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„I can feel the sun on my leaves – Making people care for plants through anthropomorphism "

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Und zu guaterlescht: A groaßes Donkschian a enk, Mami und Tati, dass es mi ollm unterstützts und mor olls zuatrauts. Ohne enk waret des olls net meglich.

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Introduction

Plants produce the oxygen we breathe, are essential parts of our diets and play crucial roles in climate systems, in shaping evolution and earth's atmosphere (Bascompte & Jordano, 2014; Isbell et al., 2011; Lenton et al., 2016; Raguso, 2020). In short, all life on earth depends on plants. Yet, in our efforts to protect and preserve the natural environment, plants are often systematically neglected (Havens et al., 2014; Kramer & Havens, 2015; Stein & Gravuer, 2008). Worldwide, about half of all endangered species are plants (IUCN, 2021). Yet, in the US only 4% of conservation money is invested in conserving plant species (Havens et al., 2014).

This bias in funding and conservation research towards animals - particularly vertebrates (Donaldson et al., 2017; Knapp, 2019) at the cost of plants has been termed "plant blindness". Evidence for plant blindness has been found in a variety of studies in different fields including psychology and education (for overviews see Hershey, 2002; Urquiza-Haas & Kotrschal, 2015; Wandersee & Schussler, 2001). The term plant blindness was first introduced by Wandersee and Schussler (1999) and describes the inability to notice plants in one's own environment, to know very little about them and to fail recognizing their importance in the biosphere and in human affairs. Crucially, plant blindness also includes not being able to appreciate plants as the unique life forms they are and being generally seen as inferior to animals. This last point in particular might lead to the conclusions that plants are undeserving of our consideration and conservation efforts.

Multiple factors contribute to our absence of plant appreciation (Balding & Williams, 2016). Because plants are mostly grouped together and are often uniform in color, they blend together visually and are difficult to see (Wandersee & Schussler, 2001). In a bottom-up manner, visual attention thus mediates human relationships with plants at the first steps of noticing plants in everyday life. This aspect of plant blindness seems plausible when taking on an evolutionary perspective: In the course of human evolution, threats coming from potential animal predators were much more time-sensitive than those coming from slowly moving plants (even if they were poisonous) and required more immediate attention, monitoring and appropriate reactions (New et al., 2007; Wandersee & Schussler, 1999). Entities that move autonomously, usually process information and have intentions and goals that are easily understood by us – and sometimes their goals can be to predate on a human. Most plants, however, do not move visibly and are usually not harmful. An evolutionary account would thus frame our disregard for plants as a result of an adaptation for high salience towards moving objects and thus towards perceiving agents. Our evolutionary history therefore provides another clue towards a central aspect involved in plant blindness: movement. Further evidence for this comes from studies that show that detection of agents from non-agents is derived from different features, for example over having a face and eyes, but also to a high degree over autonomous movement (Barrett, 2015; Gelman & Spelke, 1981; Klapper et al., 2014; Morewedge et al., 2007; for an early qualitative example see Heider & Simmel, 1944). Interestingly, specific types and velocities of movement seem to influence our assumptions of animacy and agency in different ways (Kilner et al., 2007; Visch & Tan, 2009). One study specifically investigates how movement and perceptions of agency, more specifically of mind perception, are connected (Morewedge et al., 2007). Mind perception is a process that entails attributing different mental states to target objects and life forms while in the process making sharp distinctions between agents and non-agents. Participants were more likely to attribute a mind to various targets, if they moved at the speed of human movement, termed "timescale bias" (Brenner, 2017; Morewedge et al., 2007). In the study by Morewedge and colleagues (2007), participants rated various animals, plants and objects on their speed of movement and the presence of a mind. Indeed, deviations from human-like speed predicted mind perception scores, in a way that the more similar to human movement speed a target was perceived, the more the target appeared to have a mind. Unfortunately, plant targets were omitted from analysis and the influence of seeing plants in motion on mind perception was not investigated further.

Regarding mind perception, two factors have been identified in some studies: agency and experience (Gray et al., 2007; although there is doubt about this two-dimensional structure: Tzelios et al., 2022). The two factors are distinct in their allocation of moral responsibility and consequences. Experience specifically includes capacities such as feeling pain and pleasure, hunger, fear and other emotions and is correlated with moral care and concern. Agency includes attributions of self-control, memory, recognizing emotion, planning and communication and correlates with moral responsibility. Thus, targets rated highly on agency are seen as being morally responsible for their actions, while targets rated highly on experience ought to be protected from harm and evoke feelings of care (Gray et al., 2007; Gray et al., 2012; Nijssen et al., 2019). Attributing moral rights and responsibilities therefore strongly depends on whether targets are thought to experience emotions, thoughts, pain and pleasure.

As further empirical evidence for the connection of autonomous movement and mind perception in the domain of plants is scarce, one can also turn to the field of human-machine interactions, where perceptions of agency and mind have been researched to a greater extent. For example, children being introduced to an apparently autonomous robot ascribed more sentience, desires and mind to it than when the same robot was introduced by being remote-controlled (Chernyak & Gary, 2014). Children in the condition where autonomous movement was cued, were also more likely to cite moral reasons against harming the robot. Related to this, humanized (i.e., anthropomorphized) agents are less likely to be sacrificed in a moral dilemma scenario than neutrally presented agents, indicating higher moral consideration for humanized agents (Nijssen et al., 2019). This happened when agents exhibited anthropomorphic appearance (i.e., in a bottom-up manner), as well as when participants were cued to ascribe anthropomorphic mental states (i.e., top-down). Thus, our mind perception of others, even of non-living things, depends at least in part on how easily we can anthropomorphize them, which in turn amplifies our moral concern for them. We might be less likely to feel and be concerned for less similar beings (Miralles et al., 2019) and be less likely to attribute higher cognitive abilities to them (Eddy et al., 1993). As plants are seen as less similar to humans than many animals, we are less inclined to anthropomorphize them at a baseline level (Epley et al., 2007).

The broader concept of anthropomorphism relates to mind perception in the following way: Anthropomorphism describes a process of “attributing humanlike properties, characteristics, or mental states … to nonhuman agents or objects” (Epley et al., 2007, p. 865), meaning that these nonhuman agents and their minds are interpreted through a human lens. Anthropomorphizing other life forms and objects can be very useful in predicting actions and behaviors of such agents and is inherently a process of social cognition (Barrett, 2015; Urquiza-Haas & Kotrschal, 2015). How much people tend to anthropomorphize specific targets depends, similar to mind perception, in part on the likelihood that knowledge about humans is activated situationally. It is activated more readily when the target is perceived as similar to the self. This similarity can also be activated bottom-up or top-down. Bottom-up similarity can either be similarity of movement (as observable in the timescale bias) or morphological similarity (Edwards & Shafer, 2022). Thus, in the process of anthropomorphizing (and the related mind perception), autonomous movement is one key factor. Additionally, top-down processes can also contribute cues to agency (Klapper et al., 2014; Wiese et al., 2012). Such top-down processes refer to beliefs or knowledge about an entity and can be activated for example by conveying anthropomorphic information via texts or stories. These two routes through which anthropomorphism can be activated could make us appreciate and care for plants more. Anthropomorphism has been shown to be a useful tool for enhancing pro-environmental attitudes and behaviors in general (Borovik & Pensini, 2022; Liu et al., 2019; Tam et al., 2013, Tam, 2019; Williams et al., 2021) and eliciting anthropomorphic processes might help us to increase moral concern for plants.

No studies to date have investigated the influence of anthropomorphism on our moral concern and conservation effort for plants in particular. The current study closes this gap and focuses on the impact of anthropomorphic information and visible movement on our moral concern for plants and relatedness with plants, which should result in higher conservation effort toward them. In the current study, moral expansiveness is measured as a state variable to determine if anthropomorphic information and movement can enhance moral concern for a specific plant, meaning if this plant is included in participants' moral boundaries. Anthropomorphic information is presented directly (i.e., top-down) and visible movement indirectly (i.e., bottom-up) in four experimental groups. It is expected that seeing autonomous movement of a plant as well as receiving direct anthropomorphic information about it will increase people's tendency to anthropomorphize said plant, enhance their mind perception and in turn their moral concern for a plant, as well as connectedness with it. If a person feels connected to a plant, this can lead to caring and intentional behaviors that benefit plants and other life forms, such as conservation effort. In this study, conservation effort is measured directly via an effortful task in return for donations to a pro-environmental organization.

Methods

Participants

A power analysis using G*power 3.1.9.4 (Faul et al., 2007) with α = .05, β = .95, and partial $\eta 2$ = .06 (assuming a medium effect) resulted in a targeted sample size of 140 participants.

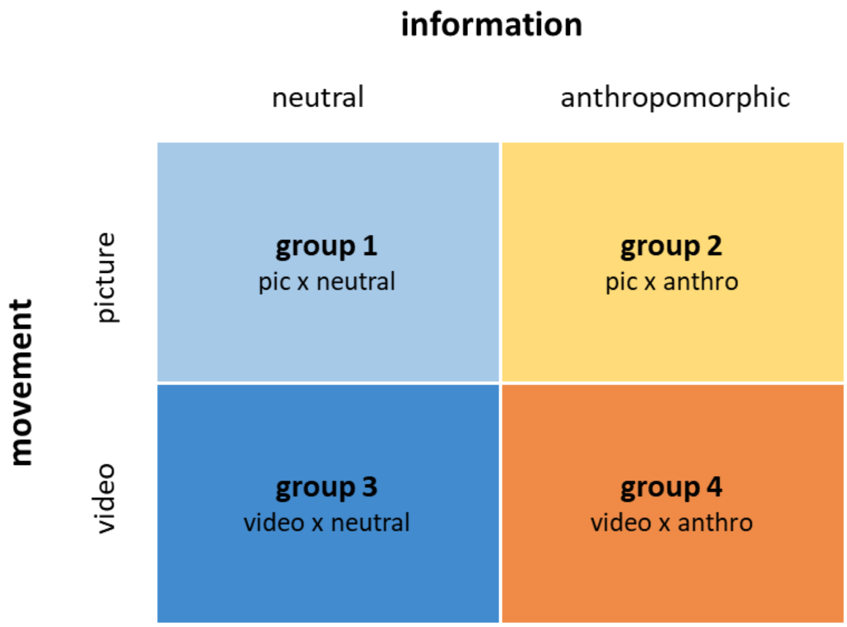
Participants consisted of a convenience sample, recruited via personal contacts, social groups from the University of Vienna and the platform SurveyCircle (63 responses). The study was carried out online and took participants around 10 minutes to fill out. Ultimately, 160 participants carried out the study to the point of having seen one of the experimental videos (M_{age} = 28.99, SD_{age} = 10.23, female 68.13%, male 29.38 %, other 2.5%). Participants were distributed fairly equally among the four experimental groups (group 1: n = 40, group 2: n = 38, group 3: n = 42, group 4: n = 40). Roughly half of participants (56.25%) were students or in school and were either studying in the field of Psychology, Biology or Cognitive Science (n = 80). Their nationalities were German (n = 24), Austrian (n = 22), Italian (n = 23), Swiss (n = 1), other EU states (n = 35) and other non-EU states (n = 44). Overall, participants rated themselves slightly to moderately knowledgeable about plants (M = 2.48, SD = 0.82).

Experimental Design and Procedure

An online survey containing different outcome measures, combined with a two-by-two factorial between-subjects design of experimental conditions was carried out via the survey platform Qualtrics (www.qualtrics.com). It consisted of four randomly presented videos, consisting of combinations of the two factors movement and information. Regarding the factor of movement, either a moving plant was shown in a time-lapsed video or was represented by one picture only. Combined with this, the factor information was varied: audio vignettes were presented either explaining the plant's movement in a factual or in an anthropomorphized way. Six different outcome measures were assessed (see Materials). The entire study was conducted in English. Informed consent was asked and the covariate Nature Relatedness was presented first. Then instructions were shown, followed by the auto-played video. Participants were asked if they were able to see and hear the video. If “no” was selected, participants were forwarded to the end of the survey. Then, participants were asked to provide answers for the different outcome measures and additional variables.

Figure 1

The four experimental groups based on the 2x2 combinations of the factors information and movement



Materials

Videos

Four videos were created, consisting of the four possible combinations resulting from the two-by-two factorial design. These four combinations are referred to as experimental groups 1-4 (see figure 1). The two factors are movement (visible movement vs. static image) and type of information (neutral vs. anthropomorphic). As previously stated, visible autonomous movement might be one factor contributing to mind perception and the absence of movement might be detrimental to it. Thus, presenting a plant in natural (but time-lapsed) movement in comparison to a still of the same plant is fitting. Visible movement was manipulated by presenting one of two different videos: the video without visible movement showed a still of a grown bean plant; the video with visible movement showed the same bean plant in a time-lapse - sprouting from its seed, spreading out roots and growing. Both the video and the still were taken from the same YouTube video (GPhase, 2018). The goal was to make autonomous movement visible, while still keeping both videos as similar as possible in regard to other factors.

Type of information was manipulated by presenting one of two audio vignettes simultaneously to the video or still of the plant. One vignette was designed to present information about the plant's growth in a neutral way, the other to present the same information in an anthropomorphic way. The goal was to make differences between the two vignettes as big as possible (while still controlling that the content of the information stayed roughly the same) in order to estimate the effect anthropomorphized information would have on the outcome variables. The vignette with neutral information contained a description of biological processes and physiology of the growing plant. The vignette with anthropomorphic information contained the same content, but in an anthropomorphized style. It included phrases like "they love the feeling of sunlight on their body […]", "they recognize their plant siblings and talk to them" and put emphasis on the plants' agency and experience (for example by ascribing human-like emotions and intentions to it). Both texts were written in third person, recorded in English by the same adult female person and combined with the videos via Clipchamp (Microsoft, 2020). All four videos were approximately the same length (between 1:37 minutes and 1:39 minutes long) and can be found under the following link: https://seafile.curilan.org/d/07118f5373274e15b85e. The full texts of the vignettes can be found in Appendix A, Table A1.

Outcome Measures

As a manipulation check, two items inspired by the two factors of mind perception were formulated (Gray et al., 2007) – agency and experience. Both included a short description of their meaning and were rated on a 5-point Likert scale. Additionally, a single-item measure of mind perception (used by Morewedge et al., 2007) was used. This included marking a continuous scale with the two anchors "does not appear to have a mind" and "definitely appears to have a mind".

The first main outcome measure was the Moral Expansiveness Scale (MES) (Crimston et al., 2016), which was used to operationalize moral concern or moral expansiveness more specifically. Moral expansiveness can be used to estimate the breadth and depth of and individual’s moral concern and moral treatment of beings. A person high in moral expansiveness includes many entities in their moral consideration and care (Crimston et al., 2016). The MES consists of three rings that symbolize different levels of moral concern with increasing moral concern for the innermost circle, as well as the option of outside of the moral boundary, where no moral concern or standing is attributed to the object in question. Participants were asked in which moral circle they would place the specific plant shown in the video, thus turning it into a state variable.

The second main outcome measure was derived from the Inclusion of the Other Scale (Aron et al., 1992), originally intended to measure interpersonal interconnectedness. The original uses seven Venn-like diagrams, that overlap to different degrees one representing the Self, the second the Other. Participants are instructed to choose the diagram that best describes their relationship with the Other. In the current study, these diagrams are tailored towards the specific plant that is presented during the study. The word “Other” from the original measure was replaced with the word “Plant”, now measuring how close the connection between the self and the specific plant is as a state variable. Both moral concern and perceived similarity with the plant could be seen as psychological mechanisms, wherein participants develop an emotional bond with a plant, which in turn leads to caring and pro-plant behaviors/conservation effort.

The third main outcome measurement was the Work for Environmental Protection Task (WEPT-task; Lange & Dewitte, 2021). The WEPT task gives participants the opportunity to voluntarily make an additional effort by screening a series of tables containing two-digit numbers. In return, small donations for an environmental organization are made. This task therefore provides an actual measure of pro-environmental behavior at real behavioral costs, instead of using self-reports or hypothetical scenarios. The number of filled out pages reflects participants’ willingness to invest time and effort into pro-environmental causes. In this study, 15 pages of 40 numbers each were presented to the participants. Per filled-out page, 10 eurocents were donated to Kuratorium Wald (http://www.kuratoriumwald.com), an environmental non-profit organization located in Vienna. Kuratorium Wald works on the preservation of Austrian forests and invests in reforestation and environmental education, especially tailored to plants and forest ecosystems. Kuratorium Wald was chosen because it is relatively unknown. This ensured that attitudes towards the organization were generally neutral and mainly guided by the information that was provided within the study. After a short introduction to the task (see Lange & Dewitte, 2021) and Kuratorium Wald (Appendix A, Text A1), participants were asked if they were willing to fill out additional pages of the task. If they declined, they were forwarded to the end of the survey. Before each of the 15 pages, participants were asked anew.

Covariate and Additional Measures

Items measuring Nature Relatedness were included in the survey. Nature Relatedness is the extent to which a person feels an interconnectedness or relatedness with the natural world and also includes experiential aspects of an individuals' connection to nature (Mayer & Frantz, 2004; Nisbet et al., 2008; Schultz, 2002). Trait beliefs of belonging to nature can lead to more empathic and altruistic behavior towards nature, as well as increased moral concern (Crimston et al., 2016). In line with this, high values in nature relatedness have been shown to correlate with pro-environmental behaviors (Barragan-Jason et al., 2021; Liu et al., 2019; Martin et al., 2020; Mayer & Frantz, 2004; Vesely et al., 2021). This makes Nature Relatedness an important covariate that needs to be included when wanting to estimate effects of the experimental manipulation. To measure Nature Relatedness, the short 6-item version of the Nature Relatedness Scale (NR-6; Nisbet & Zelenski, 2013) was used. Further, self-constructed items assessing experience with plants and daily interactions with them were included in addition to demographic variables.

Data Analysis

Data analysis was carried out via R. Participants who reported not being able to see or hear the video were excluded. As no participants rated their own English comprehension as "terrible" or "poor", no further exclusions were set. Univariate outliers were determined via Boxplot and excluded only if they were extreme (i.e., when above or below the third quartile plus 3 times the interquartile range). This was the case for two participants regarding the outcome variable Inclusion of the Plant in the Self.

For MANCOVA analysis, no multivariate outliers were found when using Mahalanobis distance at $p < .001$. Regarding the WEPT task, the number of at least 90% correctly filled out pages was calculated and used as an outcome variable. This operationalization was used, because it presumably reflects both the scrutiny, with which pages were filled out, as well as the singular decisions at the time of being asked to fill out an additional page.

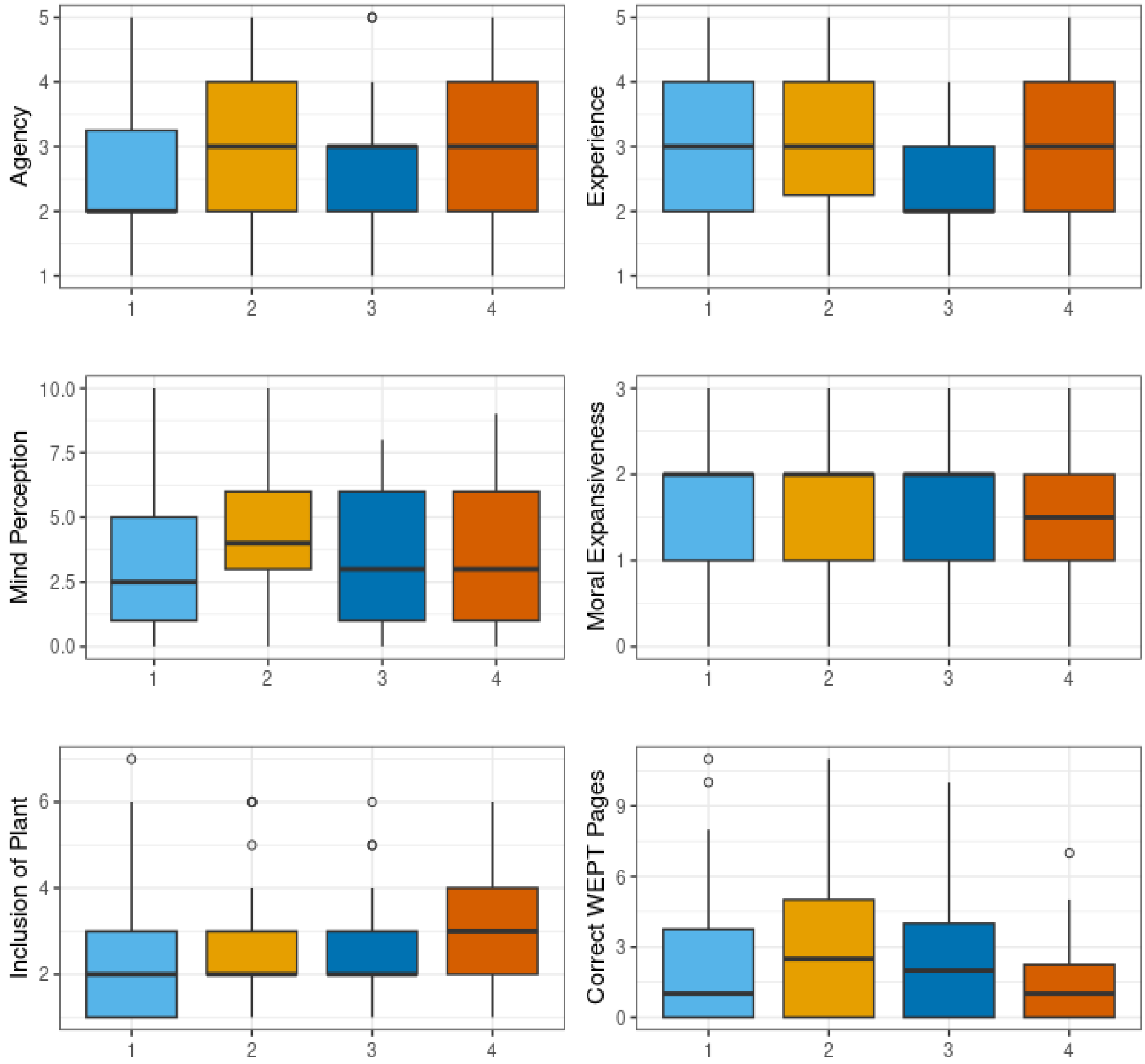
A two-factorial between-subjects multivariate analysis of covariance (MANCOVA) was calculated with the two independent factors movement (picture vs. video) and information (neutral vs. anthropomorphic) and their interaction, while controlling for Nature Relatedness. The three outcome variables were agency, experience and mind perception. With the other outcome variables, separate two-factorial analyses of covariance (ANCOVAs) were performed to examine the effects of information and movement on Inclusion of Plant in the Self and Moral Expansiveness respectively, after controlling for Nature Relatedness. For these, type III sums of squares were used. Additionally, a generalized linear model (GLM) was fitted to assess the effects of information and movement on filled out pages of the WEPT task. For all tests *p* values less than .05 were considered significant. Corrections for multiple testing were applied using the Benjamini-Hochberg method.

Results

For all analyses, assumptions for parametric tests were tested. In the ANCOVA for Inclusion of Plant in the Self, the assumption of normality of residuals was violated (Shapiro-Wilk test: $W = 0.92$, $p < .001$). Regarding the MANCOVA, the assumption of univariate normality could also not be met (Shapiro-Wilk test: $W = 0.99$, $p = .001$). However, all other assumptions for ANCOVA and MANCOVA were met and histograms of residuals suggested no extreme departure from normality. Analysis of variance are known to be robust against moderate violations from normality (Blanca et al., 2017; Schmider et al., 2010). Hence, these analyses were conducted as planned. Boxplots split by experimental groups can be found in Figure 2.

Figure 2

Boxplots for all outcome variables by experimental group



Note. The x- axis denotes the four experimental groups (see figure 1). In the boxplot for correct WEPT pages, participants that filled out 15 pages are removed.

The outcome variables agency, experience and mind perception all pertain to the same construct of mind perception and were assessed for multicollinearity using Pearson correlations (Appendix B, Table B1). All three correlated significantly with each other to a moderate degree, making them suited for analysis via MANCOVA. To evaluate whether the experimental manipulation had the intended impact on mind perception, a two-way MANCOVA was performed (Table 1). Using Pillai's trace and type III sums of squares, there was no significant effect of information and movement on the variates constructed from agency, experience and mind perception when controlling for Nature Relatedness. The factor information failed to reach significance (F(3, 153) = 2.46, p = .065). Univariate tests revealed significant effects of information on agency (F(1, 155) = 5.07, p = .026) and experience (F(1, 155) = 5.85, p = .017). The effect of information on mind perception was not significant (F(1, 155) = 3.17, p = .077). The factor movement as well as the covariate Nature Relatedness had no significant effect on either of the three outcome variables (Appendix B, Table B2).

Table 1

MANCOVA (Type III) for Agency, Experience and Mind Perception - Pillai's Trace

Measure	*V*	*approx. F*	*num df*	*den df*	*p*
Intercept	.272	19.03	3	153	<.001
Nature Relatedness	.008	0.40	3	153	.755
Information	.046	2.46	3	153	.065
Movement	.016	0.85	3	153	.467
Information x Movement	.014	0.75	3	153	.526

The covariate Nature Relatedness was significantly related to Inclusion of Plant in the Self, F(1, 153) = 9.58, p = .002, partial $\eta^2 = .06$, indicating that Nature Relatedness had a positive relationship with Inclusion of Plant in the Self (Estimate = 0.37) (Table 2). The main effect for movement on Inclusion of Plant in the Self when controlling for the effect of Nature Relatedness just failed to reach significance, F(1, 153)= 3.87, p = .051, partial η^2 = .02. No significant effect of information (F(1, 153) = 2.36, p = .13) or for the interaction of information and movement was found (F(1, 153) = 0.41, p = .52). Adjusted means were higher for the level of movement where the time-lapsed plant was shown (M_{pic} = 2.37, 95% CI[2.08, 2.66], M_{vid} = 2.77, 95% CI[2.49, 3.06]).

Table 2

ANCOVA (Type III) for Inclusion of the Plant in the Self

Measure	*SS*	*df*	*F*	*p*
Intercept	12.62	1	7.57	.007
Nature Relatedness	15.97	1	9.58	.002
Information	3.93	1	2.36	.127
Movement	6.46	1	3.87	.051
Information x Movement	0.69	1	0.41	.521
Residuals	255.17	153		

Regarding the ANCOVA for moral expansiveness, the covariate Nature Relatedness was significantly related to Moral Expansiveness $F(1, 155) = 23.46$, $p < .001$, partial $\eta^2 = .13$, indicating that Nature Relatedness had a positive relationship with Moral Expansiveness (Estimate = 0.37). There was no significant effect of information (F(1, 155) = 0.00, p = .998) or movement (F(1, 155) = 0.29, p = .59) when controlling for the effect of Nature Relatedness. The interaction effect was non-significant, $F(1, 155) = 0.47$, p = .49 (Appendix B, Table B3).

Through their completion of WEPT pages, participants generated donations of €85.5. On average, participants completed 5.34 WEPT pages (SD = 5.89, median = 3). Visual exploration of at least 90% correctly filled out pages of the WEPT task revealed that it did not follow a normal distribution, but was bimodal instead (Appendix B, Figure B1). This bimodality was a result of a subpopulation of participants (n = 40, 25% of all participants), that filled out all WEPT pages. The percentage of these "completionists" was similar in all experimental groups (group 1 = 25%, group 2 = 31.58%, group 3 = 23.81%, group 4 = 20%). Participants that filled out all 15 pages of the WEPT task were thus excluded, resulting in a final sample size for the WEPT task of n = 120 and data that was approximately Poisson distributed. A generalized linear model (GLM) with negative binomial distribution was fitted as the correctly filled out pages of the WEPT task (excluding participants who had filled out 15 pages) represent count data. As an initial step, the GLM was fitted using the Poisson family, which showed overdispersion (Residual deviance = 378, Residual deviance *df* = 115) and was then substituted for a negative binomial distribution. Information, movement, Nature Relatedness and the interaction of information and movement were included in the model. Neither of these independent variables predicted the correctly filled out pages of the WEPT task (see Appendix B, Table B4). Additional analyses where “completionists” were included or excluded were also conducted, but are limited in their approach and are not elaborated on further (Appendix B, Tables B5-B8).

When correcting for multiple testing, the effects of Nature Relatedness on Moral Expansiveness and Inclusion of the Plant in the Self remained significant (critical $p_{\text{moral expansiveness-NR}} = 0.0125$ and critical $p_{\text{inclusion-NR}} = 0.025$). The effect of information in the MANCOVA and subsequently also the effect of movement for Inclusion of the Plant in the Self just failed to reach significance (critical $p_{\text{MANCOVA-information}} = 0.05$).

Exploratory analyses, where all biology students (n = 27) were excluded were also conducted (Appendix B, Tables B9-B14) to gauge if previous knowledge about plant biology would influence the effect of experimental manipulations. These exploratory ANCOVAs revealed slightly differing patterns from the full dataset.

Discussion

Research suggests that plants are underappreciated in conservation and research (Havens et al., 2014; Kramer & Havens, 2015; Stein & Gravuer, 2008). One possible factor contributing to this harmful bias might be difficulty when anthropomorphizing plants, presumably because they are often missing visible movement and other features that usually prompt anthropomorphism (Heider & Simmel, 1944; Kilner et al., 2007; Klapper et al., 2014; Morewedge et al., 2007). In the current study, the two factors information (neutral vs. anthropomorphic) and movement (visible movement vs. static image) were manipulated in a 2x2 between-subjects design to induce anthropomorphism. Higher mind perception, perceived similarity, moral concern and conservation effort were expected for participant groups that saw a plant in motion and received anthropomorphic information about it. Relatedness with nature was included as a covariate throughout statistical analysis. Results suggest, that the factors information and movement had no straightforward or consistent influence on the outcome variables.

Regarding the manipulation check, a significant effect of information on agency and experience, but not on mind perception as a whole was found. Against predictions, visible movement of the plant did not lead to higher mind perception of that plant. This is surprising, as higher scores for all three variables were expected for the moving and anthropomorphically described plant. Thus, the experimental manipulation might only have worked partially. Possible reasons for this could be inadequate speed of movement. The time-lapsed plant might have moved too slowly or too quickly and missed a “sweet spot” to elicit the perception of goal-directed movement (Morewedge et al., 2007; Visch & Tan, 2009). As the plant was shown in isolation, it is possible that providing more context (for example light sources or interactions with other plants) could aid participants in perceiving a mind by increasing interactivity (i.e., goal-directed movement) (Schultz et al., 2005). Other important features of movement in plants (more than just the absence or presence of movement) could be tested systematically in future studies. Interestingly, in an exploratory analysis where all biology students were excluded, no effects of movement were found either, although the effects of information on all items of mind perception were more consistent. Given that half of all participants in the current study were either biologist, psychologists or cognitive scientists and thus either familiar with plant behavior or cognition in general, this could have reduced the effects of the experimental manipulation substantially. Future studies could investigate the effects of similar experimental manipulations in naive subgroups. Because the effects on agency, experience and mind perception were inconsistent and nonexistent for the factor movement, all following analyses are also unlikely to reveal strong main effects.

Results regarding the first proposed psychological mechanism revealed a weak effect of movement on perceived similarity between the self and the plant. Participants that had seen the plant in movement perceived higher similarity between themselves and the plant. Although confirming predictions, this effect is surprising, given that visible movement had no apparent effect on the manipulation check of mind perception. This could suggest an entirely different mechanism by which seeing an agent in movement leads to higher perceived similarity.

Regarding the second psychological mechanism - moral concern towards the plant - neither type of information nor movement had an effect. This is contrary to predictions. One could argue, that the Moral Expansiveness Scale is simply not suited to detect state differences in moral concern, but instead still reflects more global beliefs at the trait level. This seems plausible, as the Moral Expansiveness Scale was developed as a trait variable and is relatively stable over time (Crimston et al., 2016; Crimston et al., 2018). Furthermore, a trait as broad as moral concern is unlikely to be changed by a one-and-a-half-minute long video. It has also been proposed, that individuals low on moral concern could be more susceptible to further constricting their moral concern when faced with conflicting motivations (Crimston et al., 2018). Thus, for future studies, moral concern could be included as a covariate and could be better measured via another scale already validated for measuring state moral concern.

For both perceived similarity with the plant and moral concern, relatedness with nature had a medium-sized effect. Participants with higher relatedness with nature perceived higher similarity between themselves and the plant and had higher moral concern for the plant. These effects are in line with previous studies that show a connection of high relatedness with nature to increased moral concern (Crimston et al., 2016). Thus, the current study confirms relatedness with nature as an important covariate to be included in future studies.

Regarding the final outcome of conservation effort, neither visible movement nor anthropomorphic information, nor relatedness with nature were able to predict performance in the WEPT task. This is surprising as relatedness with nature has been shown to have a positive influence on pro-environmental behavior in many different studies (Barragan-Jason et al., 2021; Liu et al., 2019; Martin et al., 2020; Mayer & Frantz, 2004; Vesely et al., 2021). Possible reasons for the lack of effects of experimental manipulations are manifold and some limitations apply.

First, as the manipulation check suggests, the experimental videos could have been insufficient to elicit strong mind perception, which could have led to the lack of influence on conservation effort. Secondly, while it is possible, that the chosen statistical analyses were not ideal, the observed bimodal distribution of filled out pages of the WEPT task suggests that it is more likely that the operationalization of the WEPT task applied in the current study was unsuitable. The original authors of the WEPT task did not use an accuracy-based criterion but instead measured the amount of time spent on each WEPT page (Lange & Dewitte, 2021). A newer study by the same authors, however, found consistent effects both when using an accuracy-based or time-based criterion (Lange & Dewitte, 2023). In this newer study, WEPT performance correlated positively with biospheric and altruistic value orientations, but surprisingly also with egoistic value orientations. It is possible, that the current sample consisted of a high percentage of participants with strong achievement goals that were motivated to fill out all WEPT pages, regardless of experimental manipulation. Additionally, the willingness to fill out pages in the WEPT task has been shown to depend on the amount of donations offered in return (Lange & Dewitte, 2021). The amount offered in this study could simply not have been enough to elicit large differences between experimental groups. A third possibility is, that the mechanism of anthropomorphism is not as effective in mediating effects on pro-environmental behavior as the literature suggests.

For some of the analyses conducted in this study, statistical constraints apply as well. Although group sizes were similar, they were not equal and outcome variables were not normally distributed. Even though the F-test is usually robust under violation of normality, major exceptions can sometimes be found for unequal sample sizes (Ito, 1980). This means, that the analysis could have been further improved by transforming outcome variables (Tabachnick & Fidell, 2013). Participant sample size was predetermined by Power Analysis, but it was difficult to estimate an effect size as empiric evidence was scarce. It is thus possible that a larger sample size would have been needed to detect significant and consistent effects.

To conclude, the current study found that mind perception in plants could be prompted by an anthropomorphic description of said plant. Seeing a plant in time-lapsed movement, however, did not lead to higher mind perception. There was no consistent evidence that showing a plant in motion and describing it in an anthropomorphic way leads to higher connections with the plant, as well as moral concern and conservation effort towards it. Relatedness with nature, however, showed a positive relationship with feelings of connectedness towards a plant and with including this plant within participants' moral concern.

Despite its limitations, the current study is one of the first to investigate anthropomorphizing of plants and possible effects on conservation effort, connection towards plants and mind perception. Its two-by-two design allows entangling effects of previously found bottom-up and top-down features via a multimodal presentation. It creates a starting ground for research that is getting more and more important. As we are trying to navigate biodiversity loss and mitigate climate change, it is crucial to consider full systems and their complexity, and to protect all forms of life. Only then can sustainable long-term decisions be made and new ways be found to reduce our impacts on the earths' ecosystems.

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Appendix A

Additional Survey Information

Table A1

Text Vignettes with Varying Neutral and Anthropomorphic Type of Information

Neutral	Anthropomorphic
The growth of this plant begins with the growth of roots. Cells in the root start to divide and nutrients are acquired through chemical processes. Additionally, the roots anchor the plant.	This plant begins their life by spreading out roots. With these roots, the plant feels around the earth and discovers food and water. Growing bigger and bigger, they stabilize themselves by pressing the roots firmly into the ground.
The sprout is pushed upwards and reaches the earth's surface. Light particles have an influence on molecules in the cells, which then – without awareness -divide in a specific way. As a result, the plant seems to turn towards light sources, although it happens unwittingly.	As soon as they're strong enough, the young seedling finally pushes through the earth's surface. They love the feeling of sunlight on their body and will immediately stretch towards the light, hoping to catch as much of it as possible.
The cells of a plant depend on sunlight in order to photosynthesize. C02 and water are chemically converted into oxygen and sugar. Leaves are formed, creating a big surface for photosynthesis to occur on. Additionally, water pressure-changes within the plant can make its leaves move following a daily rhythm.	They need the warm sunlight to breathe. On every inhale, they create sugar, which they eat when they're hungry. They spread out their leaves as widely as possible in order to soak up all of the light. When they aren't getting enough sun, they intentionally turn their leaves. When sleeping, they relax their leaves and their whole body.
The plant's tip also seems to rotate in a circle, although this is not an intentional process, but rather a by-effect of uneven cell growth. Presumably, the evolutionary function of this is to be able to find and attach to other objects to get mechanical support.	By proudly swaying their tendrils around, they actively search for contact with other plants and forest dwellers. They recognize their plant siblings and talk to them. Sometimes these plant communities purposely share food to help each other grow, or warn each other about drought, diseases or predators.
The plant continues growing, flowers are created, which pollinators are attracted to. Finally, the plant reproduces as evolutionarily programmed.	The plant continues growing and becomes an adult, eventually creating beautiful flowers to attract bees and other helpers and finally gives birth to their own offspring.

Text A1

WEPT Instructions Including a Description of Kuratorium Wald

Thank you very much!

You now have the option to continue with this number-identification task for a little longer. The official part of this study is over.

In the following, we will ask you if you want to complete additional pages of the number-identification task. For each page that you correctly complete, we will make a donation to Kuratorium Wald, an environmental non-profit organization working on the preservation of Austrian forests. Kuratorium Wald invests, for example, in reforestation and environmental education in Vienna, especially tailored to plants and forest ecosystems. Additionally, Kuratorium Wald provides legal assistance in environmental proceedings and is involved in environmental decision-making.

It is up to you to decide how much time and effort you want to invest in the task. There are a maximum of 15 pages that you can complete. For each page, we will tell you how many numbers you will have to check (so that you can estimate the effort) and how much money we will donate if you complete the task. You can then decide, for each page separately, if you want to do this additional effort or not.

Doing this task is completely voluntary. If you want, you can decline checking the numbers (by clicking "no") and go directly to the end of the study. However, please do not simply close the survey before you have reached the end of it.

Appendix B

Additional Statistical Analyses and Information

Table B1

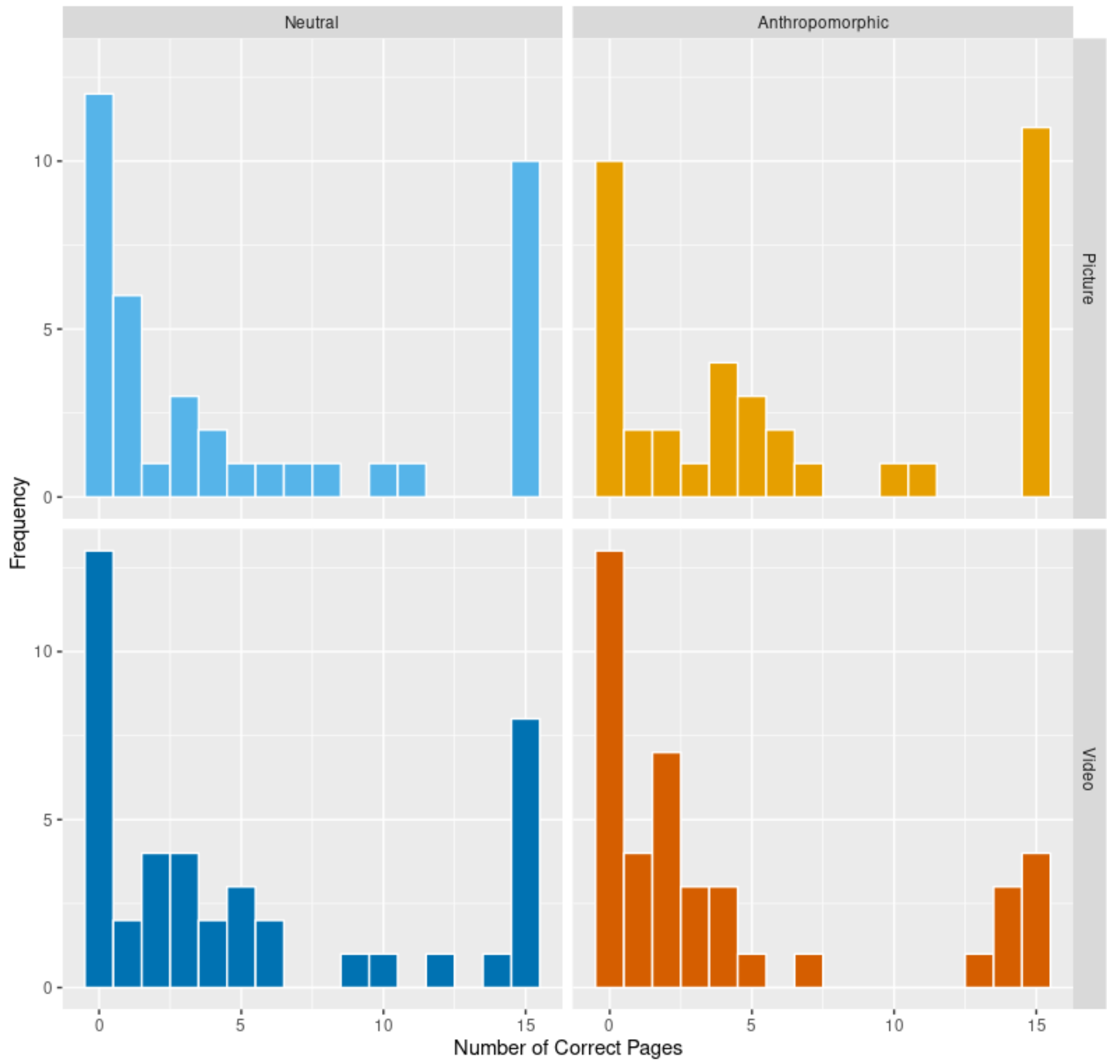
Descriptive Statistics and Correlations for Outcome Variables

Variable	*n*	*M*	*SD*	1	2	3
1. Agency	160	2.8	1.2	—		
2. Experience	160	2.9	1.1	.50***	—	
3. Mind Perception	160	3.6	2.7	.38***	.63***	—

***p < .001.

Figure B1

Distribution of at Least 90% Correctly Filled out Pages of the WEPT Task



Note. Histograms of raw data of the WEPT task where only pages were counted that participants had filled out at least 90% correctly. Histograms are plotted separately for each experimental group.

Table B2

Univariate MANCOVA (Type III) Results for Agency, Experience and Mind Perception

Univariate MANCOVA (Type III) Results for Agency

Measure	*SS*	*MS*	*df*	*F*	*p*
Nature Relatedness	0.89	0.89	1	0.64	.427
Information	7.10	7.10	1	5.07	.026
Movement	0.03	0.03	1	0.02	.885
Information x Movement	0.71	0.71	1	0.51	.478
Residuals	217.05	1.40	155		

Univariate MANCOVA (Type III) Results for Experience

Measure	*SS*	*MS*	*df*	*F*	*p*
Nature Relatedness	0.64	0.64	1	0.52	.472
Information	7.21	7.21	1	5.85	.017
Movement	2.04	2.04	1	1.66	.200
Information x Movement	0.00	0.00	1	0.00	.952
Residuals	190.88	1.23	155		

Univariate MANCOVA (Type III) Results for Mind Perception

Measure	*SS*	*MS*	*df*	*F*	*p*
Nature Relatedness	0.07	0.07	1	0.01	.919
Information	22.91	22.91	1	3.17	.077
Movement	1.00	1.00	1	0.14	.711
Information x Movement	7.13	7.13	1	0.99	.322
Residuals	1121.29	7.23	155		

Table B3

ANCOVA (Type III) for Moral Expansiveness

Measure	*SS*	*df*	*F*	*p*
Intercept	0.45	1	0.65	.422
Nature Relatedness	16.30	1	23.46	<.001
Information	0.00	1	0.00	.998
Movement	0.20	1	0.29	.592
Information x Movement	0.33	1	0.47	.493
Residuals	107.71	155		

Table B4

GLM for Correctly Filled-Out WEPT Pages, Excluding "Completionists"

Measure	*SS*	*SE*	*z*	*p*
Intercept	0.28	0.58	0.47	.636
Nature Relatedness	0.16	0.14	1.10	.270
Information	0.26	0.35	0.75	.454
Movement	0.01	0.33	0.03	.978
Information x Movement	-0.69	0.49	-1.42	.156

Note. Null deviance = 134.55, *df* = 119. Residual deviance = 129.74, *df* = 119

Analyses of (Co-)Variance When Including and Excluding "Completionists"

Table B5

ANCOVA (Type III) for Correctly Filled-Out WEPT Pages, Including "Completionists"

Measure	*SS*	*df*	*F*	*p*
Intercept	22.70	1	0.67	.415
Nature Relatedness	128.6	1	3.78	.054
Information	16.80	1	0.49	.483
Movement	2.40	1	0.07	.789
Information x Movement	39.8	1	1.17	.281
Residuals	5278.40	155		

Table B6

ANCOVA (Type III) for Correctly Filled-Out WEPT Pages, Excluding "Completionists"

Measure	*SS*	*df*	*F*	*p*
Intercept	6.93	1	0.92	.340
Nature Relatedness	10.58	1	1.40	.239
Information	6.60	1	0.88	.352
Movement	0.01	1	0.00	.972
Information x Movement	16.95	1	2.25	.137
Residuals	867.68	115		

Table B7

Robust ANOVA (Type III) for Correctly Filled-Out WEPT Pages, Including "Completionists"

Measure	*Q*	*p*
Information	0.01	.939
Movement	2.14	.148
Information x Movement	1.50	.225

Table B8

Robust ANOVA (Type III) for Correctly Filled-Out WEPT Pages, Excluding "Completionists"

Measure	*Q*	*p*
Information	0.25	.618
Movement	0.71	.405
Information x Movement	2.21	.143

Exploratory Analyses

Table B9

ANCOVA (Type III) for Agency, Excluding Biology Students

Measure	*SS*	*df*	*F*	*p*
Intercept	23.85	1	18.39	<.001
Nature Relatedness	3.53	1	2.72	.101
Information	4.72	1	3.64	.059
Movement	0.41	1	0.32	.575
Information x Movement	0.53	1	0.41	.524
Residuals	167.31	129		

Table B10

ANCOVA (Type III) for Experience, Excluding Biology Students

Measure	*SS*	*df*	*F*	*p*
Intercept	31.05	1	26.38	<.001
Nature Relatedness	3.66	1	3.11	.080
Information	3.64	1	3.09	.081
Movement	0.67	1	0.57	.453
Information x Movement	0.05	1	0.05	.830
Residuals	151.83	129		

Table B11

ANCOVA (Type III) for Mind Perception, Excluding Biology Students

Measure	*SS*	*df*	*F*	*p*
Intercept	30.09	1	4.56	.035
Nature Relatedness	8.22	1	1.25	.267
Information	26.02	1	3.95	.049
Movement	3.62	1	0.55	.460
Information x Movement	3.94	1	0.60	.441
Residuals	850.63	129		

Table B12

ANCOVA (Type III) for Inclusion of Plant in the Self, Excluding Biology Students

Measure	*SS*	*df*	*F*	*p*
Intercept	2.73	1	1.44	.232
Nature Relatedness	20.79	1	10.96	.001
Information	1.75	1	0.92	.339
Movement	6.51	1	3.43	.066
Information x Movement	0.00	1	0.00	.994
Residuals	244.64	129		

Table B13

ANCOVA (Type III) for Moral Expansiveness, Excluding Biology Students

Measure	*SS*	*df*	*F*	*p*
Intercept	0.07	1	0.10	.750
Nature Relatedness	14.92	1	21.82	<.001
Information	0.10	1	0.14	.710
Movement	0.20	1	0.30	.587
Information x Movement	0.31	1	0.45	.503
Residuals	88.16	129		

Table B14

GLM (Type III) for Correctly Filled-out WEPT Pages, Excluding Biology Students and "Completionists"

Measure	*Estimate*	*SE*	*z*	*p*
Intercept	0.11	0.64	0.17	.865
Nature Relatedness	0.21	0.16	1.28	.202
Information	0.27	0.37	0.73	.463
Movement	0.06	0.35	0.18	.857
Information x Movement	-0.90	0.54	-1.66	.097

Note. Null deviance = 118.02, *df* = 105; Residual deviance = 112.61, *df* = 101

Abstract

In conservation, research and everyday life, plants are often overlooked and their worth underappreciated. Because plants look and move vastly different from us, they are more difficult to understand and to appreciate than other forms of life that are more similar to us. Therefore, showing plants in motion and increasing their understandability through anthropomorphism might help us to first increase our moral concern for plants and in turn increase pro-plant behaviours. This thesis investigates the influence of anthropomorphized information and visible movement in a two-by-two between-subjects design and measures their influence on perceptions of mind, perceived similarity with the plant, moral concern and conservation effort. Four videos were created, where a growing plant was either shown in time-lapsed movement or not moving at all, combined with a neutral or anthropomorphic description of its growth. Results suggest that the experimental manipulation worked only partially as intended, with information having an effect on mind perception, while movement had none. There was however, an influence of type of movement on perceived similarity with the plant and consistent effects of trait levels of relatedness with nature. There was no straightforward influence of experimental manipulations on conservation effort. The question on how to effectively elicit moral concern and conservation effort towards plants thus remains to be investigated.

Zusammenfassung

Im Naturschutz, in der Forschung und im täglichen Leben werden Pflanzen oft übersehen und ihr Wert unterschätzt. Da Pflanzen anders aussehen und sich anders bewegen als wir, fällt es uns schwerer, sie zu verstehen und zu schätzen als andere Lebensformen, die uns ähnlicher sind. Daher könnte die Darstellung von Pflanzen in Bewegung und die Verbesserung ihrer Verständlichkeit durch Anthropomorphismus dazu beitragen, unser Interesse an Pflanzen zu steigern und pflanzenfreundliches Verhalten zu fördern. Die vorliegende Arbeit untersucht in einem zwei-mal-zwei Zwischensubjektdesign den Einfluss von anthropomorphischer Information und sichtbarer Bewegung auf die sogenannte „mind perception", die wahrgenommene Ähnlichkeit mit der Pflanze, die moralische Sorge und Naturschutzverhalten. Es wurden vier Videos erstellt, in denen eine wachsende Pflanze entweder in zeitgeraffter Bewegung oder bewegungslos gezeigt wurde, kombiniert mit einer neutralen oder anthropomorphischen Beschreibung ihres Wachstums. Die Ergebnisse deuten darauf hin, dass die experimentelle Manipulation nur teilweise wie beabsichtigt funktionierte, wobei die anthropomorphische Beschreibung zwar einen Einfluss auf die „mind perception" hatte, die Bewegung der Pflanze jedoch keinen. Es gab dennoch einen Einfluss der Art der Bewegung auf die wahrgenommene Ähnlichkeit mit der Pflanze und konsistente Effekte der Merkmalsausprägungen von Naturverbundenheit. Es wurde kein direkter Einfluss der experimentellen Manipulationen auf das Naturschutzverhalten gefunden. Die Frage, wie Menschen zu Pflanzenschutz motiviert werden können, bleibt also noch offen.