of Melbourne, VIC 3010. Tel: +61 3 8344 2073 or Email: HumanEthics-complaints@unimelb.edu.au**. All complaints will be treated confidentially. In any correspondence please provide the name of the research team or the name or ethics ID number of the research project.

Visitor attitudes and experience questionnaire

You are invited to participate in a research project investigating the zoo visitor attitudes towards the intelligence and capacities of tortoises. This research is being conducted through The University of Melbourne and Zoos Victoria by Mark Learmonth (PhD Candidate) and Professor Paul Hemsworth (Animal Welfare Science Centre, The University of Melbourne).

Research on this topic is important to identify how visitors perceive the lives of tortoises and reptiles in captivity, and how visitors feel about zoo animal research and questions of zoo ethics.

As an important part of the zoo community, your experience, interests and concerns are of value and therefore I would greatly appreciate any insight you can offer. The questionnaire is completely anonymous, and has been approved by the Human Research Ethics Committee of the University of Melbourne.

Consent Form

Animal Welfare Science Centre (AWSC), Faculty of Veterinary and Agricultural Sciences

Project: Zoo visitor perceptions of animal welfare and ethics

Mr Mark Learmonth, PhD Candidate (Student Researcher)
Email: mlearmonth@student.unimelb.edu.au

Professor Paul Hemsworth, AWSC (Supervisor, Responsible Researcher)
Email: phh@unimelb.edu.au

Dr Sally Sherwen, Zoos Victoria (Co-supervisor)
Email: ssherwen@zoo.org.au

1. I consent to participate in this project, the details of which have been explained to me, and I have been provided with the option to keep a printed Plain Language Statement if I wish.
2. I understand that the purpose of this research is to investigate and understand zoo visitor attitudes and beliefs about human-animal interactions and about ethical questions regarding how animals live in zoo environments.
3. I acknowledge that the possible effects of participating in this research project have been explained to my satisfaction.
4. In this project I will be required to complete a short (10-12 minute) survey, asking me to answer questions about my beliefs and attitudes towards questions related to animal welfare and animal ethics, for some zoo animals.
5. I understand that my participation is anonymous and voluntary, and that I am free to withdraw from this project anytime without explanation or prejudice and to withdraw any data that I have provided.
6. I understand that the data from this research will be stored by The University of Melbourne and retained for a period of 10 years.
7. I have been informed that the confidentiality of the information I provide will be safeguarded subject to any legal requirements; my data will be password protected and accessible only by named researchers.
8. I understand that after I agree to this consent form, the form will be retained by the researcher.

YES

☐

NO

☐

Demographics Block

Type of visitor (choose one)

Zoo member

☐

Non zoo member

☐

Are you?

- ☐ Male
- ☐ Female
- ☐ Non-binary
- ☐ Other
- ☐ Prefer not to say

What is your age?

What is your highest level of education?

- ☐ No formal schooling
- ☐ Primary school
- ☐ Secondary school
- ☐ Technical or further education institution (e.g. TAFE). Field? (write)
- ☐ University (Undergraduate; Bachelor degree). Field? (write)
- ☐ Post-graduate University (Masters/PhD). Field? (write)
- ☐ Post-doctoral researcher/academic. Field? (write)
- ☐ Other educational level (write)

If you are an Australian resident (permanent or temporary), what is your current POSTCODE or SUBURB and STATE?

POSTCODE

Suburb

State

If you are a visitor from overseas, WHAT COUNTRY are you visiting from?

Country

Which zoo did you visit when asked to participate in this survey?

Melbourne Zoo

Werribee Open Range Zoo

Healesville Sanctuary

What date did you visit that zoo?

	Day	Month	Year
Please Select:			2020

Which type of experience did you have? (Choose the most relevant one)

Which type of experience did you have? (Choose the most relevant one)

Which type of experience did you have? (Choose the most relevant one)

Intelligence and Awareness Block

On a scale from 0-5 how would you rate the intelligence of tortoises? (0 = no intelligence to 5 = as smart as humans).

0	1	2	3	4	5

Would you rate all reptiles as the same as tortoises?

Yes

☐

No

☐

If NO, how would you rate the intelligence of the SMARTEST type of reptile you can think of? (0 = no intelligence to 5 = as smart as humans).

0	1	2	3	4	5
---	---	---	---	---	---

What type of reptile are you thinking of? (e.g. snake, python, lizard, turtle, etc.)
Write in a general reptile type or a specific species.

Do you think that tortoises:

	Definitely not	Probably not	Might or might not	Probably yes	Definitely yes
Are aware of visitors?	☐	☐	☐	☐	☐
Find visitors interesting?	☐	☐	☐	☐	☐

	Definitely not	Probably not	Might or might not	Probably yes	Definitely yes
Find visitors fear-provoking?	☐	☐	☐	☐	☐
Are not bothered by visitors at all?	☐	☐	☐	☐	☐

Attitudes Block

Non-Close Contact Question Set

Please give the following statements the rating you feel is most appropriate:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Don't know
I believe tortoises CAN make choices	☐	☐	☐	☐	☐	☐
I would like to get closer to the tortoises	☐	☐	☐	☐	☐	☐
I like seeing the tortoises active and engaging in lots of behaviours	☐	☐	☐	☐	☐	☐
I do not like when the tortoises hide or are inactive	☐	☐	☐	☐	☐	☐
I like seeing tortoises basking in the sun or under heat lamps	☐	☐	☐	☐	☐	☐
I would enjoy seeing the tortoises outside of their enclosure	☐	☐	☐	☐	☐	☐
I felt a sense of connection to the tortoises	☐	☐	☐	☐	☐	☐
I want to physically interact with the tortoises	☐	☐	☐	☐	☐	☐
Touching the tortoise would make me feel good	☐	☐	☐	☐	☐	☐
Touching the tortoise would make me care about it more	☐	☐	☐	☐	☐	☐
The tortoises like being scratched on the shell	☐	☐	☐	☐	☐	☐
The tortoises don't mind being picked up and held by people	☐	☐	☐	☐	☐	☐
These tortoises are from an endangered or threatened species	☐	☐	☐	☐	☐	☐

Close Contact Question Set

Please give the following statements the rating you feel is most appropriate:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Don't know
I believe the tortoises CAN make choices	☐	☐	☐	☐	☐	☐
I enjoyed being close-up to the tortoises	☐	☐	☐	☐	☐	☐
I like seeing the tortoises active and engaging in lots of behaviours	☐	☐	☐	☐	☐	☐
I do not like when the tortoises hide or are inactive	☐	☐	☐	☐	☐	☐
I like seeing tortoises basking in the sun or under heat lamps	☐	☐	☐	☐	☐	☐

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Don't know
I enjoyed seeing the tortoises outside of their enclosure	☐	☐	☐	☐	☐	☐
I felt a sense of connection to the tortoises	☐	☐	☐	☐	☐	☐
I enjoyed physically interacting with the tortoises	☐	☐	☐	☐	☐	☐
Touching the tortoise made me feel good	☐	☐	☐	☐	☐	☐
Touching the tortoise made me care about it more	☐	☐	☐	☐	☐	☐
The tortoises like being scratched on the shell	☐	☐	☐	☐	☐	☐
The tortoises don't mind being picked up and held by people	☐	☐	☐	☐	☐	☐
These tortoises are from an endangered or threatened species	☐	☐	☐	☐	☐	☐

Ethics Block

Please give the following statements the rating you feel is most appropriate:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I believe that it is acceptable to keep ALL types of animals in zoos	☐	☐	☐	☐	☐
I believe that ONLY endangered or threatened animals should be in zoos	☐	☐	☐	☐	☐
I believe that ONLY animals that can thrive in captivity should be in zoos, whether endangered or not	☐	☐	☐	☐	☐
I believe that NO animals should be in zoos	☐	☐	☐	☐	☐
I believe that animals can be cared for well in zoos	☐	☐	☐	☐	☐
Animals are in zoos to prevent them from going extinct	☐	☐	☐	☐	☐
Animals are in zoos to educate people	☐	☐	☐	☐	☐
Animals are in zoos for human entertainment only	☐	☐	☐	☐	☐
Humans should be allowed to interact with ALL animals in zoos	☐	☐	☐	☐	☐
Humans should be allowed to interact with only SOME animals in zoos	☐	☐	☐	☐	☐
Humans should NOT interact with ANY animals in zoos	☐	☐	☐	☐	☐
Interacting with an animal is the best part of my day	☐	☐	☐	☐	☐
I feel a very close connection with animals I interact with	☐	☐	☐	☐	☐
Animals in zoos should be in natural settings ONLY	☐	☐	☐	☐	☐

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I don't mind seeing zoo animals in wholly artificial environments if they look happy and well cared for	☐	☐	☐	☐	☐
Natural settings are best for animals, but some artificial elements are fine	☐	☐	☐	☐	☐
The most important aspect of animal wellbeing is displaying natural behaviours	☐	☐	☐	☐	☐
The most important aspect of animal wellbeing is the animal looking happy	☐	☐	☐	☐	☐
Zoo animals are wild animals	☐	☐	☐	☐	☐
Zoo animals are like pets	☐	☐	☐	☐	☐
Zoo animals are not wild, but not pets either	☐	☐	☐	☐	☐
Zoo animals should be treated exactly the same as their species in the wild	☐	☐	☐	☐	☐
Zoo animals should be treated like pets	☐	☐	☐	☐	☐
Zoo animals should be treated differently to wild animals, but not like pets either	☐	☐	☐	☐	☐

Uninformed Block

Please rate how strongly you feel motivated to physically touch or hold a tortoise here at the zoo.

Not at all	A little motivation	Would like to, but not necessary	Would very much like to	Absolutely want to
1	2	3	4	5

How much do you want to touch or hold the tortoises?

Please rate how good you think a tortoise would be as a pet.

Not at all	Not a very good pet	An ok pet - not good, not bad	A quite good pet	An excellent pet
1	2	3	4	5

Would this tortoise be a good pet?

Please rate how strongly you feel motivated to interact with animals in general IN THE WILD (not in a zoo).

Don't want to interact at all, leave them be	Want to observe from afar, would move back if the animal approached	Want to observe from a moderate distance, would stay still if the animal approached	Want to observe close-up, and hope the animal would approach me	Want to physically interact (touch or hold) close-up, may entice the animal with food
1	2	3	4	5

How much do you want to interact with animals IN THE WILD?

Randomised Information Statements (Equal Groups)

This next section will quickly describe the effects of human interaction on a few reptile species.

There is a large range of documented animal responses to interactions with humans. These can be **positive**, **negative**, or **neutral** for the animal.

Negative Information

Some **NEGATIVE** interactions may include:

Human handling of some tortoises (such as picking tortoises up off the ground and holding them) may be stressful, as the tortoises make "swimming motions" with their legs - a sign that they are trying to crawl away, or are uncomfortable or stressed being held off the ground.

Riding, sitting on or pushing giant tortoises may increase their stress levels - as indicated by tortoises' attempts to hide their heads, or move away from the negative interaction.

Often, pet reptiles such as tortoises are kept in inadequate conditions or are neglected, due to lack of knowledge of what care they actually require.

Many wild tortoises are disturbed by or fearful of humans. Many are even stolen from the wild and sold on the black market as pets or trophies, or to be killed to make ornaments and furniture.

Positive Information

Some **POSITIVE** interactions may include:

Patting, scratching, rubbing or brushing tortoise shells and necks. Many tortoise species will approach humans to gain positive tactile interactions. They will even go into what is known as a "tortoise trance" and freeze in place for as long as the tactile interaction continues. These may be especially positive when the tortoises are able to control when and where they have these interactions.

Often, pet reptiles such as tortoises are cared for quite well, have very good lives, and can live to see multiple generations of owners.

Wild giant tortoises often have symbiotic relationships with other animals such as birds and lizards, that crawl on their shells and help exfoliate the skin, and eat bugs and other parasites off the tortoises - keeping them clean. Sometimes wild tortoises approach people for interactions such as this.

Informed Block

After reading this information, please rate your previous responses again.

Please rate how strongly you feel motivated to physically touch or hold a tortoise here at the zoo.

Not at all	A little motivation	Would like to, but not necessary	Would very much like to	Absolutely want to
1	2	3	4	5
How much do you want to touch or hold the tortoises?				

Please rate how good you think a tortoise would be as a pet.

Not at all	Not a very good pet	An ok pet - not good, not bad	A quite good pet	An excellent pet
1	2	3	4	5
Would this tortoise be a good pet?				

Please rate how strongly you feel motivated to interact with animals in general IN THE WILD (not in a zoo).

Don't want to interact at all, leave them be	Want to observe from afar, would move back if the animal approached	Want to observe from a moderate distance, would stay still if the animal approached	Want to observe close-up, and hope the animal would approach me	Want to physically interact (touch or hold) close-up, may entice the animal with food
1	2	3	4	5
How much do you want to interact with animals IN THE WILD?				

Final Comments

FINAL COMMENTS

Are there any other comments you would like to make about the tortoises or reptiles in general? Any comments about human-animal interactions, or ethical dilemmas for zoos? If yes, please comment below:

Thank you for taking the time to complete this survey!

If you would like to stay informed of the survey results, on the next page you can enter your email address (listed separately to your survey responses to keep you anonymous).

Make sure you press NEXT to save your responses (and enter your email address if you chose YES).

Powered by Qualtrics