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LETTER

Probing the Link between Biodiversity-Related Knowledge and Self-Reported Proconservation Behavior in a Global Survey of Zoo Visitors

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Abstract

Many environmental communication interventions are built on the assumption that increased knowledge will lead to changes in proenvironment behaviors. Our study probes the link between biodiversity-related knowledge and self-reported proconservation behavior, based on the largest and most international study of zoo visitors ever conducted. In total, 6,357 visitors to 30 zoos from 19 countries around the globe participated in the study. Biodiversity understanding and knowledge of actions to help protect biodiversity were significantly related, but only 0.6% of the variation in knowledge of actions to help protect biodiversity could be explained by those same respondents' biodiversity understanding. Biodiversity understanding was only the sixth most important variable in significantly predicting knowledge of actions to help protect biodiversity. Moreover, biodiversity understanding was the least important variable of those that were significantly related to self-reported proconservation behavior. Our study indicates that knowledge is a real, but relatively minor, factor in predicting whether members of the public – zoo visitors in this case – will know about specific proenvironment behaviors they can take, let alone whether they will actually undertake such behaviors.

Introduction

The need to actively conserve the world's biodiversity has arisen primarily because of people (Mascia *et al.* 2003; St John *et al.* 2010; Schultz 2011; Heberlein 2012a; Moon & Blackman 2014). The threats that animal species face in the wild such as habitat loss, climate change, over-harvesting and human–wildlife conflict are all affected by the needs and desires of people. A first-order priority to address the global decline in biodiversity is to change modern societies and human behavior. This much is well known, but achieving such transformation is an extremely complex and multifaceted undertaking (e.g., Jensen & Wagoner 2009).

The most commonly used method to attempt to influence proconservation behavior change has almost certainly been education. Indeed, it has been argued that the "ultimate aim of education is shaping behavior" (Hungerford & Volk 1990, page 8). Furthermore, environmental education's goal has been defined as the "development of environmentally responsible and active citizens" (Hines *et al.* 1987, page 1). These are worthy aims, but previous research indicates that the link between increased knowledge (via education) and behavior change (of all types) is weak at best (Schultz 2011). Yet, organizations seeking to promote proconservation behaviors continue to invest in educational programming at a level far beyond other social interventions. To further investigate the relationship between knowledge and behavior change, our study focuses on the world's zoos and aquariums (from here on referred to as "zoos"), environmental education providers with global biodiversity conservation aims.

Vast numbers of people around the world visit zoos. In a recent study, Gusset & Dick (2011) reported that
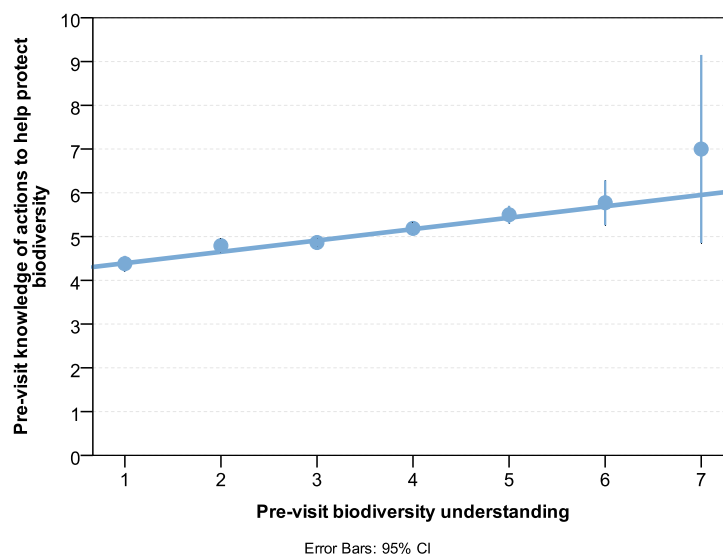
Figure 1 Relationship between respondents' biodiversity understanding and knowledge of actions to help protect biodiversity (both measured on 10-point scales).

more than 700 million visits are made to zoos each year. Could this large cohort of people exposed to environmental education outputs be persuaded to undertake more proconservation behaviors? If so, zoos could be powerful catalysts for global action to help protect biodiversity. Many zoos have already made strategic commitments to providing public education to visitors, on topics including environmental and conservation education (Moss & Esson 2013). At regional and global levels, zoo accreditation bodies also support the education of visitors, via their own mission statements, strategic statements, or collaboration in global biodiversity conservation initiatives. For example, the World Association of Zoos and Aquariums (WAZA), the unifying organization for the world zoo and aquarium community, has a publically stated educational vision that aims for zoos "to engage with visitors [. . .] to encourage conservation-sensitive behaviors that support biodiversity conservation" (Barongi *et al.* 2015, page 49).

In 2010, governments agreed to the Strategic Plan for Biodiversity 2011–2020, which is aimed at halting and eventually reversing the loss of biodiversity on the planet (www.cbd.int/sp/default.shtml). To build support and momentum for this urgent task, the United Nations General Assembly declared 2011–2020 the United Nations Decade on Biodiversity. There are five strategic goals and 20 ambitious targets, collectively known as the Aichi Biodiversity Targets (http://www.cbd.int/sp/targets/default.shtml). Their purpose is to inspire broad-based action in support of biodiversity over this decade. Target 1 of strategic goal A states that "by 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably." This is an educational target; that is, the goal is to increase knowledge regarding

biodiversity and the actions to help protect it. It is also a target that zoos can already claim some success in achieving. Moss *et al.* (2015) surveyed almost 6,000 visitors to 26 zoos from 19 countries around the globe and found that aggregate biodiversity understanding and knowledge of actions to help protect biodiversity both significantly increased over the course of zoo visits (also see Moss *et al.* 2014). Other studies have shown significant aggregate improvements in children's understanding of conservation biology stemming from zoo visits (Jensen 2014; Wagoner & Jensen 2015) as well as proconservation learning trajectories (Wagoner & Jensen 2015). Clearly, such biodiversity knowledge gains are viewed as an important outcome. Yet, how would success in achieving Aichi Biodiversity Target 1's awareness and knowledge goals actually translate into the social and behavior change required to achieve greater biodiversity conservation?

To begin addressing this question, we need to consider how behavior change operates, starting at the individual level. We begin by exploring where knowledge might fit within some of the most widely used behavior change models. The most commonly used models are probably the theory of reasoned action (Fishbein & Ajzen 1975) and its later incarnation, the theory of planned behavior (Ajzen 1991). Both models identify attitudes and social norms as key influences on a person's intention to behave in one way or another. The models assume that individuals evaluate the potential outcomes of performing a particular behavior or not, making rational decisions based on available information (St John *et al.* 2010). The theory of planned behavior adds an extra component, perceived behavioral control. Put simply, this refers to an individual's evaluation of how difficult

Table 1 Tests of fixed effects factors from generalized linear mixed model output on respondents' knowledge of actions to help protect biodiversity

	F	df	P
World region	**6.473**	**4,646**	**<0.001**
First visit to this zoo	0.304	4,646	0.581
First visit to any zoo	**7.962**	**4,646**	**<0.050**
Zoo member or season ticket holder	1.876	4,646	0.171
Gender	**21.115**	**4,646**	**<0.001**
Local to area or visitor	2.138	4,646	0.144
Watched TV nature shows in last 12 months	0.415	4,646	0.520
Member of environmental group	**14.834**	**4,646**	**<0.001**
Number of zoo visits in last 12 months	0.497	4,646	0.481
Age	**25.372**	**4,646**	**<0.001**
Years of formal education	**9.535**	**4,646**	**<0.050**
Biodiversity understanding	**91.967**	**4,646**	**<0.001**
Number of people in visiting group	1.013	4,646	0.314

Significant effects are in bold.

a behavior will be to complete, again based on available information. Knowledge does not feature as part of the decision-making process in either model, but there is an implicit assumption that individuals will need to "know" something about the behavior in order to initiate a rational decision-making process.

The transtheoretical model of behavior change (cf. Prochaska & Velicer 1997) holds that people progress through a linear series of stages based on their motivation to pursue behavior change (Heimlich & Ardoin 2008). This is a model that has been mainly used with health-related behaviors such as smoking cessation, but Dierking *et al.* (2004) applied the model to a zoo exhibit that was specifically designed to encourage proconservation behaviors. While they found that the model was of some use in documenting the stages of intended behavior change, they concluded that for a suite of related behaviors (such as the range of proconservation behaviors), the model was less effective than when applied to specific health behaviors.

The responsible environmental behavior model (Hines *et al.* 1987) stresses the importance of "personality factors" in predicting behavioral intentions, such as the person's attitudes toward the behavior and evaluation of her or his ability to successfully carry out the behavior ("locus of control"). This model explicitly includes knowledge – knowledge of the issues and knowledge of action strategies – as another predictor of behavioral intentions. Superficially at least, these two knowledge components (issues and actions) appear similar to the two knowledge components of Aichi Biodiversity Target 1. However, it is worth noting that the intention to behave should not be conflated with actual behavior. Webb & Sheeran (2006) found that these two variables

are not necessarily as closely linked as one might expect, reporting that a medium to large change in intention is associated with a small to medium change in behavior.

In recent years, relatively simplistic models of human cognition and behavior have gained favor among organizations targeting proconservation social change. At the leading edge of this trend are mechanistic approaches such as "social marketing." As the name implies, this is a framework that applies commercial marketing techniques such as the selection of target audiences, the defining of the barriers and benefits in relation to the behaviors in question, then implementing a variety of "tools" to alter behaviors that are problematic for conservation (Heimlich & Ardoin 2008).

Models such as these are implying a causal relationship between knowledge and behavior. In social studies of science, this relationship has been shown to be highly fraught. The term "knowledge-deficit model" has come to represent the presumption that increased scientific knowledge will yield concomitant increases in support for scientific positions and proscience behavior. In the 1980s, for example, U.K. scientists and scientific institutions focused on perceived deficits in public scientific literacy, or "public understanding of science." As the Royal Society's (1985, page 9) report states, "Better public understanding of science can be a major element in promoting national prosperity, in raising the quality of public and private decision making and in enriching the life of the individual." This "public understanding of science" model was dominant in European science policy discourse for 15 years. The "recurrent elements" of this model included "a concern at the 'scientific ignorance' of the populace, a consequent desire to create a 'better informed' citizenry and an enthusiasm for making science more accessible" (Irwin 1995, page 10).

However, high-profile scientific controversies, such as mad cow disease and genetically modified crops, occasioned a reassessment in European science policy. Underpinned by science studies scholarship from Brian Wynne (1996), Alan Irwin (1995), and others, this reassessment highlighted the limitations of the knowledge-deficit model of public understanding of science. Increasingly, the concept of a two-way "dialogue" or "public engagement" gained support. The term "public engagement" has since increasingly replaced the earlier concept of "public understanding of science" in governmental rhetoric (Irwin 2006) and in science communication discourse (Holliman & Jensen 2009). Although the knowledge-deficit model has been debunked following decades of social scientific research (e.g., Wynne 1996), it remains remarkably persistent in scientifically based communication approaches across a wide spectrum of particular domains, including conservation. Yet, there have not been

any large-scale assessments of the relationship between knowledge and behavior in the domain of public engagement with conservation. To investigate how critiques of the knowledge-deficit model may apply to conservation efforts, our study probes the link between biodiversity-related knowledge and self-reported proconservation behavior using surveys conducted with people entering zoos around the world.

Methods

This study is part of a larger repeated measures, survey-based evaluation of educational impacts of visits to zoos around the world. This analysis focuses on previsit data in order to assess the relationship between key outcome variables for zoo visitors prior to encountering any educational impacts from their visit (Moss *et al.* 2015). Previsit surveys were designed to measure our three dependent variables (biodiversity understanding, knowledge of actions to help protect biodiversity, and self-reported proconservation behavior) and to assess the potential impact of several independent variables on these dependent variables. The two knowledge-related dependent variables were operationalized with open-ended questions. To measure biodiversity understanding, we asked respondents to list anything that came to mind when they thought of biodiversity (space for up to five responses provided). To measure knowledge of actions to help protect biodiversity, we asked respondents to think of an action they could take to help save animal species (space for up to two responses provided). To assess proconservation behavior, we asked respondents the closed-ended question whether, if they have listed an action above, they have done it in the last month (yes, no, or not sure). In addition to the three dependent variables, data relating to a number of independent variables (both categorical and continuous) were collected (for detailed methods and summary statistics, see supporting information and Moss *et al.* 2015).

In short, the survey was designed to be printed by participating institutions, distributed on paper by staff members and self-administered by respondents. Potential survey respondents – visitors ≥10-year-old – were selected using systematic sampling (every nth visitor) or on a continual-ask basis (once one survey response was completed, the next visitor to cross an imaginary line was selected as the potential next respondent). Surveys were conducted from November 1, 2012 to July 31, 2013. Thirty WAZA member organizations (from 19 countries around the globe) participated, two of which sampled visitors at more than one institution. The total number of valid surveys received across participating institutions was 6,357. We do not claim that these zoo visitors are representative of the global general population, as this is not relevant for this study. Here, we focus our attention on the internal relationships between variables within the sample, not on inferring characteristics of the general population.

Any refusals to participate in the research were recorded on a refusals log that contained easily observable visual information about the person (gender, apparent age, and apparent ethnicity) plus the stated reason for refusal. From this we calculated a mean refusal rate across participating institutions of 46.2%. The basic demographics of those visitors who chose not to participate in the survey were not different from the study sample.

The qualitative data from the two knowledge-related dependent variables were subjected to content analyses (for details, see supporting information) to provide quantitative data suitable for statistical analyses. Once quantified, we used Tobit regression and generalized linear mixed models (GLMM) with independent variables as fixed effect factors and participating institutions as a (categorical) random effect factor. Tobit regression was used to account for the potentially censored nature of the two knowledge-related dependent variables. For the GLMM, the restricted maximum likelihood method was used to estimate variance components. Wald tests of exogeneity were used to uncover any endogeneity within the two knowledge-related dependent variables. All statistical tests were two-tailed, had a significance level of $P \leq 0.05$ and were conducted with either IBM SPSS Statistics 21 or Stata 14.

Results

Bivariate analysis of knowledge-related variables

We first analysed the direct relationship between our two knowledge-related variables. There was a close relationship between biodiversity understanding and knowledge of actions to help protect biodiversity (Figure 1). While this relationship was statistically significant ($F = 97.330$, $P < 0.001$), only 0.6% of the variation in knowledge of actions to help protect biodiversity could be explained by those same respondents' biodiversity understanding ([Tobit] $R^2 = 0.006$). On average, there was a 0.271 point increase in knowledge of actions to help protect biodiversity for each one-point increase in biodiversity understanding. Both variables were measured on a 10-point scale. No significant endogeneity was found in either variable (biodiversity understanding: Wald $\chi^2 = 0.030$, $P = 0.863$; knowledge of actions to help protect biodiversity: Wald $\chi^2 = 0.510$, $P = 0.473$).
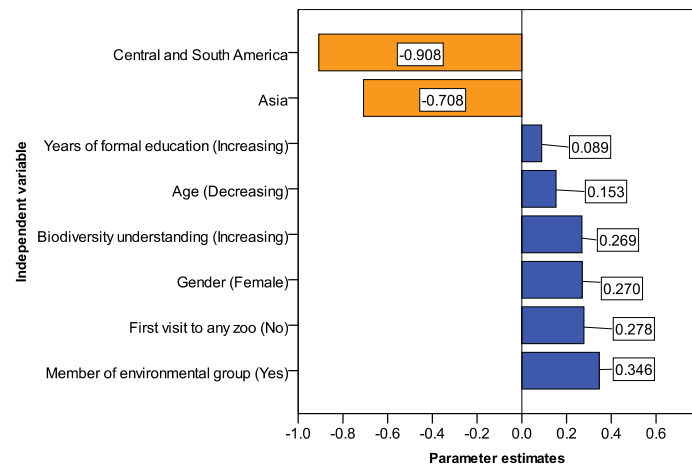
Figure 2 Visualization of generalized linear mixed model parameter estimates for significant fixed effects factors (see Table 1) in relation to respondents' knowledge of actions to help protect biodiversity.

Table 2 Tests of fixed effects factors from generalized linear mixed model output on respondents' self-reported proconservation behaviour

	F	*df*	*P*
World region	0.474	4,330	0.796
First visit to this zoo	1.131	4,330	0.252
First visit to any zoo	0.179	4,330	0.672
Zoo member or season ticket holder	0.610	4,330	0.435
Gender	2.397	4,330	0.122
Local to area or visitor	2.236	4,330	0.135
Watched TV nature shows in last 12 months	**4.373**	**4,330**	**0.037**
Member of environmental group	**10.324**	**4,330**	**0.001**
Number of zoo visits in last 12 months	2.134	4,330	0.144
Age	**3.997**	**4,330**	**0.046**
Years of formal education	2.128	4,330	0.145
Biodiversity understanding	**3.910**	**4,330**	**0.048**
Knowledge of actions to help protect biodiversity	**55.878**	**4,330**	**<0.001**
Number of people in visiting group	**4.787**	**4,330**	**0.029**

Significant effects are in bold.

Predictors of knowledge of actions to help protect biodiversity

We next analysed the relative impact of a range of independent variables (including biodiversity understanding) on knowledge of actions to help protect biodiversity. Seven of the independent variables significantly predicted respondents' knowledge of actions to help protect biodiversity (Table 1). On a 10-point scale, knowledge of actions to help protect biodiversity was lower in respondents from Central and South America (-0.908) and Asia (-0.708) compared to respondents from other regions; increased by 0.089 with each additional year of formal education; and decreased by 0.153 with each additional year of age (Figure 2). Female respondents scored 0.270 higher than their male counterparts. First-time zoo visitors scored 0.278 lower than those who had visited zoos previously. Members of a nature, conservation, or environmental group scored 0.346 higher than those who were not.

Respondents' biodiversity understanding was also influential (Figure 2), with each one-point increase seeing a corresponding 0.269 increase in respondents' knowledge of actions to help protect biodiversity. However, biodiversity understanding was only the sixth most important variable in significantly predicting knowledge of actions to help protect biodiversity.

Predictors of self-reported proconservation behavior

Finally, we analysed the relative impact of a range of independent variables (including biodiversity understanding and knowledge of actions to help protect biodiversity) on self-reported proconservation behavior. Six of the independent variables were significantly related to respondents' self-reported proconservation behavior (Table 2): whether the respondent has watched any TV

nature shows in the last 12 months (0.224); whether the respondent is a member of a nature, conservation, or environmental group (0.358); the age of the respondent (0.072); and the respondent's visiting group size (0.087).

Respondents' biodiversity understanding (0.066) and knowledge of actions to help protect biodiversity (0.236) were both also influential, especially the latter. Biodiversity understanding, however, was the least important variable of those that were significantly related to self-reported proconservation behavior.

Discussion

From these findings, we can broadly conclude two things. First, biodiversity understanding is related to knowledge of actions to help protect biodiversity, but it is by no means the strongest predictive variable. Second, our two knowledge-related variables are linked to respondents' self-reported proconservation behavior. But again, they were not the only predictive variables. In short, there is a relatively weak link between biodiversity-related knowledge and self-reported proconservation behavior in our sample.

We found that the two components of Aichi Biodiversity Target 1 – biodiversity understanding and knowledge of actions to help protect biodiversity – are related. This much is true, but our expectation was to actually find a stronger relationship between the two knowledge-related variables. This was perhaps due to our naivety in assuming that the two strands of knowledge regarding biodiversity (essentially, what it is and how you protect it) would essentially be complementary. That is, by understanding biodiversity as a concept, we assumed that respondents would be interested in, and have knowledge of, the actions that would help protect it. What we actually uncovered was more complex. By including the whole suite of independent variables available to us from the survey data, we constructed a model where biodiversity understanding was only one of eight significant predictive variables; in fact, it was only the sixth most important predictor, with participants' region of origin being the strongest.

We also found that our two knowledge-related variables were predictors of respondents' self-reported proconservation behavior with, as might be predicted, increasing knowledge of actions to help protect biodiversity being the more influential of the two. But surprisingly, knowledge of actions to help protect biodiversity was not the strongest predictor – participants' membership in an environmental group was more important. And, biodiversity understanding was in fact only relatively weakly linked with self-reported proconservation behavior. Our analysis shows the importance of nonknowledge factors

such as cultural differences across world regions, education, age, and gender.

Exploring where knowledge might fit within some of the most widely used behavior change models – theory of reasoned action, theory of planned behavior, transtheoretical model of behavior change, and responsible environmental behavior model – shows that these models are implying a causal relationship between knowledge and behavior, albeit mediated by factors such as perceived control and social norms. European science policy and science communication practice discussions have shifted sharply away from this now-debunked knowledge-deficit model in recent years (Jensen & Holliman 2016). Yet, many environmental communication interventions, including those in zoos, are built on the assumption that increased knowledge will lead to changes in proenvironment behaviors. Our study indicates that knowledge is a real, but relatively minor, factor in predicting whether members of the public – zoo visitors in this case – will know about specific proenvironment behaviors they can take, let alone whether they will actually undertake such behaviors.

Furthermore, it has been demonstrated that, when asked, people will often cite society-level causes for environmental problems (such as capitalism), but only be able to quote individual-level behaviors to attempt redress. This can leave individuals with a sense of powerlessness and pessimism over the perceived benefits of such behaviors (Kenis & Mathijs 2012). Moreover, individualizing problems that have their roots in much larger social structures may create a situation in which proconservation campaigns have localized success, while failing to contribute to changes needed at the society level (e.g., Jensen & Wagoner 2009). For example, it could be argued that governmental lobbying and legislative change would be more effective in the long term at addressing many conservation issues than targeting individual consumer knowledge and behavior. An alternative explanation highlighted by Heberlein (2012b, page 62 ff) pertains to the "specificity principle." That is, broadly framed, general attitudes (e.g., biodiversity understanding in our case) do not tend to translate into specific behaviors (e.g., specific proconservation actions in our case). However, more specific attitudes pertaining to particular behaviors tend to be much more likely to translate into actions, especially when underpinned by relevant values, affective orientation, and social norms.

At this point, we must acknowledge some of the limitations of our study. The most problematic is the measure of proconservation behavior itself. Namely, we relied on respondent self-report (Webb & Sheeran 2006). Of course, the most valid way to measure proconservation behavior is to do just that – measure it directly. However,

for many of the behaviors in question, this is a practical impossibility. Therefore, we believe that improved, more detailed, and more verifiable behavioral self-report measures, measured over a longer timeframe, are the next logical step for this research methodology. We must also be cautious in defining any causal relationships within this study, not only in the origin of cause but also in the direction. That is, a change in respondent behavior could have conceivably caused a change in related respondent knowledge, rather than the other way round.

We conclude that interventions with the goal of promoting proenvironment social change should not assume that education is the only means of reaching that goal. As Jensen & Wagoner (2009) have argued, there are a host of mechanisms for social change that institutions such as zoos and individuals could target in their efforts to create a more environmentally sustainable society. Indeed, individual-level behavior change may be a problematic default focus from the outset. For example, the long-understood tendency toward overproduction and uncontrolled consumption within capitalism is undoubtedly one of the major sources of global unsustainability and threats to the long-term survival of life on earth. If such fundamental structural factors as an unsustainable consumption-based economy are left unchecked, individualized behavior change may not be sufficient to turn the tide. Therefore, we believe that efforts to address the undoubtedly important individual level of knowledge and behavior should be supplemented by interventions that target the structural threats to global biodiversity.

Acknowledgments

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

Supporting Information

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