Is Litter in the Eye of The Beholder?
The Influence of Goal Frames on Attention to Litter in Pictures of Nature

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Abstract

Despite knowing that climate change exists, and counteraction is needed, many people still fail to consistently act pro-environmentally in their day-to-day life. Theories like goal framing theory attempt to explain why and when people act pro-environmentally or fail to do so. Goal framing theory states that in each situation thoughts, behavior, and attention of a person are influenced by an active goal frame (Lindenberg & Steg, 2007). Using eye-tracking, the current study investigates whether active hedonic or normative goal frames influence attention to litter in pictures of a littered natural environment. We expected that in a hedonic goal frame, people direct their attention away from the litter to avoid displeasure, while people in a normative goal frame direct their attention towards litter as a clue of a norm violation. In an experimental study (n = 65) we manipulated a student sample into a normative, hedonic, or neutral goal frame using picture material and targeted instructions. We presented 25 pictures showing a beautiful natural environment containing litter and used eye-tracking to measure the attentional allocation to litter and the beautiful nature aspects of these pictures. The results do not show a difference between the groups in the attentional allocation to litter or the beautiful environment, and most participants correctly remembered seeing litter in all pictures. These findings suggest that goal frames do not influence the attentional processes captured in this experiment. More research is needed to assess the influence of goal frames on cognitive processes like attention.

Keywords: goal-framing theory, eye-tracking, attention, litter

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Climate change is one of the biggest threats to life as we know it, and stopping it is one of the most crucial challenges for our society. Currently, the measures to stop climate change are insufficient to reach the goal of limiting global warming to 1.5 degrees (IPCC, 2023). One key factor in mitigating climate change is human behavior (Steg, Bolderdijk et al., 2014; Winter & Koger, 2004). Understanding when and why people act pro-environmentally or fail to do so, is an important step toward supporting people in acting pro-environmentally (Steg & Vlek, 2009; Steg, Bolderdijk et al., 2014). To understand human behavior, investigating the cognitive processes underlying a certain behavior can provide valuable insights. Suri and Gross (2015) found, for example, that attentional processes can explain why people often, despite knowing what would be best for them, do not act accordingly. They found that, simply by increasing a person's attention to a health-relevant decision, it became more likely that this person would opt for the healthy behavior, for example taking the stairs instead of the escalator (Suri & Gross, 2015). Protecting the planet is in anyone's best interest, and still, people fail to consistently act pro-environmentally.

Goal framing theory (Lindenberg & Steg, 2007) provides a framework for understanding the motivators and barriers to pro-environmental behavior. According to this theory, cognitive processes, behavioral alternatives and, ultimately, behavior, are influenced by the activation of three goals: The hedonic goal frame to feel better, the normative goal frame to act appropriately, and the gain goal frame to increase one's resources (Lindenberg & Steg, 2007; Steg, Bolderdijk et al., 2014). So far, research applying goal framing theory predominantly neglected to investigate the assumptions about cognitive processes like attention (Do Canto et al., 2023). Including measures of attention, however, could add explanatory power to goal framing theory by testing its theoretical assumptions on a pre-behavioral, subconscious, level. On a practical scale, this could be one step towards understanding why people act pro-environmentally in some situations while failing to do so in others, and how to help people act more pro-environmentally. This empirical study uses eye-tracking to measure attention and test the assumptions of goal framing theory on a pre-behavioral level, answering the following question: Do people in different goal frames, hedonic versus normative, pay attention to different aspects of an ambivalent natural situation, which contains hedonic and normative cues?

Hedonic and Normative Goal Frames

Goal framing theory states that in each situation one goal, hedonic, normative, or gain, takes the focal position and influences cognitive processes, and behavior, dominantly, while the other goals are working in the background (Lindenberg & Steg, 2007; Steg, Bolderdijk et al., 2014). When the hedonic goal is focal, people are mainly focused on feeling better, thus approaching aspects of their environment that improve their mood, and avoiding aspects that worsen their mood or involve effort and discomfort (Lindenberg et al., 2018). On the other hand, when the normative goal is focal, people are mainly concerned with acting appropriately, even if it entails effort (Steg, Bolderdijk et al., 2014). Thus, the normative goal frame is most predictive of pro-environmental behavior, as acting pro-environmentally is seen as appropriate but often costly (Lindenberg & Steg, 2007; Steg, Bolderdijk et al., 2014).

Goal frames are activated by an interaction of cues in the environment and the values of a person (Steg, Bolderdijk et al., 2014). Values are "desirable goals that serve as guiding principles in people's life" (Steg & De Groot, 2012, p. 81). The hedonic goal frame is, for example, strengthened by hedonic values, while the normative goal frame is associated with biospheric values (De Groot & Steg, 2008; Steg & De Groot, 2012; Steg, Perlaviciute et al., 2014). Hedonic values are values, that "focus on attaining pleasure, positive feelings and reducing effort" (Bouman et al., 2018, p. 3), while biospheric values "reflect a concern for the environment itself without a clear link to human beings" (Bouman et al., 2018, p.2). The activation of a goal frame thus depends on situational cues as well as stable, trans-situational personal factors (Schwartz & Bilsky, 1987; Schwartz, 1992; Schwartz et al., 2012; Steg & De Groot, 2012). By adding goal-consistent environmental cues it should therefore be possible to artificially activate goal frames. Lindenberg and colleagues (2018) provided initial support for this, by artificially activating a hedonic goal frame in their participants by showing them pictures of a chocolate cake and attractive women, and a normative goal frame by showing a picture of the Statue of Lady Justice.

Application of Goal Framing Theory

Goal framing theory can explain why people act pro-environmentally in some situations, but not in others, and how pro-environmental behavior might be increased by strengthening a normative goal frame (Lindenberg & Steg, 2007). The distinction of the three goal frames has been empirically validated (Do Canto et al., 2023), and the theory has been widely applied to explain technology adaptation behavior (Dastjerdi et al., 2019), consumer behavior (Barbopoulos & Johansson, 2016; Thøgersen & Alfinito, 2020), customer market segmentation (Bösehans & Walker, 2020), and moral behavior (Lindenberg et al., 2018; Onwezen, 2023).

Despite the broad application of this theory, most studies rely on self-reports of behavior (De Canto et al., 2023), with only a few studies experimentally testing the assumptions underlying the goal framing theory (De Canto et al., 2023; Lindenberg et al., 2018; Thøgersen & Alfinito, 2020). This reflects a general overreliance on self-report measures in environmental psychology research, recently criticized by Lange and colleagues (2023). Besides possibly being subject to social desirability bias (Ewert & Galloway, 2009), self-reports are also ill-suited to give insight into the cognitive processes behind behavior (De Canto et al., 2023; Lange et al., 2023). Assessing cognitive processes can improve our understanding of behavior, but so far studies targeting cognitive variables are rare in environmental psychology (Sörqvist, 2016; Berg & Steg, 2018). Including measures of cognitive processes like attention can add explanatory power to theories by explaining how a situation translates into a behavioral outcome. An increased amount of attention to different aspects of the environment, based on the active goal frame, could account for different behavioral outcomes (Suri & Gross, 2015). To test this assumption, the current study uses eye tracking to test if the activation of goal frames creates goal-frame consistent attentional biases. If different goal frames can predict attentional biases, this is one possible way to explain how goal frames influence behavior.

The Influence of Goal Frames on Attention

Goal framing theory states that goal frames influence cognitive processes like attention (Lindenberg & Steg, 2007). Attention is the process of filtering relevant information from the large amount of information present in every situation (Katsuki & Constantinidis, 2013; Posner & Cohen, 1984). There are two filtering mechanisms of attention: top-down and bottom-up. Bottom-up attention is guided by attributes in the situation, like the color and shape of an object, while top-down attention is guided by internal factors like goals (Desimone & Duncan, 1995; Katsuki & Constantinidis, 2013). The influence of goal frames on attention, which the goal framing theory proposes, would be considered a top-down process (Lindenberg & Steg, 2007; Steg, Bolderdijk et al., 2014).

Eye movements are directly connected to visual attention, and it can be inferred that gaze location is an appropriate proxy for attention (Deubel & Schneider, 1996; Posner & Cohen, 1984; Just & Carpenter, 1980; Lu & Pesarakli, 2022), which is commonly used as a measure for attentional bias (Carter & Luke, 2020; McNamara et al., 2023). This study measures the gaze to make inferences about attentional allocation and attentional biases to different aspects of an ambivalent picture of nature.

Previous research has shown that attention is influenced by the active goal of a person in each situation (Vogt et al., 2010; 2011) and that the mood of a person can influence attention toward emotional stimuli (Becker & Leinenger, 2011; Sollberger et al., 2017; Todd et al., 2012). In the field of clinical psychology, the influence of clinical symptoms like depression (Suslow et al., 2020), eating disorders (Bauer et al., 2017; Kerr-Gaffney et al., 2019), and addiction (Soleymani et al., 2020) on attention is well researched, whereas in environmental psychology, studies about top-down attention are rare (Carter & Luke, 2020).

Some studies in the field of environmental psychology found evidence for an attentional bias toward climate change images that is stronger in environmentally conscious individuals (Beattie & McGuire, 2012; Carlson et al., 2019), and people with liberal political views in the United States (Luo & Zhao, 2019), while other studies did not find a relation between attention and pro-environmental attitudes (Beattie & McGuire., 2015; Meis-Harris et al., 2021). These mixed results are also reflected in an eye-tracking study by Beattie et al. (2010) who found that climate-relevant information on product packaging only attracted attention for products with additional sustainability cues. This finding is in line with goal framing theory, as it suggests that not only stable interpersonal differences like pro-environmental attitudes influence attention, but also cues in the situation. By modifying the cues in the situation, it should, therefore, be possible to direct visual attention (Carlson et al., 2022).

According to goal framing theory, pleasurable aspects in a situation should attract attention when a person is in a hedonic goal frame. Nature is a common pleasurable stimulus as it has various beneficial effects on humans (Bratman et al., 2015), and looking at beautiful natural scenes is rewarding (Joye, Köster et al., 2024; Joye, Lange et al., 2024), can improve one's mood (Ulrich, 1983; Todd et al., 2012), and is generally preferred over looking at human-made environments (Batool et al., 2021). Littering on the other hand is an anti-environmental behavior that is easily observable and commonly understood as norm-violating and unpleasant (e.g. Cialdini et al, 1990; Schultz et al., 2013). Moreover, dealing with a littered environment would involve effort and discomfort to pick up and dispose of the litter.

Thus, when looking at ambivalent pictures of nature, with on the one hand beautiful natural scenery and on the other hand piles of litter, people in a hedonic goal frame are expected to have an attentional bias away from the litter and towards the beautiful natural scenery, the aesthetic part of the picture, compared to people in a neutral goal frame, or a normative goal frame (H1).

Individuals in a normative goal frame, however, should, according to goal framing theory, have an attentional bias toward aspects of their environment that are related to norms and norm violations (Lindenberg et al., 2018). Therefore, we expect people in the normative goal frame to have an attentional bias to the litter in the ambivalent nature pictures compared to people in a neutral or hedonic goal frame (H2).

Attention and thus gaze location are also related to the cognitive processing of stimuli (Deubel & Schneider, 1996; Just & Carpenter, 1980; Lu & Pesarakli, 2022; Posner & Cohen, 1984). Participants in the normative condition, attending more to the litter in the pictures, are, therefore, also likely more aware of the presence of the litter in the pictures. Following that increased awareness, we expect that participants in the normative condition correctly recollect seeing litter in more pictures than participants in the neutral or hedonic condition (H3).

Method

Participants

We aimed to recruit 60 participants to reach a power of 0.80, to detect a small to medium-sized effect (f = .20) with a significance level of α = 0.05, assuming a small to medium correlation (r = .20) of the repeated measures (Cohen, 1988), based on a power calculation using G*Power (Faul et al., 2007). The initial sample consisted of 76 psychology students of the University of Groningen who received course credits for their participation. All participants reported normal or corrected to normal vision. 6 participants had to be excluded from data analysis, due to computer errors during the experiment, and 1 due to an error of the eye-tracking equipment. Of the remaining 69 participants, 5 participants' calibration procedure was not monitored by the researcher because of a misunderstanding in the task instructions. The data of these participants was included in the data analysis as the calibration procedure is assessed as self-explanatory enough to yield acceptable results, also without supervision.

Upon analysis of trackloss data, missing eye-tracking data due to blinks or connection loss between the eye-tracker and the eyes, 4 additional participants were removed as their amount of trackloss data was more than one standard deviation above the group mean. A total of 3 data points were missing for the measurement of hedonic and biospheric values, as well as 2 data points for the number of recollected litter pictures. The missing data was replaced by the group mean of the relevant question. According to Tabachnick and Fidell (2014), replacing missing data with group means is an appropriate technique for dealing with small amounts of missing data. This resulted in a final data set of 65 participants (49 females) and a majority (89%) of young (18-24) participants, which is to be expected in a sample of university students. The participants were allocated to the 3 experimental conditions using a random number generator. This resulted in the following distribution of participants: 26 in the hedonic, 19 in the normative, and 20 in the neutral condition.

Material

Manipulation Material

We used a picture of a chocolate cake (Lindenberg et al., 2018) for the hedonic condition that was created using an online AI image creation program (Runway AI, Inc., 2024). Chocolate is considered especially pleasurable in Western Countries (Parker et al., 2006; Wansink et al., 2003), and is associated with a hedonic appeal (De Pelsmaeker et al., 2022; Parker & Brotchie, 2012). Even though there are gender differences in the liking of chocolate, with females scoring higher on chocolate liking (Rozin et al., 1991) and craving (Parker & Brotchie, 2012), the hedonic appeal of chocolate exists irrespective of gender (De Pelsmaeker et al., 2022; Kiortsis et al., 2018; Rozin et al., 1991; Wansink et al., 2003). Therefore, looking at the picture of a chocolate cake should strengthen the hedonic goal frame of the participants irrespective of gender. To strengthen the manipulation participants were instructed to have fun during the experiment, and they were informed that they would receive a cookie at the end of the study.

For the normative condition, we created a picture of Lady Justice (Lindenberg et al., 2018), using the Runway AI, Inc (2024) image creation tool. After pre-testing the picture material, the AI-created picture was replaced by an iStock picture showing a Statue of Lady Justice in the context of a courtroom as only one in four people recognized Lady Justice in the AI-created picture. Aarts and Dijksterhuis (2003) found that images of a library could activate the norm of being silent in their participants when it was paired with a behavioral intention to visit the library. Therefore, the picture of Lady Justice was paired with instructions to act according to the rules, and the information that the participants can be observed by the researcher during the experiment. The feeling of being observed increases norm-compliant behavior (Bateson et al., 2006; Dear et al., 2019; Kawamura & Kusumi, 2017), and should therefore strengthen the normative goal frame additionally.

For the neutral condition, a picture of a chair in an empty room was created using the same online AI image creation program (Runway AI, Inc., 2024), with the prompt "simple chair with neutral background, high definition". Participants did not receive any additional instructions. See Appendix A for the pictures and full instructions used in the manipulation.

Manipulation Check

To check the success of the manipulation, an open text input about feelings toward the study was analyzed. In the neutral condition, 3 participants did not answer the question about their feelings toward the study and were excluded from this manipulation check. The most named feelings in the neutral condition were "relaxed", "excited", and variations of "fine". In the normative condition, the most stated feeling was "curious", followed by "fine". Participants in the hedonic condition felt "good" and "excited" about the experiment and expected to have "fun". The data does not allow for drawing definite conclusions about the success or failure of the manipulation, but it does hint towards group differences in the feelings toward the experiment, likely caused by the experimental manipulation. See Appendix B for a complete list of the expressed feelings toward the experiment by the participants.

Stimuli

The 25 ambivalent nature pictures were created using pictures of nature provided by the author and edited using online AI-based picture editing software (Runway AI, Inc., 2024) with the prompt "Scattered pieces of litter, photorealistic". Initially, 17 edited pictures were pretested with a convenience sample of 15 participants, to test the perceived realism of the pictures using a 7-point Likert scale from 1 = strongly disagree to 7 = strongly agree. The realism ratings (M = 5.12, SD = 0.65) of the pictures supported the assumption that pictures created or edited using artificial intelligence can be used for studies in the social sciences (Eberl et al., 2022), as they are generally perceived as realistic. Based on these results the 10 highest-scoring pictures were selected for the experiment and 15 additional images were created resembling those pictures. A table is provided in Appendix C showing the pictures.

Each picture was separated into four equal-sized Areas of Interest (AOI), one litter AOI, and three aesthetic AOIs, based on the AOI creation guidelines by Hessels and colleagues (2016). The litter AOI represented the area of the image containing the litter, whereas the other three aesthetic AOIs represented the beautiful nature parts (see Appendix C for an example).

The mean trial duration was 10.42 seconds (SD = 0.60). Variances in trial duration were caused by differences in the processing speed of the computers and technical errors. Trial duration did not significantly differ between picture stimuli (F (24, 1600) = 0.58, p = .95)

Control Variables

Personal values can influence the activation of goal frames (Steg, Bolderdijk et al., 2014). To ensure that possible differences in attention are not based on differences in personal values between the conditions, we measured biospheric and hedonic values using two subscales of the environmental portrait value questionnaire (E-PVQ, Bouman et al., 2018), and compared the results between the three experimental conditions. The seven items of the two subscales of the E-PVQ, three items targeting hedonic (Cronbach's α = .80), and four items biospheric values (Cronbach's α = .83), ask participants to rate their similarity to a person in the same age range and gender who is upholding these values on a 7-point Likert scale. (e.g. "It is important to [him/her] to protect the environment." [Bouman et al., 2018, p. 4]).

Apparatus

Two GazePoint GP3 eye trackers were used to collect the eye-gaze data of both eyes with a 60Hz sample rate, and an accuracy of 0.5-1 degree angle (Gazepoint, n.d.). The data collection took place in two separate cubicles within the research laboratories of the

University of Groningen. Chinrests were used to increase the accuracy of the data (Holmqvist et al., 2011). Stimuli were presented on a 27-inch Ilyama G2773HS monitor with a 120Hz refresh rate. The distance between the monitor and the chinrest was 70 cm. The size of the picture stimuli was 1024 x 768 pixels. The experiment was designed in OpenSesame (Mathôt et al., 2012) using the eye-tracking plug-in to collect the eye-gaze data.

Procedure

First, the chinrest was adjusted to fit the participant's height, and participants were instructed to follow the instructions on the screen. A random number generator assigned each participant to one of the three experimental conditions upon starting the experiment. Then participants gave their informed consent to participate and to the processing of their data. To avoid demand effects, participants were informed that the purpose of the study was to measure changes in pupil dilation related to differences in color and brightness of nature pictures (Sollberger et al., 2017). Under the pretense of calibrating the eye-tracker, one of the manipulation pictures (chocolate cake, lady justice, chair) was presented to the participant for 10 seconds. To strengthen the manipulation, participants were asked to describe the pictures in a few words. Participants were then informed about the procedure of the picture task, and based on their condition, either instructed to have fun and promised a cookie (hedonic), act appropriately and be told that they were being observed (normative), or receive no further instruction (neutral). They were informed that they would be looking at 25 pictures of nature and instructed to let their gaze wander freely. As a manipulation check, participants were asked to describe their current feelings towards the experiment. Then participants completed the 9-point calibration of the eye-tracker. The researcher checked that the calibration was successful and if necessary, recalibrated once. Afterward, participants would look at the 25 ambivalent nature pictures in a randomized order. Before every picture was presented a drift correction using a fixation dot in the center of the screen was executed. Every picture was presented for 10 seconds (Beattie et al., 2010; Beattie & McGuire, 2012; 2015). After looking at the pictures, participants were asked in how many of the pictures they remembered seeing litter. Then they were asked to indicate their age and gender and fill in the E-PVQ questionnaire subscales. Lastly, all participants were informed about the real purpose of the study and the manipulation. Upon being informed, they were given another opportunity to remove their data. All participants were thanked for their participation and offered a cookie at the end of the study.

Data Reduction and Planned Analysis

To measure attentional bias the combined gaze point of both eyes was used to determine in which AOI the gaze was located per measurement timepoint. We used the total dwell time, defined as the total time the gaze was located within an AOI, including fixations and non-fixations, during one trial (Holmqvist et al., 2011). Using the package GazeR (Geller et al., 2020) in R, we calculated the total dwell time per AOI and the amount of trackloss, due to blinks or eye-tracking failures. The mean trackloss per trial was M=0.75s (SD = 0.65s). The sum of the dwell time of the three aesthetic AOIs comprised the aesthetic dwell time measure. Higher dwell times on the litter AOI would indicate an attentional bias to litter aspects of the picture, while higher dwell times on the aesthetic AOIs would indicate an attentional bias to the aesthetic aspects. As the size of the aesthetic AOIs is three times the size of the litter AOI, comparisons of aesthetic dwell times to aesthetic dwell times, and litter to litter dwell times are more insightful than comparisons between litter and aesthetic AOI dwell times. Thus, we calculated two mixed-methods ANOVAs to compare, respectively, the attentional bias to aesthetic aspects of the pictures (H1), and the attentional bias to litter aspects of the pictures (H2) between the three experimental groups. To test the recollection of seeing litter in the pictures (H3) a between-subjects ANOVA was calculated. All statistical tests were performed in R.

Results

Descriptives

A MANOVA showed that the three experimental conditions, hedonic, normative, and neutral, did not differ significantly in biospheric and hedonic values (F (4, 124) = 0.86, p = .49). Table 1 displays the mean scores, standard deviations, and follow-up tests for group differences of value scores. Neither of the follow-up ANOVAs for group differences for biospheric (F (2, 62) = 1.29, p = .28) or hedonic (F (2, 62) = 0.59, p = .56) values were significant. Correlations between the values and the dwell time on aesthetic and litter aspects of the picture stimuli are displayed in Table 2.

Table 1

Means, Standard Deviations, and One-Way Analysis of Variance in Biospheric and Hedonic Values

Measure	Hedonic		Normative		Neutral		F(2, 62)	η²
	M	*SD*	*M*	*SD*	*M*	*SD*		
Biospheric values	5.47	1.23	5.89	0.93	5.88	0.68	1.29	0.04
Hedonic values	6.38	0.58	6.22	0.8	6.18	0.71	0.59	0.02

Table 2

Descriptive Statistics and Correlations for Study Variables for Full Sample

Variable	*M*	*SD*	1	2	3	4
1. Biospheric values	5.70	1	--			
2. Hedonic values	6.27	0.68	-.13**	--		
3. Dwell time on aesthetic aspects	5.21	1.88	.05*	-.01	--	
4. Dwell time on litter aspects	4.46	1.85	-.04	-.02	-.89**	--

*p <.05 **p<.01.

Group means for the dwell time on the aesthetic aspects of the pictures were slightly higher in the normative (M = 5.33, SD = 1.9) than in the neutral (M = 5.17, SD = 1.75) and hedonic condition (M = 5.15, SD = 1.97). Group means for the dwell time on the litter aspect were highest in the hedonic condition (M = 4.59, SD = 1.88), followed by the neutral (M = 4.49, SD = 1.65) and normative condition (M = 4.26, SD = 1.96). Despite the size differences between aesthetic and litter AOIs, with the aesthetic AOI region being three times the size of the litter AOI region, across all subjects, the mean dwell time on litter aspects of pictures (M_{Total} = 4.45, SD = 1.85) was only slightly shorter than on aesthetic aspects (M_{Total} = 5.21, SD = 1.88).

Hypotheses Testing

Attentional Bias to Aesthetic Aspects of Pictures

To test H1, which assumed group differences in the attentional allocation to the aesthetic aspects of the pictures, with the hedonic group having the highest dwell time, followed by the neutral, and normative group, a mixed model analysis of variance was calculated. This mixed model ANOVA was performed with total dwell time on the aesthetic AOIs as the dependent variable, pictures as the within-subject factor, and experimental condition as the between-subject factor. The normality assumption for the dwell time on aesthetic aspects of the pictures was investigated graphically and tested using the Shapiro-Wilks test of normality (Shapiro & Wilk, 1965). For all but seven of the 25 time points the assumption of normality was supported by the data. ANOVAs are considered robust to moderate violations of normality (Sawyer, 2009; Tabachnick & Fidell, 2014), thus despite these violations the ANOVA is still considered an appropriate test to detect group differences in the dwell time data. To correct for the violation of the assumption of sphericity the Greenhouse-Geisser epsilon correction was performed (Greenhouse & Geisser, 1959).

The mixed model ANOVA did not support the hypothesis (H1) of group differences in dwell time for the aesthetic aspects of the stimuli pictures (F (2, 62) = 0.2, p = .82). The experimental groups did not differ in the amount of time they were looking at aesthetic aspects of the picture stimuli.

Attentional Bias to Litter Aspects of Pictures

A second mixed model ANOVA was performed to test H2 which assumed group differences in dwell time on the litter AOI of the pictures, with the normative group having the highest dwell time on the litter, followed by the neutral and the hedonic group. The total dwell time on the litter AOI served as the dependent variable, pictures as the within-subject factor, and experimental conditions as the between-subject factor. Graphic investigations and the Shapiro-Wilks test of normality (Shapiro & Wilk, 1965), support the assumption of normality for the litter dwell time for all but seven out of 25 time points. Sphericity was violated for the dwell time on litter data, so the Greenhouse Geisser epsilon correction was performed (Greenhouse & Geisser, 1959). The hypothesis that the groups would differ in dwell time on the litter aspects of the picture stimuli (H2) was not supported by the mixed model ANOVA (F (2, 26) = 0.66, p = .52). The experimental groups did not differ in the amount of time they were looking at the litter aspects of the picture stimuli.

Number of Pictures with Litter

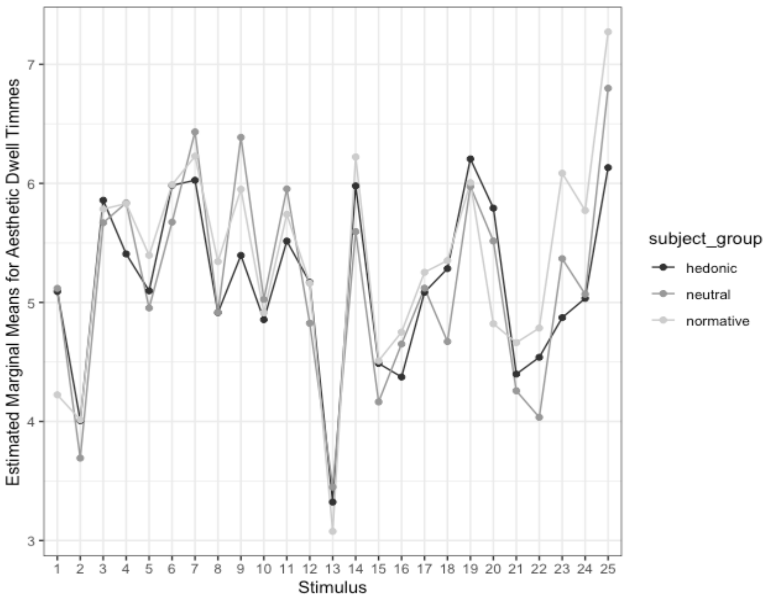
To test the hypothesis assuming a difference in the number of pictures, in which participants recalled seeing litter, between experimental groups (H3) a one-way ANOVA was performed with recollected picture number as the dependent variable and experimental groups as the between-subject factor. The ANOVA did not support the hypothesis of group differences in the number of recollected litter pictures (F (2, 62) = 2.25, p = .11). The normality assumption and the assumption of equal variances were violated in the data set. There were also serious ceiling effects as 55 out of 65 participants correctly remembered seeing litter in all 25 pictures. Thus, it is difficult to draw conclusions about possible group differences based on this data. The hypothesis of a group difference in the number of pictures, in which participants recollect seeing litter, is not supported by the data.

Exploratory Analyses

The mixed model ANOVAs for hypotheses 1 and 2 did not reveal any significant differences in dwell time on aesthetic or litter aspects of the pictures between groups. The effect of pictures, on the other hand, was significant for dwell time for aesthetic aspects (F (24, 1488) = 17.59, p <.001) and litter aspects (F (24, 1488) = 17.53, p <.001). Thus, at least one of the pictures differs from the others regarding the dwell time on aesthetic and litter aspects. Graphical exploration of the data, see figures 1 and 2, revealed that for pictures 2 and 13 the dwell time on the picture was noticeably lower for aesthetic aspects and higher for the litter aspects, while pictures 7, 9, 14, 19, and 25 were higher for the aesthetic aspects, and lower for the litter aspects than the average picture.

Figure 1

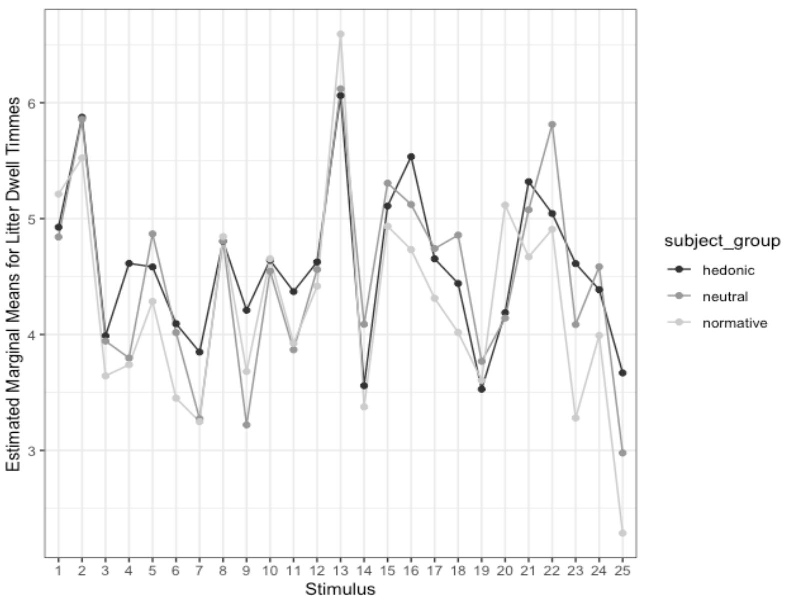
Estimated Marginal Means for Aesthetic Dwell Times per Experimental Group



Note: The figure shows the estimated marginal means for the dwell time on the aesthetic aspects of the stimulus pictures separated for experimental conditions. The numbers on the x-axis correspond to the picture numbers in the overview of pictures in Appendix C.

Figure 2

Estimated Marginal Means for Litter Dwell Times per Experimental Group



Note: The figure shows the estimated marginal means for the dwell time on the litter aspects of the stimulus pictures separated for experimental conditions. The numbers on the x-axis correspond to the picture numbers in the overview of pictures in Appendix C.

To explore these differences further we grouped the pictures 7, 9, 14, 19, and 25 in a "high aesthetic" group, the pictures 3 and 4 in a "high litter" group, and the remaining pictures in an "average" group. Then we performed two one-way ANOVAs with this grouping as a between-subject factor and the differences in dwell time on litter and dwell time on aesthetic aspects as dependent variables. The ANOVAs for aesthetic dwell time ($F\,(2, 1622) = 99.3$, $p < .001$, $\eta^2 = .11$), and litter dwell time ($F\,(2, 1622) = 99.22$, $p < .001$, $\eta^2 = .11$) revealed that there were statistically significant differences between at least one of the picture groups. Tukey's post hoc comparison revealed that all three groups differed significantly ($p < .001$) from one another for aesthetic and litter dwell times. This suggests that at least some of the stimuli pictures differed regarding their attraction potential of attention to litter and aesthetic aspects. Possible reasons for these differences will be explored in the discussion.

Discussion

This study represents one of the first studies to experimentally test the influence of goal frames on attention. According to goal framing theory, the focal goal should direct attentional processes toward goal-consistent elements of the environment, representing one pathway of influence of goals on behavior (Lindenberg & Steg, 2007; Steg, Bolderdijk et al., 2014). The purpose of this study was to test if a hedonic goal frame caused an attentional bias to elements consistent with the hedonic goal to have fun (aesthetic aspects), while a normative goal frame caused an attentional bias to elements consistent with the normative goal to act appropriately (litter aspects). Between-group comparisons of the total dwell time, the total amount of time the gaze was located within the litter or the aesthetic AOIs during a trial (Holmqvist et al., 2011), did not provide support for the hypothesized influence of goal frames on attention. Contrary to our hypothesis, there were also no significant differences in the number of correctly recollected pictures containing litter between the experimental conditions. Instead, almost all participants correctly remembered seeing litter in all 25 pictures. Exploratory analyses of the dwell time data revealed that the attention to litter was proportionally higher than to the aesthetic aspects of the images and that the pictures themselves significantly differed in the total dwell time on aesthetic and litter aspects across the groups.

General Findings

The findings of this study suggest that neither a hedonic goal frame is effectively guiding the attention away from the litter in the pictures, nor that a normative goal frame is increasing the attention to the litter. Previous eye-tracking studies found that people with a high pro-environmental attitude (Beattie & McGuire, 2012; 2015) or a liberal political view in the United States (Luo & Zhao, 2019), paid more attention to pictures showing evidence of climate change. Artificially inducing a temporally higher pro-environmental stance by strengthening the normative goal frame in our study, however, did not lead to increased attention to litter as a form of environmental pollution. Interestingly, however, the effects of pro-environmental attitudes in the studies by Beattie and McGuire (2012; 2015) were only significant when operationalized as implicit, not explicit, pro-environmental attitudes. While explicit attitudes reflect the attitude a person would report when asked about a topic, the implicit attitude is argued to be the true attitude a person holds (Beattie & McGuire, 2012; 2015; Greenwald et al., 1998). Thus, attention seems to be influenced by pro-environmental attitudes, but only if these pro-environmental attitudes reflect a person's implicit attitude. Similarly, only pro-environmental behavior was associated with increased attention to negative images of climate change in a study by Meis-Harris and colleagues (2021). Their attempt to increase attention to climate change images by priming pro-environmental attitudes with picture material, however, failed (Meis-Harris et al., 2021). It is possible that only the values, being stable and trans-situational, and thus more likely to represent implicitly held beliefs of the participants, influenced their attentional allocation in our experiment. As the experimental groups did not differ regarding biospheric and hedonic values, it is plausible that we did not find differences in attentional allocation between the groups.

This does not necessarily mean that goal frames do not influence attention at all. Attention is a two-way process with a more deliberate top-down control mechanism, guiding attention based on the goals of a person, and a more automatic bottom-up mechanism, guiding attention based on the attributes of the stimuli people are looking at (Desimone & Duncan, 1995; Katsuki & Constantinidis, 2013; Perugini, 2005). In our study, and the above-mentioned eye-tracking studies (Beattie & McGuire, 2012; 2015; Luo & Zhao, 2019), a free-viewing task was used to measure attention. In our study, we specifically instructed the participants to look at the pictures naturally, refraining from giving any real instructions as we wanted to avoid demand effects. This might have led to a primary influence of automatic, bottom-up attentional mechanisms in our experiment, instead of the balanced influence of top-down and bottom-up attention found in natural situations (Desimone & Duncan, 1995; Katsuki & Constantinidis, 2013; Pinto et al., 2013). Automatic processes are largely influenced by implicit attitudes (Perugini, 2005), and in the case of attention, by the attributes of the situation (Desimone & Duncan, 1995; Katsuki & Constantinidis, 2013). Thus, it might be that the type of attention which is captured with the free viewing task, is not suitable to detect differences that go beyond automatic processes. Only attributes of the stimuli, the pictures in our study, or the different objects in an eye-tracking study by Beattie and colleagues (2010), and implicit, stable attitudes would influence this type of attention. This could explain why the pictures themselves significantly influenced attentional allocation. Possibly subtle differences within the pictures guided the attention in the absence of a concrete task to direct attention (Parkhurst & Niebur, 2004). Goal frames, on the other hand, might influence more deliberate actions, like top-down attention or behavior, that were not captured in our experiment (Perugini, 2005).

Another interesting finding is that people independent of their goal frames paid attention to litter in the pictures. Almost all participants recollected seeing litter in all 25 pictures, and the attention to litter was proportionally higher than to the aesthetic aspects of the images. If indeed only automatic attentional processes were captured in our experiment, this means that instances of environmental pollution automatically attract attention, independent of the current mindset of a person. This is in line with previous findings, indicating that climate change images effectively attract attention (Carlson et al., 2019;

O'Neill & Nicholson-Cole, 2009). This can be considered positive news. Most people pay attention to climate change images, and according to the results of this study see and remember instances of environmental pollution even in a hedonic mindset.

Strengths of the Study

This research represents an innovative study in the field of environmental psychology. Firstly, we looked at a widely applied theory of environmental psychology, the goal framing theory (Lindenberg & Steg, 2007) from the often-overlooked cognitive perspective (Do Canto et al., 2023; Lange et al, 2023). We experimentally tested the assumptions underlying the goal framing theory by manipulating the goal frames of the participants and used eye-tracking measures, instead of self-reports (Do Canto et al., 2023; Ewert & Galloway, 2009; Lange et al., 2023). Through this, we could show that goal frames do not induce attentional biases in a free-viewing task, which raises questions about the influence of goal frames on attention. Secondly, we used picture stimuli that were created and manipulated using AI. While artificial intelligence recently gained much popularity and media attention, the possibility of using it to create customary experimental material is still mostly unexplored (Eberl et al., 2022). This study showed that the use of AI to create customized stimuli is simple, cost-, and time-efficient. Thirdly, we were able to provide initial experimental evidence that even in a hedonic mindset, people pay attention to the negative aspects of the surrounding environment. This finding can inform pro-environmental communication, by highlighting that increasing attention to environmental damage might not be the most urgent area of action. Lastly, our results give rise to many new open questions that hopefully inspire and motivate further research on the cross-section between environmental and cognitive psychology.

Limitations and Future Research

The biggest strength of the study, its innovativeness, is also the root of its limitations. Most of the study material, the manipulation material, and the stimuli pictures were not validated. While the manipulation material was based on a previous study by Lindenberg and colleagues (2018), and checked using a manipulation check, it is not guaranteed that the manipulation itself was successful or stable. It is possible that looking at the picture stimuli itself influenced the activation of goal frames, as seeing litter can strengthen the hedonic goal frame (Keizer et al., 2008; 2011; 2013), and seeing beautiful nature can strengthen the normative goal frame (Perlin & Li, 2020; Piff et al., 2015). Future studies might benefit from multiple manipulation checks throughout the experiment to improve the understanding of variations in goal frame activation.

It should also be considered that participants, expected to see pictures of nature but did not expect to see litter. Novelty and unexpectedness can lead to an increase in attention and dwell time (Ernst et al., 2020; Horstmann, 2015; Horstmann & Herwig, 2015; Itti & Baldi, 2009). The litter aspects of the pictures might have attracted attention simply by being unexpected. This may explain why the dwell time on the litter AOI was disproportionally high relative to its size, despite evidence that people generally prefer looking at nature (Batool et al., 2021). The artificiality of the litter might also have played a role in attracting attention. While Eberl and colleagues (2022) successfully created stimulus material using AI that was not recognized by their student sample, another study by Doss and colleagues (2023) suggests that especially university students have a high success rate in distinguishing real material from deepfakes. As our sample consisted exclusively of university students, it is possible that they recognized or at least suspected that the pictures were manipulated.

Another limitation lies in the way we operationalized attention. As explained above, it is possible that the dwell time measure in a free viewing task only captures the automatic, non-deliberate aspect of attention. To test the assumption of goal framing theory (Lindenberg & Steg, 2007) on attention more thoroughly it is important, that the whole spectrum of attention, bottom-up and top-down processes, is considered (Desimone & Duncan, 1995). Other measures that give insight into cognitive processes beyond purely measuring natural gaze could give valuable insights. Measuring pupil dilation for example might help to test assumptions of the goal framing theory by providing information about the emotional processes while looking at pictures (Brosch, 2021; Hess & Polt, 1960; Mathôt, 2018). Furthermore, we recommend that future research investigates the influence of goal frames on the automatic and deliberate processes, as we described earlier. Testing the influence of values and goal frames distinctively for highly automatic processes, like attention in free-viewing tasks, and highly deliberate processes, like actual behavior, could bring additional explanatory and predictive value to the goal framing theory.

Despite new advancements in eye-tracking technology enabling researchers to collect high-quality data in field research, most eye-tracking studies, like ours, are still conducted in laboratories (Nordfält & Ahlbom, 2024). Laboratory experiments are mostly characterized by high artificiality. While the results of laboratory experiments often transfer well to real life, this depends on the topic under study (Holleman et al., 2020). Simply looking at pictures of nature is not the same as experiencing nature with all senses, and environmental pollution, is likely to be more troubling in the real world than in a picture (Brooks et al., 2017). Furthermore, a laboratory setting might not be the most suitable option to research how people behave in a fun, hedonic setting. Adjustments like inducing a pleasant smell or decorating the laboratory could marginally improve the ecological validity of laboratory studies about hedonic behavior (Li et al., 2007). However, future research would likely benefit more from investing in innovative technical solutions like virtual reality glasses that allow full immersion into the experiment (Parsons, 2015) or mobile eye-tracking devices that enable high-quality eye-tracking outside of laboratories (Nordfält & Ahlbom, 2024).

Lastly, our sample consisted exclusively of students who participated to gain course credits. This obligatory nature could have influenced the prior goal frames of the students. The rather low sample size, resulting from exclusions due to computer errors and recruiting difficulties, plus the randomization procedure resulting in an unbalanced design, decreased the power of our statistical analyses (Tabachnick & Fidell, 2014). While our sample size was still sufficient based on the power analysis described in the method section, future studies might benefit from a larger, more diverse sample. Especially studies that aim to investigate the influence of the value aspects of goal frames should take particular care to sample participants with a wider range of values than our mostly homogenous student sample.

Implications for Practice

There was no difference between the goal frame conditions in the amount of attention participants paid to litter aspects and beautiful nature. We found, however, that most participants paid proportionally more attention to litter than beautiful natural scenery. While it is hard to draw definite conclusions about behavior in the real world from our results, it might be, that people, independent of their goals in a situation pay attention to environmental pollution, like litter. Thus, even in purely hedonic settings, people seem to be generally aware of litter. This could imply that it is not necessary to increase attention to environmental pollution even further to support pro-environmental behavior. However, due to the unnaturalness of the study in a laboratory setting and the rejection of our hypotheses only very limited implications for practice can be drawn. More research is necessary to provide a sound recommendation regarding the possible use of goal frames to support pro-environmental behavior in practice.

Conclusion

Our results do not indicate an influence of goal frames, hedonic or normative, on attentional allocation to litter in pictures of nature. While the experimental conditions did not differ regarding the allocation of attention, different pictures attracted different levels of attention to litter and natural aspects. Across all conditions, however, attention to litter was proportionally higher than attention to the beautiful aspects of nature, which could indicate that independent of the goal frame, people pay attention to environmental pollution like litter. The lack of influence of goal frames on attention might be a result of the type of attentional measurement used. Future research is needed to investigate the influence of goal frames on cognitive and behavioral processes.

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Appendix A

Manipulation Material

Figure A1

Pictures and Instructions Used for the Hedonic, Normative, and Neutral Manipulation

Hedonic	Remember, the most important thing is that you are having fun! After you are done with the experiment you will receive a cookie as a reward!	
Normative	Remember, the most important thing is that you are adhering to the rules! While you are looking at the pictures the researcher can watch your behavior via the eye-tracking camera.	
Neutral	---	

Appendix B

Manipulation Check Responses

This appendix consists of the full responses to the question about the participant's feelings towards the study after the manipulation procedure. The responses are sorted based on the experimental group: hedonic, normative, and neutral. The responses are reported verbatim.

Participants' Responses in the Hedonic Condition:

- "I feel curious"
- "I'm curious for the pictures and feeling good"
- "pretty good, relaxed, dont really know what to expect"
- "it seems really fun and relaxing."
- "fine"
- "Excited because it sounds fun and easy"
- "quite okay"
- "good"
- "im excited to see the photos, since i love the nature"
- "curious"
- "I feel great"
- "I feel fine and relaxed."
- "relaxed, comfortable, a little bit hungry"
- "I feel excited to know that my eye movement and pupil size is being recorded according to the picture I am looking at"
- "I am quite enjoying this epxeriemnt. I like tryingf new things and this is somethinf ive necer done. I also enjoy how this study is investigating somthing that is not so traumatizing and it is more fun and relaxed"
- "a bit indifferent, it's a pretty relaxing experiment"
- "im feeling good. i have done a similar experiment before so i am not nervous or anything"

- "happy about cookie"
- "Im excited"
- “A bit stressed that I won t look at it naturally"
- "Im curious about what Im going to see and since ive never done eye tracking before, Im also looking forward to the experience."
- "Good"
- "good"
- "excited for the cookie"
- "i am excited"

Participants’ Responses in the Normative Condition:

- "i feel relaxed"
- "I feel fine. I am wondering about the experiment. I hope I can watch naturally, as expected."
- "Im very curious. I think/hope it will be relaxing"
- "i am curious about the pictures"
- "i am curious about it because i never thought about the relation between natural landscapes an pupil dialation before but it seems interesting."
- "Intrigued as to the information gained from undergoing this experiment"
- "I like nature so I dont have any complaints"
- "I feel fine"
- "I am curious what pictures I will see."
- "curious, interested by the eye tracker"
- "I feel quite excited"
- "I feel pretty normal, i am curious what the pictures of nature will entail"
- "I am a little bit scared for how my head is going to feel after this because of the eye tracker, and also that it will leave marks on my head, but otherwise I feel fine about it, and am interested in what I will have to do."

- "exited since I like nature"
- "excited"
- "I dont have any concrete feelings in regards to this experiment, so I guess I would say neutral."
- "Curious and excited, I love nature"
- "I feel fine about it, no major concerns, just need to follow the procedure as it goes"
- "i feel fine and i am curious"

Participants' Responses in the Neutral Condition:

- "I am pretty relaxed. A bit tired right now but also excited for this study."
- "excited. Never done an eye-tracking experiment before so I think it is exciting"
- "i think it will be quite fun compared to other sona experiments ive done"
- "i am looking forward to see some pictures about nature"
- "it is kind of wierd to have my head resting on this thing, but i think it is interesting so far"
- "good it sounds interesting and a bit relaxing"
- "I feel curious about how the experiment will be, and what pictures will be shown."
- "i feel fine."
- "relaxed and excited to begin"
- "curious,open-minded, relaxed"
- "i feel well rested but a little hungry"
- "I feel relaxed and curious about what type of pictures will appear."
- "i feel good, relaxed and comfortable"
- "great"
- "excited, Ihave never used an eyetracker before"
- "Quite positive, im feeling good and like to look at nature."

Appendix C

Stimuli Pictures

Figure C1

List of the Pictures Used in the Experiment with their Numerical Identifiers

Picture 1

Picture 2

Picture 3

Picture 4

Picture 5

Picture 6

Picture 7

Picture 8

Picture 9


Picture 10


Picture 11


Picture 12


Picture 13


Picture 14


Picture 15


Picture 16


Picture 17


Picture 18


Picture 19


Picture 20


Picture 21

Picture 22

Picture 23

Picture 24

Picture 25

Figure C2

Example of Stimulus Picture with Aesthetic and Litter AOIs

Note. The red outlining marks the litter AOI, and the yellow outlining marks the three aesthetic AOIs. The sum of the three aesthetic AOIs was used as the total dwell time on aesthetic aspects of the pictures.