



The voice of choice: A scoping review of choice-based animal welfare studies

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ABSTRACT

“Choice and control” is a phrase used widely in animal welfare science to describe providing captive animals with the ability to select between possible outcomes (stimuli or events). This concept has gained traction as a pivotal management technique across a variety of captive settings; however, little has been done to quantitatively evaluate choice as a welfare-improving practice. Our goal was to use a PRISMA framework to identify and review the current empirical literature on the welfare effects of choice provisions by examining measurable behavioural and biological outcomes. We evaluated choice-based studies which used an experiment design to compare choice to non-choice conditions and the impact of choice on welfare. Covidence software was used to screen and extract data from peer-reviewed literature identified across PubMed, Web of Science Advanced, and Scopus Advanced databases. Study inclusion was contingent upon a methodology which offered options for at least two or more stimuli/events given concurrently and which also contrasted a choice condition to a non-choice condition. A total of 13 papers were identified and included in this review. The majority of the papers included choices associated with enclosure access, food, and enrichment devices which resulted in improved behavioral and physiological welfare indicators across zoological, agricultural, and research laboratory settings. However, the presence of a couple papers reporting unclear or neutral impacts highlighted the need for further empirical research into the welfare impacts of choice. Increased experimental examinations with a wider range of captive settings and species are discussed and considered necessary to better comprehend the welfare benefits of providing increased choice opportunities for captive animals.

1. Introduction

1.1. Choice initiatives in welfare science

The intrinsic value of choice does not appear to be a uniquely human quality. Animals make choices continuously as they navigate their environment, which itself functions as a form of behavioural and biological selection (Dawkins, 2023; Leotti et al., 2010). In the realm of animal welfare, the term “choice” is frequently entwined with the word “control”, describing an approach that aims to empower animals by offering various environmental options or alternatives (“choices”), thereby enhancing their ability to exert change (“control”) over their

surroundings (Brando and Buchanan-Smith, 2018; Fernandez et al., 2023). For animal welfare purposes, choice and control has become a pivotal aspect of management in zoos, farms, research labs, and companion animals, with increasing focus on whether animals value the opportunity to choose, regardless of the outcome (Decker et al., 2023).

Choice as a welfare-improving strategy has been implemented with captive animals in environments such as zoos for nearly half a century (Markowitz, 1978; see Fernandez and Martin, 2021 for a review). In the laboratory, animal experiments have explored topics such as forced-choice over preference-for-choice in pigeons (Catania, 1975; Catania and Sagvolden, 1980). Nonetheless, designating a universally applicable definition of choice has persisted in philosophical debate for

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decades. For instance, Pierce and Cheney define choice as "...the distribution of operant behaviour among alternative sources of reinforcement" (2004, p. 422). While Englund and Cronin define it as the "act of choosing or selecting from more than one alternative" (2023, p. 2). That said, in order to devise a set of practical and working criteria for evaluating the effect of choice provision on animal welfare, we devised our own operational definition which constitutes choice as being two-or-more stimuli or events that are simultaneously offered. The primary goal of our operational definition was to provide a framework in which we could systematically assess choice as the influencing factor (i.e., independent variable) on welfare. Additionally, the term *control* can also be multifaceted and difficult to define. When used in the context of "choice and control" in animal welfare literature, control typically refers to the capacity for the animal to achieve desired outcomes reliably and successfully, which may provide a sense of predictability for the animal (Englund and Cronin, 2023; Fernandez et al., 2023). For the purposes of this review, the authors describe control as the animal's ability to have a measurable effect on its environment, and this concept is therefore beyond the scope of the paper.

1.2. Objectives

The integration of choice opportunities within animal settings marks a progressive stride towards acknowledging and enhancing welfare for captive species. However, evidence of improved welfare through increased choice is often assumed, or if it is assessed, the effects are often only described anecdotally. This has resulted in a lack of empirical evidence supporting the animal-based welfare impacts of increased choice opportunities (Fernandez and Martin, 2023), despite strong theoretical support for the idea (Stamp Dawkins, 2021). A review of the interconnectivity of providing choice as a means to improve welfare was detailed by Englund and Cronin (2023), though, this paper was limited to a conceptual review of choice. For these reasons, our primary objective is to report the welfare impact of choice-based studies on quantifiable behavioural and physiological outcomes.

2. Methods

2.1. Study design

This literature assessment adhered to and reported results in accordance with both PRISMA and PRISMA-ScR guidelines (Page et al., 2021; Tricco et al., 2018).

2.2. Search strategy

The advanced search feature of PubMed, Web of Science (WoS) Advanced, and Scopus Advanced databases was accessed on 16 October 2023 to perform the systematic search for relevant literature. The results from the database searches were limited to papers in English, as resources were not available to translate non-English papers; review articles, proceeding papers, conference papers, and conference reviews were also excluded from the results. A list of the complete search strategies for each database, along with the specific filters applied, is included as Table A1 in the Appendix.

2.3. Eligibility criteria

We evaluated the literature through the lens of our operational definition of choice, in which studies must include an experimental design (i.e., comparison of at least one choice condition to at least one non-choice condition), with at least two or more stimuli/events presented concurrently for the choice condition. Our eligibility criteria encompassed peer-reviewed articles which focused on choice-based provision and captive species' welfare, irrespective of publication date. We developed a framework to assess the choice experiments based

on five contingent conditions, which included: 1) the offered alternatives constituted as two or more stimuli or events presented simultaneously (e.g., selecting between two enrichment items presented at the same time), as opposed to only presenting the animal with the ability to engage or not engage with one stimulus/event; 2) the choice condition was evaluated against a scenario where no choice was provided (i.e., a control condition); 3) the study assessed specific stimuli or events against the non-choice condition, explicitly excluding scenarios involving a treatment package of novel stimuli (e.g., a new enclosure, with no specific choice stimuli/events identified); 4) the study design utilised quantifiable data for evaluating behaviours and/or welfare; and, 5) the welfare impact was assessed directly as the result of the presence and absence of choice. Papers were excluded if they: did not fit into the conceptual framework of the study, focused on preference between stimuli without a non-choice condition, were solely based on qualitative assessments, excluded primary data, or made welfare assertions with no empirical evidence. Furthermore, studies based on an indirect comparison of multiple stimuli or events where no clear set of choice variables or conditions were measured, such as an animal introduced to a newly designed or renovated exhibit, were also excluded.

2.4. Study selection

Search results from all three databases were exported to EndNote reference manager, and the combined literature was exported to Covidence to remove duplicate records. Subsequently, the abstracts of the remaining titles were assessed against inclusion criteria; papers which met the inclusion criteria or those that could not be excluded based on abstract examination were then retrieved for full-text screening. Full texts were then analysed by all reviewers to minimise the risk of excluding any relevant literature, and disagreements were resolved by group discussion and consensus. Throughout the process, reasons for exclusion were documented, and the study selection process did not involve the use of automation tools.

2.5. Data extraction and synthesis

Data extraction was performed in Covidence by two reviewers, based on an extraction template developed by the primary author. The two reviewers independently extracted information including setting type, species, sample population size, choice type, and methodology. Extracted output measures included behaviour, physical biomarkers, and physiological results. Discrepancies in the extracted data were automatically identified in Covidence, and the templates were compared to discuss and concede on results. The authors categorised welfare impact as positive, negative, neutral, or unclear. In instances where a paper lacked a clear welfare assertion, the authors assigned an outcome after reviewing the biological outputs and coming to a unanimous decision. Papers which investigated multiple species with separate welfare outcomes for each species were documented as a single paper with two distinct welfare study outcomes. For example, Kurtycz et al. (2014) examined indoor and outdoor choice on the welfare of two primate species, chimpanzees and gorillas, and reported notably different welfare outcomes for each species (one positive welfare result and one potentially negative result interpreted as less clear); therefore, this paper was reported as one paper which yielded two separate welfare study results. Consequently, our review resulted in a total of 13 papers with 14 study results.

2.6. Subcategories of data

For better clarity, the following data was organised into specific subcategories: research setting, choice type, methodology, and welfare assessment. Explanations for each subcategory, as formulated by the researchers, are presented in Table 1.

Table 1
Categories and operational definitions for setting, choice type, methodology and welfare assessment.

Study setting
• Agriculture: Research conducted within a farm, aquaculture, or livestock production facility.
• Laboratory: Studies conducted in a research laboratory setting.
• Zoo: Research conducted within a zoological park, aquarium, or animal sanctuary.
• Companion animal/pet shelter: Research performed on domesticated animals that live in homes, shelters, or function as service animals.
Choice type
• Enclosure: Any choice condition which involved increased numbers of enclosure areas, such as indoor and outdoor access, or choice variables such as temperature or substrate type.
• Food: Any choice condition which involved different choices based on food variety such as composition, different sizes, or foraging/distribution options.
• Enrichment: Any choice condition which involved objects, typically described as a form of environmental enrichment.
• Training: Any trial conducted during a structured animal training session.
• Social: Any condition which utilised options related to access to conspecifics.
Methodology
• Within-subject: Studies which evaluated the provision and absence of choice for each subject (i.e., subjects typically experience multiple conditions; comparison is made within subjects).
• Between-subject: Studies which evaluated the provision and absence of choice as independent conditions (i.e., subjects typically experience one condition; comparison is made between subjects).
Welfare assessment
• Positive welfare impact: Any statistically significant changes in outcomes, such as reduced stereotypic behaviours, increased foraging behaviours, or decreased stress physiology.
• Neutral or unclear impact: Data which lacks statistical significance or may be open to differing conclusions due to the subjectivity of interpreting the welfare implications (e.g., Kurtczyk et al. (2014) interpreting increased inactivity and decreased object manipulation and feeding in gorillas as 'less robust' rather than a negative welfare impact).
• Negative welfare impact: Any statistically significant changes such as increased stereotypic behaviours, decreased foraging, or increased stress physiology.

2.7. Risk of bias assessment

The three authors screened the same 13 papers to minimize inconsistencies or bias. In instances of reviewer disagreement, discussions were held to reach a consensus on outcomes.

3. Results

The database search yielded 3078 results, with five additional reports retrieved from citation searches, for a total result of 3083 papers (see Fig. 1). After deduplication, 2018 records were evaluated for relevance based on title and abstract screening, and 1921 were excluded without further review due to not directly testing a choice condition on a quantitative measure of welfare. Subsequently, 97 papers were retrieved

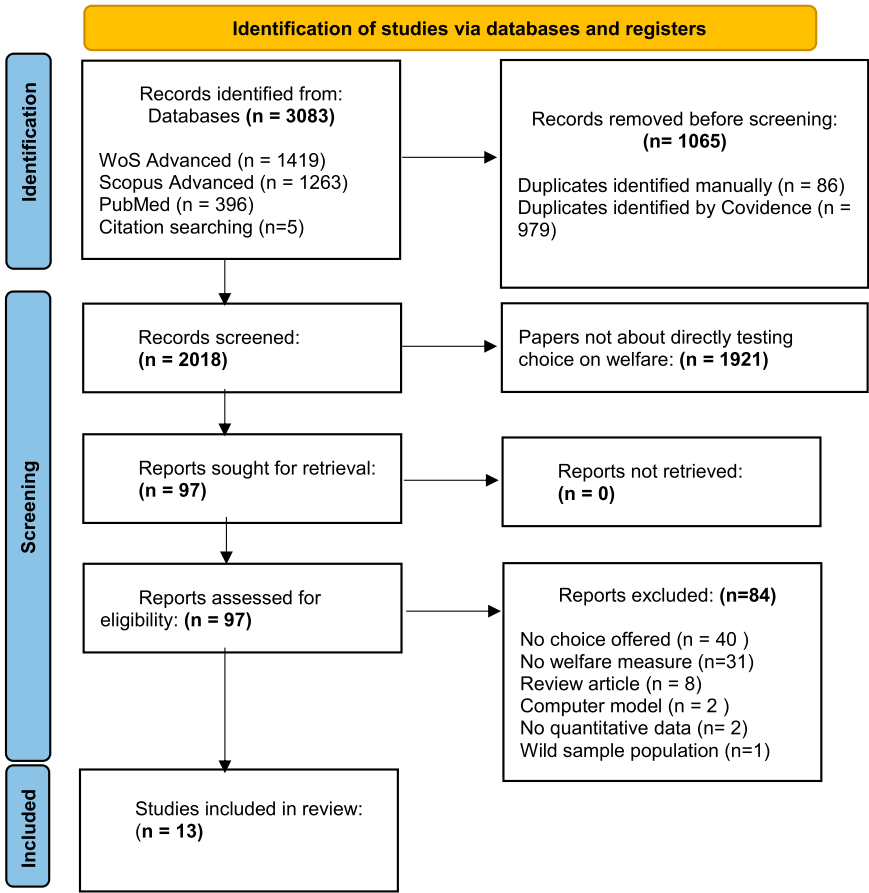


Fig. 1. PRISMA diagram of the literature identification and screening process for this scoping review. From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi: 10.1136/bmj.n71.

for full-text screening; of these, 84 of those papers were excluded based on the eligibility criteria for inclusion in this review. The reasons for exclusion are detailed in the figure below. Ultimately, 13 papers were included in the scoping review, with each paper having been published in peer-reviewed journals.

3.1. Summary of included studies

Table 2 outlines the key details of the 13 papers included in this review. All literature was published between 2005 and 2023, with 64% of the papers published after 2012.

3.2. Study setting

Studies in this review occurred within only three of the four previously described setting categories (see Fig. 2). More than half of all the papers in our review were done in a zoo setting (54%), with agriculture and laboratory settings making up the remainder of the papers.

3.3. Population of interest

A total of 8447 individuals and 13 unique species of captive animals were identified across the 13 included papers, identified by Order and common name in Fig. 3; but notably, one fish farm study accounted for 8000 individuals (Sanhueza et al., 2018). The majority of the papers (11 papers; 85%) involved mammals, with 1 paper each studying a bird or fish species. Of the seven included Orders, carnivores were predominantly represented (31%; 4 papers), while primates, hoof stock, and elephants each had two papers each, representing 15%, respectively. The data also featured one paper (8%) from each of these Orders: Aves, Rodentia, and Salmoniformes.

3.4. Types of choice

Of the five possible choice types previously defined, only three were identified: enclosure, food, and enrichment (Fig. 4). The majority of the papers (69%) in this review examined an enclosure choice, with 6 of those 9 papers (67%) involving a choice between simultaneous indoor and outdoor enclosure access.

3.5. Choice experiment methodology

In nine of the papers (69%), the control trials to establish behavioural and physiological baselines were conducted within-subject, with the same experimental group as the choice tests. Conversely, only four papers (31%) evaluated the impact of choice based on a between-subject comparison utilising separate control and experimental groups.

3.6. Behavioural and physiological measures

This scoping review identified a diverse array of biological measures; consequently, behavioural and physiological outputs were categorized into groups based on presumed functional similarity (see Table 3). All 13 included papers monitored multiple behavioural outputs, with 4 papers (31%) also measuring various physiological outputs in combination with behavioural outputs. Of the behavioural measures, three categories were predominant themes: active behaviours (12 papers, 92%), feeding and foraging (11 papers, 85%), and aberrant behaviours (10 papers, 77%). Ancillary themes included inactive behavioural (7 papers, 54%) and social dynamic behaviours (6 papers, 46%). Three papers investigated distinctive behavioural outputs which were not identified in any of the other papers. These outliers were listed in the Miscellaneous category (Table 3), and include: thermal preference, height preference, and judgment bias; each respective subcategory was represented by one paper (8%). Measures of cortisol received notable attention, with three out of four physiological output papers (75%) incorporating this

measure, which constituted 23% of the total papers. Morphometric data and molecular measures each accounted for two of the total papers (15%), respectively.

3.7. Welfare impact

Twelve of the 14 results (86%) pointed towards a welfare benefit through provisioning choice, while two study results (14%) indicated a neutral or unclear welfare impact: gorillas and mink. None of the papers reported a negative welfare outcome as a result of providing choice; albeit, some of the results from Kurtycz et al. (2014) resulted in statistically significant effects which could be interpreted as indicating a negative welfare impact. Of the three statistically significant values from the gorilla behavioural data, all three outputs resulted in a perceived behavioural decline during the choice condition. Specifically, when the gorillas had the choice to access an additional outside yard, they displayed reduced object manipulation, decreased feeding, and increased inactivity. In contrast, when the gorillas were limited to only one enclosure (non-choice condition) they displayed increased object manipulation, increased feeding, and reduced inactivity, which could thereby be interpreted as a negative welfare impact from a choice condition. Along with gorillas, mink were also classified as having a neutral/unclear welfare impact, as choice over concurrently offered enrichment objects did not decrease the frequency of stereotypic behaviours nor positively impact any other behavioural outputs.

Table 4 outlines the various behavioural and physiological changes across each species under the various type of choice conditions. Among the thirteen species reviewed, eleven showed improvements in behavioural outputs (85%), with gorillas and mink being the exception (15%). The most frequently observed behavioural benefit across the studies was a decrease in repetitive or stereotypic behaviours, with seven species (54%) exhibiting this improvement during choice conditions. Additional behavioural benefits included increased activity or play (6 species; 46%) and increased prosocial behaviour (3 species; 23%). Furthermore, giant pandas, sheep, mice and salmon were observed with both a physiological and behavioural benefit due to the provision of choice. Though, some behaviours remained unaffected by choice, such as activity level in pandas, stereotypic pacing in tigers, and repetitive behaviours in mink. As mentioned earlier, gorillas were the only species which demonstrated absolutely no behavioural improvement across any statistically significant outputs.

4. Discussion

The aim of this review was to synthesise all the literature which has experimentally assessed the effect of choice on animal welfare. Out of the initial 2,000+ reports which were identified as papers pertaining to “choice and control” within captive animals, only 13 papers experimentally examined the impact of choice on quantifiable welfare measures. Of those 13 papers, the majority involved mammals, occurred in zoos, and involved enclosure-related choice experiments, particularly those examining simultaneous access to indoor and outdoor spaces. Positive welfare impacts were reported across all three setting types, including six out of the seven taxonomic orders, underlining the potential welfare benefit that providing opportunities to express choice may have for a host of animal species, irrespective of agriculture, laboratory, zoo, or companion-animal setting. The two most common behavioural benefits reported were decreased stereotypies and increased activity/play, with both observed in roughly half of all the included species; increased prosocial behaviour was also a theme, although not as frequent. Two excluded papers asserted observed welfare benefits related to increased choice, including more dynamic and varied swim patterns in beluga whales when multiple pools were available (Hill and Nollens, 2019) and reduced stress in laboratory mice when given choice and control over nesting opportunities (Froberg-Fejko, 2010). However, neither paper provided quantitative data in

Table 2

Summary of the key details from the 13 included papers in this scoping review.

Author(s)	Title	Species	Sample size	Choice type	Output type measured	Welfare impact	Key Findings
<i>Agriculture setting</i>							
Axelsson et al. (2009)	Behaviour in female mink housed in enriched standard cages during winter	Mink (<i>Neovison vison</i>)	75	Enrichment	Behaviour	Neutral/unclear	The type or choice of multiple enrichment objects did not reduce stereotypic behaviour.
Catanese et al. (2013)	The importance of diet choice on stress-related responses by lambs	Corriedale lambs (<i>Ovis aries</i>)	24	Food	Behaviour & physiology	Positive	Choice over multiple food variety resulted in blood parameters indicative of lower stress; food choice also resulted in a greater intake rate, increased restful behaviour, and increased activity.
Sanhueza et al. (2018)	Thermal Modulation of Monoamine Levels Influence Fish Stress and Welfare	Atlantic salmon (<i>Salmo salar</i>)	8000	Enclosure	Behaviour & physiology	Positive	Fish housed in a tank with choice of a wider thermal range resulted in hormonal and behavioural findings, such as decreased aggression, territoriality, and fin damage, which have positive effects on fish welfare.
Smid et al. (2018)	Dairy cow preference for different types of outdoor access	Holstein cows (<i>Bos taurus taurus</i>)	96	Enclosure	Behaviour	Positive	Cows spent less time perching during the day when given the option of indoor and outdoor access; perching behaviour is associated with lameness so choice option may benefit welfare.
<i>Laboratory setting</i>							
Bailloo et al. (2018)	Effects of cage enrichment on behavior, welfare and outcome variability in female mice	Mice (<i>Mus musculus</i>)	192	Enrichment	Behaviour & physiology	Positive	Mice with the highest degree of enclosure complexity and enrichment had the highest welfare condition in terms of behavioural and physiological measures. Enclosures with the highest number of choices over the environment yielded the mice with the least stereotypic behaviour, greatest exploration, and lowest stress physiology, but results varied based on strain.
Rozek et al. (2010)	Over-sized pellets naturalize foraging time of captive Orange-winged Amazon parrots (<i>Amazona amazonica</i>)	Amazon parrots (<i>Amazona amazonica</i>)	10	Food	Behaviour	Positive	Increased food pellet size resulted in increased foraging behaviour compared to conventional sized pellets. Removal of food choice resulted in a 50-fold increase for biting/chewing enrichment objects.
<i>Zoo setting</i>							
Herrelko et al. (2015)	Perception of available space during chimpanzee introductions: Number of accessible areas is more important than enclosure size	Chimpanzees (<i>Pan troglodyte</i>)	22	Enclosure	Behaviour	Positive	Increased choice in number of enclosure areas resulted in decreased arousal-related behaviours during social introductions. An increase in the amount of space only decreased yawning.
Kurtycz et al. (2014)*	The Choice to Access Outdoor Areas Affects the Behavior of Great Apes	Chimpanzees (<i>Pan troglodytes</i>) and Western lowland gorillas (<i>Gorilla gorilla</i>)	15	Enclosure	Behaviour	Chimp: Positive Gorilla: Neutral/unclear	Chimpanzees were more active and demonstrated more prosocial behaviours when permitted choice of outdoor access. The gorillas' behavioural response to choice was less clear or potentially negative, as they exhibited increased inactivity and decreased object manipulation and feeding during the choice condition.
Owen et al. (2005)	Enclosure choice and well-being in giant pandas: Is it all about control?	Giant pandas (<i>Ailuropoda melanoleuca</i>)	4	Enclosure	Behaviour & physiology	Positive	Providing pandas a choice to move off exhibit lowered urinary cortisol and behavioural agitation but, they did not change overall activity levels. When bears were confined to one exhibit, they had higher rates of stereotypic behaviours and higher urinary cortisol levels.
Powell and Vitale (2016)	Behavioral changes in female Asian elephants when given access to an outdoor yard overnight.	Asian elephants (<i>Elephas maximus</i>)	3	Enclosure	Behaviour	Positive	The choice to access indoor and outdoor areas overnight resulted in a decrease in stereotypic behaviour and an increase in standing and play behaviours.
Ritzler et al. (2023)	The Effects of Choice-Based Design and Management on the Behavior and Space Use of Zoo-Housed Amur Tigers (<i>Panthera tigris altaica</i>)	Amur Tigers (<i>Panthera tigris altaica</i>)	3	Enclosure	Behaviour	Positive	The tigers increased locomotion and decreased inactivity when provided with choice to access multiple enclosures, but stereotypic pacing was unchanged.
Ross (2006)	Issues of choice and control in the behaviour of a pair of captive polar bears (<i>Ursus maritimus</i>)	Polar bears (<i>Ursus maritimus</i>)	2	Enclosure	Behaviour	Positive	Choice to access indoor and outdoor enclosure space resulted in a decrease of behavioural stereotypes and pacing. Increased social play was also observed as a result of choice.

(continued on next page)

Table 2 (continued)

Author(s)	Title	Species	Sample size	Choice type	Output type measured	Welfare impact	Key Findings
Schiffmann & Clauss (2019)	Impact of a new exhibit on stereotypic behaviour in an elderly captive African elephant (<i>Loxodonta africana</i>).	African elephant (<i>Loxodonta africana</i>)	1	Enclosure	Behaviour	Positive	Providing choice to access indoor and outdoor areas and increased social choice led to a decrease in stereotypic swaying behaviour for an elderly female; swaying only occurred when access was restricted to one area, whether indoor or outdoor.

* In the Kurtycz et al. (2014) paper, two primate species were examined, but each produced divergent welfare outcomes based on the statistically significant outputs. Environmental choice resulted in clear behavioural benefits for the chimpanzees; however, it resulted in an unclear welfare benefit for gorillas, which may even be interpreted as a negative welfare impact. Therefore, this paper will be presented as two different welfare results from Section 3.6 onwards, for a total of 13 papers with 14 study results.

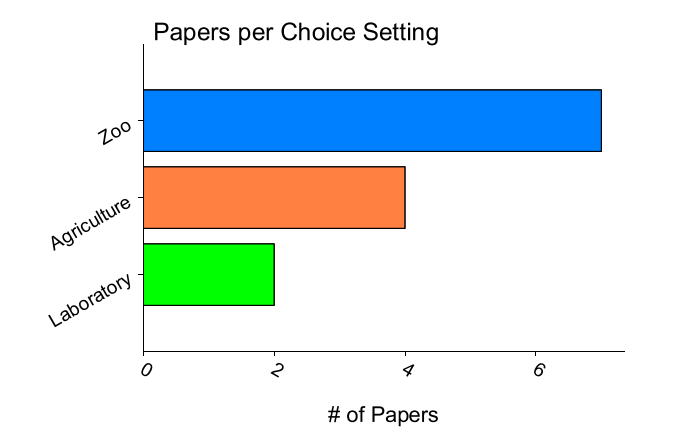


Fig. 2. Bar graph analysis of 13 published paper articles across three setting types (Zoo, Agriculture, and Laboratory).

relation to the concept; as a result, they were excluded from our review. Surprisingly, despite “choice and control” clearly gaining traction as a mainstream topic across animal welfare science, as inferred from the publication dates and large volume of literature identified, very few studies met the criteria for providing experimentally-examined choice to the animals in order to directly evaluate its effect on welfare compared to a non-choice condition. This is at least partially explained by the variability in the use of the term “choice” to describe a wide array of conditions with an implied, but not directly assessed, increase in options or opportunities. For example, where an animal is introduced to a newly renovated enclosure, the new enclosure may imply choice through increased complexity or options, but there was often no direct assessment of the proposed choice stimuli or events themselves. Likewise, a number of papers experimentally examined choice through methods such as preference assessments; and although the implications of these papers were of improved welfare, there were often no direct measures of changed welfare outputs. These papers were excluded since both a direct comparison of a choice condition to a non-choice condition, as well as an assessment of the effects of those choice/non-choice conditions on welfare were required for inclusion in our review. Finally, a total of 40 papers were excluded from our review due to no choice being offered. According to our choice criteria, two or more stimuli/events had to be simultaneously compared, which excluded conditions in which “choice” was defined as being able to select or not select one stimulus/event. For instance, a study might suggest they examined choice because an animal was able to select between interacting or not interacting with an enrichment device. However, such a study would have been excluded from our review since it presented only one total stimulus/event. It is worth noting that our necessary choice criteria matches the concept of “genuine choice”, as originally defined by Israel Goldiamond (1974); see also de Fernandes and Dittrich, (2018); Layng, (2009).

4.1. Limitations

It is important to highlight certain constraints within our scoping review. Firstly, the variability and interchangeable usage of the terms “choice and control”, “preference”, and “complexity” within the literature posed significant challenges in developing a precise search strategy. This resulted in over 3000 records identified and over 2000 titles and abstracts screened, which necessarily increased the difficulty in finding relevant papers. We also excluded book chapters, conference proceedings, and any literature not published through peer-reviewed journals from this review, which may have yielded more studies. Lastly, our requirements relied on statistical significance from some inferential test, thereby further limiting our identification of relevant papers.

4.2. Future directions

We suggest several avenues in which future research will benefit from a greater understanding of choice and captive welfare. These future directions include recommendations for settings, species, choice types, output measures, and additional controls.

4.2.1. Setting and species

This review reveals a notable disparity in the variety of species studied, with the absence of research on companion animals being particularly striking. Despite all three search strategies including variations of the terms “dog”, “canine”, “cat”, and “feline” as title and abstract keywords, no relevant studies were identified for this review. Future research could broaden their scope to include a more diverse array of species and settings; particularly in pet shelters where the potential for choice improving welfare is imperative. In addition, two papers indicating species-specific results highlights the importance and value of conducting choice trials across a myriad of species. A paper by Bailoo et al. (2018) cautioned against choice-related welfare generalisations, noting varied behavioural and physiological responses among different strains of mice within the same study. Another paper by Kurtycz et al. (2014) found that while chimpanzees showed clear behavioural benefits when provided with indoor and outdoor choice, the gorillas exhibited increased inactivity and decreased object manipulation and feeding behaviour when provided with the same choice. Although the authors characterised this result as less robust, the results could potentially indicate a negative welfare impact. These cases underline the necessity for conducting species-specific research related to choice, including a wide range of outputs for assessments.

4.2.2. Choice types

Another unexpected result was that there was no literature on choice experiments involving training or social-choice options. While one study taught horses to communicate their preferences by touching symbol cards (Mejdell et al., 2016), it was excluded from this review as it was classified as preference assessment with no direct welfare implication. Nonetheless, this avenue of research is promising as it may allow

Taxonomic distribution of study populations: Order & common name



Fig. 3. Sunburst analysis chart of the study populations across 13 included papers, listed by Order and common name.

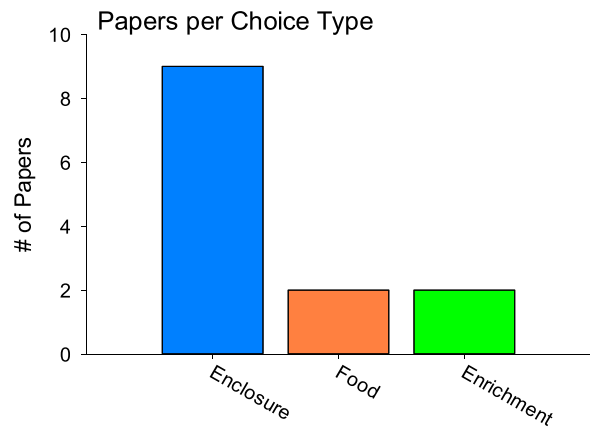


Fig. 4. Bar graph analysis of 13 published papers across three choice types (Enclosure, Food, and Enrichment).

animals to actively communicate and select for their preferred outcomes rather than the trainers imposing what they deem to be the most rewarding for the animals. A training paradigm in which an animal can select their choice of consequences to the handler may reverse the traditional power dynamic, since the animal is no longer subject to outcomes based on trainer bias (Fernandez, 2024). Furthermore, social-choice experiments which compare baseline data to social-choice trials may have potential socially mediated benefits, such as decreased aggression and increased affiliative interactions.

A third choice type, enrichment-based choice, was identified in this review but only accounted for two of the 13 papers; despite enrichment being a key factor that has been empirically demonstrated to enhance

captive-animal welfare (Maple and Perdue, 2013; Shepherdson et al., 1999; Young, 2013). Enrichment is a simple and effective method which can be utilised across agricultural, lab, zoo, and shelter settings; and training and socialisation are two well-documented methods that serve as enrichment (Fernandez, 2022; Laule and Desmond, 1998; Westlund, 2014). Consequently, experimentally examining training-choice and socialisation-choice, in itself, may provide a novel dimension of enrichment. The potential multifaceted benefits of improved behavioural health, welfare measures, and cognitive health through enrichment-choice, training-choice, and social-choice provision underscores why delving into this significant gap in the literature may advance animal welfare science.

4.2.3. Output measures

The current literature from this review suggests that the provision of choice can lead to measurable improvements in behavioural and biological health markers; whereas, studies utilising only one output measure may be more likely to produce results which provide incomplete or misleading welfare evaluations. There is evidence which indicates that purely the existence of choice options in captive animal settings may be invaluable, irrespective of active interaction or preference (Kurtycz et al., 2014; Mason et al., 2001; Pines et al., 2007; Seaman et al., 2008). Decker et al. (2023) offers a partial rationalisation for why little-to-no interaction with environmental stimuli may still provide welfare benefits, as stated through five possible explanations: (1) certain motivations may be satisfied quickly, yet still promote other welfare benefits; (2) interaction with a choice stimulus may merely serve as a method to achieve a goal, lacking inherent reward itself; (3) the sheer presence of alternatives can be fundamentally advantageous; (4) some stimuli may fulfill significant environmental or social needs by creating opportunities for separation from cohorts or aversive stimuli; and (5) certain

Table 3

Summary of behavioural and physiological outputs investigated across 13 included papers.

Behavioural outputs	
Aberrant behaviours	10 papers (Axelsson et al., 2009; Bailoo et al., 2018; Catanese et al., 2013; Herrelko et al., 2015; Kurtycz et al., 2014; Owen et al., 2005; Powell and Vitale, 2016; Ritzler et al., 2023; Ross, 2006; Schiffmann et al., 2019)
•Pacing	
•Swaying	
•Stereotypies	
•Repetitive behaviours	
•Yawning	
•Rubbing	
•Arousal-related scratching	
•Anticipatory	
•Regurgitation/reingestion	
•Reduced exploration/habituation	
Active behaviours	12 papers (Axelsson et al., 2009; Bailoo et al., 2018; Catanese et al., 2013; Glaeser et al., 2021; Kurtycz et al., 2014; Owen et al., 2005; Powell and Vitale, 2016; Ritzler et al., 2023; Ross, 2006; Rozek et al., 2010; Schiffmann et al., 2019; Smid et al., 2018)
•Locomotion/walking	
•Chasing/stalking	
•Swimming	
•Allogrooming	
•Vigilance (non-movement)	
•Play	
•Climbing/flying	
•Object manipulation	
•Enrichment interaction	
•Habitat interaction	
Inactive behaviours	7 papers (Catanese et al., 2013; Herrelko et al., 2015; Owen et al., 2005; Powell and Vitale, 2016; Ritzler et al., 2023; Rozek et al., 2010; Schiffmann et al., 2019)
•Leaning	
•Time lying	
•Standing	
•Perching	
•Resting	
Social behaviours	6 papers (Glaeser et al., 2021; Herrelko et al., 2015; Kurtycz et al., 2014; Ross, 2006; Sanhueza et al., 2018; Smid et al., 2018)
•Social play	
•Prosocial behaviour	
•Social grooming	
•Proximity to others	
•Aggressive/territorial	
Feeding and foraging behaviours	11 papers (Bailoo et al., 2018; Catanese et al., 2013; Glaeser et al., 2021; Herrelko et al., 2015; Kurtycz et al., 2014; Powell and Vitale, 2016; Ritzler et al., 2023; Ross, 2006; Rozek et al., 2010; Schiffmann et al., 2019; Smid et al., 2018)
•Feeding/drinking	
•Foraging	
•Intake rate	
Miscellaneous	3 papers (Bailoo et al., 2018; Ritzler et al., 2023; Sanhueza et al., 2018)
•Thermal preference	
•Height preference	
•Judgement bias	
Physiological outputs	
Morphometrics	2 papers (Bailoo et al., 2018; Sanhueza et al., 2018)
•Growth rate	
•Fin damage	
•Body weight	
•Organ mass	
Cortisol levels	3 papers (Bailoo et al., 2018; Catanese et al., 2013; Owen et al., 2005)
•Urinary cortisol	
•Faecal cortisol	
•Serum cortisol	
Molecular measures	2 papers (Catanese et al., 2013; Sanhueza et al., 2018)
•Neutrophil: lymphocyte ratio	
•mRNA abundance	
•Transcriptome sequencing	
•Neurotransmitters	

environmental stimuli, which provides a richness of resources, may satiate the instinctual drive for habitats that support fitness and preference. Furthermore, preferences and motivation for choices may change based on the time of day (Gaskill et al., 2009; Taylor et al., 2006), the season (Fultz et al., 2023; Lukas et al., 2003), or the current life stage of the animal (Broom, 2021; Fraser and Matthews, 1997).

Due to the potential impact of unchosen stimuli, researchers need to consider that individual assessments alone may not suffice as

Table 4

Effect of the choice condition on behavioural and physiological outputs across 13 included papers.

Choice provided	Choice condition: behavioural effect by species	Choice condition: physiological effect by species
Enclosure		
Indoor and outdoor access	Increased •Prosocial behaviour (chimps, polar bears)•Play (elephants)•Grooming (chimps)•Activity (chimps)•Swimming (polar bears) •Standing (elephants) Decreased •Stereotypies/ repetitive behaviours (pandas, polar bears, elephants)•Agitation behaviours (pandas)•Laying down (cows, elephants)•Perching (cows) •Activity (gorillas)•Object/ enrichment engagement (gorillas)•Feeding (gorillas) Unchanged •Activity (pandas)	Decreased •Urinary cortisol (pandas)
Extra enclosure access (only outdoor or only indoor)	Increased •Locomotion (tigers) Decreased •Yawning and arousal-related scratching (chimps)•Inactivity (tigers) Unchanged • Stereotypic pacing (tigers)•Allogrooming and rubbing (chimps)	
Thermal modulation (fish)	Increased •Prosocial group structure Decreased •Aggression/territoriality	Increased •Body growth•mRNA abundance•Dopamine/ serotonin levels•Hormone performance Decreased •Fin damage
Food		
Pellet size (parrots)	Increased •Food manipulation skills (podo-mandibulation)•Foraging•Activity Decreased •Engagement with enrichment objects	
Food composition variety (lambs)	Increased •Food intake rate •Activity levels •Time lying	Decreased •Serum cortisol levels•Neutrophil:lymphocyte ratio
Enrichment		
Vertical space and enrichment devices (mink)	•Unchanged repetitive behaviours	
Nesting materials, vertical space, and enrichment devices (mice)	•Increased exploratory behaviour •Decreased stereotypies	•Decreased faecal cortisol levels

comprehensive welfare evaluations in choice experiments. The effects of choice are more likely to be captured through the use of multiple welfare metrics, including both behavioural and physiological measures, as was observed in several of the papers reviewed (Bailoo et al., 2018; Catanese et al., 2013; Owen et al., 2005; Sanhueza et al., 2018). Also, the incorporation of behavioural metrics that extend beyond simply “activity budgets” and aim to collect additional observations such as behavioural diversity (Brereton and Fernandez, 2022a; Miller et al., 2020) and enclosure-use variability (Brereton and Fernandez, 2022b) may provide a deeper perspective. There is also preliminary data that indicates choice provision not only has acute impacts, but may also effect individuals on a cellular and genetic level (Catanese et al., 2013; Sanhueza et al., 2018); consequently, more studies which incorporate a broad range of biological outputs may further our understanding of the immediate and

chronic ramifications choice may have on welfare. That said, the presence of unclear or neutral outputs (for instance, see Axelsson et al., 2009; Kurtycz et al., 2014) indicates a need to investigate how different and greater number of welfare measures might impact our understanding of choice.

4.2.4. Additional controls

In addition to unclear welfare results, a specific type of enclosure-related choice evaluated in this review presented considerable ambiguity. In experiments which involved indoor and outdoor access, it was often unclear whether the output improvements were due to the opportunity of choice or simply the expansion of space. Among our findings, only one paper (Herrelko et al., 2015) out of the seven compared whether the behavioural impact was in reference to increased choice or increased space. The study results showed that while quantity of enclosure space was important to chimpanzee behaviour, the choice of multiple areas was more important than the total amount of space; hence, experimental designs which utilise similar additional controls could be advantageous for assessing the true welfare impact of choice. For instance, in the example of indoor and outdoor choice, the baseline would be collected while the animal only has access to the indoor enclosure. The additional control would measure outputs while the animal had access to both areas without the requirement to choose. Whereas, the choice trial would be designed so that the animal must perform an action, like pressing a button, to access the outdoor space. This approach would help differentiate whether the act of choosing was the beneficial welfare component, or simply the larger space.

5. Conclusion

The majority of the included studies in this review suggest that the provision of choice holds promise for improving behavioural and physiological welfare indicators for captive animals. A key area of behavioural interest was recording choice's impact on stereotypes, suggesting a growing focus on choice provision being implemented as a management technique to diminish undesired or negative welfare-related behaviours. While these studies were grouped into zoo, laboratory, and agricultural settings for the purposes of reporting results, there is an assumed welfare benefit in offering various choice types to species across all captive settings. Although, caution must be exercised in generalising the welfare benefits of all types of choice, as the majority of our papers were limited to enclosure manipulations with mammals in zoo settings. Therefore, it is critical that a wide range of choice types are measured and evaluated across many species and settings; only then can we better assess the welfare implications of increased choice manipulations. Considering that only 13 papers provided quantitative, experimental data regarding the impact of choice on welfare, there is a critical importance to improve evaluating and reporting on the welfare benefits of choice. This review underscores the pressing need for captive organisations to empirically validate welfare benefits from choice-based studies using careful experimental design, clearly defined terminology, and increased inclusion of quantitative outputs that are essential for advancing our understanding of the influence of choice on captive animal welfare.

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Kelli Rust: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation. **Isabella Clegg:** Writing – review & editing, Writing – original draft, Supervision, Data curation. **Eduardo J. Fernandez:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis,

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Appendix A. Supporting information

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