Providing information about wild animal psychology impacts public attitudes beyond ecological information

F. Blake Morton *[1], Dom Henri [2], Kristy A. Adaway [1], Carl D. Soulsbury[4], Charlotte R. Hopkins [3]

[1] Department of Psychology, University of Hull, Hull, UK

[2] School of Natural Sciences, University of Hull, Hull, UK

[3] School of Environmental Sciences, University of Hull, Hull, UK

[4] School of Life and Environmental Sciences, University of Lincoln, Lincoln, U.K.

Author Note

F. Blake Morton https://orcid.org/0000-0002-8644-1557

Dom Henri https://orcid.org/0000-0002-7574-5846

Kristy A. Adaway https://orcid.org/0009-0006-1041-8592

Carl D. Soulsbury https://orcid.org/0000-0001-8808-5210

Charlotte R. Hopkins https://orcid.org/0000-0003-0434-6378

*Author for correspondence: Dr Blake Morton, Department of Psychology, University of Hull, HU6 7RX, United Kingdom. E-mail: b.morton@hull.ac.uk

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Highlights

- Anthropomorphism impacts attitudes and beliefs about wildlife
- The influence of animal psychology research is unclear
- We tested if fox psychology research influences people's attitudes
- People given fox psychology information reported greater attitude change
- The effect was greater than information about fox ecology

Abstract

Anthropomorphism is often used to encourage positive wildlife attitudes in people but is rarely based on actual animal psychology research. It is unclear whether, or how, disseminating animal psychology research to the general public impacts attitudes towards wildlife. Through a national-level survey (n = 1,364 participants), we tested whether providing information about the boldness and problem-solving abilities of a wild carnivore, the red fox (*Vulpes vulpes*), influences people's attitudes and beliefs about this species. Half of participants were given information on fox psychology (either a video or a press release about fox boldness and problem-solving), the other half were given content unrelated to animal ecology (either a video or a press release about fox habitat use). Afterwards, all participants completed the same 24-item questionnaire evaluating fox-related attitudes and beliefs. While attitudes and beliefs relating specifically to overall fox tolerance remained unaffected by content (fox ecology vs fox psychology) or format (video vs written), 19.9% of people agreed that the fox psychology information changed their attitudes to foxes (272 participants). Across all participants, perceived attitude change, based on a Likert scale, was significantly higher for participants watching videos (3.73±0.06) versus a press release (3.54±0.06), and for fox psychology content (3.76±0.06) versus fox ecology content (3.50±0.06). This perceived attitude change was also positively correlated with overall fox tolerance. Thus, information about animal psychology may influence other facets to people's attitudes beyond general tolerance (e.g., interest factor), particularly through videos, and this effect may be greater than information about a species' basic ecology.

Key words: biodiversity crisis, human-nature connectedness, public attitudes, red fox, animal cognition, anthropomorphism

Introduction

Globally, human activities are driving the mass extinction of species, commonly referred to as the “sixth mass extinction” or the “biodiversity crisis” (Ceballos et al., 2015; Western, 1992). The loss of biodiversity threatens ecosystem services, ecosystem function and human well-being (Ceballos et al., 2015; Diaz et al., 2006; Isbell et al., 2023). In parallel with biodiversity decline, human societies are becoming increasingly disconnected from nature and local wildlife (Balmford et al., 2002; Cazalis & Prevot, 2019; Schuttler et al., 2019; Soga & Gaston, 2016, 2023; Soga et al., 2023). Spatial segregation of humans and nature, driven by factors such as rapid urbanisation and reduced opportunities to experience nature, is one driver of this growing psychological disconnection (Barragan-Jason et al., 2023). “Nature connectedness”, i.e., a person’s subjective sense of being part of the natural world (Martin et al., 2020; Mayer & Frantz, 2004), is being consistently linked to greater pro-environmentalism (Martin et al., 2020; Whitburn et al., 2020). Thus, to tackle the biodiversity crisis, there is a pressing need to understand how to promote more positive connections to wildlife, particularly in terms of how people form perceptions (i.e., interpret and organise meaningful experiences) (Clayton & Myers, 2015), attitudes (i.e., judgements and evaluations) (Clayton & Myers, 2015), and beliefs about a species (Richardson et al., 2022; Richardson, Passmore, et al., 2020).

A traditional strategy often used by conservationists to promote more positive human-wildlife connections has centred around disseminating facts, in the belief that this will lead to significant effects on how people engage with an environmental issue (Kusmanoff et al., 2020; Toomey, 2023). Providing people with new information can, in some instances, impact a person’s engagement with environmental topics even after a single exposure to that information (Johnson et al., 2016). Socio-psychological research, however, shows that in many other cases, promoting facts alone is unlikely to influence people’s minds or behaviour (Toomey, 2023). Rejection of facts may be likely if the content is contentious or contradictory to people’s pre-existing beliefs or worldview (Drummond & Fischhoff, 2017; Gormon & Gormon, 2016), and could even lead to a “boomerang” effect, whereby attempts at persuasion

encourage people to adopt an opposing stance (Kahan et al., 2012). For example, beliefs about the risks of climate change, wolf restoration, and wildlife diseases have been found to be strongly associated with partisan orientations, and some messaging strategies may increase polarisation of views (Hart & Nisbet, 2011; Meadow et al., 2005; Roh et al., 2015). By contrast, more holistic models for promoting pro-environmentalism have emphasised the role of emotion, personal values, and instinct – rather than facts – in shaping people's decision-making (Kollmuss & Agyeman, 2002; Lumber et al., 2017; Richardson, Dobson, et al., 2020; Soga & Gaston, 2016). Indeed, attitudes and beliefs shape how people see, evaluate, and engage with their surroundings, which are highly susceptible to an individual's pre-existing experiences, values, motivations, and personality (Assael, 1995). Such complex psychological interactions likely shape people's connectedness to wildlife, particularly in terms of how people interpret and catalogue their experiences with them (e.g., positive versus negative encounters).

Facts conveyed through stories and storytelling may provide an alternative approach beyond the dissemination of facts, by amplifying cognitive processes that rely on other factors such as emotion, leading to stronger human-wildlife connections (Toomey, 2023; Wilkinson, 2023). Animal imagery, for example, has been shown to have positive effects on people's attitudes and beliefs about wildlife, altering their emotional connections and willingness to protect species (Benson, 2016; Buckmaster, 2015; Schueler & Newberry, 2020; Thomas-Walters et al., 2020; Wilkinson, 2023). The framing of similarities between humans and other species in pro-environmental narratives may play a particularly important role in shaping people's attitudes and beliefs about a species based on shared bio-behavioural characteristics, such as psychological abilities (Batt, 2009).

Attributing human-like characteristics to non-human beings ("anthropomorphism") (Epley et al., 2007) is an increasingly common conservation campaign strategy aiming to create stronger pro-environmentalism within people (Williams et al., 2021). Studies have shown that anthropomorphism of nature is positively correlated with pro-environmental attitudes (Apostol et al., 2013) and with the compassionate conservation movement (Manfredo

et al., 2020). However, in some contexts, anthropomorphism of non-human species may hinder wider conservation efforts (Williams et al., 2021). For instance, attributing predators with perceived negative characteristics, including adjectives such as “sly” and “cunning”, may help explain their persecution by humans (Benavides Medina, 2020; Drouilly et al., 2021; Ordiz et al., 2013). By emphasizing anthropomorphism in conservation campaigns, attributing inaccurate psychological traits to a species may be ascribed too readily, leading to their true psychological abilities being misunderstood (Callahan et al., 2021; Maust-Mohl et al., 2012). Callahan et al. (2021) demonstrated a strong willingness by the general public to ascribe psychological abilities to animals, but there have been limited efforts to link public wildlife attitudes to information provided from *actual* psychological research about those species.

Most of the current evidence supporting a link between animal psychology research and human-wildlife connectedness comes from anecdotal observations. Knowledge about crow intelligence, for example, has apparently convinced some farmers to stop killing these so-called agricultural pests altogether (Carey, 2018). Experimental studies exist on the link between animal psychology and people's attitudes toward animals, yet these have focused on captive, exotic, or domestic species rather than wildlife. Craig and Vick (2021) reported that talking with the public about the personalities of captive chimpanzees (*Pan troglodytes*) encourages more positive attitudes towards their conservation. Similarly, Hazel et al. (2015) found that clicker training encourages more positive attitudes towards chickens (*Gallus domesticus*) because it challenges participants’ beliefs about “limited” chicken intelligence. Nevertheless, despite the importance of these studies, it remains unclear to what extent information about animal psychology drives such attitudinal shifts in people. Experimental controls are needed to rule out alternative explanations for these studies’ findings, such as the possibility that people are simply interested in animals’ outward behaviour in general (not their inward psychology *per se*), or that people simply enjoy engaging with the study animals in person, both of which could have influenced participants more than the actual information they were being given about animal psychology (Lumber et al., 2017). Furthermore, experimental research suggests that information about a species’ psychology may only impact people’s

attitudes in exotic or fictional species (Piazza & Loughnan, 2016), whereas the impact of similar information on people's connections to local wildlife may vary depending on the potential benefits (e.g., more opportunities for engagement) and costs (e.g., human-wildlife conflict) of tolerating them. Thus, further work is needed to better understand how animal psychology research might shape people's connections with wild animals.

Boldness (defined broadly as animals' responses to unfamiliar situations) (Bergvall et al., 2011; Breck et al., 2019) and novel problem-solving abilities (defined here as using new or modified behaviours to solve new or old tasks) (Lee, 1991; Reader & Laland, 2003) have important psychological underpinnings that allow some local wildlife species to persist in anthropogenic landscapes (Fehlmann et al., 2021; Griffin et al., 2017; Stanton et al., 2023). Yet, such abilities can also lead to real or perceived conflict with people, such as the belief that bolder species are more likely to attack people, or that better problem-solvers are more likely to cause public disturbances, such as bin raiding (Drouilly et al., 2021). Providing people with information about boldness and problem-solving abilities in wildlife may therefore serve to generate new, or reinforce previously held, negative attitudes and beliefs about a species regardless of their accuracy, particularly if the species has already been labelled by social constructs like "pest" or "nuisance". Presenting people with contrasting evidence (e.g., bolder animals are *not* always more likely to cause particular types of public disturbances) (Morton et al., 2023) may hinder pro-environmentalism within people if they still perceive those animals to be a high personal risk.

In the current study, we ran a series of controlled online experiments to understand how promoting information about boldness and problem-solving abilities in a wild mammalian carnivore, the red fox (*Vulpes vulpes*), might impact public attitudes and beliefs about these animals. Mammalian carnivores, such as foxes, are an example of a group of animals that display variation in boldness and problem-solving (Breck et al., 2019; Daniels et al., 2019; Morton et al., 2023; Stanton et al., 2022), which have likely enabled them to exploit a wide variety of environments (Ashish et al., 2022; Drouilly et al., 2021). Such abilities, however, are also factors underpinning their worldwide persecution based on their real or perceived threats

to people, property, and domesticated species (Ashish et al., 2022; Brand & Baldwin, 2020; Bridge & Harris, 2020; Soulsbury & White, 2015). Nevertheless, attitudes and beliefs about carnivores have a long and complicated history. Aesthetics/physical appearances (Ashish et al., 2022), knowledge about a species' ecological value (Ericsson & Heberlein, 2003), and socio-cultural contexts (Dorresteijn et al., 2016; Roskaft et al., 2007) have all been shown to be important predictors of the level of tolerance towards these animals. However, it is unclear whether providing the public with information about boldness and problem-solving abilities in wild carnivores impacts people's connectedness to them, particularly compared to other forms of information (e.g., basic ecological facts) and in terms of the medium through which such information is disseminated (e.g., reading versus watching content). Thus, our study had three aims: First, to test whether providing information to the general public about boldness and problem-solving in wild foxes influences people's attitudes and beliefs about them. Second, to test whether such effects are due to people being given information related to fox psychology, rather than other information about foxes, such as their habitat use. Third, to test whether any effect on public attitudes and beliefs about foxes is conditional on how such information is disseminated (e.g., public press release versus YouTube videos).

Materials and methods

Ethical statement

Data collection for the online survey was ethically approved by the Faculty of Health Sciences Ethics Committee of the University of Hull (FHS22-23.37). Data collection for the fox data used in the current study was ethically approved by the Animal Welfare Ethics Board of the University of Hull (FHS356) and was carried out in accordance with guidelines outlined by the Association for the Study of Animal Behaviour (ASAB, 2020). No foxes were handled, all trail cameras were placed away from footpaths to minimise public disturbance, and food items used to attract foxes were not harmful if ingested by other animals, including outdoor pets.

Survey design and sampling

An online survey of public attitudes and beliefs about foxes was administered to members of the UK general public between March and April 2023. The survey was administered by a commercial survey company (*Survation*) to ensure a UK representative sample using the company's existing participant pool. To avoid priming survey participants by exposing them to the stimulus of "psychology", all participants were informed upon recruitment that the survey was related to the broader theme of "public attitudes towards foxes". A survey composed of 43 questions was organised into three parts (A, B, C) (Appendix 1). All parts of the survey were mandatory, and participants could not return to previously answered questions to change their responses. Although there was no time limit, the entire survey should have taken no longer than 15 minutes to complete. Part A included demographic questions (i.e., age, gender, location, and home ownership characteristics) and questions pertaining to participant knowledge of, and experience with, foxes (e.g., pest control).

Table 1. Information about the online experimental and control groups.

Group	Type	Description	Link to condition
1	Experimental	Read a press release about a study on fox psychology.	See Figure A in Appendix 1.
2	Control	Read a press release about a study on fox habitat use.	See Figure B in Appendix 1.
3	Experimental	Watch a YouTube video about a study on fox psychology.	https://www.youtube.com/watch?v=Uy-ByMAUVMQ
4	Control	Watch a YouTube video about a study on fox habitat use.	https://www.youtube.com/watch?v=AZo5whONUgo

In Part B, participants were randomly assigned to one of four groups using a random number algorithm (Table 1). No questions were asked in this section of the survey. Participants were allocated to either a press release or YouTube condition (Table 1) because they are different but common ways in which information about animal psychology are disseminated to members of the public (i.e., reading or watching online content). Participants were not made

aware of the other groups. Participants in Groups 1 and 3 were presented with information about two psychological profiles (bold/shy behaviour and problem-solving ability) using trail camera data from the *British Carnivore Project*, an on-going study of wild carnivore behaviour and cognition in the UK (Morton et al., 2023). Bold/shy behaviour was defined in this study in terms of the likelihood of foxes touching and engaging with unfamiliar puzzle feeders (Morton et al., 2023). Problem-solving ability was defined in terms of the likelihood of foxes solving the puzzles (Morton et al., 2023). We selected these two profiles because they offered different scenarios for perceived conflict with foxes. As a control, participants in Groups 2 and 4 were presented with information about fox habitat use (i.e., no overt discussion about psychology); this information also used trail camera data from the *British Carnivore Project*. The experimental and control conditions within each situation very closely resembled each other (e.g., same length, number of words, and image quality) except the experimental group contained information about fox psychology while the control group contained information about fox habitat use (Table 1). Importantly, while some participants allocated to the control condition may have interpreted foxes' habitat use from a psychological perspective (e.g., foxes are perhaps bold because they travel through many habitats), our experimental design nevertheless enabled us to test whether giving *explicit* information about fox psychology (e.g., using terms like 'boldness' and 'problem-solving' in Groups 1 & 3, Table 1) impacted people beyond information where the psychological underpinnings of foxes' behaviour were not intentionally discussed (Groups 2 & 4, Table 1).

Part C included questions designed to evaluate participants' pro-environmental attitudes and beliefs about foxes, as well as their perceived attitudinal change due to the information they received in Part B. All of these items were measured using a 7-point Likert scale, whereby 1 = strongly disagree, 4 = neither agree or disagree, and 7 = strongly agree. Most of the questions about fox-related attitudes and beliefs (Questions 5-9 and 12-24) were drawn from previous questionnaires used to evaluate public attitudes towards carnivores, including foxes (Arbieu et al., 2019; Kimmig et al., 2020), but some were unique to our study: Questions 2-4 drew specific attention to the link between fox psychology and human-wildlife

conflict (e.g., “Bold behaviour in foxes would negatively impact my everyday life, e.g., raiding my garden or outdoor bin”). Questions 10 and 11 asked participants about litter and bin-raiding behaviour, i.e., a popular belief about urban foxes within the UK (Morton et al., 2023). Question 25 asked people whether fox psychology improved their overall tolerance of foxes. At the end of the survey, participants were asked whether they were a participant in the on-going citizen science programme of the *British Carnivore Project*, and whether they were aware of fox psychology research prior to completing the current survey about their attitudes and beliefs about these animals.

We opted against using a before-after comparison (i.e., administering the survey in Part C before and after people were exposed to the information given to them in Part B) because psychologists have identified a number of problems associated with interpreting experimental effects using this approach, such as psychological anchoring, priming, other demand characteristics, which could lead to bias in participants’ responses (Shadish et al., 2002). Thus, to address the aims of our study, we compared participants’ responses between the experimental and control groups for information about fox psychology and information about fox habitat use, and whether any significant effects depended on the method of dissemination (press release versus YouTube video). Studies using experimentally-controlled methods similar to ours have found significant effects of providing new information on people’s engagement with that content, such as a greater willingness to use sunscreen or participate in land use planning (Johnson et al., 2016; Vezich et al., 2017). In our study, participants were randomly allocated to one of our four conditions (Table 1); thus, if being exposed to information about fox psychology influences people’s attitudes about them, then our experimental groups (Groups 1 and 3) should significantly differ in terms of their questionnaire responses compared to the control groups (Groups 2 and 4).

Ethical statement

Data collection for the online survey was ethically approved by the University of Hull. Data collection for the fox data used in the current study was ethically approved by the Animal

Welfare Ethics Board of the University of Hull and was carried out in accordance with guidelines outlined by the Association for the Study of Animal Behaviour (ASAB, 2020). No foxes were handled, all trail cameras were placed away from footpaths to minimise public disturbance, and food items used to attract foxes were not harmful if ingested by other animals, including outdoor pets.

Principal component analysis of attitudes and beliefs about foxes

To obtain a global measure of pro-environmental attitudes and beliefs about foxes, we entered the relevant 24 items from Part C of the online survey into a Principal Component Analysis (PCA). A scree plot and parallel analysis were used to determine the number of components to extract (Horn, 1965; Morton & Altschul, 2019). Item loadings $\geq |0.4|$ were defined as salient for the PCA; items with multiple salient loadings were assigned to the component with the highest loading.

Data analysis

We used two separate linear mixed effects models (LMM) to test whether participant self-reported attitudinal change [Question 1 of Part C of the survey] or overall tolerance of foxes differed between 1) communication format (video versus written) and 2) content (fox psychology versus fox ecology). We included the interaction between format and content in each model. For all analyses, we included participant's region within Great Britain (N=11: East Midlands, East of England, London, North East, North West, Scotland, South East, South West, Wales, West Midlands, Yorkshire and the Humber), and gender as random factors, as a prior study suggested that fox-related attitudes and beliefs may be different in different regions of the UK (Morton et al., 2023) and because previous studies have found gender sampling effects on fox-related attitudes (Kimmig et al., 2020). Although age and degree of urbanisation can also impact fox-related attitudes (Kimmig et al., 2020), there were no significant differences in participants' mean age ($F(3, 1369) = .964$, $P = .409$) and degree of urbanisation ($F(3, 1369) = .895$, $P = .443$) across our treatments, hence, we opted against

including these variables within our models to avoid overparameterization. We finally conducted a linear model between overall tolerance and self-reported attitude change. Both the linear model and LMM analyses were performed in R version 4.3.1 (RCoreTeam, 2023) using the 'lme4' package (Bates et al., 2015), with Wald χ^2 values calculated using 'car' (Fox & Weisberg, 2019). Data for the statistical analyses of this study are provided in Dataset S1 in the supplementary materials.

Results

Participants

A total of 1,373 people participated in the study (Figure S1). Average age was 53 ± 18.2 years (range: 18-93 years), with 689 and 684 people identifying as male or female, respectively. In terms of location, 17% of participants were from rural settings, 50% were from suburban settings, and 33% were from urban settings. Only 197 people (14.3%) said they had previously engaged in one or more forms of fox pest control (i.e., Questions 14 and 15 in Part A of the survey). Only 96 people (<7%) said they were aware of fox psychology research prior to completing our study. Most people (>90%, 134 participants) reported that they had no involvement in our on-going citizen science programme, the *British Carnivore Project* (Question 26 in Part C of the survey). Nine people (6.5%) were excluded from our remaining analyses because they failed to correctly identify a red fox, leaving a total of 1,364 people in the sample.

Principal component analysis of attitudes and beliefs about foxes

A scree plot suggested the data were comprised of one component (Figure S2) whereas a parallel analysis suggested they were comprised of up to three components (Table S1). Thus, to help determine how many components to extract, we entered the 24 items into a principal component analysis and compared the 2- and 3-component solutions that had been rotated with the promax method (Table 2).

Table 2. PCA pattern matrices showing the 2- and 3-component solutions of the promax-rotated items relating to fox-related attitudes and beliefs.

	2-Component Solution		3-Component Solution		
Items	**PC 1**	**PC 2**	**PC 1**	**PC 2**	**PC 3**
Intelligent behaviour in foxes, such as their problem-solving abilities, would negatively impact my everyday life (e.g., raiding my garden or outdoor bin).	-.189	**.641**	-.033	**.690**	.145
Shy behaviour in foxes would negatively impact my everyday life (e.g., raiding my garden or outdoor bin).	-.106	**.627**	.105	**.776**	.045
Bold behaviour in foxes would negatively impact my everyday life (e.g., raiding my garden or outdoor bin).	-.268	**.572**	-.164	**.555**	.193
The number of foxes should be controlled by human shooting or other forms of control (e.g., poisoning).	**-.409**	.358	-.382	.280	.207
It is acceptable for people to harm or kill wild foxes.	-.326	.383	-.181	**.495**	.037
Foxes are potential carriers of diseases and shouldn't be around people.	-.340	**.475**	-.308	.367	.256
Because of the presence of wild foxes, I would be scared to walk alone outdoors.	-.045	**.671**	.318	**1.062**	-.163
The presence of wild foxes would negatively affect my leisure activities.	-.263	**.598**	.017	**.870**	-.053
Foxes try to retrieve litter and other discarded food containers shortly after discovering them.	**.447**	**.739**	.208	.101	**.703**
Foxes try to get food from peoples' outdoor rubbish bins.	.286	**.620**	-.018	-.092	**.754**
Foxes are a "nuisance" in my everyday life.	-.315	**.475**	-.058	**.748**	-.080
Foxes are dangerous for children.	-.299	**.502**	-.168	**.553**	.119
I consider foxes in urban environments a pest.	**-.526**	**.391**	-.477	.337	.208
Wild foxes should only live in nature reserves and other protected areas.	-.256	**.474**	-.003	**.742**	-.082
I enjoy seeing foxes.	**.870**	.079	.776	-.090	.072
I would be pleased having a fox in my garden/living environment.	**.871**	.087	.881	.092	-.078
It is acceptable to see a fox in my own garden or neighbourhood.	**.852**	.029	.730	-.173	.089
It is acceptable for more foxes to live in my neighbourhood (i.e., fox population growth).	**.829**	.059	.863	.111	-.123
Foxes are part of nature. They belong to our environment and should be accepted around humans.	**.850**	.032	.722	-.180	.100
Wild foxes have, like other animals, a right to live in the UK.	**.754**	.069	.492	-.383	.330
The presence of wild foxes increases the value of a landscape, whether I get to see them or not.	**.888**	.217	.835	.072	.085
For me, it is important to protect wild fox populations also for future generations.	**.912**	.181	.804	-.044	.143
Only foxes that cause problems and damages should be controlled through scaring, capturing, relocating or shooting.	.240	**.438**	.028	-.060	**.523**
The idea that fox behaviour is driven by different psychological abilities related to problem-solving and bold/shy behaviour improves my tolerance and appreciation for foxes in my neighbourhood.	**.812**	.303	.853	.287	.003

Note. Salient item loadings >|0.4| are in bold. [a] item loading is a Heywood case (>1.0), suggesting overextraction (Cooperman & Waller, 2022).

For the 2-component and the 3-component solutions (Table 2), the first component (PC 1) explained 44.78% of the variance and was characterised by high item loadings related to positive beliefs (e.g., “Foxes are part of nature”), positive feelings of engagement (e.g., “I enjoy seeing foxes”), and acceptance of foxes (e.g., “I would be pleased having a fox in my garden/living environment”). Additionally, for both solutions, the second component (PC 2) explained 7.97% of the variance was characterised by high to moderate item loadings related to more negative beliefs (e.g., “Foxes are dangerous for children”), negative attitudes (e.g., “The presence of wild foxes would negatively affect my leisure activities”), and low levels of acceptance (e.g., “Wild foxes should only live in nature reserves and other protected areas”); one of these items was extremely high (>1.0), indicative of a Heywood case (Cooperman & Waller, 2022). For the 3-component solution, the third component (PC 3) explained 5.5% of the variance and was characterised by high loadings related to a mix of beliefs (e.g., “Foxes try to get food from peoples’ outdoor rubbish bins) and tolerance of foxes (“Only foxes that cause problems and damages should be controlled through scaring, capturing, relocating or shooting”).

Both the 2- and 3-component solutions showed strong overlap in the items that loaded onto each component (Table 2). Upon examining the correlations between components for the 3-component solution, we found that PC1 and PC 2 were largely correlated (r= -0.695) and PC 2 and PC 3 were moderately correlated (r= 0.395). The 2-component solution revealed a similar pattern, with PC 1 and PC 2 showing a large correlation (r = -0.663).

Collectively, given the strong overlap in item loadings between components from both solutions, and the presence of a Heywood case in PC 2 of the 3-component solution (Cooperman & Waller, 2022), this strongly suggested that respondents’ data were likely comprised of just a single component relating to people’s overall attitudes and beliefs about the species. Thus, for our remaining analyses, we calculated composite scores for each participant by taking the average raw Likert responses for items describing positive attitudes and beliefs about foxes (i.e., items that loaded on PC1) and subtracting them by the average raw Likert responses for items describing negative attitudes and beliefs about foxes (i.e., items

that loaded on PC2 and PC3). For simplicity, throughout the remainder of this paper, we refer to this composite score as “overall tolerance” of foxes, where participants with higher composite scores reflected more pro-environmental attitudes and beliefs about the species. The calculations for these composite scores are in Dataset S1 of the supplementary materials.

Impact of materials on participants’ attitudes and beliefs towards foxes

The first question of Part C asked participants to identify whether and to what extent the science communication materials had changed their attitudes towards foxes, hereafter “perceived attitude change”. In total, 19.9% of people (272/1364 participants) agreed that the material given to them had changed their attitude to foxes. Across all participants, perceived attitude change was significantly greater among people exposed to videos versus written materials (Table 3; Figure 1a), and among people exposed to fox psychology versus fox ecology materials (Table 3; Figure 1b). Perceived attitude change was also unaffected by the interaction between content and format (Table 3).

There was no evidence that participants’ overall tolerance of the species differed significantly across either format, content or their interaction (Table 3, Figure 2). However, there was a significant positive relationship between overall tolerance and perceived attitude change (Estimate+SE=0.15+0.05, t=3.95, p<0.001; Figure 3), in which people that reported greater perceived attitude change also reporting greater overall tolerance of foxes.

Table 3: LMM model outputs showing variable estimates (±SE), Walds χ^2 and P values**.**

Model	**Variable**	**Estimate±SE**	**Wald χ^2**	**P**
Perceived attitude change	Content	0.25±0.12	10.45	0.001
	Format	-0.20±0.12	5.30	0.021
	Format x Content	0.03±0.17	0.03	0.869
Overall tolerance	Content	0.10±0.17	0.00	0.940
	Format	-0.03±0.17	1.21	0.271
	Format x Content	-0.21±0.24	0.77	0.379

Note. “Perceived attitude change” is based on participants’ responses to Question 1 in Part C of the survey. “Overall tolerance” is based on participants’ composite scores from the 24-item survey of fox-related attitudes and beliefs in Part C of the survey.

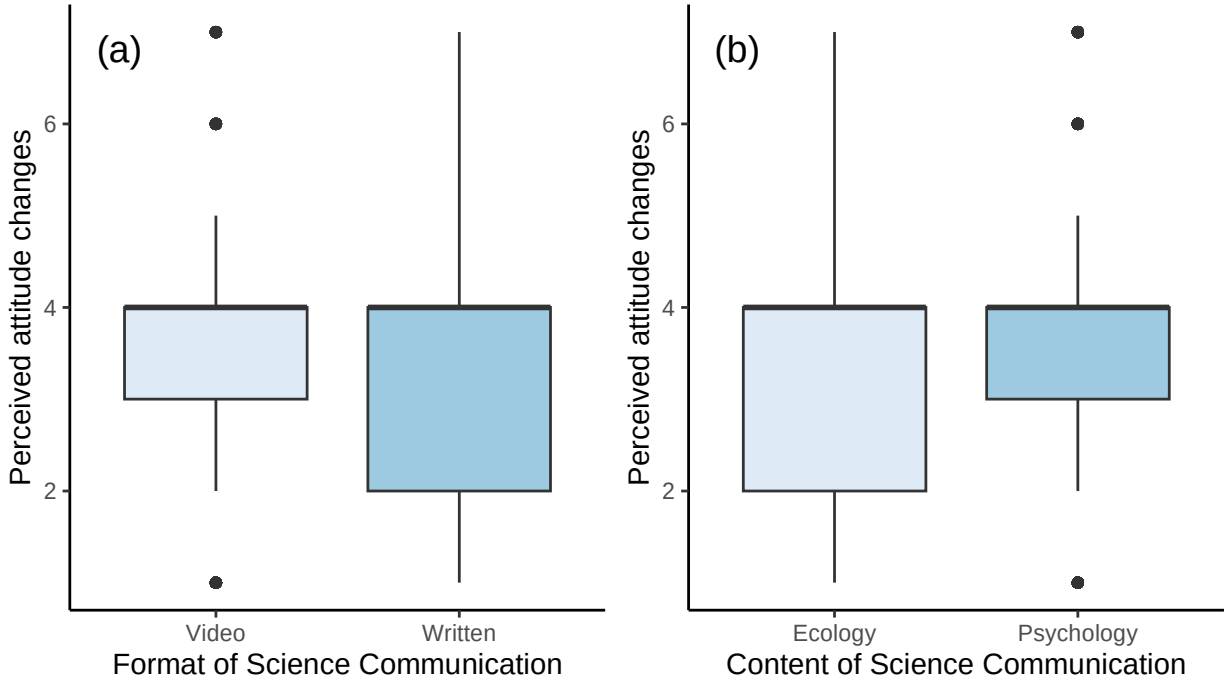

Figure 1. Relationship between perceived attitude change after participants engaged with the science communication materials (based on their responses to Question 1 in Part C of the survey) and two statistically significant predictors: a) Format of the science communication materials (p= 0.021*), b) Content of the science communication materials (p=0.001**).

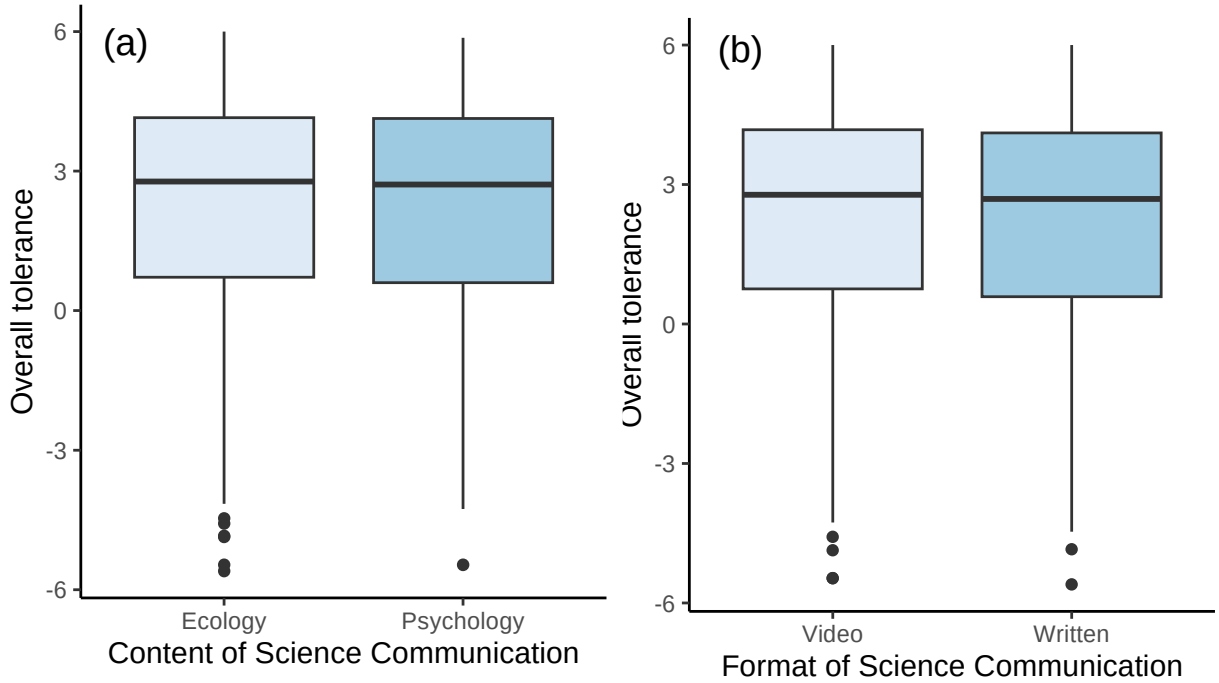

Figure 2. Relationship between overall tolerance of foxes after people engaged with the science communication materials, which was based on participants' composite scores from the 24-item survey of fox-related attitudes and beliefs in Part C of the survey, and two experimentally relevant predictor variables: a) Format of the science communication materials (p= 0.28), b) Content of the science communication materials (p=0.97).

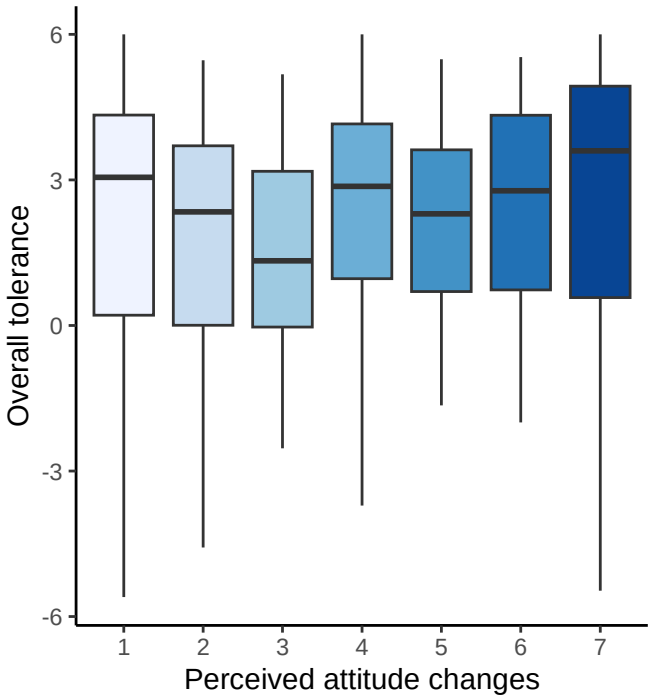

Figure 3. The relationship between overall tolerance of foxes after people engaged with the science communication materials and perceived attitude changes (1 =strongly disagree, 4 = neither agree or disagree, 7 = strongly agree).

Discussion

Information about the psychological abilities of animals has the potential to influence human-wildlife connectedness, both positively and negatively (Padovani et al., 2021). Here, we provide an experimental approach to test whether providing information about boldness and problem-solving abilities in a wild carnivore, the red fox, impacts people's attitudes and beliefs towards them. We found that participants who received communication materials about fox psychology reported greater perceived attitude changes towards foxes compared to people who received communications about fox ecology. Similarly, participants who engaged with video materials reported greater levels of attitude change than participants who engaged with written science communication materials (i.e., press releases). Despite these patterns in perceived attitude change, we found no evidence that such effects influenced people's overall tolerance of foxes after engaging with the science communication materials based on our 24-

item tolerance scale, even though individual differences in perceived attitude change were positively associated with overall tolerance of foxes. Thus, providing the public with information about animal psychology research, particularly through videos, may have a potential role in shaping human-wildlife connectedness by influencing, either positively or negatively, other facets to people's attitudes beyond those related specifically to overall tolerance, and such effects may be more impactful than information about an animal's basic ecology.

Intolerance towards carnivores has the potential to affect the long-term survival of their populations, particularly when manifested as retaliatory killing or support for large-scale efforts to reduce numbers (Ashish et al., 2022; Bruskotter & Wilson, 2014; Lischka et al., 2019). Negative attitudes and beliefs towards the conservation of predators can be influenced by a variety of factors, including over-generalization of the risks they pose towards people (Ashish et al., 2022). In the case of foxes, there is a growing potential for human-wildlife conflict if, for example, foxes are becoming bolder within urban spaces (Morton et al., 2023), and people perceive the risks resulting from such behaviour as being higher (Brand & Baldwin, 2020; Soulsbury & White, 2015). Studies suggest that while urban foxes may behave more boldly than rural populations (Morton et al., 2023), people's attitudes and beliefs about foxes may also be influenced by popular culture, which – as with other carnivore species – can be highly sensationalised and negative (Bridge & Harris, 2020). There is therefore an urgent need to understand how particular types of information influence peoples' connectedness to foxes and other carnivores (Flemming et al., 2018).

One possible explanation for the higher perceived attitudinal change within our experimental groups may be that information about fox psychology impacts certain aspects of people's attitudes beyond overall tolerance, such as their interest in the species. Indeed, perceived attitude change was positively associated with greater overall tolerance of foxes (suggesting construct validity between both attitudinal measures), and interest in a topic is an important component to people's attitudes (Lumber et al., 2017), including attitudes related to nature (Johnson et al., 2016). This proposal is supported by the combined effect of communication content and format found in our study: Videos given to participants were a

more effective medium for engendering perceived attitudinal change than written science communication, which is likely because they are a more interesting and/or engaging form of communication; a result that has some reinforcement in the wider literature (Cameron et al., 2021; Goldberg et al., 2019). Research in the field of marketing suggests that anthropomorphism also increases interest through a greater ability to relate oneself to others, which may explain why the communications about fox psychology induced greater perceived attitudinal changes than communications about fox ecology (Hart et al., 2013). If so, then it raises the possibility that public interest in animal psychology could, if harnessed correctly, offer a useful and unique platform for generating greater public engagement with important, but perhaps more distal or mundane, issues related to the biodiversity crisis (e.g., impacts of urbanisation and climate change).

Giving people new information can, in some instances, influence a person's engagement with important issues after a single exposure to that information (Johnson et al., 2016; Vezich et al., 2017). However, socio-psychological research suggests that such information is only likely to be effective when framed on a personal/emotional level, especially if it aligns with people's pre-existing values or beliefs (Meadow et al., 2005; Slagle et al., 2013; Toomey, 2023; Vezich et al., 2017). Despite studies showing a link between anthropomorphism and emotional attachment to nature in people (Williams et al., 2021), in our study, information from animal psychology research did not impact people's overall tolerance of that species. Nardi et al. (2020) found a significant interaction between attention to local news about urban wildlife and political ideology for urban coyotes. Piazza and Loughnan (2016) reported that information about the psychology of a species likely loses its effect on people if their judgments impact their own livelihoods. Thus, shifting people's tolerance of a species, such as foxes, by exposing them to information about their psychology may take time and effort to address the cognitive and emotional components to people's behaviour, especially if they are deeply entrenched by other factors.

Although anthropomorphism has undoubtedly had a positive impact on people's attitudes towards some species (Knight et al., 2004; Williams et al., 2021), anthropomorphism

based on inaccurate information (e.g., the “Disney effect”) can also distort perceptions of what constitutes “normal” wild behaviour and therefore risks people not developing meaningful human-nature connections. Increasing urbanisation is likely one of the drivers for lower human-nature connectedness (Schuttler et al., 2019), but is also leading to a higher likelihood of human-wildlife interactions as human development encroaches on wild habitat (Soulsbury & White, 2015). Promoting tolerance and co-existence of wildlife is therefore necessary for the long-term survival of species. Understanding peoples’ attitudes and how the provision of information or conservation messaging may influence the achievement of conservation objectives is therefore critically needed (Bruskotter and Wilson 2014). Our research demonstrates the complexities that must be considered when providing the public with information on the psychological abilities of wildlife. As in other studies, how to communicate such information may depend on the conservation objectives and the intended audience (Echeverri et al., 2017). Longitudinal monitoring of public attitudes towards local wildlife is needed as more studies on wildlife psychology become published, and the public’s awareness of how such information relates to human-wildlife interactions becomes more widespread.

Conclusions

Ultimately, human connectedness to wildlife is an important determinant of a species’ future survival, yet how to promote positive connections with wildlife through information, such as animal psychology research, is not fully understood. Our findings illustrate that providing the public with information about animal psychology research, particularly through videos, may influence, either positively or negatively, certain facets to people’s attitudes beyond those related to overall tolerance of a species, and that such effects can be more impactful than information about an animal’s basic ecology. These findings illustrate the unique impact that animal psychology research might have on human connectedness to wildlife.

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Appendix 1.

UNIVERSITY OF HULL

For immediate release

New study investigates psychology of wild foxes

In 2022, scientists from the University of Hull gave wild foxes a series of puzzles containing food to measure their boldness and problem-solving abilities.

Some foxes were bold enough to approach and solve the puzzles, as you can see in the photos to your right.

But not all foxes did this! Some foxes were interested in the puzzles, but too shy to touch them.

However, once scientists removed the puzzles, shyer foxes showed no hesitation to approach and eat the food that had been left behind.

Collectively, this study shows foxes are capable of problem-solving, but differ in their level of boldness towards unfamiliar objects within their environment.

For more information please email MPR@hull.ac.uk or call 07474 634992

Figure A. Press release given to Group 1 (experimental) described in Table 1.

UNIVERSITY OF HULL

For immediate release

New study investigates travel patterns of wild foxes

In 2022, scientists from the University of Hull filmed wild foxes over several months to measure their travel patterns in different types of habitat.

Foxes were seen travelling through a variety of different areas, as you can see in the photos to your right.

And the foxes travelled through all of these habitats regardless of weather too! This included windy and rainy evenings.

However, the scientists noted that most of their data showed foxes were observed travelling during dry periods when it was not stormy.

Collectively, this study shows that foxes travel in different types of habitats, and that such behaviour occurs in different types of weather.

For more information please email MPR@hull.ac.uk or call 07474 634992

Figure B. Press release given to Group 2 (control) described in Table 1.

Appendix 2. Online survey administered to human participants.

PART A

Please complete the following short survey, which is divided into three parts: Part A, B, and C. Your participation is entirely voluntary, and your responses will remain anonymous. It takes approximately 10-15 minutes to complete, but there is no time limit so please take however long you need. Complete the survey in a quiet place free of distraction. You may be asked to listen to music, so please ensure your computer speakers are fully operational before you begin. We greatly appreciate your time and thoughts!

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1. **Please note that participation in the study requires that you consent to the following statements. If you decide to take part, please click "I wish to proceed". If you decide not to take part, please exit the survey before submitting your responses.**

    - I confirm that I have read the "Participant Information Sheet" that explains the study.
    - I have had the opportunity to consider the information and have been given contact details of the researcher (email) to ask questions and discuss the study.
    - Any questions or concerns I have about the study have been answered satisfactorily.
    - I understand that my participation is voluntary and that I am free to withdraw at any time during the study without giving any reason.
    - I understand that once I have completed the study, I cannot withdraw my anonymized data.
    - I understand that the research data, which are not linked to me, will be retained by the researchers, and may be shared with others and publicly disseminated to support other research in the future.
    - I agree to take part in the above study.

    - I wish to proceed
    - I do not wish to proceed

2. **What is your current age in years?** *(open response)*

3. **What is your gender?** *(open response)*

4. **Do you currently live in the UK?**
    - Yes
    - No

5. **If you live in the UK, what is the <u>first half</u> of your postcode (e.g., EH1, YO1, G3)?**

6. **Please click the item that best describes the neighbourhood you live in:**
    - **Urban** (i.e., a town or city, lots of people live there, and there are lots of different kinds of buildings close together)
    - **Suburban** (i.e., mostly houses, located just outside a city or town)
    - **Rural** (i.e., mostly countryside with few houses or buildings)

7. **Does your current place of residence have an outdoor garden?**
    - Yes
    - No

8. **Do you live on a farm?**
    - Yes
    - No

9. **At your current place of residence, how often, if at all, do you put food in your outdoor bin?**
    - I don't have an outdoor bin
    - Never
    - Less than once a week
    - 1 to 3 times per week
    - More than 3 times per week

10. **Please click on the image of a fox:**

11. **At your current place of residence, how often, if at all, do you intentionally leave food outside for foxes?**
    - Never
    - Less than once a week
    - 1 to 3 times per week
    - More than 3 times per week

12. **At your current place of residence, how often, if at all, do you intentionally leave food outside for other wildlife (e.g., birds or hedgehogs)?**
    - Never
    - Less than once a week
    - 1 to 3 times per week
    - More than 3 times per week

13. **At your current place of residence, have you ever watched (in person or on camera) a fox eating rubbish from your outdoor bin?**
    - Yes
    - No

14. **At your current place of residence, have you ever tried to harm or kill a fox (e.g., poison or hunt them)?**
    - Yes
    - No

15. **At your current place of residence, have you ever contacted a pest control service to resolve an issue you had with foxes?**
    - Yes
    - No

16. **Within your neighbourhood, have you ever watched (in person or on camera) a fox eating rubbish from a public bin owned by your local council?**
    - Yes
    - No
    - The local council doesn't have bins in my area

PART B

<u>Instructions for Groups 1 & 2:</u> Thank you for completing Part A of the survey. You will now be asked to click on a link that will take you to a press release describing some recent work by scientists from the University of Hull. There is no time limit. Please read through all of the information as many times as you wish, then click 'next' to proceed to Part C of the survey.

<u>Instructions for Groups 3 & 4:</u> Thank you for completing Part A of the survey. You will now be asked to click on a link that will take you to a video describing some recent work by scientists from the University of Hull. The video contains music, so please turn up your volume to hear it. There is no time limit. Please read through all of the information as many times as you wish, then click 'next' to proceed to Part C of the survey.

PART C

Answer with your opinion on the 7-point scales below. There is no time limit, so take however long you need. All of your responses will remain anonymous.

1. **The study of foxes conducted by scientists at the University of Hull has changed my attitude towards foxes.**
    - 1 (Strongly disagree)
    - 2
    - 3
    - 4 (Neither agree nor disagree)
    - 5
    - 6
    - 7 (Strongly agree)

2. **Intelligent behaviour in foxes, such as their problem-solving abilities, would <u>negatively</u> impact my everyday life (e.g., raiding my garden or outdoor bin).**
    - 1 (Strongly disagree)
    - 2
    - 3
    - 4 (Neither agree nor disagree)
    - 5
    - 6
    - 7 (Strongly agree)

3. **Shy behaviour in foxes would <u>negatively</u> impact my everyday life (e.g., raiding my garden or outdoor bin).**
    - 1 (Strongly disagree)
    - 2
    - 3

- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

4. Bold behaviour in foxes would <u>negatively</u> impact my everyday life (e.g., raiding my garden or outdoor bin).

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

5. The number of foxes should be controlled by human shooting or other forms of control (e.g., poisoning).

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

6. It is acceptable for people to harm or kill wild foxes.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

7. Foxes are potential carriers of diseases and shouldn't be around people.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

8. Because of the presence of wild foxes, I would be scared to walk alone outdoors.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)

- 5
- 6
- 7 (Strongly agree)

9. The presence of wild foxes would negatively affect my leisure activities.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

10. Foxes try to retrieve litter and other discarded food containers shortly after discovering them.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

11. Foxes try to get food from peoples' outdoor rubbish bins.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

12. Foxes are a "nuisance" in my everyday life.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

13. Foxes are dangerous for children.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

14. I consider foxes in urban environments a pest.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

15. Wild foxes should only live in nature reserves and other protected areas.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

16. I enjoy seeing foxes.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

17. I would be pleased having a fox in my garden/living environment.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

18. It is acceptable to see a fox in my own garden or neighbourhood.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

19. It is acceptable for <u>more</u> foxes to live in my neighbourhood (i.e., fox population growth).

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

20. Foxes are part of nature. They belong to our environment and should be accepted around humans.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

21. Wild foxes have, like other animals, a right to live in the UK.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

22. The presence of wild foxes increases the value of a landscape, whether I get to see them or not.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

23. For me, it is important to protect wild fox populations also for future generations.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

24. Only foxes that cause problems and damage should be controlled through scaring, capturing, relocating or shooting.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

25. The idea that fox behaviour is driven by different psychological abilities related to problem-solving and bold/shy behaviour improves my tolerance and appreciation for foxes in my neighbourhood.

- 1 (Strongly disagree)
- 2
- 3
- 4 (Neither agree nor disagree)
- 5
- 6
- 7 (Strongly agree)

26. Since 2021, scientists from the University of Hull have been running a citizen science programme called the *British Carnivore Project*, where they have been studying the impact of urbanization and climate change on the cognition and behaviour of wild free-ranging foxes and badgers. Please click <u>all</u> items that best describe your involvement in that programme:

- I was copied into emails about the project
- I gave permission to access the land
- I helped collect data or monitor a trail camera
- I read through the information about the project's goals and current research findings
- I had no involvement in the study

27. Were you aware of any scientific studies of fox psychology before completing this survey?

- Yes
- No

Supplementary Materials

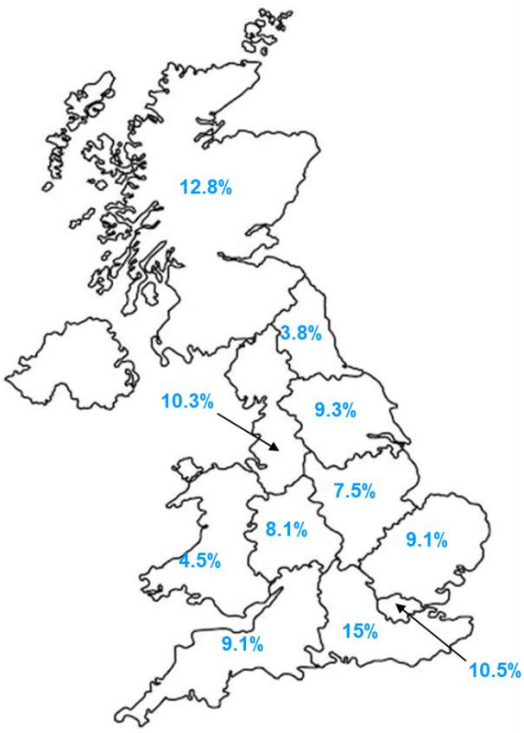

Figure S1. Geographic distribution of participants recruited for the study throughout Great Britain.

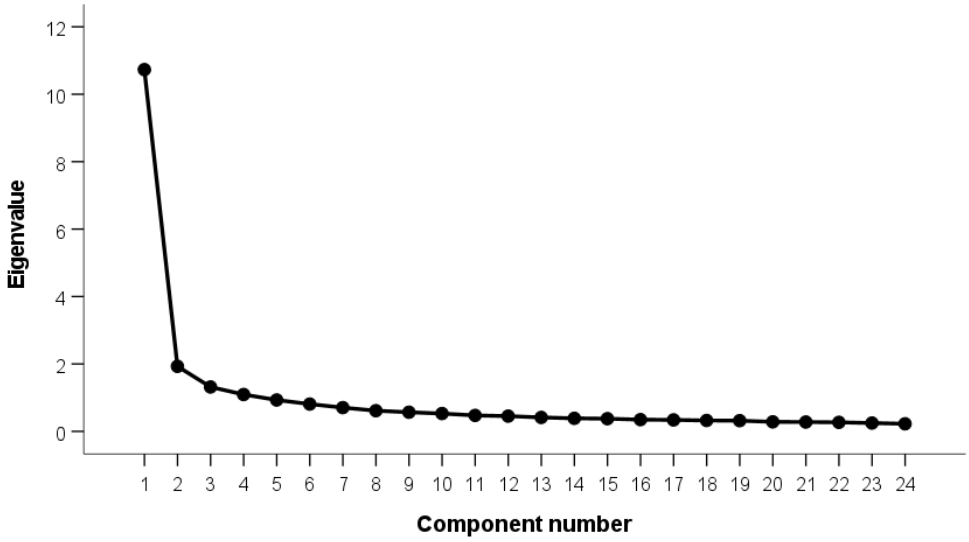

Figure S2. Scree plot of the 24-item questionnaire on fox attitudes and perceptions.

Table S1. Random data eigenvalues from parallel analysis.

Component	Mean eigenvalue	Percentile eigenvalue
1	1.245448	1.282255
2	1.208899	1.235867
3	1.180590	1.206058
4	1.155308	1.178881
5	1.133616	1.152242
6	1.110683	1.129473
7	1.091795	1.107745
8	1.074679	1.090816
9	1.054380	1.069908
10	1.036414	1.050750
11	1.020228	1.034693
12	1.004519	1.019544
13	0.986395	0.998777
14	0.969719	0.988629
15	0.952837	0.968512
16	0.937900	0.951422
17	0.919046	0.933378
18	0.903214	0.915148
19	0.886650	0.902183
20	0.868280	0.886622
21	0.848595	0.865039
22	0.828651	0.848846
23	0.805072	0.821514
24	0.777080	0.799969