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Arthropods and the Current Great Mass Extinction: Effective Themes to Decrease Arthropod Fear and Disgust and Increase Positive Environmental Beliefs in Children?

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Earth is experiencing a great mass extinction (GME) that has been caused by the environmentally destructive activities of humans. This GME is having and will have profound effects on Earth's biodiversity if environmental sustainability is not reached. Activities and curriculum tools have been developed to assist teachers in integrating the current GME theme into their existing curriculum. There has also been a recent appeal to incorporate the current GME theme into science and environmental education research but this research has yet to be conducted. This study presents the first time the current GME theme has been assessed in a research setting. This study analyzed the effect living *Poecilotheria* spider activities had on United States children. The variables measured included 1) human fear toward the *Poecilotheria* spiders; 2) human disgust toward the *Poecilotheria* spiders; and 3) human environmental beliefs associated with the current GMEs impact on the *Poecilotheria* spiders. New to this study is the finding that the use of living spiders in a positive educational setting that addresses the current GME are effective tools in decreasing fear and disgust and increasing positive environmental beliefs toward *Poecilotheria* spiders in children. Teachers of elementary children should consider arthropods, arthropod information and the current GME as effective themes to decrease arthropod fear and disgust and increase positive environmental beliefs in children. Lastly, this study presents a structural equation model showing that the reduction of fear and disgust towards specific animals can increase positive environmental beliefs in children when focused on the current GME.

Keywords: Belief; Disgust; Elementary; Environmental Belief; Fear; Mass Extinction; Spider

Introduction

Earth is currently experiencing a great mass extinction of life that has been caused by the environmentally destructive activities of humans (Alroy, 2008; Jackson, 2008; Lewis, 2006; McDaniel & Borton, 2002; Rockström et al., 2009; Rohr et al., 2008; Steffen, Crutzen & McNeill, 2007; Thomas et al., 2004; Wake & Vredenburg, 2008; Zalasiewicz et al., 2010). This great mass extinction is having and will have profound effects on Earth's biodiversity if environmental sustainability is not reached (Pimm & Raven, 2000; WWF, 2012). Activities and curriculum tools have been developed to assist teachers in integrating the current great mass extinction theme into their existing curriculum (Wagler, 2011; Wagler, 2011a; Wagler, 2012). There has also been a recent appeal to begin to incorporate the current great mass extinction theme into science and environmental education research (Wagler, 2013) but research of this nature has yet to be conducted. This study presents the first time the current great mass extinction theme has been assessed in a research setting.

One of the groups of animals being profoundly affected by the current great mass extinction are the spiders of the *Poecilotheria* genus. The *Poecilotheria* genus is composed of large arboreal spiders from India and Sri Lanka. Most of the spiders in the *Poecilotheria* genus are endangered or critically endangered. Although spiders provide both indirect and direct benefits for humans (Georgiev, Thompson, Lotana & Wrangham, 2011; Marc, Canard, Ysnel, 2009; Nyffeler & Sunderland, 2003; Pfannenstiel, 2008; Simmen, Hladik, & Ramasiarisoa, 2003; Strickman, Sithiprasasna & Southard, 1997), elevated levels of human fear and human disgust toward spiders is well documented (Davey, 1994; Gerdes, Uhl, & Alpers, 2009). The current study used living *Poecilotheria* spider activities to investigate the influence these activities had on children's psychological tendencies toward *Poecilotheria* spiders and beliefs concerning these spiders when placed in the context of the current great mass extinction. Specifically, this study analyzed the effect living *Poecilotheria* spider activities had on United States (US) Hispanic children (10-11 years of age). The variables measured included 1) human fear toward the *Poecilotheria* spiders; 2) human disgust toward the *Poecilotheria* spiders; and 3) human environmental beliefs associated with the current great mass extinctions impact on the *Poecilotheria* spiders. Four living species of *Poecilotheria* spiders were used in the study (See Table 1 and Figure 1). A pre/post design with a control group was used for the study.

Table 1. Living Spiders of the Genus *Poecilotheria* used in the Study

Scientific Name	Number of Living Spiders used in the Study	Conservation Status	Location of Indigenous Spider Populations
Poecilotheria metallica	5	Critically Endangered[a]	India
Poecilotheria ornata	5	Endangered[b]	Sri Lanka
Poecilotheria miranda	5	Endangered[a]	India
Poecilotheria rufilata	5	Endangered[a]	India

[a] IUCN, 2013
[b]Samarawckrama, V. A. M. P. K., Jananda, M. D. B. G., Ranawana, K. B. & Smith, A., 2005.

Theoretical Underpinnings of the Study

Human Fear and Human Disgust

It is theorized that the two human emotions of fear and disgust are protective and produce human avoidance of potentially dangerous and disease causing animals (Curtis, Aunger, Rabie, 2004;

Davey, 1994; Seligman, 1971). Specific animals can evoke elevated levels of fear and disgust (Prokop, Uşak & Fančovičová, 2010). For example, spiders elicit significantly greater levels of fear and disgust in humans than beetles, bees/wasps and butterflies/moths (Gerdes, Uhl, & Alpers, 2009). When humans find specific animals disgusting they can be motivated to avoid that animal (Curtis, Aunger, Rabie, 2004; Oaten, Stevenson & Case, 2009; Prugnolle, Lefevre, Renaud, Moller, Missea & Thomas, 2009). Fear can also motivate humans to avoid specific animals (Gerdes, Uhl, & Alpers, 2009; Nesse, 1990; Ohman & Mineka, 2001; Prokop, Uşak & Fančovičová, 2010; Rachman, 2004).

Human Belief

Human belief is an estimate of the likelihood that the knowledge one has about an entity is correct or, alternatively, that an event or a state of affairs has or will occur (Eagly & Chaiken, 1998). Human belief about the future is frequently associated with human expectation (Olson, Roese, & Zanna, 1996). Avoidance behavior is believed to result from an over-prediction of anxiety about an object or experience and cognitive-based beliefs are associated with these feelings of avoidance (Thorpe & Salkovskis, 1996).

Literature Review

A Brief Overview of Spiders and the Spiders of the *Poecilotheria* Genus

Spiders are arthropods that have a segmented body, a chitinous exoskeleton and jointed appendages (Budd & Telford, 2009; Johnson, 2003). They are predatory arthropods that are beneficial to humans in many ways and exist in almost all terrestrial and semi-terrestrial ecosystems on Earth. Spiders benefit humans indirectly by decreasing the densities of arthropods (e.g., insects) in global environments. Many of these arthropod species, when present in high numbers, decrease yields in agricultural plant crops that sustain humans (Marc, Canard, Ysnel, 2009; Nyffeler & Sunderland, 2003; Pfannenstiel, 2008). They also benefit humans indirectly by eating many arthropods that can be vectors for disease in humans (Strickman, Sithiprasasna & Southard, 1997). Furthermore, spiders indirectly benefit humans by serving as a food sources for animals humans eat and for animals humans enjoy esthetically such as monkeys, apes and lemurs (Georgiev, Thompson, Lotana & Wrangham, 2011; Simmen, Hladik, & Ramasiarisoa, 2003). Lastly, they benefit humans directly by serving as a food source in many cultures.

The *Poecilotheria* genus is made up of large arboreal spiders from India and Sri Lanka (See Figure 1). The International Union for Conservation of Nature (IUCN) Red List of Threatened Species is the most comprehensive and authoritative source for the conservation status of Earth's species (IUCN, 2013). The IUCN's conservation status scale of species has seven levels of increasing severity. They are 1) Least Concern (LC); 2) Near Threatened (NT); 3) Vulnerable (VU); 4) Endangered (EN); 5) Critically Endangered (CR); 6) Extinct in the Wild (EW) and 7) Extinct (EX) (IUCN, 2013). The IUCN Red List of Threatened Species and others list most of the spiders in the *Poecilotheria* genus as endangered or critically endangered (See Table 2). The conservation status of some of the spider species in the *Poecilotheria* genus is unknown.

Figure 1. The critically endangered Indian arboreal spider *Poecilotheria metallica.* Photograph used with permission. Photograph by Tom Patterson.

Table 2. Known Conservation Status of Spiders of the Genus *Poecilotheria*

Scientific Name	Conservation Status	Location of Indigenous Spider Populations
Poecilotheria fasiata	Endangered[b]	Sri Lanka
Poecilotheria formosa	Endangered[a]	India
Poecilotheria hanumavilasumica	Critically Endangered[a]	India
Poecilotheria metallica	Critically Endangered[a]	India
Poecilotheria miranda	Endangered[a]	India
Poecilotheria ornata	Endangered[b]	Sri Lanka
Poecilotheria regalis	Least Concern[a]	India
Poecilotheria rufilata	Endangered[a]	India
Poecilotheria smithi	Endangered[b]	Sri Lanka
Poecilotheria striata	Near Threatened[c]	India
Poecilotheria subfusca	Endangered[b]	Sri Lanka
Poecilotheria vittata	Endangered[b]	Sri Lanka

[a] IUCN, 2013
[b] Samarawckrama, Janananda, Ranawana & Smith, 2005
[c] Siliwal, Gupta & Molur, 2013

The Current Great Mass Extinction

There have been five past great mass extinctions (Erwin, 2001; Jablonski, 1995) during Earth's 4.5 billion years history (Dalrymple, 2001). Throughout all of these past great mass extinctions, there was "a profound loss of biodiversity during a relatively short period" (Wake & Vredenburg 2008, 11466). We have now entered a sixth great mass extinction caused by our environmentally destructive activities (Alroy, 2008; Jackson, 2008; Lewis, 2006; McDaniel & Borton, 2002; Rockström et al., 2009; Rohr et al., 2008; Steffen, Crutzen & McNeill, 2007; Thomas et al., 2004; Wake & Vredenburg, 2008; Zalasiewicz et al., 2010). The major human activities (i.e., direct drivers) negatively affecting global biodiversity are (1) habitat modification, fragmentation, and destruction; (2) pollution; (3) climate change; (4) overexploitation of species; and (5) the spread of invasive species and genes (MEA, 2005; WWF, 2012).

Human Psychological Tendencies and Beliefs toward Spiders and Other Arthropods

Educational research studies addressing children's psychological tendencies and beliefs toward spiders are very limited. Because of this, educational research is presented that addresses human psychological tendencies and beliefs toward spiders and other arthropods. Bjerke, Odegardstuen and Kaltenborn (1998) explored Norwegian children and adolescents degree of preference for animals. They found that the degree of preference for animals varies depending on the type of animal. The worm, spider, bee and crow were found to be the least favorite species while the cat, dog, rabbit and horse were the favorite species. Very few of the studies participants were willing to save ecologically-significant insects (i.e., ants, bees and lady beetles) from going extinct (Bjerke, Odegardstuen & Kaltenborn, 1998).

Weinburgh (2007) assessed the impact a nine week course intervention using mealworms (*Tenebrio obscurus*) had on the self-efficacy, content knowledge and attitude of preservice elementary teachers. Before the course intervention the preservice elementary teachers showed "limited prior content knowledge about mealworms, expressed neutral attitudes toward mealworms upon first exposure to them, and were uncomfortable with the idea of having to teach with and about them" (Weinburgh, 2007, p. 801). After the intervention the preservice elementary teachers showed improved content knowledge about mealworms, improved self-efficacy about using mealworms in their teaching and improved attitudes toward mealworms.

Prokop and Tunnicliffe (2008) assessed spider and bat attitudes in Slovakian boys and girls ranging in age from 10-16 years. Children had more negative attitudes toward spiders than bats with female participants having greater negativity than male participants. Irrespective of children's age or gender, alternative conceptions and knowledge of bats and spiders were distributed randomly (Prokop & Tunnicliffe, 2008). A moderate correlation between attitude and knowledge of bats was found but this tendency was not found with spiders (Prokop & Tunnicliffe, 2008).

Among university entry-level psychology students, spiders tend to elicit significantly greater fear, disgust and perceived danger when compared to beetles, bees/wasps and butterflies/moths (Gerdes, Uhl, & Alpers, 2009). Ratings of disgust and fear of spider pictures significantly predicted the questionnaire scores for fear of spiders. Dangerousness ratings of other arthropods and spiders did not provide any predictive power. Gerdes, Uhl and Alpers (2009) results showed that the potential harmfulness of a spider cannot explain why spiders are feared so often.

A strong, statistically significant, association has been found between kindergarten through fourth grade (K-4 [(i.e., approximately 5 to 10 years of age]) preservice elementary teacher's attitudes towards a specific animal and their likelihood to include or exclude information about that animal from their future science classroom (Wagler, 2010). Specifically, if a non-science major K-4 preservice elementary teacher had a positive attitude toward an animal

they were much more likely to believe they would incorporate information about that animal into their future science classroom. Conversely, if a K-4 preservice elementary teacher had a negative attitude toward an animal they were much more likely to believe they would not incorporate information about that animal into their future science classroom. Based on these beliefs the science learning environment that the vast majority of the preservice elementary teachers in the study would construct for their future students would be dominated by mammals (Wagler, 2010). The learning environment would be void of any information about invertebrates (e.g., sponges, corals, worms, mollusks, insects [Excluding the butterfly], crustaceans, and arachnids), amphibians and reptiles. Wagler's study (2010) provided the first empirical evidence that a preservice elementary teacher's attitude toward an animal affected their belief about using information about that animal in their future science curriculum.

Attitudes towards spiders and the level of knowledge of spiders of high school students from Slovakia and South Africa have also been compared (Prokop, Tolarovičová, Camerik & Peterková, 2010). Biology teaching in Slovakia is based on systematic zoology and botany while the South African system is based on ecosystems. A statistically significant but low correlation between knowledge and attitude was found among the Slovakian students. Based on Kellert's (1996) categories of attitude (scientistic, negativistic, naturalistic, and ecologistic), South African students had higher scores in the categories of scientistic, naturalistic, and ecologistic attitudes. Prokop, Tolarovičová, Camerik and Peterková (2010) also found that Slovakian students have less fear of spiders than South African students.

Non-science major K-4 preservice elementary teachers that received frequent direct contact with Madagascar hissing cockroaches *(Gromphadorhina portentosa)* in an educational setting during their preservice training programs had their attitudes and likelihood of arthropod incorporation in future science curriculum changed in a positive way toward the Madagascar hissing cockroaches but not toward other arthropods that they did not have contact with (Wagler & Wagler, 2011). A pre/post randomized design with a control group was used for the study. The non-contact arthropods included a butterfly, lady beetle, dragonfly, grasshopper, spider, crayfish, millipede, centipede and scorpion. This finding provided evidence that in order to positively change preservice elementary teacher attitudes and incorporate beliefs toward a specific animal, frequent direct contact in an educational setting with that specific animal is needed (Wagler & Wagler, 2011).

The general trend observed was that the preservice elementary teachers displayed two different types of attitudes and incorporation rates depending on what arthropod picture they were shown (Wagler & Wagler, 2011). Specifically, the preservice elementary teachers had positive to extremely positive attitudes toward the butterfly, lady beetle and dragonfly and negative attitudes toward the Madagascar hissing cockroach (i.e., pretest only), spider, crayfish, centipede, grasshopper, millipede and scorpion (Wagler & Wagler, 2011). The preservice elementary teachers also had likely to extremely likely belief of future science classroom incorporation rates for the butterfly, lady beetle, dragonfly and unlikely incorporation rates for Madagascar hissing cockroach (i.e., pretest only), spider, crayfish, centipede, grasshopper, millipede and scorpion (Wagler & Wagler, 2011).

Wagler and Wagler (2012) conducted a study to investigate if the external morphology of an insect had a negative effect on preservice elementary teacher's attitudes toward insects and beliefs concerning the likelihood of incorporating insects into future science education settings. Non-science major kindergarten through sixth grade preservice elementary teachers participated and a randomized design with a control group was used for the study. The participants were shown color pictures of three insects (i.e., butterfly, lady beetle or dragonfly) using a Microsoft PowerPoint presentation and were asked to rate their attitude toward the insects and beliefs concerning the likelihood of incorporating the insects into future science education settings. The treatment group was shown a picture of the larva and adult stage of the insect. The control group

was only shown the adult stage of the insect. Unique to the study, was the finding that the external morphology of an insect was a causal factor that could negatively affect preservice elementary teacher's attitudes toward insects and beliefs concerning the likelihood of incorporating insects into future science education settings.

Human negativity toward arthropods has been well documented but the factors that contribute to this negativity have been elusive. Wagler and Wagler (2013) explored knowledge of arthropod (i.e., insect and spider) carnivory and herbivory as possible casual factors that contribute to the negative tendencies preservice elementary teachers have toward most arthropods. Specifically, the study investigated the effect knowledge of arthropod carnivory and herbivory had on United States kindergarten through sixth grade preservice elementary teacher attitude toward that arthropod and belief concerning the likelihood of incorporating information about that specific arthropod into their future science classroom. A randomized design with a control group was used for the study. Unique to the study was the finding that arthropod carnivory and herbivory are causal factors that strongly affect preservice elementary teacher attitude and belief toward arthropods. When the participants of the study were made aware that an arthropod they thought was an herbivore was actually a carnivore, their attitude and likelihood of incorporation significantly declined. When the participants of the study were made aware that an arthropod they thought was a carnivore was actually an herbivore, their attitude and likelihood of incorporation significantly increased.

Methodology

Research Questions

Research Question 1: What is the impact of the *Poecilotheria* spider activities on the participant's level of human fear toward the *Poecilotheria* spiders; human disgust toward the *Poecilotheria* spiders; and human environmental beliefs associated with the current great mass extinctions impact on the *Poecilotheria* spiders?

Research Question 2: What is the relationship between the participant's level of human fear toward the *Poecilotheria* spiders; human disgust toward the *Poecilotheria* spiders; and human environmental beliefs associated with the current great mass extinctions impact on the *Poecilotheria* spiders?

Study Participants

The participants of the study were US children that were 10-11 years of age and lived in a US midsized urban southwestern border region city with a predominantly Hispanic/Latino population. The treatment and control group consisted of 201 US children. Of the 107 participants in the treatment group, 52 were female and 55 were male. The participants mean age was 10.43 years. All 107 of the children in the treatment group were Hispanic/Latino. Of the 94 participants in the control group, 46 were female and 48 were male. The participants mean age was 10.31 years. All 94 of the children in the control group were Hispanic/Latino. The participants were from local public schools. The treatment and control groups were drawn from a similar demographic and the chi-square test shows that the two groups have the same demographic characteristics.

Study Procedure

The pretest was administered to all participants (i.e., treatment and control group) before the children performed the living *Poecilotheria* spider activities. The participants of the study were shown four living *Poecilotheria* spiders (See Table 1) in clear round plastic containers (17.5 cm

dia. X 8 cm H) with secure clear plastic lids and 1 mm ventilation holes. All of the living spiders were mature adult females. The four living spider species were randomized. Based on this randomization, each participant was allowed to view a spider from each *Poecilotheria* species for up to 60 seconds from an approximate distance of 60 cm. The participants also viewed a picture of a dolphin (*Tursiops truncatus*). For each animal the participants were asked to rate their level of fear (Likert scale: Not at all [1] to Extremely [5]), disgust (Likert scale: Not at all [1] to Extremely [5]) and environmental beliefs (Likert scale: Strongly Disagree [1] to Strongly Agree [5]) associated with the current great mass extinctions impact on the animals (i.e., *Poecilotheria* spiders or dolphin). The participants rated their level of environmental belief by answering the five questions in Figure 2. Each question (i.e., 1-5) is associated with one of the five major direct drivers of the current great mass extinction (MEA, 2005; WWF, 2012). Question six is a summative question assessing the participant's belief about if humans should let the specific animal go extinct in the natural habitat the animal lives in (MEA, 2005; WWF, 2012). All six questions were independently assessed by experts in the field to verify the content validity and the assessors concluded that the questions reflect the principles expressed in the five major direct drivers of the current great mass extinction (MEA, 2005; WWF, 2012). The treatment group then participated in five *Poecilotheria* spider activities. The control group did not participate in the *Poecilotheria* spider activities or receive information about the current great mass extinction. For the posttest, both groups rated their level of fear, disgust and environmental beliefs just as they had done for the pretest.

1. I believe humans should not modify, fragment or destroy the natural habitat this animal lives in.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

2. I believe humans should not pollute the natural habitat this animal lives in.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

3. I believe humans should not change the climate of the natural habitat this animal lives in.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

4. I believe humans should not take too many of this animal from the natural habitat they live in.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

5. I believe humans should not let invasive species into the natural habitat this animal lives in.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

6. I believe humans should not let this animal go extinct in the natural habitat this animal lives in.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Figure 2. To what extent do you agree or disagree with the following statements. Please circle your answer.

***Poecilotheria* Spider Activities**

Five activities with living *Poecilotheria* spiders were conducted with the treatment group. All of the activities were 60 minutes in length. All living spiders were present for all activities and were in secure locked glass enclosures for viewing and observation. Each vertical enclosure had one spider, one water dish, a moist coir substrate for flooring and a vertical piece of cork bark which the spider normally remained on. The spiders were never removed from these enclosures during the activity.

Each 60 minute activity focused on one of the five major direct drivers responsible for the current great mass extinction, how that specific major driver was or will affect the spiders, how the spiders benefit their ecosystems (and the animals that live in them) and how they benefit humans. For example, one of the activities focused on habitat modification, fragmentation, and destruction as one of the main factors impacting the *Poecilotheria* spiders of Sri Lanka is human destruction and fragmentation of their habitat (Samarawckrama, Janananda, Ranawana & Smith, 2005). The children participated in inquiry learning activities that allowed them to see that, if the natural forests that this group of spider's lives in disappears, these spiders will (over time) become extinct in the wild.

Other shorter enjoyable hands-on spider lessons occurred during the main activity that let the children observe the spiders and their behavior. For example, Figure 3 shows anatomically correct spiders that children made after observing the living *Poecilotheria* spiders. This lesson also allowed the children to explore how the spider's characteristics allow them to perform ecologically beneficial services that strengthen ecosystems.

Figure 3. An example of two children's spider models built from fruit and candy. Photograph by Ron Wagler.

Selection of Study Animals

The spiders of the *Poecilotheria* genus were chosen for the study for multiple reasons. First, in order to address the studies research questions, living animals were needed that prior research shows humans fear and find disgusting (Davey, 1994; Gerdes, Uhl, & Alpers, 2009). Second, to further address the studies research questions, living animals were needed that were endangered or critically endangered (i.e., almost Extinct in the Wild) but also available to the researchers. Even though the spiders of the *Poecilotheria* genus are endangered/critically endangered in their natural habitats they can be bred in captivity. All of the spiders used in the study were bred in captivity and not removed from their natural habitat of India or Sri Lanka. Lastly, the low human fear and low human disgust bottlenose dolphin (*Tursiops truncatus*) (Barney, Mintzes, & Yen, 2005) was used as a point of comparison and reference to the high human fear and high human disgust of the *Poecilotheria* spiders.

Statistical Analysis of the Study

Multi-group longitudinal structural equation models (SEMs) were utilized to assess the two research questions of the study. In particular, the model utilized was a multiple indicator multiple causes (MIMIC) model, a special form of a SEM where the latent variable (Environmental Belief) is predicted via observed variables. These are useful for assessing the structural properties of a scale with a set of covariates as well as assessing the construct validity of a scale (Zumbo, 2005). Indicator variables distinguish participants in the treatment from the control group, whether the animal being rated is the dolphin or one of the *Poecilotheria* genus spiders, and the time point of the study (pre versus post). All other variables (e.g., fear and disgust scores) are ordinal ratings spanning from 1=Strongly Disagree to 5=Strongly Agree. For the analysis, the *lavaan* package (Rosseel, 2012) in the statistical analysis software package R is utilized (R Core Team, 2012). The parameters of the MIMIC model are estimating using the generalized least squares (GLS) method using the indicator variable for the treatment/control as the group. Reasonable equality constraints on the MIMIC model (i.e., equal loadings and regression parameters) are considered and simultaneous interval estimation of the regression parameters follows the analysis. All intervals are controlled for multiplicity using Bonferroni corrections to the critical value. Finally, bootstrap simulation is utilized to obtain robust standard errors for the regression parameter estimates.

Results

Descriptive Statistics

Table 3 contains the sample means for the pre-test and post-test time points and treatment and control groups. Review of this table demonstrates that the treatment and control groups had similar emotions toward the spiders and dolphin at the outset. Also note that the control group ratings are stable across the two time periods. In contrast, in the treatment group there is a marked increase in the spider means for the environmental belief questions (EB1-EB5) and a decrease in the fear and disgust ratings. These results will be explored in more detail in the remainder of this section.

Internal Consistency for Environmental Belief

The scores resulting from the items measuring environmental belief show strong evidence of internal consistency. For the treatment and control groups the lower bound on internal consistency (e.g., Cronbach's alpha) is 0.902 and 0.901, respectively. The overall measure of internal consistency is 0.914.

Structural Analysis of Environmental Belief, Fear and Disgust

The MIMIC model showing how environmental beliefs relate to fear and disgust for particular animals and across time fits the data moderately well (χ^2=204.274 and p-value<0.0001 with χ^2_{trt}=122.097 and χ^2_{con}=82.176, RMSEA=0.050 with 90% CI: (0.043, 0.058), SRMR=0.021, and CFI=0.885). There was no significant lack of fit associated with allowing equal loadings across the groups, however, tests for equal intercepts (means) or regression relationships resulted in severe lack of fit for the MIMIC model. Thus, the model allowing for freely estimated regression parameters and equal loadings across the treatment and control groups is illustrated in Figure 4.

Table 3. Sample Means (Standard Deviations) for Animal Ratings

Group	Time	Animal	EB-1	EB-2	EB-3	EB-4	EB-5	EB-6	F	D
Control	Pre	Spiders	2.15 (0.82)	2.22 (0.69)	2.26 (0.68)	2.25 (0.88)	2.23 (0.88)	2.31 (0.88)	4.38 (0.90)	4.12 (0.91)
Control	Pre	Dolphin	4.49 (0.84)	4.62 (0.74)	4.55 (0.71)	4.55 (0.74)	4.57 (0.68)	4.62 (0.68)	1.29 (0.50)	1.35 (0.63)
Control	Post	Spiders	2.18 (0.84)	2.22 (0.68)	2.22 (0.72)	2.24 (0.88)	2.27 (0.82)	2.32 (0.82)	4.31 (0.97)	4.10 (0.96)
Control	Post	Dolphin	4.52 (0.85)	4.62 (0.78)	4.54 (0.73)	4.55 (0.77)	4.51 (0.73)	4.55 (0.73)	1.32 (0.51)	1.34 (0.60)
Treatment	Pre	Spiders	2.21 (0.81)	2.24 (0.75)	2.32 (0.69)	2.29 (1.04)	2.30 (0.97)	2.31 (0.97)	4.46 (0.87)	4.15 (0.99)
Treatment	Pre	Dolphin	4.58 (0.65)	4.62 (0.72)	4.58 (0.71)	4.66 (0.61)	4.58 (0.66)	4.59 (0.66)	1.28 (0.49)	1.19 (0.42)
Treatment	Post	Spiders	4.17 (0.81)	4.14 (0.86)	4.14 (1.05)	4.20 (0.85)	4.20 (0.92)	4.17 (0.92)	2.34 (0.78)	2.08 (0.67)
Treatment	Post	Dolphin	4.56 (0.68)	4.63 (0.73)	4.57 (0.67)	4.70 (0.57)	4.53 (0.71)	4.53 (0.71)	1.24 (0.49)	1.19 (0.39)

Note: A=Animal, T=Time, F=Fear, D=Disgust and EB=Environmental Beliefs.

Simultaneous confidence bounds for the relevant regression parameters from the MIMIC model are presented in Table 4. In this table, whenever an interval comparing the slopes is positive, this indicates that this factor's slope is significantly greater for the treatment versus control group. If the interval is negative, then the slope is smaller for the treatment group versus the control group. If the interval contains 0, then there is no difference between the treatment and control group regression parameter.

Analysis of Research Question 1. One focus in this study is to understand how the *Poecilotheria* activities are associated with the ratings of fear, disgust, and environmental belief, as stated in research question 1. In order to focus in on research question 1, multiplicity-adjusted confidence bounds were utilized to assess how the regression relationships differed across the treatment and control populations for the factors of fear, disgust and environmental belief. The slopes for the regression relationships in the MIMC models are simultaneously significant with negative slopes for fear and disgust and a positive slope for environmental belief (See Table 4) for the treatment versus control groups and across the pre and posttest periods. In particular, according to the simultaneous confidence bands shown in Table 4, the difference in the slopes for time for the treatment and control group are significantly different from 0. Moreover, the

treatment group has a positive slope ($\beta_{T,TRT}$ = 1.75) on the latent environmental belief variable while the control group slope ($\beta_{T,CON}$ = -0.05) for time has no effect on environmental belief (See Figure 4).

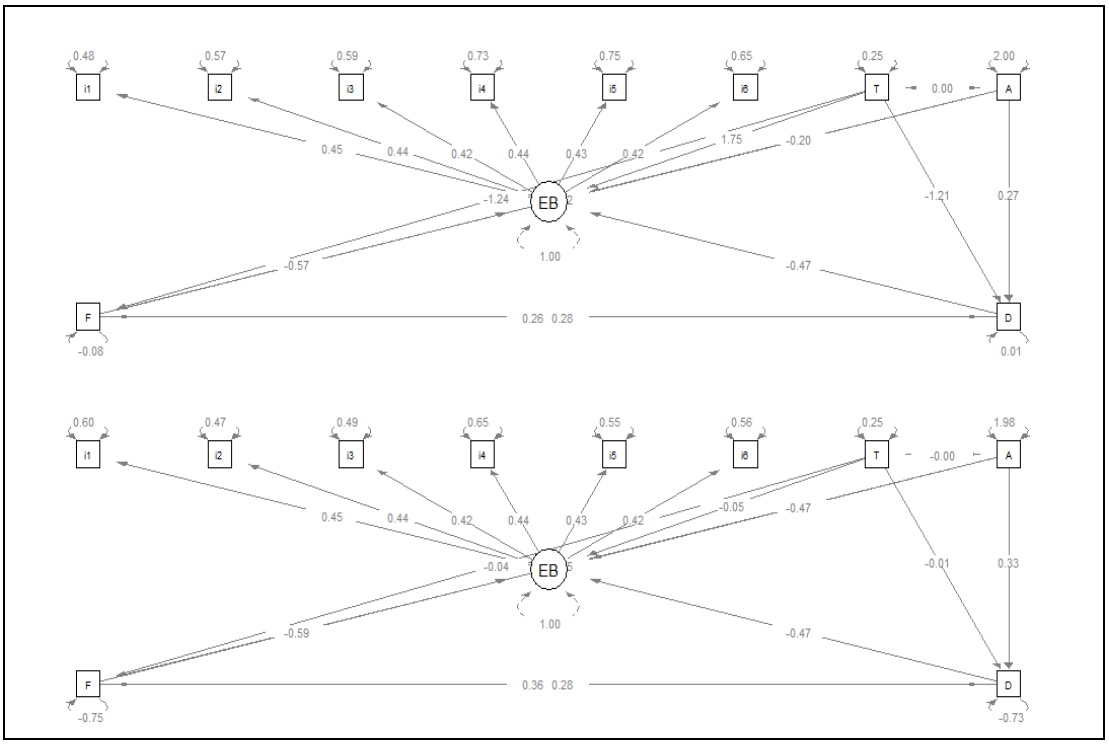

Figure 4. MIMIC Models of Fear, Disgust and Environment Belief Ratings.
Note: A=Animal, T=Time, F=Fear, D=Disgust and EB=Environmental Beliefs.

Analysis of Research Question 2. Another focus of this study is to investigate how the scores of fear and disgust affect environmental belief among the participants, as stated in research question 2. The results indicate that the structural relationship between scores of fear and disgust and the response, environmental belief, are stable across the treatment and control groups since the intervals contain 0 for these parameters (See Table 4). Moreover, the regression parameters are $\beta_{F,TRT}$ = -0.57 and $\beta_{D,TRT}$ = -0.47 for the effect of fear and disgust on environmental belief for the treatment group and are $\beta_{D,CON}$ = -0.59 and $\beta_{D,CON}$ = -0.47 for the effect of fear and disgust on environmental belief for the control group. This implies that if fear and disgust can be changed, then this change has a mediating effect on environmental belief since decreases in human feelings of fear and disgust increase environmental belief for the *Poecilotheria* spiders. Similarly, the effect on environmental belief when the animal is a spider significantly decreases the environmental belief for individuals in the control group while, in comparison, minimally impacts the environmental belief ratings for the treatment group. Note that the slope for Animal is also negative and statistically significantly less than 0 for the treatment group ($\beta_{A,TRT}$ = -0.20), but the effect of animal type on environmental belief is minimized in comparison to the control group ($\beta_{A,CON}$ = -0.47) (See Figure 4).

Table 4. Simultaneous Confidence Bands for Difference of MIMIC Regression Parameters (Trt-Con)

95% Confidence Bounds			
	Slope	Lower	Upper
Research Question 1	EB~T	1.464	2.112
	F~T	-1.344	-1.070
	D~T	-1.336	-1.073
Research Question 2	EB~F	-0.106	0.143
	EB~D	-0.120	0.119

Note: A=Animal, T=Time, F=Fear, D=Disgust and EB=Environmental Beliefs.

Discussion

This study shows that the participants initially had negative psychological tendencies (i.e., human fear and disgust) toward spiders. This is consistent with prior research (Gerdes, Uhl, & Alpers, 2009; Prokop, Tolarovičová, Camerik, & Peterková, 2010; Prokop & Tunnicliffe, 2008; Wagler, 2010; Wagler & Wagler, 2011; Wagler & Wagler, 2012; Wagler & Wagler, 2013). This study also shows that the participants were initially willing to let the *Poecilotheria* spiders go extinct in their natural habitat. This is also consistent with prior research (Bjerke, Odegardstuen & Kaltenborn, 1998).

New to this area of study is the finding that initially the participants had negative beliefs (i.e., human environmental beliefs associated with the current great mass extinctions impact on the *Poecilotheria* spiders) but participation in the *Poecilotheria* spider activities that addresses the current great mass extinction theme (See Research Question 1) greatly decreased the participants' fear and disgust toward the *Poecilotheria* spiders, greatly increased their positive environmental beliefs toward the *Poecilotheria* spiders and greatly increased their desire to not let the *Poecilotheria* spiders go extinct in their natural habitat. These changes were not observed in the control group participants (See Table 4 and Figure 4).

This study also provides new evidence that a structural relationship exists between human fear, human disgust and human environmental beliefs associated with the current great mass extinctions impact on the *Poecilotheria* spiders (See Research Question 2). This structural relationship did not significantly differ for the treatment and control groups or for the type of animal (i.e., spider or dolphin). This statistical analysis provides strong evidence that if human fear and human disgust toward an animal can be reduced in a positive educational setting that incorporates the current great mass extinction theme, positive environmental beliefs toward that animal will increase (See Table 4 and Figure 4).

Implications

Seventy five percent of all animal species on Earth are arthropods (Lewis, Gaffin, Hoefnagels & Parker, 2002). As part of the current great mass extinction, many of these species are on the edge of extinction (IUCN, 2013). Arthropods perform many essential ecological services for humans that make human existence possible (Wilson, 1987). Even though this is the case, rarely are they used as an educational tool to positively increase environmental beliefs and often this role is filled by charismatic mammals (Barney, Mintzes, & Yen, 2005). This study shows that the use of living spiders in a positive educational setting that addresses the current great mass extinction are effective tools in decreasing fear and disgust and increasing positive environmental beliefs toward *Poecilotheria* spiders in children. Teachers should consider living arthropods, arthropod

information and the current great mass extinction as effective themes to decrease arthropod fear and disgust and increase positive environmental beliefs in children.

When teachers use living arthropods in educational settings they should attempt to use captive bred arthropods instead of arthropods that have been removed from natural ecosystems. As part of the current great mass extinction, the practice of humans removing arthropods from their natural ecosystem is one of the major direct drivers pushing some arthropod species closer to extinction (MEA, 2005; WWF, 2012). For educators that would like to use arthropods and the current great mass extinction theme in their classroom, the Further Resources section provides examples of activities with living arthropods that can be performed in a classroom and articles that provide detailed information about the current great mass extinction theme. With all of these arthropod activities, once the teacher has educated themselves about the current great mass extinction theme, they can easily incorporate this information into these activities. The arthropod activity articles also explain the proper ethical care of these arthropods and techniques for ensuring the animals are not stressed or harmed during activities.

A major implication of this study concerns the confirmation of the measurement of human fear, human disgust and human environmental beliefs associated with the current great mass extinctions impact on the *Poecilotheria* spiders. Based on the MIMIC model, the measurement properties of the environmental belief scale used in this study are valid with respect to the content and construct validity. There is also evidence that these measurement properties are invariant across the populations of those who were exposed to the environmental activities (treatment group) and those who were not exposed to the environmental activities (control group). This implies that the covariance structure of observed scores from the environmental belief scale does not substantively vary across the treatment and control groups, but shows similar relationships among the items and does not imply the mean ratings do not vary across the groups. In particular, the loadings for the measurement part of the MIMIC model are constant across the treatment and control populations. This study also demonstrates that the environmental belief scale is valid for Hispanic children (i.e., 10-11 year of age), but needs further validation for use with other populations. Beyond the measurement properties of the scale, the confirmation of the theorized structural relationship between human fear, human disgust and human environmental beliefs is very significant. This study demonstrates that, for Hispanic children, when human fear and human disgust decrease as a result of exposure to learning activities about the roles of these animals and the current great mass extinction, then the environmental beliefs also increase. Moreover, this study shows that human fear, human disgust and environmental beliefs are malleable factors in this population. This confirms the need for environmental outreach for children by inclusion of arthropod activities that incorporate the current great mass extinction theme into science classrooms and other educational settings.

Further Resources

Arthropod Activity Articles

Wagler, R. (2013). The wonders of terrestrial isopods. *Science Scope*, 37(2), 59-67.

Wagler, R. (2011). Look at that! Using Madagascar hissing cockroaches to develop and enhance the scientific inquiry skill of observation in middle school students. *Science Scope, 35*(4), 36-47.

Wagler, R. (2010). Home sweet home: How to build a Madagascar hissing cockroach habitat out of recycled materials. *Science Scope, 33*(8), 34-39.

Wagler, R. (2009). Chow down! Using Madagascar hissing cockroaches to explore basic nutrition concepts. *Science Scope, 32*(7), 12-18. http://learningcenter.nsta.org/product_detail.aspx?id=10.2505/4/ss09_032_07_12

Wagler, R. & Mosley, C. (2005). Cockroaches in the classroom: Incorporating the Madagascar hissing cockroach into your science curriculum. *Science Scope, 28*(6), 34-37.

The Current Great Mass Extinction Articles

Wagler, R. (2013). Incorporating the current sixth great mass extinction theme into evolution education, science education and environmental education research and standards. *Evolution: Education and Outreach, 6*(9), doi:101186/1936-6434-6-9.

Wagler, R. (2012). The sixth great mass extinction. *Science Scope, 35*(7), 36-43.

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