Beyond biophobia: positive appraisal of bats among German residents during the COVID-19 pandemic - with consequences for conservation intentions

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Research Article

Keywords: Chiroptera, Conservation Social Science, Disgust, Fear, Emotional Shift, Germany

Posted Date: October 30th, 2023

DOI: https://doi.org/10.21203/rs.3.rs-3495844/v1

Additional Declarations: No competing interests reported.

Abstract

Bats are often considered to be objects of biophobia, the tendency to respond with a negative emotion, such as fear or disgust, even more so during the COVID-19 pandemic. However, existing studies have rarely compared both positive and negative emotions towards bats, leading to a potential negativity bias. This is crucial as emotions are important in human behavior, in relation to bats, for instance, in bat conservation-related actions.

In two online surveys conducted among German residents, we aimed to i) assess both positive and negative emotions toward bats, ii) examine emotional shifts during the pandemic, and iii) explore how emotions, along with socio-demographics, predict intentions for bat conservation actions. The first survey was undertaken ten months after the official declaration of the COVID-19 pandemic (December 2020 - January 2021), when bats gained societal attention due to speculation about the origin of the SARS-CoV-2 virus and the second twelve months later (January 2022).

Overall, respondents held higher positive emotions than negative ones towards bats in both surveys, with no significant emotional shift observed. Positive emotions positively correlated with intentions for bat conservation actions, while negative emotions did not show such a connection.

Although our findings might be context-specific to the German or European population due to EU legislation protecting bats and their habitats, they highlight the nuanced and complicated emotions that can be associated with certain species. Understanding these emotions can guide targeted conservation strategies and public outreach. Our results caution against overly generalizing biophobia discussions in conservation.

Research Ethics

There were no institutional requirements for ethical clearance. However, the survey was undertaken in accordance with the General Data Protection Regulation (GDPR) of the European Union. A consent form was provided to participants ensuring their anonymity, information about the general aim of the study, data that will be collected, contact and that there would be no disadvantages for participants if they resign from the study at any stage of their participation. Participants had to agree to this consent form and be of full age (18 years) before they could start the survey.

1. Introduction

Emotions are central to the daily life experiences of humans and to relationships with phenomena in the world ‘out-there’ (LeDoux 1996; Damasio 2000). By extension, emotions are important factors shaping our relationships with wildlife (Manfredo 2008; Jacobs 2009). Emotions influence virtually all other mental processes, including attention (LeDoux 1996), motivation (Damasio, 2000), memory formation (Talarico & Rubin 2003) and intention (Frijda 1986). While a consensual definition has not emerged, scholars agree that emotional reactions consist of physiological, expressive and experiential components (Bradley &

Lang 2000; Mauss et al. 2005). For instance, a fear response usually includes an increased heartbeat, a scared facial expression, tendency to freeze or flee, and conscious negative feelings such as fear (LeDoux 2013).

Biophobia is the tendency to respond with a negative emotion, such as fear or disgust, towards natural stimuli (slightly amended from Soga et al. 2023). Bats are frequently described as stimuli of biophobia (Kingston 2016; Eklöf & Rydell 2021; Soga et al. 2023), likely because of the unfamiliarity of their behaviour and morphology, which often forms the basis of myths and other misperceptions (Eklöf & Rydell 2021). Bats are active at night, rest upside down, and, with the exception of the Old World fruit bats (family Pteropodidae), tend to lack traits that are considered cute or charismatic (e.g., neotenic features such as big eyes and large heads, colorful fur or feathers, large size and majestic bearing; Verbrugge et al. 2013; Estévez et al. 2015; Albert et al. 2018; Jaric et al. 2020). In a direct comparison of 100 mammals, Macdonald et al. (2015) found that smaller and dark mammals (among other characteristics) were less preferred than larger mammals with a single bright color; with the common vampire bat (*Desmodus rotundus*) ranked 97th and traditional charismatic species (especially from the Felidae family) ranked highly. In addition, while only three of the > 1 450 bat species feed on blood, and those that do are restricted to Central and South America, this habit is often attributed to bats in general, reinforcing negative perceptions and myths. For example, Prokop et al. (2009) found that around 20% of Slovakian students believed that bats feed on blood; probably due to the link between this belief and vampire stories. This belief was even more common (37%) among children aged 10–16 years in Slovakia (Prokop & Tunnicliffe 2008). Further, bats are described as unclean animals in the bible (Eklöf & Rydell 2021).

Earlier literature also characterized bats as fear-relevant animals, i.e., highly feared without posing a real threat (as opposed to being a threat through predatory attacks; e.g., Davey et al. 1994; Ware et al. 1994, Arrindell 2000, Polák et al. 2019). Fear of bats has likely increased in recent years, because several recently emerged infectious viral diseases may have ancestral or recent origins in bats (e.g., COVID-19, Nipah, Ebola, Olival et al. 2017; Epstein et al. 2020). While links between bats and zoonoses are frequently speculative and often confused by inaccurate communication and consequent misunderstanding (López-Baucells et al., 2018, Shapiro et al. 2021), these links have also led to bats being commonly associated with the emotion of disgust. Fear and disgust are the two emotions known to be evoked by animals considered dangerous (Ekman 1999). Feared objects or situations can even elicit a combination of both fear and disgust (Coelho et al. 2022). While fear is an adaptive response to an imminent threat of injury or even death (LeDoux 2021), or to other elements such as sensory experiences (e.g. pain, Coelho et al. 2022), disgust is considered part of the behavioural system that protects humans against the transmission of pathogens or contamination (Matchett & Davey 1991; Curtis et al. 2011). Persecution of bats is widespread (Straka et al. 2021) and has increased during the COVID-19 pandemic (Zhao 2019). So, it is reasonable to hypothesize that biophobia of bats has also increased during the COVID-19 pandemic (Soga et al. 2023). In the realm of human-wildlife relationships, other emotions deemed significant include sadness and anger (Ekman 1999). Although not directly linked to animals considered dangerous (Ekman 1999), these emotions remain relevant within the context of understanding and addressing human-bat interactions (Straka et al. 2020); maybe even more so during the pandemic.

Sadness may arise in relation to bats and the pandemic from a sense of empathy and sorrow about the unjust persecution of bats, while anger can stem from feelings of frustration or resentment towards bats.

Despite the many myths and recent concerns, bats are not universally feared. For instance, fear of bats appears rare or infrequent among people in Michigan, United States (Hoffmaster et al. 2016) and students in Germany (Straka et al. 2020). Further, while a study in Norway examined the attitudes of urban residents towards wildlife, finding that bats were less liked than other animals in their sample (Bjerke & Østdahl 2004), positive associations with bats are suggested to be common in Swedish (Nordic) history (Eklöf & Rydell 2021). Another study in Kenya found that people living in villages close to bat caves held generally an interest above neutral value in bats (Musila et al. 2018). In Asia Pacific cultures, a review of publications on the cultural values of bats found that the majority of cultural values associated with bats are positive, with only a small percentage negative (Low et al. 2021). This indicates that negative emotions towards bats are context-specific (as in the case of vampire bats; Lopez-del-Toro et al. 2009), simply over-emphasized or dependent on which emotions or other psychometric concepts are being compared. For instance, the above-mentioned studies (Davey et al. 1994, Ware et al. 1994; Arrindell et al. 2000; Polák et al. 2019) investigated negative emotions such as fear and disgust in relation to different animals, including bats, but did not simultaneously investigate positive emotions. Yet, to our knowledge, there are no published studies that simultaneously investigated both positive and negative discrete bat-related emotions that are relevant in human-wildlife relationships (Ekman, 1999; Izard 2007). Consequently, the existing literature on human emotions concerning bats may be influenced by a negativity bias (Buijs & Jacobs, 2020), given the contextual limitations of the studies and the use of different measurement approaches. Clearly, studies focusing on negative emotions associated with bats or comparing bats with other animals fail to explore the full range of humans' emotional relationships with bats. Hence, we cannot conclude that negative emotions matter more than positive emotions in shaping human-bat relationships. Practically, an overemphasis on the negative emotions associated with bats might limit the discovery of potential avenues to understand and raise public support for bat conservation. For example, if positive emotions exist, then instead of working to counter negative emotions, it might be more effective to reinforce or invoke positive emotions in outreach campaigns. Moreover, it is suggested that emotions and behaviours are linked (Strack et al. 2016); thus, gaining a comprehensive understanding of emotions can be important for conservation efforts.

The term 'emotion' can refer to a state or a trait (Jacobs et al. 2014). Emotional responses are states, that is, momentary reflections of *how* one is. The term 'emotions' is also used to denote traits, i.e., stable properties reflecting *who* one is. In the present study, we use emotions in the second sense, labelled as emotional dispositions (Frijda 1996). Emotional dispositions act as mental criteria for judging the emotional relevance of stimuli to the individual (Jacobs et al. 2014). Meaning, if a person claims they fear wolves, this indicates their emotional disposition, but not that they are, in that moment, in a state of fear, which rarely occurs for most people. Compared to emotional responses (which are time and context dependent), emotional dispositions are more amenable to measurement through surveys. Scholars of emotions use two different theoretical approaches – discrete and dimensional — to account for the variety of emotions. In the discrete approach, emotions are classified as qualitatively different from each

other (Izard 2007). Researchers using this perspective examine specific emotions such as fear, disgust, or joy. In the dimensional approach, emotions are characterized by a limited number of dimensions, usually valence (positive-negative) and arousal (the level of activation; Russell 2003). Compared to the dimensional approach, the discrete approach better matches how people usually evaluate their own emotions (Jacobs et al. 2014), so we used it for our study.

Given the current academic overemphasis on negative emotions relating to bats and that to our knowledge, the lack of studies investigating both negative and positive emotions towards bats, as well as the potential influence of the COVID-19 on people's emotions towards bats with implications for bat conservation, our study aimed to i) assess both positive and negative emotions towards bats, ii) examine emotional shifts during the pandemic and iii) explore the predictive potential of positive and negative emotions, along with socio-demographics, on behavioural intention to engage in bat conservation actions. We surveyed the German public during the pandemic and investigated self-assessed emotions towards bats and bat conservation-relevant behaviours. We ran the survey twice to examine whether negative emotions occurred and increased during the pandemic. We further assessed the link between emotions and bat conservation-relevant behavioural intentions. This is specifically relevant to determine whether bat conservation is likely to benefit more by focusing on mitigating negative emotions (biophobia) or fostering positive emotions (biophilia).

The present research makes a new contribution to conservation social science by examining both negative and positive emotions toward bats. In particular, an understanding of emotions towards bats at a time when bats have been the focus of (negative) societal attention (due to speculation about the origin of the SARS-CoV-2 virus) requires empirical research. While some studies have considered evaluations of bats during this time (Lu et al. 2021; Ejotre et al. 2022) including how negative emotions towards bats can reduce willingness to cohabit with bats (Lundberg et al. 2021), none has investigated changes in emotions of the public and their consequences for bat conservation during the pandemic. We asked if this period exacerbated negative emotions in relation to bats, as suggested by the literature (Ejotre at al. 2022).

2. Methods

2.1. Survey sample

We launched our first survey approximately ten months after the official declaration of the COVID-19 pandemic (mid December 2020-mid January 2021; hereafter 2021) and the second one twelve months later (January 2022; hereafter 2022). We created our online questionnaire in SoSci survey (https://www.soscisurvey.de/) and distributed it at both time periods on the same online platforms (Survey Circle, Facebook) and sent it to over 500 email addresses from diverse public institutions to reach the broad public (Table S1). We emailed reminders to the institutions and posted on social media channels two weeks after the first call. We selected this online convenience sample because it was the most feasible option during the pandemic. The questions analyzed in this study were presented as part of

a wider survey to understand the effect of photo stimuli and narratives about bats on people's emotions and behavioural intentions. In this manuscript, we focus only on the questions relating to self-assessed emotions and behavioural intentions, which appeared at the beginning of the surveys to avoid any potential confounding interactions between questions.

2.2. Survey items

We used five-point scales to assess three parameters. First, discrete bat-related emotions deemed relevant to human-wildlife relationships (Ekman 1999; Izard 2007): three positive (joy, interest, compassion) and four negative (anger, disgust, fear, sadness). While interest is not always labeled as an emotion in the literature, some studies do consider it to be a basic emotion (Izard 2007; Silvia 2008; Fredrickson 2013). For instance, manifesting as a distinctive and identifiable pattern of facial expressions and heart-rate changes in infants (Izard 2007) and it is considered a crucial emotion to practical problems of learning, education and motivation (Silvia 2008). In our case, motivation is relevant in the context of getting involved in bat-conservation actions. Second, four behavioural intentions to get involved in bat conservation actions: (1) engaging in bat conservation projects, (2) motivating others to do something for bat conservation, (3) donating money to bat conservation projects and (4) learning more about bats; adapted from Jacobs & Harms 2014). Lastly, we measured socio-demographic variables (Table 1) to compare our sample populations and understand the influence of socio-demographics on emotions and behavioural intentions.

Table 1
Survey items and variable types (original survey found in Fig. S1)

Concept	Item(s)	Variable type
Emotions	When I think about bats, I feel [interest, compassion, joy, fear, anger, disgust, sadness]	Ordinal 1 = completely disagree 2 = disagree 3 = neither disagree nor agree 4 = agree 5 = completely agree
Behavioural intentions	I want to [engage in bat conservation projects, motivate other people to do something for bat conservation, donate money to bat conservation projects, learn more about bats]	Ordinal 1 = completely disagree 2 = disagree 3 = neither disagree nor agree 4 = agree 5 = completely agree
Age	Respondents' age	Ordinal 1 = 18–29 2 = 30–45 3 = 46–55 4 = 56–65 5 = 66 +

Concept	Item(s)	Variable type
Gender	Respondents' gender	Categorical 1 = female 2 = male 3 = diverse
Place of living	Respondents' current place of living (self-assessed, no definitions of urban, suburban, rural provided)	Categorical 1 = urban 2 = suburban 3 = rural

2.3. Statistical analyses

To assess whether participants in the 2021 and 2022 surveys had similar socio-demographic backgrounds, we used Chi-squared tests using the 'chisq.test' function in the 'MASS' package (Venables and Ripley 2002) of R 4.2.2. We specifically compared the distributions of age, gender and place of living between samples (Table 2).

To understand the underlying structure of the seven assessed discrete emotions (Table 1), we performed a factor analysis with a varimax rotation (assuming that the discrete emotions are uncorrelated) using the 'fa' function in the R package 'psych' (Revelle 2022). In other words, we were interested in whether the discrete emotions that we measured could be condensed into a smaller number of unobserved (latent) emotion factors. Here, the factor analysis revealed that two factors with eigenvalues > 1.0 explained 66% of the variance. Anger, fear and disgust loaded above 0.5 in one component (hereafter referred to as 'negative emotions'), explaining 52% of the data, whereas interest, compassion and joy loaded above 0.5 in the second factor (hereafter 'positive emotions'), explaining 48% of the data; Table S2. Sadness loaded below 0.5 in both factors, so we omitted it from further analyses. Using the 'alpha' function from the 'psych' package, we then estimated the internal consistency for the derived (latent) emotion factors via Cronbach's alpha reliability coefficient. The Cronbach's alpha scores for negative and positive emotions were 0.71 and 0.73, respectively, and thus in the range generally considered acceptable (Cortina 1993). Consequently, we calculated indices for positive and negative emotions derived from average scores from the associated emotions.

We further assessed the internal consistency of the four behavioural intention items (Table 1) using Cronbach's alpha reliability coefficient. Cronbach's alpha values for all four behavioural intention items were 0.88, so we also created a composite scale for behavioural intentions from the average scores of the associated four items measuring behavioural intentions.

After Shapiro-Wilk tests revealed that the distributions of the emotion and behavioural intentions variables were significantly non-normal, we used Wilcoxon rank-sum test to compare emotions and behavioural intentions within (aim 1) and between (aim 2) samples.

Lastly, we fitted ordinal logistic regression models using the ‘polr’ function in the ‘MASS’ package (Ripley 2002) to understand the effects of the factored positive and negative emotions and of socio-demographic variables on behavioural intentions (aim 3). We tested for interactions between age and place of living and found no significant interactions.

For all statistical analyses, we applied a rejection criterion of $\alpha = 0.05$.

3. Results

3.1 Data screening and transformation

In total, we received 711 responses (410 in 2021, and 301 in 2022). Upon examining the sociodemographic characteristics, we found no significant differences in socio-demographics between both sample populations (although living place did approach a marginally significant level of difference; Table 1). This suggests that both sample populations were similar in terms of socio-demographic characteristics. However, it is noteworthy that both samples, when compared to the national averages in Germany, were skewed towards a younger, female and urban-dwelling demographic.

Table 2
Socio-demographic backgrounds of survey respondents in 2021 and 2022

	2021 (n = 410)	2022 (n = 301)	Chi-square (between years)
Gender			$\chi^2 = 0.46$, df = 2, p = 0.79
Female	244	200	
Male	114	96	
Other	2	3	
Age			$\chi^2 = 5.02$, df = 4, p = 0.29
18–29	154	107	
30–45	72	76	
46–55	58	55	
56–65	47	40	
66+	30	21	
Living place			$\chi^2 = 5.25$, df = 2, p = 0.07
Urban	249	227	
Suburban	66	51	
Rural	43	21	

3.2 Comparison of positive and negative emotions towards bats (aim 1)

Respondents expressed positive emotions more strongly than negative emotions (Table 3). As an illustration, the average score of positive emotions (the index) was ca. 3.5 (on a scale from 1–5) in both years. Thus, positive emotions are felt not intensely, but rather moderately. In contrast, the average score for negative emotions was ca. 1.5. This means that respondents hardly express negative emotions toward bats. The differences between positive and negative emotions were large (i.e., two points on a five-point scale) in both years.

Table 3
Average score and standard deviation (SD) of positive and negative emotions towards bats and behavioural intention indices in 2021 and 2022 samples. Analyses based on Wilcoxon rank-sum W and *P*-value marked in grey, significant results in bold

	2021	**2022**	
Emotions	Mean ± SD	Mean ± SD	Between years
Positive emotion index *(average scores from three positive discrete emotions)*	3.51 ± 1.29	3.46 ± 1.09	W = 63279, *P* = 0.10
Negative emotion index *(average scores from three negative discrete emotions)*	1.42 ± 0.80	1.48 ± 0.87	W = 55782, *P* = 0.27
Positive versus negative emotions	**W = 11505, p < 0.001**	**W = 4525, p < 0.001**	
Behavioural intentions index *(average scores from four items)*	2.84 ± 1.11	3.20 ± 0.96	**W = 46457, P < 0.001**

3.3 Shifts in emotions and conservation intentions during the COVID-19 pandemic (aim 2)

We found no evidence of shifts in (estimated at the level of the composite indices) negative (W = 63 279; $p = 0.10$) or positive (W = 55 782, $p = 0.27$) emotions between samples (Fig. 1, Table 3) despite observed shifts in discrete emotions (Figure S2). Behavioural intentions were significantly higher in the second sample than in the first one (W = 46 457; $p < 0.001$).

3.4 Predictive potential of emotions and socio-demographics on behavioural intentions (aim 3)

All behavioural intentions were positively predicted by positive but not negative emotions (Table 4). As for socio-demographic variables associated with behavioural intentions, age was the only impactful variable: participants in the 46 to 55 years old category were more in support of donation and motivating others when compared to the reference group (18–29 years old); respondents aged 66 and above for were also more likely to support motivating others than the reference group. In contrast, the 56–65 age group was less in favour of learning more about bats compared to the reference group. The observed associations between socio-demographics and emotions include decreasing positive emotions and increasing negative emotions with increasing age (Table S3).

Table 4

Effect size ± SD of positive (interest, joy and compassion) and negative (fear, disgust and anger) emotions and socio-demographic variables on behavioural intentions to get involved in bat conservation (four behavioural intentions) based on ordinal logistic regression analyses and generalized linear model (behavioural intention composite scale). Results that meet the threshold for statistical significance are highlighted in bold (significance levels shown as *** < 0.001, ** < 0.01 and * < 0.05), however it should also be noted that several other results reach a level of near significance but are not highlighted.

	Learn more **Effect ± SD** ***P*-value**	**Engagement** **Effect ± SD** ***P*-value**	**Donation** **Effect ± SD** ***P*-value**	**Motivating others** **Effect ± SD** ***P*-value**	**Behav. intention (comp scale)** **Effect ± SD** ***P*-value**
Emotions					
Positive	**1.38 ± 0.10***** **p < 0.001**	**1.16 ± 0.09***** **p < 0.001**	**1.06 ± 0.09***** **p < 0.001**	**1.31 ± 0.10***** **p < 0.001**	**1.50 ± 0.09***** **p < 0.001**
Negative	-0.15 ± 0.12 *p* = 0.24	-0.25 ± 0.13 *p* = 0.05	-0.02 ± 0.13 *p* = 0.88	-0.21 ± 0.12 *p* = 0.09	-0.17 ± 0.12 *p* = 0.15
Socio-demographic variables *Gender (compared to female)*					
Male	-0.12 ± 0.16 *p* = 0.47	-0.05 ± 0.16 *p* = 0.74	-0.04 ± 0.16 *p* = 0.81	-0.30 ± 0.16 *p* = 0.06	-0.13 ± 0.15 *p* = 0.41
Other	0.68 ± 1.00 *p* = 0.50	1.04 ± 0.81 *p* = 0.20	0.37 ± 0.77 *p* = 0.63	-0.44 ± 0.85 *p* = 0.60	0.43 ± 0.75 *p* = 0.57
Age (compared to 18–29)					
30–45	0.16 ± 0.20 *p* = 0.41	-0.05 ± 0.16 *p* = 0.78	0.36 ± 0.19 *p* = 0.06	0.39 ± 0.20 *p* = 0.05	0.25 ± 0.19 *p* = 0.18
46–55	-0.35 ± 0.22 *p* = 0.11	-0.06 ± 0.21 *p* = 0.78	**0.64 ± 0.21*** **p = 0.03**	**0.46 ± 0.22*** **p = 0.03**	0.20 ± 0.20 *p* = 0.32
56–65	**-0.67 ± 0.25**** **p = 0.006**	-0.02 ± 0.24 *p* = 0.93	0.34 ± 0.24 *p* = 0.15	0.39 ± 0.23 *p* = 0.10	0.03 ± 0.23 *p* = 0.88
66+	-0.33 ± 0.30 *p* = 0.26	0.13 ± 0.29 *p* = 0.65	0.58 ± 0.29 *p* = 0.05	**1.25 ± 0.29**** **p = 0.001**	0.49 ± 0.28 *p* = 0.08

	Learn more Effect ± SD *P*-value	Engagement Effect ± SD *P*-value	Donation Effect ± SD *P*-value	Motivating others Effect ± SD *P*-value	Behav. intention (comp scale) Effect ± SD *P*-value
Living place (compared to urban)					
Suburban	-0.21 ± 0.20 *p* = 0.28	0.19 ± 0.19 *p* = 0.32	-0.09 ± 0.19 *p* = 0.62	0.16 ± 0.19 *p* = 0.41	-0.04 ± 0.27 *p* = 0.89
Rural	-0.24 ± 0.25 *p* = 0.34	0.21 ± 0.24 *p* = 0.38	-0.01 ± 0.24 *p* = 0.97	0.20 ± 0.25 *p* = 0.41	-0.04 ± 0.23 *p* = 0.86

4. Discussion and Conclusion

While most earlier studies have suggested that bats are the object of negative emotions and biophobia, a majority of studies focused on negative emotional responses (e.g., Davey et al. 1994; Ware et al. 1994, Arrindell 2000, Polák et al. 2019). As such, our understanding of the full spectrum of human-bat relationships remains limited. We studied positive and negative bat-related emotions in relation to each other and the COVID-19 pandemic. Our findings suggest that positive emotions are highly important. First, positive emotions towards bats are felt more intensely than negative emotions (which are hardly felt at all). This is important because positive emotions predict bat-conservation intentions much better than negative emotions. In addition, in contrast to our expectations, we observed no increase in negative emotions in our study population over the course of the pandemic. Interestingly, we also found that the strength of behavioural intentions increased between samples. Taken together, these results suggest that, at least in this population, bats are not objects of widespread biophobia, and that even if the moderately positive emotions expressed by this population are not sufficient to constitute love of bats, they still underscore the importance of measuring both positive and negative emotions, particularly in light of the significant relationship between positive emotions and intent to adopt conservation-relevant behaviors.

To fully appreciate our findings, their potential interpretations and their implications for social science and conservation, it is important to emphasize the study context. Most of our respondents were young, female, and living in urban environments. Also, our use of convenience sampling presumably led to some self-selection in the constitution of samples. Using a repeated measures design could reduce the potential confounding effects of individual variation, as demonstrated in a recent study on disgust during the COVID pandemic (Schwambergová et al. 2023). While we are confident in the broad pattern of our results, we also note that these practical constraints may have had some influence on the observed results. Although we are unaware of systematic research into associations between demographics and emotions towards wildlife, the literature on wildlife value orientations (basic beliefs that give meaning and direction to fundamental values in the context of human-wildlife interactions) might present a model

for informed reasoning about these associations. Two predominant wildlife value orientations have emerged: domination (wildlife exists for humans to use) and mutualism (an egalitarian orientation translating into willingness to coexist; Jacobs et al. 2018). Research in various countries suggests that mutualism orientation increases among: urbanites, younger people, females and people who grew up in more affluent circumstances (Manfredo et al. 2009; Vaske et al. 2011; Gamborg & Jensen 2016; Jacobs et al. 2022). Because mutualism-oriented individuals are more disposed to expressing positive emotions towards wildlife compared to domination orientated people (Zainal Abidin & Jacobs 2019), we believe our sample may be biased toward positive emotions. This effect may be magnified by self-selection. Meaning, people who like bats might have been particularly keen to take our survey. In addition, we labeled interest as a positive emotion based on emotion theory and research (Izard 2007; Ortony 2022), even though it does not occur in some well-known lists of basic emotions (e.g., Ekman, 1999) and is also in some studies treated as a component of attitudes (e.g. scientific attitudes and an interest in the biology of bats, Musila et al. 2018). Besides the theoretical argument (see methods section), our statistical analyses support combining interest with joy and compassion as a measure of a latent construct (which we labeled as positive emotions), because the factor loading of interest was > 0.5 and the reliability index was 0.73. In other words, our measurement of interest behaves in the same way as our measurement of joy and compassion. Removing interest from the positive emotion scale results in a marginal reduction in mean scores (i.e., year one to 3.30 and year two to 3.07) but does not alter either the pattern of results or our conclusions.

Another important aspect of context is that European bat diversity is low – all but five species belong to two families: Vespertilionidae and Rhinolophidae (Russo et al. 2016). Furthermore, all European bats are protected by strong conservation laws. Essentially, it is illegal to kill, keep or exploit bats, to damage or destroy their habitats and to disturb them during the breeding, migration, and hibernation seasons. In Germany, bat species are “strictly protected” (Federal Nature Conservation Act, BNatSchG), and five species require the designation of "special protection areas” (annex II, Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora). Finally, since 1997, the annual European “Bat Night” has been educating people in more than 30 countries about bats. In all these ways, Europe’s context is one of longstanding efforts to protect its remaining bats and bring people closer to them – all of which might have contributed to a positive image of bats among the public. Further, the global response of conservationists may even have reduced the persecution of bats during the COVID-19 pandemic (Nanni et al. 2022). Lastly, many regions, especially in the tropics, experience diverse and economically impactful human-bat conflicts, such as vampire bats biting and transmitting rabies to livestock (Reid 2016) and frugivorous bats damaging fruit crops (Aziz et al., 2016). Human-bat conflicts are much rarer in Germany and mainly involve bats residing in buildings. Germany has even established services by many different institutions (e.g. Landesbund für Vogelschutz, NABU, BUND) to help people deal with bats in buildings. In countries such as Germany, where bats appear to be viewed positively, or China, where bats hold cultural significance, bat-related emotions may have been uniquely affected by the COVID-19 pandemic (Lu et al. 2021). The underlying factors responsible for such variation (e.g., regulatory measures or other influences) remain unclear. Nevertheless, it would be worth investigating

whether and how bat-related behaviours and emotions shift in response to major events within countries that have divergent (i.e., positive vs negative) views of bats, as such studies could highlight the intersection of cultural context, events, and public reactions.

For all these reasons, we must be cautious and avoid overgeneralizing our findings to represent the emotions held by the German or any other population. Still, we found no association between demographics and conservation intentions and hardly any associations between demographics and emotional dispositions. The only demographic variable that mattered was age: older people felt decreased positive and increased negative emotions relative to younger people; albeit within a generally young study population (Table S3). While Lundberg et al. (2021) call for further investigation into the role of age in shaping attitudes and emotions towards bats, we also propose a nuanced consideration of cultural context. Cultural variations may influence what people think and feel about bats (e.g., Low et al. 2021). Hence, future research should explore the interplay between age, cultural factors, and emotional responses to gain a comprehensive understanding of the subject. Also, the differences between positive and negative emotions were large (two points on a five-point scale). As such, we speculate that in other samples and contexts, positive emotions may also be more prevalent than negative ones but that the differences might be smaller than those we observed. What is needed now is research using representative samples of other populations to assess support for this hypothesis.

Besides asking whether the relationships among concepts in our study are observable elsewhere, we urge researchers who seek to understand the gamut of human-bat relationships not to be guided by traditional assumptions that bats are the objects of negative appraisals (be they emotions, beliefs, norms or values). Negative appraisals may well prevail in certain contexts, but our study at least provides convincing evidence that this is not always true and adds to indications that bats are positively regarded in many societies (e.g., Low et al 2021). Conservation social science is often motivated by the desire to solve conservation problems (Bennett et al. 2017) and this may also be a key motivation for funders of such research (Manfredo 2008). As such, the prevailing focus on problematic relationships (e.g., conflicts) that could hamper public support for conservation is understandable (Buijs & Jacobs 2021). Yet, as our findings demonstrate, this focus can easily create a blind spot when it comes to capitalizing on positive emotions to foster conservation.

In our view, conservation practitioners should be modest about opportunities to influence the public's emotional dispositions towards wildlife for the sake of conservation because opportunities to do so are limited. The mechanisms that underpin emotional dispositions toward wildlife can be diverse and include genetically predisposed and innate tendencies, conditioning, and culturally shared narratives (Jacobs 2007). Some of the mechanisms manifest in regions of the brain that are insensitive to linguistic input. Also, because emotional dispositions might be central to one's identity, they may resist change, especially after one's formative years. In addition, with the thousands of messages a person receives in a week, any one message is highly unlikely to drastically change their emotional disposition.

A more effective avenue to promote bat conservation may be to capitalize on people's existing emotional dispositions. For example, there is experimental evidence that telling whale-watching tourists stories emphasizing positive emotions (as opposed to facts about whales or human responsibility for whales) had a more drastic and widespread effect on their conservation intentions (Jacobs & Harms 2014). Since (in our study), positive emotions predict bat conservation intentions, we recommend testing the impacts of narratives designed to activate these emotions. For example, researchers could ask: what gets people to act meaningfully to conserve bats – stories that evoke positive emotions, stories that aim to reduce negative emotions, stories that communicate facts, or no stories at all. Positive narratives can be expanded to encompass not only the ecosystem services that bats provide, but also their sentience and individuality. Narratives might emphasize both the unique attributes of bats within mammals (e.g., wings supporting powered flight, sophisticated echolocation for navigation and prey detection) and their properties as mammals that point to their kinship with people. Both can evoke an appreciation for the complexity and even personal identification (S. Rogge et al., unpublished data). It is important to recognize that different narratives have the potential to resonate with different individuals, allowing for a diverse range of perspectives and connections to be formed. MacFarlane and Rocha (2020) also provide guidelines for communicating about bats specifically connected to potential persecution related to the COVID-19 pandemic.

We used the discrete emotion perspective to study emotions toward bats. The two factors that emerged from exploratory factor analysis reflect positive and negative emotions. Yet, this does not imply that our composite indices reproduce valence, the pleasant-unpleasant dimension in the dimensional approach. The concept of valence reflects one continuum, with positive and negative as opposite ends (Russel & Barrett 1999). Our analysis suggests that positive and negative emotions are largely independent dispositions (as a logical consequence of factor analysis). Ancillary analysis revealed that the association between the positive and negative emotion indices (Spearman's rho) was − 0.39 ($P < 0.001$). This suggests that most of the covariance is explained by independent variation between these two dimensions. Theoretically, a person can simultaneously be both disgusted by and joyous about bats. Bats have many traits, stories about them emphasize many different aspects, and the human mind is complex and able to incorporate different perspectives. Therefore, a disadvantage of the dimensional approach is its inability to capture the simultaneous coexistence of positive and negative emotional dispositions within individuals. So, we recommend using the discrete approach when measuring the potential multidimensionality of emotions (and note that sadness did not load on either factor in our study and thus could be considered a third dimension).

As mentioned, with few exceptions, the literature on human-bat relationships overwhelmingly focuses on the negative emotions, e.g., conflicts (see also Straka et al 2021). Our study demonstrates that, at least in some cases, positive emotions toward bats prevail in both occurrence and influence on conservation intentions. All while reiterating our caution against over-extrapolation to other contexts, we point out that the difference is large enough to question the emphasis on negative appraisals and to suggest that perhaps people love bats more than researchers tend to believe.

Declarations

Acknowledgement

We thank all survey participants who participated in our two surveys and Ricardo Rocha for helpful suggestions that improved this manuscript.

Author contribution

T.M.S. and M.H.J. conceived the ideas and designed the methodology; S.R. collected the data; T.M.S. and J.C. analysed the data, T.K. and E.A.M. critically contributed to the interpretation of the results. T.M.S. and M.H.J. led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

Data availability statement

Data and R code will be available upon request.

Author contribution

The authors declare no conflict of interest.

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Figures

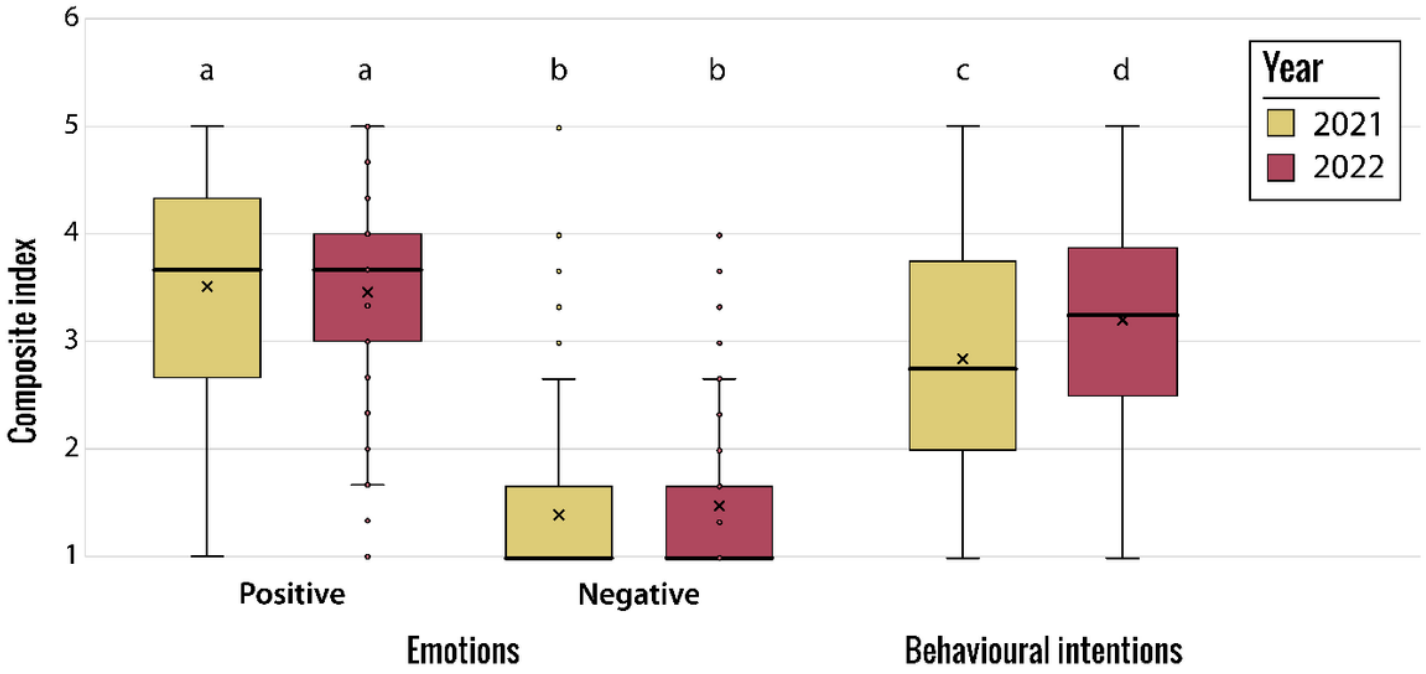

Figure 1

Composite indices of positive and negative emotions and behavioural intentions in 2021 compared to 2022. Significant differences from Wilcoxon rank-sum test between years are marked with different letters. Mean marked with an “x”

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