Nature's path to thinking about others and the surrounding environment

Kathryn E. Schertz[a1], Hiroki P. Kotabe[a], Kimberly L. Meidenbauer[a2], Elliot A. Layden[a], Jenny Zhen[a], Jillian E. Bowman[a], Tanvi Lakhtakia[a], Muxuan Lyu[a3], Olivia A. Paraschos[a], Elizabeth A. Janey[a], Anya L. Samtani[a], Andrew J. Stier[a], Kathryn Gehrke[c], Stephen C. Van Hedger[b], Kathleen D. Vohs[d], Marc G. Berman[a]

a) University of Chicago
b) Huron University College
c) University of Illinois
d) University of Minnesota

Corresponding Authors: KES (schertzk@umich.edu) and MBG (bermanm@uchicago.edu)

Author Notes

Funding: This work was supported by the National Science Foundation (DGE-1746045 to K.E.S.; BCS-1632445 and S&CC-1952050 to M.G.B.).

Author contributions: Conceptualization: K.E.S., H.P.K., K.L.M., K.D.V., and M.G.B. Data curation: K.E.S., K.L.M. Formal analysis: K.E.S. Funding acquisition: K.E.S. and M.G.B. Investigation: J.E.B., T.L., M.L., O.P., E.A.J., A.L.S., K.G., and J.Z. Project administration: M.G.B. Software: K.E.S., K.L.M., and J.Z. Supervision: K.D.V. and M.G.B. Visualization: K.E.S. Writing - original draft: K.E.S. Writing - review & editing: J.E.B., H.P.K., K.L.M.,

[1] Present address: University of Michigan
[2] Present address: Washington State University
[3] Present address: Hong Kong Polytechnic Institute

E.A.L., J.Z., T.L., M.L., O.P., E.A.J., A.L.S., A.J.S., K.G., S.C.V.H., K.D.V., and M.G.B.

Contributions are in accordance with CRediT and generated by *tenzing* (Holcombe et al., 2020).

Competing interests: The authors declare that they have no competing interests.

Data and materials availability: Data and code are available on OSF: https://osf.io/cu6jr/.

Abstract

Research has shown differences in pro-social and pro-environmental attitudes after exposure to different physical environments. It is unclear whether these perspective shifts are associated with changes in conscious thoughts and feelings about other people and the environment. In Study 1, we used a within-subject design to measure social and environmental thought content throughout one-hour environmental explorations of a nature conservatory and an indoor mall. At three survey time points, participants (N = 86, undergraduates and community members) reported whom they were thinking about and how connected they felt to the physical and social environment. Using Bayesian multi-level models, we found that while visiting the conservatory, participants were less likely to think about themselves, felt closer to people nearby and around the world, and felt higher connectedness to their social and physical environment. In Study 2, we used a correlational design to investigate the association between perceived naturalness of city parks and feelings of connection to nearby others and the physical environment while visiting. Participants (N = 303, Chicago residents) reported feeling higher levels of connection to nearby people and the physical environment when they were visiting city parks rated as more natural. These studies further our understanding of the ways in which natural environments influence conscious thoughts and feelings about the social and physical environment.

Keywords: social orientation, natural environments, public spaces, experience sampling

Public spaces, such as parks, plazas, and community centers, are important and highly influential places in contemporary human social life. These spaces are composed of social and physical elements that can influence physical and mental health, cognitive and affective states, and overall well-being (Benita et al., 2019; Cattell et al., 2008; Francis et al., 2012; Giles-Corti et al., 2005; Trawalter et al., 2021). Within the realm of physical environments, natural environments and stimuli have been shown to be especially salubrious for health and well-being (Berman, Kardan, et al., 2019, 2019; Bratman et al., 2019; Hartig et al., 2014; Kardan et al., 2015; Schertz & Berman, 2019). For example, urban greenspaces provide benefits at the community level by supporting social engagement, social capital, and place attachment (Arnberger & Eder, 2012; Jennings & Bamkole, 2019)**.** Urban greenspaces also provide places for neighbors to meet and establish social ties (Coley et al., 1997; Peters et al., 2010; Sullivan et al., 2004).

There is a robust literature on the psychological effects of being in natural environments. One category of effects focuses on social orientation. Considering how environments can contribute to social orientation is especially important given that many people feel increasingly disconnected from others (Feng & Astell-Burt, 2022; Konrath, 2013). Thinking about oneself is not inherently bad, however orientation towards others and prosocial purpose may improve health and reduce loneliness (Bains & Turnbull, 2019). Exposure to natural environments, on both acute and long-term bases, has been shown to positively influence pro-social behaviors and attitudes (Goldy & Piff, 2020). For example, a study in which people were directed to either notice natural or human-built elements of their environment found that those in the nature group reported greater pro-social orientation and connection to others at the end of a two-week period (Passmore & Holder, 2017). In another study, people who viewed nature scenes, compared to

human-made scenes, reported stronger prosocial and other-focused values (Weinstein et al., 2009).

In addition to pro-social orientation, increased pro-environmental orientation has also been associated with exposure to natural environments. In an observational study, participants who visited nature more often reported engaging in more household pro-environmental behaviors, a relationship which was moderated by nature connectedness (Martin et al., 2020). Another study found that interacting with natural environments for psychological restoration was associated with self-reported improvements in ecological behavior, even when controlling for concern for the environment (Hartig et al., 2007). Given concerns, particularly in Western society, about disconnection from the natural world (Hartig & Kahn, 2016; Kesebir & Kesebir, 2017), as well as issues of climate change and the destruction of the natural environment, investigating ways to increase connection to the natural world is of utmost importance.

In the current studies, we sought to investigate how environmental effects on social and environmental orientation might be reflected in conscious thoughts and feelings while exploring public spaces with different levels of naturalness. What people spend their time thinking about forms an important part of their lived experience (Baumeister et al., 2020; Larson & Csikszentmihalyi, 2014; Sripada & Taxali, 2020), and thought content is important to examine to fully understand the myriad effects of the external environment on human health and well-being (Berman, Kardan, et al., 2019; Berman, Stier, et al., 2019). Previous work has found relationships between thought content and the visual features in one's physical environment (Schertz et al., 2018, 2020), suggesting that the surrounding environment can influence conscious thoughts.

The dominant psychological theories explaining the benefits of natural environments on cognitive and affective processing (i.e., attention restoration theory (Kaplan, 1995), stress reduction theory (Ulrich et al., 1991), perceptual fluency account (Joye & van den Berg, 2011) do not address socially or environmentally focused outcomes, focusing instead on general affective and cognitive processes. One recent theory, relational restoration theory (Hartig, 2021), focuses on how natural environments may restore access to social support when multiple people experience the environment at the same time, which touches on connection to other people, but still does not directly focus on how individuals' social and environmental thoughts are shaped by their surrounding physical environments. Studies directly focused on this topic will build a body of knowledge to help update the current theories or develop new theories in this area.

Examining thought content directly may show if people consciously have more pro-social or pro-environmental thoughts when in natural environments. In terms of thought content and feelings, pro-social attitudes and orientation towards others may manifest in several ways. First, people may think less about themselves, and more about other people, or more about themselves together with other people, in a natural environment. Second, they may feel more connected to their social environment. And third, they may feel closer to others, such as family and friends, people in the surrounding environment, or even people around the world. Increased environmental orientation may result in feeling closer to the surrounding physical environment as well as having more thoughts about the physical surroundings, when in a natural environment. We conducted two studies to examine these possibilities.

In Study 1, we used a within-person experimental design and experience sampling methodology to measure differences in social and environmental thought content throughout a

one-hour environmental exploration of a nature conservatory and a large indoor mall to specifically address the following research questions:

1) Do people have more socially oriented thoughts and feelings while in a natural public space compared to a non-natural public space, as operationalized by: a) fewer thoughts about themselves and more thoughts about other people or themselves with other people, b) greater feelings of closeness to others, and c) higher connection to their social environment?

2) Do people have more environmentally oriented thoughts and feelings while in a natural public space compared to a non-natural public space, as operationalized by: a) higher connection to their physical environment and b) more thoughts about their physical surroundings?

Experience sampling methods such as ecological momentary assessment generate structured reports about what people are thinking and feeling throughout the day by asking them in real-time (Larson & Csikszentmihalyi, 2014; Stone & Shiffman, 1994). Short-term experience sampling studies, for example, covering one to two hours, have been used to get more intensive reports of thoughts in specific environments (Doherty et al., 2014). By surveying participants multiple times over their walk, we could examine how quickly differences in thought emerged between the two environments. The results reported here are a subset of broader measures we collected during this study, with results for environmental effects on affect and working memory, for example, being reported in Schertz et al. (2022).

In Study 2, we used a correlational design to examine the association between perceived naturalness and feelings of connectedness to a) nearby people and b) the physical environment during visits to hundreds of city parks. Given that there are many differences between the nature conservatory and mall in Study 1, this informs our hypothesis that naturalness is a key feature

contributing to differences in feelings of social and environmental connection. The results reported here are part of a larger study on environmental impacts throughout the city of Chicago (https://osf.io/pjfcd/). Given recent findings showing that social context influences social thinking (Mildner & Tamir, 2021), supplemental findings for both Study 1 and Study 2 investigated how the number of people in the surroundings interacted with the influence of the environments on social thought. Additionally, as some people may be more or less sensitive to their environment (Aron & Aron, 1997), we explored whether individual personality traits were associated with social and environmental thoughts.

1. Study 1

1.1. Material & Methods

1.1.1 Participants

A total of 99 participants participated in the study from October 2018 through April 2019. Ten participants did not return for the second session of the two-part study. Data collection issues resulted in the loss of three participants' data, leaving full analyzable data for 86 participants. Participants (mean age = 21.57 years, SD = 3.79 years, Range 18-39) were either University XXXX students or adults from the surrounding communities recruited through Facebook, flyers posted in the community, and the university's research participation system. There were 39 men, 58 women, and 2 participants who selected 'other' for gender. In terms of ethnicity, 31 participants identified as white/Caucasian, 31 identified as Asian/Asian American, 16 identified as Hispanic, Latino, or Chicano, 15 identified as Black/African American, 5 identified as multiple ethnicities and 1 participant identified as another race/ethnicity. In the final sample of 86 participants (mean age 21.60 years, SD = 3.78 years, Range 18-39), there were 32 men, 53 women, and 1 participant who selected 'other' for gender. Participants were paid $74 to

complete the study. This research was approved by the Institutional Review Board of the University XXXX. Sample size was determined primarily through resource constraints (e.g., time, money) and is similar to other studies examining the effects of nature exposure (McMahan & Estes, 2015). No data analysis was performed until after data collection was finished.

1.1.2 Locations

The nature conservatory study location was the Garfield Park Conservatory (referred to as 'conservatory' throughout) located in the Garfield Park neighborhood of Chicago (https://garfieldconservatory.org). The mall location was the Water Tower Place mall (referred to as 'mall' throughout) located in the Near North neighborhood of Chicago (https://www.shopwatertower.com/en.html). Figure 1 shows example images from the spaces.

Figure 1. Example images of Garfield Park Conservatory (left) and Water Tower Place mall (right). Images from Wikimedia Commons (Jrissman, 2010; Kenraiz, 2016).

1.1.3 Procedure

The study was conducted over two sessions, spaced one week apart. The order of environments (i.e., conservatory, mall) was counter-balanced across participants. There was a maximum of 12 participants in each study session, due to practical limitations in transporting participants to the testing locations and the need to maintain a manageable ratio of participants to research assistants. Participants completed the trait questionnaires online via before arriving to the first session. All tasks during the study sessions were completed on Moto G5 Android cell phones.

When participants arrived at the laboratory building for each session, they were met by research assistants and directed to a shuttle bus. Research assistants collected participants' personal mobile devices and distributed the experimental cell phones. Participants then completed the baseline survey and working memory task on the bus while it was stationary at the laboratory building. The shuttle bus then drove participants and research assistants to one of the study locations. Both study locations were approximately 30 minutes away from the laboratory.

Upon arrival at the study location, participants were instructed to explore the environments and answer survey questions on the experimental cell phone when indicated. Participants were prompted by a timer on the cell phone to complete the ambulatory survey after 20 minutes (Survey 1), 40 minutes (Survey 2), and 60 minutes (Survey 3). When they completed the third survey, they were prompted to meet the research assistants at the entrance. They were then directed to complete the working memory task again. The shuttle bus then drove everyone back to the laboratory building. Each session lasted approximately 2-2.5 hours. Figure 2 shows a diagram representation of the study procedure.

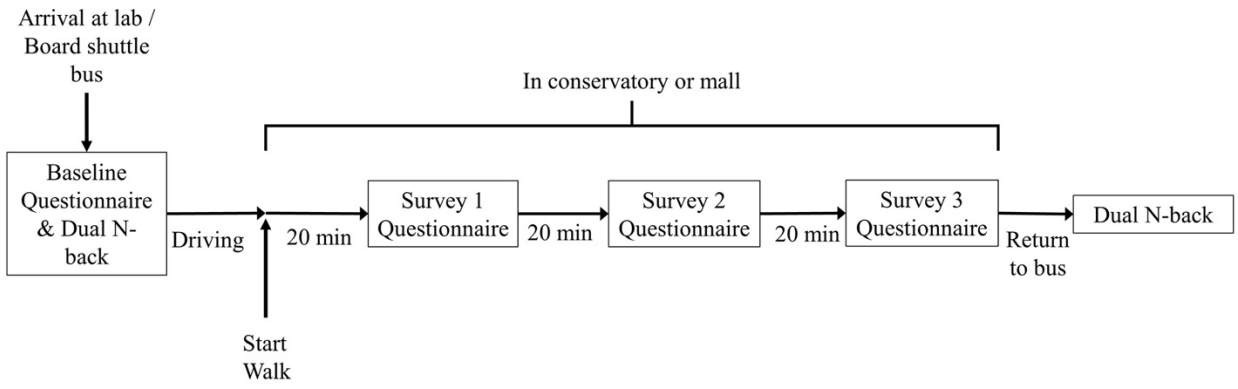


Figure 2. Study Procedure.

1.1.4 Survey Questions

1.1.4.1 Trait Questionnaires

Trait questionnaires were completed at home by participants when they signed up for the study. In addition to providing demographic information, participants responded to a short form Big Five inventory (mini-IPIP) (Donnellan et al., 2006), the Reflection-Rumination Questionnaire (RRQ) (Trapnell & Campbell, 1999), the Subjective Vitality Score (SVS) (Ryan & Frederick, 1997), the Valuing Emotions (VE) scale (Mangelsdorf & Kotabe, 2017), the Trait Rash Impulsivity Scale (TRIS) (Mayhew & Powell, 2014), and the 3-item loneliness scale (Hughes et al., 2004). The mini-IPIP assesses five factors of personality – extraversion, agreeableness, conscientiousness, neuroticism, and intellect (or openness to experience). Although previous research has not linked Big Five measures to nature exposure, it is a widely utilized personality measure in psychology. The RRQ assesses two factors of private self-focus - rumination, which is considered to be a maladaptive pattern of self-referential thought, and reflection, which is conceptualized as intellectual self-attention (Trapnell & Campbell, 1999). VE assesses the belief in one's own emotions as being helpful or harmful (Mangelsdorf &

Kotabe, 2017). As reflection, rumination, and valuing emotions all interrogate different aspects of one's focus on the self, these scales were included as people scoring higher on these measures may be differentially susceptible to environmental effects on their mental state. SVS assesses vitality, or physical and mental energy (Ryan & Frederick, 1997). Exposure to nature has been associated with increased levels of state vitality (Ryan et al., 2010). TRIS measures general levels of impulsivity (Mayhew & Powell, 2014). Higher trait impulsivity has previously been found to be associated with greater affective differences in response to exposure to natural environments (i.e., more impulsive individuals had a larger difference in positive affect in nature compared to urban settings than individuals with lower impulsivity) (Bakolis et al., 2018).

1.2.4.2 Baseline Questionnaire

Upon arrival to each study session, before being transported to the study locations, participants completed the baseline questionnaire regarding their recent thoughts and feelings. Participants reported whether their most recent thought was about themselves, other people, both themselves and other people, or something other than people. They also answered questions about how close they felt to their friends and family, people in their surroundings, and people around the world, as well as how connected they felt to their physical and social environments. Due to a coding error, Likert scales in the baseline questionnaire went from 0-7 while Likert scales in the ambulatory questionnaire went from 0-10. For all analyses, baseline responses were rescaled to 0-10. The participants were allowed to define each term in the questions for themselves, as we did not further define any of the concepts.

1.1.4.3 Ambulatory Questionnaire

While walking around the study locations, participants completed the ambulatory survey three times. These surveys included the same questions as the baseline questionnaire, with an additional question that asked how many people were visible around them.

1.1.5 Statistical Analyses

Statistical analyses were conducted in a Bayesian framework using multi-level models, with participant as a random/varying intercept. Continuous dependent variables were analyzed using linear regression. Categorical dependent variables (i.e., self/other focus of thought) were analyzed using logistic regressions. In all models, the independent variables were the interaction term between condition (i.e., conservatory and mall) and survey/timepoint (i.e., Baseline, Survey 1-3), thus including 8 time points in total. Main effects for condition were not included as the baseline survey for each condition was taken before participants were transported to the two environments, thus resulting in an uninterpretable main effect.

Regularizing priors were used for all models. Regularizing priors prevent models from overfitting to the sample by slowing the rate of learning from the data. We do not have assumptions for the priors based on previously collected data, thus regularizing priors are most appropriate. This, in combination with mixed effects modeling makes overfitting, and thus finding spurious effects, less likely. Sensitivity analyses (see Appendix A) were conducted to confirm results were robust to chosen priors. Full specifications of the models, including their priors, are shown in the Results section for each variable. Each model was run with 10,000 draws and 1,000 warmup draws for four Markov Chain Monte Carlo (MCMC) chains, for a total posterior distribution of 36,000 post-warmup draws. Posterior distributions have been summarized by reporting the 89% percentile intervals (PI). PIs are also referred to as quantile intervals and indicate the probability mass centered around the mean of the posterior

distributions. Since PIs are not the same as frequentist confidence intervals, the 89th percentile interval was chosen to avoid both conscious and subconscious attempts at hypothesis testing that may occur if presented with a conventional 95% interval, as suggested by McElreath (McElreath, 2020). Bivariate correlations between dependent measures are reported in Supplemental Figure A1.

We used a Bayesian analysis framework instead of traditional frequentist approaches because it offers many benefits. One benefit of this Bayesian approach is that we are able to generate estimates and credible intervals for any derived parameter, and differences, ratios and novel parameter combinations can be directly computed from the posterior distribution. The focus of our approach is on parameter estimation rather than binary inference. A second benefit is that the Bayesian approach allows us to compute computationally robust estimates of parameter values and their credible intervals, which do not depend on large-N approximations or on the number of intended tests (Kruschke, 2021). Additionally, credible intervals in Bayesian analysis, unlike confidence intervals of frequentist statistics, are in line with intuitive understandings of probability such that they indicate how likely a parameter has a value within that interval (Pek & Van Zandt, 2020) and not how extreme a parameter estimate is based on imaginary resampling of the data. Finally, with a Bayesian approach we can select regularizing priors that prevent the model from overfitting, thus increasing the likelihood of the model generalizing to out of sample data. As overfitting has been proposed as a key contributor to psychology's replication and generalizability crisis (Nosek et al., 2022; Yarkoni, 2022), a Bayesian approach which minimizes this risk is likely to lead to more reproducible results.

1.1.6 Transparency and Openness

Data and analysis code are available at https://osf.io/cu6jr/. Models were run in R 4.1.1 (R Core Team, 2017) using the 'brms' package (Bürkner, 2017). This study's design and its analysis were not pre-registered. Additional dependent measures were collected during this study that are not reported here. The full list of dependent measures is shown in Supplemental Table 1. Results for some of the additional dependent measures (including, for example, working memory, affect, and thought valence) are reported in (Schertz et al., 2022), which uses data from the same study.

1.2. Results

1.2.1 Socially Oriented Thoughts

1.2.1.1 Thoughts of Self and Others

Socially focused thinking was assessed in several ways, one of which was by measuring thoughts about the self and/or others. Participants responded to the question "Was [your most recent] thought mostly about yourself, mostly about others, about yourself and others, or not about people?" These responses are mutually exclusive; thus, participants could only select one response. Each of the four response options (i.e. 'myself', 'other people', 'myself and other people', 'something other than people') was modeled as a logistic regression in the form:

$Response_i \sim \text{Binomial}(1, p_i)$	Likelihood
$\text{logit}(p_i) = 1 + \beta_{\text{condition*survey[j]}} + \alpha_{\text{participant[i]}}$	Logistic Regression Model
$\beta_j \sim \text{Normal}(0, 0.5)$, for j=1-8	Prior for betas (8 survey by condition combinations, 2 conditions and 4 time points)
$\alpha_{participant[i]} \sim \text{Normal}(\overline{\alpha}, \sigma_\alpha)$, for $i = 1 - 86$	Adaptive prior for each participant
$\overline{\alpha} \sim \text{Normal}(0, 1.5)$	Prior for Average Participant
$\sigma_\alpha \sim \text{Exponential}(1)$	Prior for SD of participant

Participants were less likely to report thoughts about themselves in the conservatory compared to the mall during all ambulatory surveys, see Figure 3a. After being in the

environment for ~20 minutes (i.e., at Survey 1), the odds ratio between the two settings was 2.05 (i.e., participants were 2.05 times more likely to think about themselves in the mall vs. the conservatory), 89% PI [1.42, 2.85], with 99.9% of the MCMC samples showing an odds ratio greater than one. In probability terms, this was a difference of 24% probability of self-focused thoughts in the conservatory and 47% probability of self-focused thoughts in the mall. At Survey 2 (~40 minutes), the probability of self-focused thoughts was 29% in the conservatory and 38% in the mall, with a modeled odds ratio of 1.39 (89% PI [0.96, 1.91]), with 92.3% of the MCMC samples showing an odds ratio greater than one. At Survey 3 (~60 minutes), the probability of self-focused thoughts was 27% in the conservatory and 54% in the mall, with an odds ratio of 2.03 (89% PI [1.46, 2.76]), with 100% of the MCMC samples showing an odds ratio greater than one.

When participants did think about themselves in the conservatory, it was often as part of a social relationship. That is, there was also evidence, though weaker, that participants reported more thoughts about 'themselves and others' throughout the conservatory walk compared to the mall walk (Figure 3b). At Survey 1, the odds ratio between conservatory and mall was 1.40 (89% PI [0.93, 2.00]) with 90.2% of the MCMC samples showing an odds ratio greater than one. At Survey 2, the odds ratio was 1.27 (89% PI [0.82, 1.83]), with 79.6% of the MCMC samples showing an odds ratio greater than one. At Survey 3, the odds ratio was 1.47 (89% PI [0.99, 2.07]), with 94% of the MCMC samples showing an odds ratio greater than one.

There was no evidence of a conditional difference for reporting thoughts about only other people at any survey (Figure 3c). At Survey 1, the odds ratio was 1.10 (89% PI [0.54, 1.80]. At Survey 2, the odds ratio was 0.76 (89% PI [0.42, 1.24], and at Survey 3, the odds ratio was 1.32

(89% PI [0.69, 2.20]). Results for the remaining option, non-social thoughts, are discussed in Section 1.2.2.2.

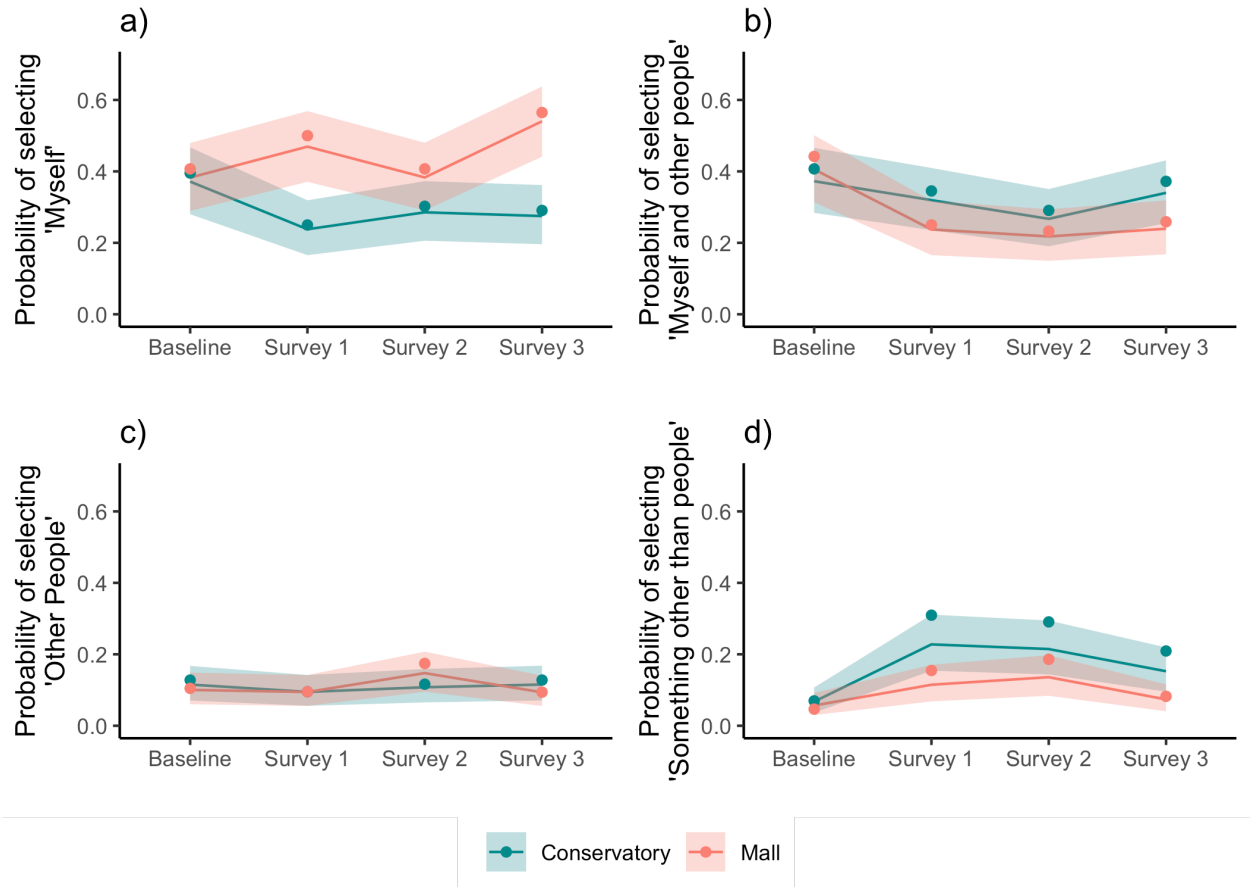


Figure 3. Observed and modeled selection of a) self, b) self and others, c) others, and d) non-interpersonal focused thinking. Points are observed probabilities from the raw data. The fitted line is the logistic regression model's predicted estimate. The shaded area represents the 89th percentile interval of the posterior distribution.

1.2.1.2 Feelings of closeness to others

Sociality was also examined through feelings of closeness to various social groups, ranging from people in general to those with whom they have personal relationships. Specifically, they rated feelings of closeness to their family and friends, people in their

surroundings, and people all over the world (0 = not at all close; 10 = very close). Responses were modeled as linear regressions of a continuous variable in the form:

$$Response_i \sim \text{Normal}(\mu, \sigma)$$
$$\mu_i = 1 + \beta_{\text{condition*survey[j]}} + \alpha_{\text{participant[i]}}$$
$$\beta_j \sim \text{Normal}(0, 0.5) \text{ , for } j=1-8$$
$$\alpha_{participant[i]} \sim \text{Normal}(\overline{\alpha}, \sigma_\alpha) \text{ , for } i = 1 - 86$$
$$\sigma \sim \text{Exponential}(1)$$
$$\overline{\alpha} \sim \text{Normal}(5, 1.5)$$
$$\sigma_\alpha \sim \text{Exponential}(1)$$

Participants reported feeling closer to people around the world while in the conservatory compared to the mall at all three survey timepoints, Figure 4a. On a 10-point scale, the posterior distribution was 1.08 points (89% PI [0.71,1.45]) higher at Survey 1 in the conservatory compared to the mall. At Survey 2, the difference was 0.90 points (89% PI [0.53,1.26]), and at Survey 3, the difference was 0.91 points (89% PI [0.55,1.28]). 100% of MCMC chains showed a difference greater than 0 at all three time points.

Participants also reported feeling closer to people in their surroundings while in the conservatory compared to the mall at all three survey timepoints, Figure 4b. On a 10-point scale, the posterior distribution was 1.15 points (89% PI [0.72,1.59]) higher at Survey 1 in the conservatory compared to the mall with 100% of MCMC chains showing a difference greater than 0. At Survey 2, the difference was 0.93 points (89% PI [0.51,1.35]) with 100% of MCMC chains showing a difference greater than 0, and at Survey 3, the difference was 0.51 points (89% PI [0.09,0.94]), with 97.4% of MCMC chains showing a difference greater than 0.

Feelings of closeness to friends and family showed an unexpected baseline difference, despite ratings taking place before going to the conditional locations (Figure 4c). Therefore, we subtracted baseline scores in each condition. In this adjusted model, there was no evidence of an interaction between conditions (Survey 1: difference = 0.14, 89% PI [-0.28, 0.57]; Survey 2:

difference = 0.02, 89% PI [-0.40, 0.43]; Survey 3: difference = -0.09, 89% PI [-0.51, 0.33]). See Supplemental Table 3 for full regression models.

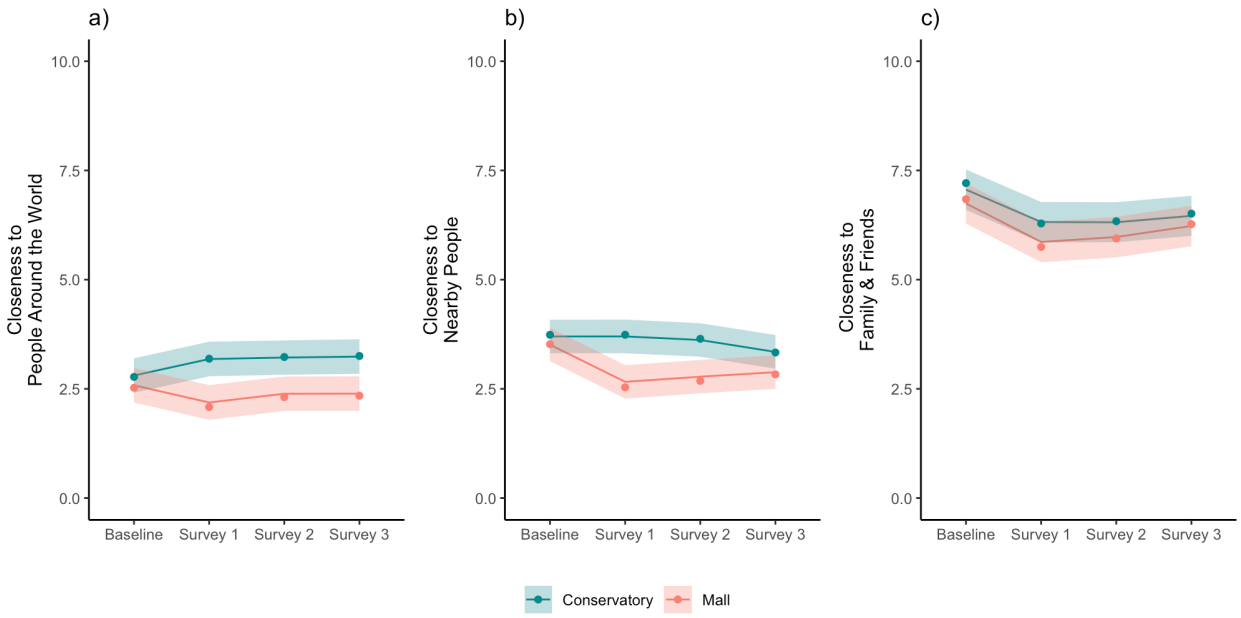


Figure 4. Observed and modeled ratings for feelings of closeness to a) people around the world, b) people in the surroundings, and c) friends and family. Points are mean observed ratings from the raw data. The fitted line is the linear model's predicted estimate. The shaded area represents the 89th percentile interval of the posterior distribution.

1.2.1.3 Feelings of connection to the social environment

As a final indicator of sociality, participants responded to the question "How much do you feel connected to the social environment around you?" on a scale from 0 (not at all) to 10 (very much). To assess feelings about the physical environment, participants also indicated how connected they felt to the physical environment. These two responses were modeled as linear regressions of a continuous variable in the form:

$$Response_i \sim \text{Normal}(\mu, \sigma)$$
$$\mu_i = 1 + \beta_{\text{condition*survey[j]}} + \alpha_{\text{participant[i]}}$$
$$\beta_j \sim \text{Normal}(0, 0.5) \text{ , for } j=1-8$$
$$\alpha_{participant[i]} \sim \text{Normal}(\overline{\alpha}, \sigma_\alpha) \text{ , for } i = 1-86$$
$$\sigma \sim \text{Exponential}(1)$$

$$\bar{\alpha} \sim \text{Normal}(5, 1.5)$$
$$\sigma_{\alpha} \sim \text{Exponential}(1)$$

Similar to the results for interpersonal thoughts and feelings, there was a condition by survey interaction for feelings of connection to the social environment (Figure 5a). Participants felt more connection to their social environment when walking in the nature conservatory. On a 10-point scale, the posterior distribution showed that connection to the social environment was 0.43 points higher (89% PI [0.00, 0.86]) in the conservatory compared to the mall at Survey 1, with 94.5% of MCMC chains showing a difference greater than 0. At Survey 2, connection was rated 0.60 points higher (89% PI [0.17, 1.02]) with 98.8% of MCMC chains showing a difference greater than 0. At Survey 3, connection was rated 0.52 points higher (89% PI [0.10, 0.94]), with 97.5% of MCMC chains showing a difference greater than 0.

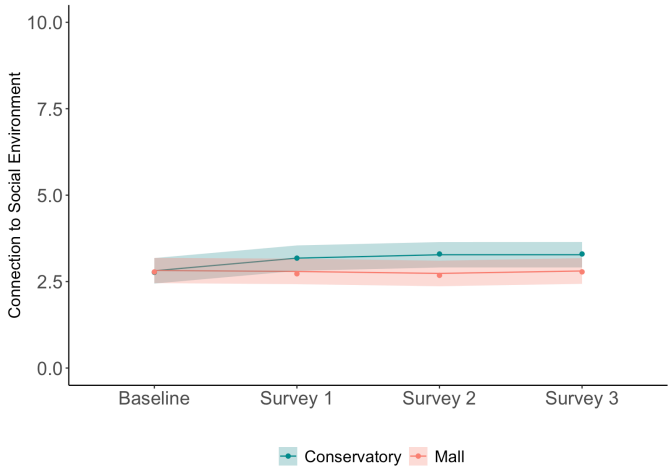


Figure 5. Observed and modeled ratings for feelings of connection to the social environment. Points are mean observed ratings from the raw data. The fitted line is the linear model's predicted estimate. The shaded area represents the 89th percentile interval of the posterior distribution.

1.2.2. Environmentally Oriented Thoughts

1.2.2.1 Feelings of connection to the physical environment

Expanding beyond the social environment, the results showed that participants reported higher levels of connection to the physical environment in the conservatory compared to the mall at all three surveys (Figure 5b). On a 10-point scale, the posterior distribution showed that connection to the physical environment was 2.47 points higher (95% CI [1.93, 3.02]) in the conservatory compared to the mall at Survey 1, 2.38 points higher (95% CI [1.82, 2.93]) at Survey 2, and 2.35 points higher (95% CI [1.79, 2.91]) at Survey 3. All MCMC chains showed a difference greater than 0 for all three interactions. See Supplemental Table 4 for full regression models.

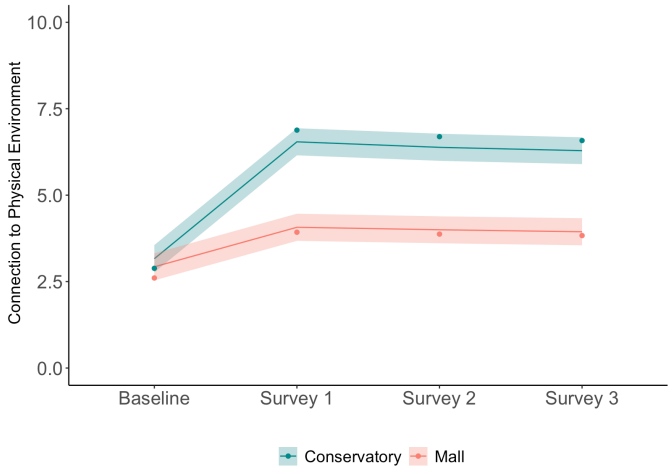


Figure 6. Observed and modeled ratings for feelings of connection to the physical environment. Points are mean observed ratings from the raw data. The fitted line is the linear model's predicted estimate. The shaded area represents the 89th percentile interval of the posterior distribution.

1.2.2.2 Thoughts about the physical environment

The fourth response option to the question "Was [your most recent] thought mostly about yourself, mostly about others, about yourself and others, or not about people?" was "focused on things other than people." These non-social thoughts were more prevalent during walks in the conservatory compared to the mall at all survey time points (Figure 3d). After ~20 minutes, (i.e.,

at Survey 1), the odds ratio between the two settings for these non-interpersonal thoughts was 2.12 (i.e., 2.12 times more likely to think about things other than people in the conservatory vs. the mall), 89% PI [1.24, 3.35], with 99% of the MCMC samples showing an odds ratio greater than one. The probability of non-interpersonal thoughts was 23% in the conservatory and 11% in the mall. At Survey 2, the probability of non-interpersonal thoughts was 21% in the conservatory and 14% in the mall. The odds ratio was 1.68 (89% PI [1.00, 2.59]), with 94.4% of the MCMC samples showing an odds ratio greater than one. At Survey 3, the probability of non-interpersonal thoughts was 15% in the conservatory and 7% in the mall, with an odds ratio of 2.26 (89% PI [1.20, 3.77]), and 98.4% of the MCMC samples showing an odds ratio greater than one. See Supplemental Table 2 for full regression models. Additionally, having thoughts about things other than people was correlated with feelings of connection to the physical environment while in the conservatory (rho = .21, 89% PI [.02, .41]), but not while in the mall (rho = 0.01, 89% PI [-.19, .22]).

1.3.5. Relationships between personality measures and thought content

We computed Bayesian bivariate linear correlation estimates (rho) between participant trait measures (e.g., Agreeableness) and dependent variables (e.g., closeness to nearby people) that had shown time by environment interactions in the main analyses. Cronbach alphas for composite trait variables are reported in Supplemental Table A8; all were in the acceptable to good range. Each participant's reported ratings within each environment (i.e., responses at Surveys 1-3) were averaged and correlations were conducted separately for each environment. There were not many strong correlations between the trait measures and dependent variables. Trait intellect (sometime referred to as openness to experience) was positively correlated with feelings of connection to the physical environment in the conservatory (rho = .29, 89% PI [.10,

.48]). Subjective vitality was positively correlated with feeling closer to nearby people and people around the world in both environments (close nearby, conservatory rho = .28, 89% PI [.08, .47], mall rho = .25, 89% PI [.05, .44]; closeness around the world, conservatory rho = .44, 89% PI [.26, .59], mall rho = .27, 89% PI [.07, .46]. See Supplemental Figure 4 for all other correlations. Overall, the results were not substantially moderated by individual differences and thus were fairly consistent across the measured personality types.

1.4 Discussion

Across numerous measures we observed that being in a natural public space led to a greater emphasis on social and environmental thoughts and feelings compared to being in a retail environment. Participants had fewer self-focused thoughts in the conservatory and had more thoughts about themselves in a relational sense (that is, themselves with other people). Participants reported feeling closer to people all over the world and people nearby, and more connected to their social environment when in the conservatory compared to the mall. They also felt more connected to physical elements of their environment and had more non-interpersonal thoughts (i.e., thoughts about things other than people) while walking in the conservatory. These effects were not explained by number of people in sight, although number of people around did interact with condition for some of the outcomes (see Supplementary Materials Appendix A).

2. Study 2

2.1. Materials & Methods

2.1.1 Recruitment Method

Participants were recruited via social media and listservs for seven 2-week study windows between May 31 and September 25, 2022. Our targeted N was between 400 and 500 participants based on budgetary constraints and the aim to collect data only during summer

months. Specifically, geo-targeted Facebook advertisements were used to recruit participants from the Chicago area, the study was advertised on Reddit.com on several Chicago-specific subreddits, and on Craigslist. An email was also shared with several Chicago-based community organizations to reach a larger sample of Chicagoans. Participants were instructed to email us if interested, and subsequently were given additional information and a pre-screening questionnaire to evaluate eligibility. Participants were eligible to participate in the study if they met the following criteria: a) Were 18 years or older, b) Lived in the Chicago city proper (zip code provided started with 606##), and c) Were not living in a Chicago Community Area where we already had a large number of participants (applicable starting in wave 4). Participants who met these criteria were sent instructions on how to enroll in a given study wave using the ExpiWell app. Not all participants who were sent enrollment details downloaded the ExpiWell app and completed the consent form or study procedures. Only those who completed the consent form and who provided non-fraudulent data (see QA section in Appendix) on at least one of the surveys are included below.

2.1.2. Participant info

A total of 426 participants participated in the study procedures. Of these 426 participants, 9 participants were flagged as potentially providing partially fraudulent data. Participants were from 67 out of 77 Chicago community areas. The mean age was 35.96 years (SD = 12.29, Min = 18, Max = 73). One hundred four identified as male, 274 identified as female, and 13 identified as nonbinary or gender nonconforming. Sixty-four participants identified as Asian/ Asian American, 105 as Black/ African American, 58 as Hispanic/ Latino /Chicano, 4 as Native American/Alaska Native, 2 as Native Hawaiian/ Pacific Islander, 5 as Middle Eastern/ North African, 183 as White/ Caucasian, 6 as another racial or ethnic identity, and 2 preferred not to

provide this information. Of the participants who responded to this question, 29 selected more than one ethnic or racial identity from this list. Some participants did not complete the study procedures required to link the background survey with the other surveys completed. There were 20 participants in Wave 1, 79 participants in Wave 2, 80 participants in Wave 3, 81 participants in Wave 4, 53 participants in Wave 5, 63 participants in Wave 6, and 59 participants in Wave 7. 394 participants completed the baseline survey and 303 completed at least 1 park evaluation survey (average = 4.08 surveys per person, total park surveys = 1,235, unique parks = 443).

2.1.3 Study Procedures

All study procedures were approved by the University XXXX Institutional Review Board. Participants were instructed that some study elements were required and others were optional. However, participants were paid based on the surveys they completed regardless of whether they did all of the required surveys. Upon downloading the ExpiWell app, participants first provided informed consent. Though the study periods were each 2-weeks long, participants were able to download the app, provide informed consent, and enroll in the study up to 3 days before this two week period. All participants were asked to complete a Background (Baseline) survey which took approximately 15-20 minutes and for which they were paid $25. The Background survey was listed as a "required" study component and was completed via Qualtrics and could be done as soon as they enrolled in the study (i.e., before the 2-week window started).

Once the 2-week period started, participants were asked to complete between 3 (minimum) and 5 (maximum) park surveys while in Chicago parks. These surveys were completed in the ExpiWell app. GPS was required to verify that participants were indeed in the location they specified (see QA checks section below for more details). Participants were paid $10 per park survey, which took approximately 5 minutes each.

To increase participation throughout the study window, participants were sent reminder messages via the Expiwell app mid-way through the 2-week period. These reminders included information on how many and which of the required surveys participants still needed to be completed and how many days they still had to complete these activities. After data quality checks were completed, participants were paid up to $135 in Amazon gift cards based on how many (valid) surveys were completed. Specific information on data quality checks can be found in Appendix B. Other study components (i.e., general outdoor surveys, RC-RAGE impulsive aggression task) were also conducted and are not reported on here. Details of all procedures can be found on the project OSF page (link).

2.1.4. Survey Questions

2.1.4.1 Park Survey

Participants were instructed "Please fill out the following survey while in a Chicago park. Each survey must be completed in a different park. Note that we will use GPS to verify your location inside a park to avoid fake responses. This survey should take approximately 5 minutes."

Participants first provided the name of the park they were visiting. They rated how connected they felt to others in their environment ("How connected do you feel to other people around you?") and their physical surroundings ("How connected do you feel to the physical environment around you?"). They were asked to approximate the number of people in the park.

2.1.4.2 Background (Baseline) Survey

The background survey included general demographic and geographic questions (year of birth, gender, racial/ethnic identity, educational attainment, income, zip code, community area). A series of standardized questionnaires were included to evaluate: depressive and anxiety

symptoms via the Patient Health Questionnaire-9 (PHQ-9) (Kroenke & Spitzer, 2002), trait impulsivity via the Barratt Impulsiveness Scale-11 (BIS-11) (Patton et al., 1995), trait aggression via the Buss-Perry Aggression Questionnaire (BPAQ) (Buss & Perry, 1992), environmental sensitivity via the Highly Sensitive Persons Scale (HSP) (Aron & Aron, 1997), sense of belongingness via the General Belongingness Scale (Malone et al., 2012), life satisfaction via the Satisfaction with Life Scale (Diener et al., 1985), Big Five personality traits via the Big Five Inventory-2 Short Form (BFI-2S) (Soto & John, 2017), self-nature overlap via the Inclusion of Nature in Self scale (INS) (Schultz, 2002), tendencies towards rumination vs. reflection via the Rumination and Reflection Questionnaire (RRQ) (Trapnell & Campbell, 1999).

2.1.5 Statistical Analysis

Statistical analyses were conducted in a Bayesian framework using multi-level models, with participant as a random/varying intercept. Connection to nearby people and the physical environment were modeled as continuous dependent variables with perceived naturalness as a continuous independent variable using linear regression. Alternative modeling choices (e.g., treating the dependent variable as an ordered categorical instead of continuous) were included as robustness checks and are reported in Supplementary Materials, Appendix B.

As in Study 1, regularizing priors were used for all models. Sensitivity analyses (see Appendix B) were conducted to confirm results were robust to chosen priors. Full specifications of the models, including their priors, are shown in the Results section for each variable. Each model was run with 10,000 draws and 1,000 warmup draws for four Markov Chain Monte Carlo (MCMC) chains, for a total posterior distribution of 36,000 post-warmup draws. Posterior distributions have been summarized by reporting the 89% percentile intervals (PI).

2.1.6 Transparency and Openness

Data and analysis code are available at https://osf.io/XXXX/. Models were run in R 4.2.2 (R Core Team, 2017) using the 'brms' package (Bürkner, 2017). This study's analysis was pre-registered (https://osf.io/6uvmp). As noted above, additional dependent measures were collected during this study that are not reported here. Information about all variables and study activities available on the main "Mapping Chicago" OSF project page (https://osf.io/pjfcd/). All variables collected during the Baseline and Park surveys are reported in Supplementary Materials Appendix B.

2.2 Results

2.2.1 Relationship between naturalness and connection to nearby people

Responses to the question "How connected do you feel to the other people around you?" were modeled as linear regressions of a continuous variable in the form:

$$Response_i \sim \text{Normal}(\mu, \sigma)$$
$$\mu_i = 1 + \beta_1 \text{naturalness} + \alpha_{\text{participant[i]}}$$
$$\beta_1 \sim \text{Normal}(0, 0.5)$$
$$\alpha_{participant[i]} \sim \text{Normal}(\overline{\alpha}, \sigma_\alpha), \text{for } i = 1 - 300$$
$$\sigma \sim \text{Exponential}(1)$$
$$\overline{\alpha} \sim \text{Normal}(3.5, 1)$$
$$\sigma_\alpha \sim \text{Exponential}(1)$$

There was a positive relationship between the perceived naturalness of a park and the feelings of connection to nearby people while visiting, beta = 0.19 (89% PI [0.13, 0.25]), see Figure 7. This relationship was robust to modeling choices, such as including park as an additional varying intercept (beta = 0.20, 89% PI [0.14, 0.27]), including varying slopes for participant (beta = 0.20, 89% PI [0.14, 0.27]), and treating connection as an ordered categorical instead of continuous variable (beta = 0.15, 89% PI [0.10, 0.20]) (See Appendix B for details on these additional models).

2.2.2 Relationship between naturalness and connection to the physical environment

Responses to the question "How connected do you feel to the physical environment around you?" were modeled as linear regressions of a continuous variable in the form:

$$Response_i \sim \text{Normal}(\mu, \sigma)$$
$$\mu_i = 1 + \beta_1 \text{naturalness} + \alpha_{\text{participant[i]}}$$
$$\beta_1 \sim \text{Normal}(0, 0.5)$$
$$\alpha_{participant[i]} \sim \text{Normal}(\overline{\alpha}, \sigma_\alpha), \text{for } i = 1 - 300$$
$$\sigma \sim \text{Exponential}(1)$$
$$\overline{\alpha} \sim \text{Normal}(3.5, 1)$$
$$\sigma_\alpha \sim \text{Exponential}(1)$$

There was a positive relationship between the perceived naturalness of a park and the feelings of connection to the physical environment while visiting, beta = 0.42 (89% PI [0.37, 0.47]), see Figure 7. This relationship was robust to modeling choices, such as including park as an additional varying intercept (beta = 0.42, 89% PI [0.36, 0.47]), including varying slopes for participant (beta = 0.42, 89% PI [0.36, 0.49]), and treating connection as an ordered categorical instead of continuous variable (beta = 0.35, 89% PI [0.30, 0.40]) (See Appendix B for details).

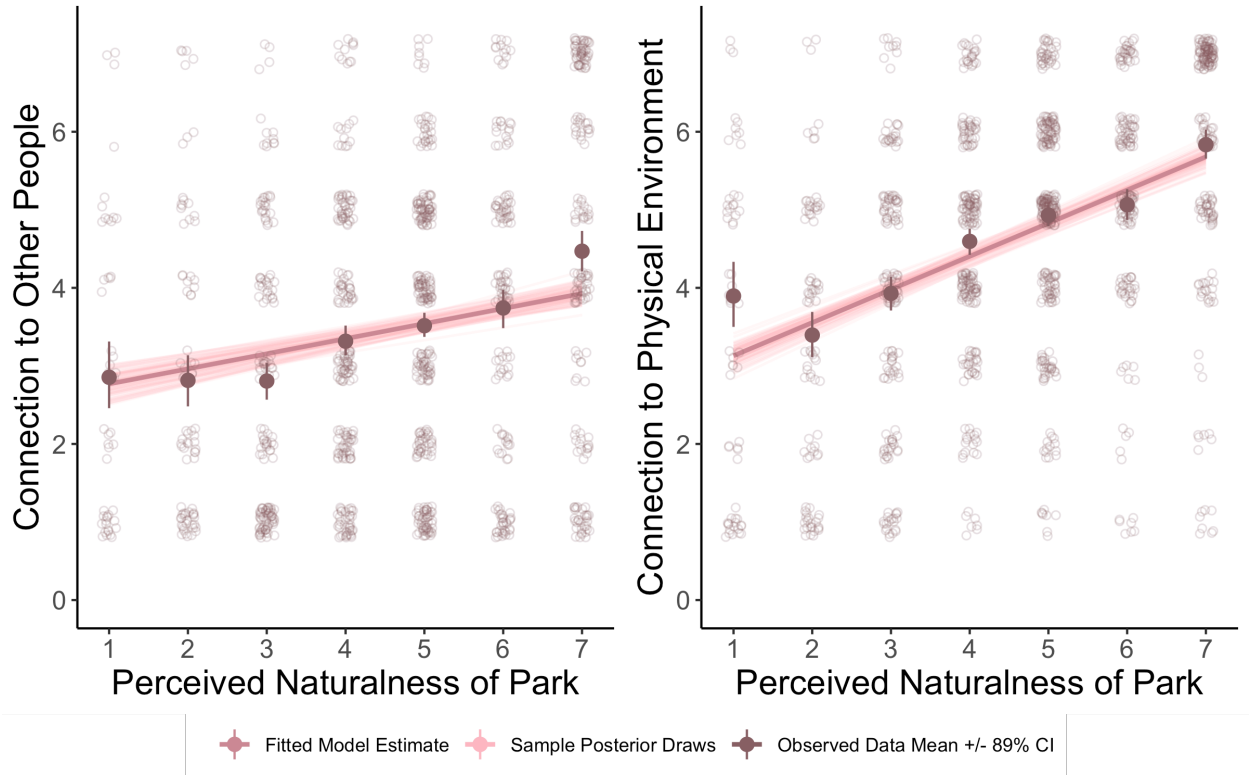


Figure 7. Association between perceived naturalness and connection to other, nearby people (left) and the surrounding physical environment (right). Dark pink line is the fitted model prediction, light pink lines are sample posterior draws, open circles are raw data points, and filled circles are the mean of observed data at each naturalness level, with 89% CI.

2.3.3 Associations between feelings of connection and personality traits

We computed Bayesian bivariate linear correlation estimates (rho) between participant trait measures (e.g., Agreeableness) and dependent variables (i.e., connection to nearby people, connection to the physical environment). Cronbach alphas for composite trait variables are reported in Supplemental Table B5; all were in the acceptable to good range. Each participant's reported ratings were averaged before calculating the correlation. As in Study 1, not many strong correlations between personality traits and the dependent variables were observed. Open-mindedness had been positively correlated with feelings of connection to the physical environment in the conservatory in Study 1, but that was not replicated in this sample (rho = .07, 89% PI [-.04, .18]). The strongest correlations were between Inclusion of Nature in Self with both connection to other people (rho = .19, 89% PI [.08,.3]) and connection to the physical environment (rho = .35, 89% PI [.24, .44]). See Supplemental Figure B2 for all other correlations. Overall, the results were not substantially moderated by individual differences and thus were fairly consistent across the measured personality types.

2.4 Discussion

We found positive relationships between naturalness and feelings of connection to nearby people and the surrounding physical environment. Number of people in sight did not explain

these relationships (see Supplementary Materials Appendix B). This suggests that naturalness is a key component of public spaces that influences feelings of connection.

3. General Discussion

Our results are in line with previous work showing that exposure to natural environments may increase orientation towards others (Goldy & Piff, 2020), but extend the work to include conscious thoughts and feelings. Broadly, these results suggest a pattern of thoughts and feelings while in a natural space that is less self-focused and instead more focused on, and connected to, both people and other things in the surrounding environment. Study 2 complemented the results of Study 1, focusing on connection to people nearby and the physical environment, by demonstrating that they generalize across a continuum of naturalness in public spaces and are seen in a more diverse group of participants. Within our Study 1 results, we can be most certain of the higher levels of connection to people around the world and connection to the physical environment in the nature conservatory, as the models showed all draws in the posterior distribution (i.e., all MCMC chains) being above zero at all timepoints for those metrics. The percentage of the posterior distribution that matches the direction (positive/negative) of the point estimate can be understood as the likelihood that the parameter is, in fact, in that direction. Thus, we are also very certain about the higher levels of connection to the social environment (96.7% positive MCMC chains) and closeness to nearby people (99.1% positive MCMC chains) in the conservatory, as well as more thoughts about the self (97.4% MCMC chain with odds ratios greater than one) in the mall. We have less confidence in the difference for thoughts about the self with others, as overall 87.9% of MCMC chains showed an odds ratio greater than one for the conservatory.

In Study 1, we did not define the term "social environment" for participants, which meant they were allowed to interpret what the construct meant for them. There were similar patterns of results for connection to the social environment and closeness to people nearby, as well as closeness to people around the world. The ratings on these questions all showed large, positive correlations as well, with connection to the social environment correlating more strongly with closeness to nearby people than people around the world. This may reflect participants using similar cues from their surroundings to answer these questions.

By having participants report thought content repeatedly while in the two environments of Study 1, we were able to measure how differences in thoughts changed over time with increasing amounts of exposure. All observed differences were present at the first surveyed timepoint, indicating that spending approximately 20 minutes in these environments was sufficient to induce differences in thoughts and feelings. Additionally, all differences in thought content were present at all three time points, indicating the strong persistence of these effects. Findings like this indicate the value of collecting measurements *during* explorations of different environments.

It remains unknown how persistent thought content differences would be after participants left the respective environments. For example, at the end of the hour walk in the nature conservatory, participants were less likely to be thinking about themselves, but we do not know if this shift away from self-focused thinking would persist for another hour after leaving the conservatory. Doing so would require new studies that continue to monitor thoughts after participants leave different environments, which could be conducted using our ecological momentary assessment procedure. Additionally, given the causal impact of conscious thoughts on behavior (Baumeister et al., 2011), studies that examine social thinking with pro-social

behavior, or environmentally focused thinking with pro-environmental behavior, could elucidate links between thought content and behavior in these domains. For instance, conscious feelings of connection to others may mediate the occurrence of pro-social behavior that has been observed after exposure to natural environments. Given that nature connectedness is associated with pro-environmental behaviors (Geng et al., 2015), having access and opportunity to visit safe, urban greenspace may be helpful for environmental conservation efforts (Maurice et al., 2021), which is of consequence given issues like climate change.

There are several limitations for the generalizability of this study. Study 1 was limited to two locations in one large US city. The design and amenities at conservatories and malls, as well as other natural and commercial spaces more broadly, around the world may influence thoughts about the social and physical environments. Results may also be influenced by cultural differences in the purposes of these public spaces. Our study locations were chosen in part because they were accessible year-round, similar in size, free to enter, desirable and frequently visited, and approximately equal distance from our lab. In addition to differing in their degree of naturalness, our two study locations differed on other factors, such as their neighborhood and demographics of visitors. It will be informative to replicate this study in additional locations, of both conservatories and malls but also other public spaces, to determine which results dimensions of spaces are important for the observed effects. We attempted to conduct the study in an ecologically valid manner by having participants visit the locations during normal operating hours throughout the week with other visitors present, while using mobile devices. One aspect that may be different from typical environmental exposure, however, is that participants visited these locations without companions. Visiting these locations with companions is likely to shape the thoughts individuals have about themselves and others.

Study 2 addresses some of the limitations of Study 1 by including a wide range of public parks in Chicago and showing that relationships between connection to others and the environment hold over a range of perceived naturalness. Additionally, park visits during Study 2 routinely took place simply as part of a participants daily life – answers to a question about whether they visited the park to just fill out the survey or for other reasons included comments such as "having a walk with my niece", "I was walking by to run an errand", and "Was on my morning walk and decided to stop in," adding to the real-world validity of the findings.

In conclusion, this study further informs the immediate impact of our surrounding physical environment on conscious thoughts and feelings, through interactions with different public spaces that vary in naturalness. We present evidence that natural public spaces, in particular, seem to be beneficial for increasing feelings of connection to other people as well as the environment around us. In an age where people increasingly feel disconnected from others (Konrath, 2013) and the natural world (Hartig & Kahn, 2016; Kesebir & Kesebir, 2017), visiting urban greenspace may counteract these feelings.

References

Arnberger, A., & Eder, R. (2012). The influence of green space on community attachment of urban and suburban residents. *Urban Forestry & Urban Greening*, *11*(1), 41–49. https://doi.org/10.1016/j.ufug.2011.11.003

Aron, E. N., & Aron, A. (1997). Sensory-processing sensitivity and its relation to introversion and emotionality. *Journal of Personality and Social Psychology*, *73*(2), 345–368. https://doi.org/10.1037/0022-3514.73.2.345

Bains, K. K., & Turnbull, T. (2019). Improving Health Outcomes and Serving Wider Society: The Potential Role of Understanding and Cultivating Prosocial Purpose Within Health Psychology Research and Practice to Address Climate Change and Social Isolation and Loneliness. *Frontiers in Psychology*, *10*. https://www.frontiersin.org/article/10.3389/fpsyg.2019.01787

Bakolis, I., Hammoud, R., Smythe, M., Gibbons, J., Davidson, N., Tognin, S., & Mechelli, A. (2018). Urban Mind: Using Smartphone Technologies to Investigate the Impact of Nature on Mental Well-Being in Real Time. *BioScience*, *68*(2), 134–145. https://doi.org/10.1093/biosci/bix149

Baumeister, R. F., Hofmann, W., Summerville, A., Reiss, P. T., & Vohs, K. D. (2020). Everyday Thoughts in Time: Experience Sampling Studies of Mental Time Travel. *Personality and Social Psychology Bulletin*, *46*(12), 1631–1648. https://doi.org/10.1177/0146167220908411

Baumeister, R. F., Masicampo, E. J., & Vohs, K. D. (2011). Do Conscious Thoughts Cause Behavior? *Annual Review of Psychology*, *62*(1), 331–361. https://doi.org/10.1146/annurev.psych.093008.131126

Benita, F., Bansal, G., & Tunçer, B. (2019). Public spaces and happiness: Evidence from a large-scale field experiment. *Health & Place*, *56*, 9–18. https://doi.org/10.1016/j.healthplace.2019.01.014

Berman, M. G., Kardan, O., Kotabe, H. P., Nusbaum, H. C., & London, S. E. (2019). The promise of environmental neuroscience. *Nature Human Behaviour*, *3*, 414–417.

Berman, M. G., Stier, A. J., & Akcelik, G. N. (2019). Environmental neuroscience. *American Psychologist*, *74*(9), 1039–1052. https://doi.org/10.1037/amp0000583

Bratman, G. N., Anderson, C. B., Berman, M. G., Cochran, B., Vries, S. de, Flanders, J., Folke, C., Frumkin, H., Gross, J. J., Hartig, T., Kahn, P. H., Kuo, M., Lawler, J. J., Levin, P. S., Lindahl, T., Meyer-Lindenberg, A., Mitchell, R., Ouyang, Z., Roe, J., … Daily, G. C. (2019). Nature and mental health: An ecosystem service perspective. *Science Advances*, *5*(7), eaax0903. https://doi.org/10.1126/sciadv.aax0903

Bürkner, P.-C. (2017). brms: An R Package for Bayesian Multilevel Models Using Stan. *Journal of Statistical Software*, *80*(1), Article 1. https://doi.org/10.18637/jss.v080.i01

Buss, A. H., & Perry, M. (1992). The Aggression Questionnaire. *Journal of Personality and Social Psychology*, *63*, 452–459. https://doi.org/10.1037/0022-3514.63.3.452

Cattell, V., Dines, N., Gesler, W., & Curtis, S. (2008). Mingling, observing, and lingering: Everyday public spaces and their implications for well-being and social relations. *Health & Place*, *14*(3), 544–561. https://doi.org/10.1016/j.healthplace.2007.10.007

Coley, R. L., Sullivan, W. C., & Kuo, F. E. (1997). Where Does Community Grow?: The Social Context Created by Nature in Urban Public Housing. *Environment and Behavior*, *29*(4), 468–494. https://doi.org/10.1177/001391659702900402

Diener, E., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). The Satisfaction With Life Scale. *Journal of Personality Assessment*, *49*(1), 71–75. https://doi.org/10.1207/s15327752jpa4901_13

Doherty, S. T., Lemieux, C. J., & Canally, C. (2014). Tracking human activity and well-being in natural environments using wearable sensors and experience sampling. *Social Science & Medicine*, *106*, 83–92. https://doi.org/10.1016/j.socscimed.2014.01.048

Donnellan, M. B., Oswald, F. L., Baird, B. M., & Lucas, R. E. (2006). The Mini-IPIP Scales: Tiny-yet-effective measures of the Big Five Factors of Personality. *Psychological Assessment*, *18*(2), 192–203. https://doi.org/10.1037/1040-3590.18.2.192

Feng, X., & Astell-Burt, T. (2022). Lonelygenic environments: A call for research on multilevel determinants of loneliness. *The Lancet Planetary Health*, *6*(12), e933–e934. https://doi.org/10.1016/S2542-5196(22)00306-0

Francis, J., Wood, L. J., Knuiman, M., & Giles-Corti, B. (2012). Quality or quantity? Exploring the relationship between Public Open Space attributes and mental health in Perth, Western Australia. *Social Science & Medicine*, *74*(10), 1570–1577. https://doi.org/10.1016/j.socscimed.2012.01.032

Geng, L., Xu, J., Ye, L., Zhou, W., & Zhou, K. (2015). Connections with Nature and Environmental Behaviors. *PLOS ONE*, *10*(5), e0127247. https://doi.org/10.1371/journal.pone.0127247

Giles-Corti, B., Broomhall, M. H., Knuiman, M., Collins, C., Douglas, K., Ng, K., Lange, A., & Donovan, R. J. (2005). Increasing walking: How important is distance to, attractiveness, and size of public open space? *American Journal of Preventive Medicine*, *28*(2, Supplement 2), 169–176. https://doi.org/10.1016/j.amepre.2004.10.018

Goldy, S. P., & Piff, P. K. (2020). Toward a social ecology of prosociality: Why, when, and where nature enhances social connection. *Current Opinion in Psychology*, *32*, 27–31. https://doi.org/10.1016/j.copsyc.2019.06.016

Hartig, T. (2021). Restoration in Nature: Beyond the Conventional Narrative. In A. R. Schutte, J. C. Torquati, & J. R. Stevens (Eds.), *Nature and Psychology: Biological, Cognitive, Developmental, and Social Pathways to Well-being* (pp. 89–151). Springer International Publishing. https://doi.org/10.1007/978-3-030-69020-5_5

Hartig, T., & Kahn, P. H. (2016). Living in cities, naturally. *Science*, *352*(6288), 938–940. https://doi.org/10.1126/science.aaf3759

Hartig, T., Kaiser, F. G., & Strumse, E. (2007). Psychological restoration in nature as a source of motivation for ecological behaviour. *Environmental Conservation*, *34*(4), 291–299. https://doi.org/10.1017/S0376892907004250

Hartig, T., Mitchell, R., de Vries, S., & Frumkin, H. (2014). Nature and Health. *Annual Review of Public Health*, *35*(1), 207–228. https://doi.org/10.1146/annurev-publhealth-032013-182443

Hughes, M. E., Waite, L. J., Hawkley, L. C., & Cacioppo, J. T. (2004). A Short Scale for Measuring Loneliness in Large Surveys. *Research on Aging*, *26*(6), 655–672. https://doi.org/10.1177/0164027504268574

Jennings, V., & Bamkole, O. (2019). The Relationship between Social Cohesion and Urban Green Space: An Avenue for Health Promotion. *International Journal of Environmental Research and Public Health*, *16*(3), 452. https://doi.org/10.3390/ijerph16030452

Joye, Y., & van den Berg, A. (2011). Is love for green in our genes? A critical analysis of evolutionary assumptions in restorative environments research. *Urban Forestry & Urban Greening*, *10*(4), 261–268. https://doi.org/10.1016/j.ufug.2011.07.004

Jrissman. (2010). *English: This is a photograph of the Water Tower Place mall in Chicago, IL. It has eight levels and opened in 1975.* Own work. https://commons.wikimedia.org/wiki/File:WaterTowerPlaceMall.JPG

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, *15*(3), 169–182.

Kardan, O., Gozdyra, P., Misic, B., Moola, F., Palmer, L. J., Paus, T., & Berman, M. G. (2015). Neighborhood greenspace and health in a large urban center. *Scientific Reports*, *5*, 11610. https://doi.org/10.1038/srep11610

Kenraiz, K. Z. (2016). *English: Garfield Park Conservatory in Chicago*. Own work. https://commons.wikimedia.org/wiki/File:Garfield_Park_Conservatory_kz16.jpg

Kesebir, S., & Kesebir, P. (2017). A Growing Disconnection From Nature Is Evident in Cultural Products. *Perspectives on Psychological Science*, *12*(2), 258–269. https://doi.org/10.1177/1745691616662473

Konrath, S. (2013). *The Empathy Paradox: Increasing Disconnection in the Age of Increasing Connection* [Chapter]. Handbook of Research on Technoself: Identity in a Technological Society; IGI Global. https://doi.org/10.4018/978-1-4666-2211-1.ch012

Kroenke, K., & Spitzer, R. L. (2002). The PHQ-9: A New Depression Diagnostic and Severity Measure. *Psychiatric Annals*, *32*(9), 509–515. https://doi.org/10.3928/0048-5713-20020901-06

Kruschke, J. K. (2021). Bayesian Analysis Reporting Guidelines. *Nature Human Behaviour*, *5*(10), Article 10. https://doi.org/10.1038/s41562-021-01177-7

Larson, R., & Csikszentmihalyi, M. (2014). The Experience Sampling Method. In M. Csikszentmihalyi (Ed.), *Flow and the Foundations of Positive Psychology: The Collected Works of Mihaly Csikszentmihalyi* (pp. 21–34). Springer Netherlands. https://doi.org/10.1007/978-94-017-9088-8_2

Malone, G. P., Pillow, D. R., & Osman, A. (2012). The General Belongingness Scale (GBS): Assessing achieved belongingness. *Personality and Individual Differences*, *52*(3), 311–316. https://doi.org/10.1016/j.paid.2011.10.027

Mangelsdorf, H. H., & Kotabe, H. P. (2017, April). *Psychological consequences of valuing emotions*. University of Chicago Cognitive Brown Bag, Chicago, IL, US.

Martin, L., White, M. P., Hunt, A., Richardson, M., Pahl, S., & Burt, J. (2020). Nature contact, nature connectedness and associations with health, wellbeing and pro-environmental behaviours. *Journal of Environmental Psychology*, *68*, 101389. https://doi.org/10.1016/j.jenvp.2020.101389

Maurice, A.-C., Prévot, A.-C., Bessa-Gomes, C., & Baudry, E. (2021). Orientations toward 'people' and 'things' are associated with nature connectedness in a representative sample of the French adult population. *Sustainability Science*, *16*(5), 1489–1502. https://doi.org/10.1007/s11625-021-00997-w

Mayhew, M. J., & Powell, J. H. (2014). The development of a brief self-report questionnaire to measure 'recent' Rash Impulsivity: A preliminary investigation of its validity and association with recent alcohol consumption. *Addictive Behaviors*, *39*(11), 1597–1605. https://doi.org/10.1016/j.addbeh.2014.03.022

McElreath, R. (2020). *Statistical Rethinking: A Bayesian Course with Examples in R and STAN*. CRC Press.

McMahan, E. A., & Estes, D. (2015). The effect of contact with natural environments on positive and negative affect: A meta-analysis. *The Journal of Positive Psychology*, *10*(6), 507–519. https://doi.org/10.1080/17439760.2014.994224

Mildner, J. N., & Tamir, D. I. (2021). The people around you are inside your head: Social context shapes spontaneous thought. *Journal of Experimental Psychology: General*, *150*(11), 2375–2386.

Nosek, B. A., Hardwicke, T. E., Moshontz, H., Allard, A., Corker, K. S., Dreber, A., Fidler, F., Hilgard, J., Kline Struhl, M., Nuijten, M. B., Rohrer, J. M., Romero, F., Scheel, A. M., Scherer, L. D., Schönbrodt, F. D., & Vazire, S. (2022). Replicability, Robustness, and Reproducibility in Psychological Science. *Annual Review of Psychology*, *73*(1), 719–748. https://doi.org/10.1146/annurev-psych-020821-114157

Passmore, H.-A., & Holder, M. D. (2017). Noticing nature: Individual and social benefits of a two-week intervention. *The Journal of Positive Psychology*, *12*(6), 537–546. https://doi.org/10.1080/17439760.2016.1221126

Patton, J. H., Stanford, M. S., & Barratt, E. S. (1995). Factor structure of the barratt impulsiveness scale. *Journal of Clinical Psychology*, *51*(6), 768–774. https://doi.org/10.1002/1097-4679(199511)51:6<768::AID-JCLP2270510607>3.0.CO;2-1

Pek, J., & Van Zandt, T. (2020). Frequentist and Bayesian approaches to data analysis: Evaluation and estimation. *Psychology Learning & Teaching*, *19*(1), 21–35. https://doi.org/10.1177/1475725719874542

Peters, K., Elands, B., & Buijs, A. (2010). Social interactions in urban parks: Stimulating social cohesion? *Urban Forestry & Urban Greening*, *9*(2), 93–100. https://doi.org/10.1016/j.ufug.2009.11.003

R Core Team. (2017). *R: A language and environment for statistical computing.* (3.3.3). R Foundation for Statistical Computing. https://www.R-project.org/

Ryan, R. M., & Frederick, C. (1997). On Energy, Personality, and Health: Subjective Vitality as a Dynamic Reflection of Well-Being. *Journal of Personality*, *65*(3), 529–565. https://doi.org/10.1111/j.1467-6494.1997.tb00326.x

Ryan, R. M., Weinstein, N., Bernstein, J., Brown, K. W., Mistretta, L., & Gagné, M. (2010). Vitalizing effects of being outdoors and in nature. *Journal of Environmental Psychology*, *30*(2), 159–168. https://doi.org/10.1016/j.jenvp.2009.10.009

Schertz, K. E., & Berman, M. G. (2019). Understanding Nature and Its Cognitive Benefits: *Current Directions in Psychological Science*, *28*(5), 496–502. https://doi.org/10.1177/0963721419854100

Schertz, K. E., Bowman, J. E., Kotabe, H. P., Layden, E. A., Zhen, J., Lakhtakia, T., Lyu, M., Paraschos, O. A., Van Hedger, S. C., Rim, N. W., Vohs, K. D., & Berman, M. G. (2022). Environmental influences on affect and cognition: A study of natural and commercial semi-public spaces. *Journal of Environmental Psychology*, *83*, 101852. https://doi.org/10.1016/j.jenvp.2022.101852

Schertz, K. E., Kardan, O., & Berman, M. G. (2020). Visual features influence thought content in the absence of overt semantic information. *Attention, Perception, & Psychophysics*. https://doi.org/10.3758/s13414-020-02121-z

Schertz, K. E., Sachdeva, S., Kardan, O., Kotabe, H. P., Wolf, K. L., & Berman, M. G. (2018). A thought in the park: The influence of naturalness and low-level visual features on expressed thoughts. *Cognition*, *174*, 82–93. https://doi.org/10.1016/j.cognition.2018.01.011

Schultz, P. W. (2002). Inclusion with Nature: The Psychology Of Human-Nature Relations. In P. Schmuck & W. P. Schultz (Eds.), *Psychology of Sustainable Development* (pp. 61–78). Springer US. https://doi.org/10.1007/978-1-4615-0995-0_4

Soto, C. J., & John, O. P. (2017). Short and extra-short forms of the Big Five Inventory–2: The BFI-2-S and BFI-2-XS. *Journal of Research in Personality*, *68*, 69–81. https://doi.org/10.1016/j.jrp.2017.02.004

Sripada, C., & Taxali, A. (2020). Structure in the stream of consciousness: Evidence from a verbalized thought protocol and automated text analytic methods. *Consciousness and Cognition*, *85*, 103007. https://doi.org/10.1016/j.concog.2020.103007

Stone, A. A., & Shiffman, S. (1994). Ecological Momentary Assessment (Ema) in Behavioral Medicine. *Annals of Behavioral Medicine*, *16*(3), 199–202. https://doi.org/10.1093/abm/16.3.199

Sullivan, W. C., Kuo, F. E., & DePooter, S. F. (2004). The fruit of urban nature—Vital neighborhood spaces. *Environment and Behavior*, *36*, 678.

Trapnell, P. D., & Campbell, J. D. (1999). Private self-consciousness and the five-factor model of personality: Distinguishing rumination from reflection. *Journal of Personality and Social Psychology*, *76*(2), 284–304. https://doi.org/10.1037/0022-3514.76.2.284

Trawalter, S., Hoffman, K., & Palmer, L. (2021). Out of place: Socioeconomic status, use of public space, and belonging in higher education. *Journal of Personality and Social Psychology*, *120*(1), 131–144. https://doi.org/10.1037/pspi0000248

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress Recovery during Exposure to Natural and Urban Environments. *Journal of Environmental Psychology*, *11*, 201.

Weinstein, N., Przybylski, A. K., & Ryan, R. M. (2009). Can Nature Make Us More Caring? Effects of Immersion in Nature on Intrinsic Aspirations and Generosity. *Personality and Social Psychology Bulletin*, *35*(10), 1315–1329. https://doi.org/10.1177/0146167209341649

Yarkoni, T. (2022). The generalizability crisis. *Behavioral and Brain Sciences*, *45*, e1. https://doi.org/10.1017/S0140525X20001685

Supplemental Materials

Appendix A

Supplementary Materials for Study 1

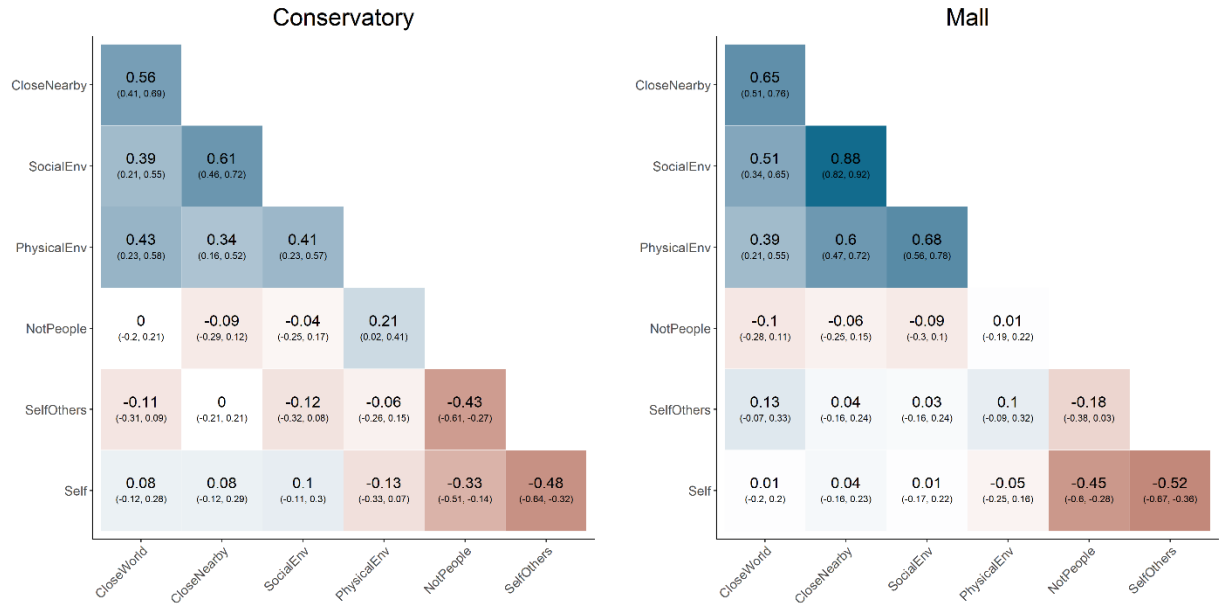
Supplemental Table A1. Study 1 Survey Questions

Question	Possible Responses	Measure	Analyzed in MS
Was the thought mostly about yourself, mostly about others, about yourself and others, or not about people?	Mostly about myself, Mostly about others, About myself and others, Something else/not about people (with free response)	Personal Aspect	X
[If answered 'mostly about others' or 'mostly about myself and others'] Who was your thought about?	Significant other, Family, Friends, Acquaintances, Coworkers, People I don't know, Other (with free response)	Personal Aspect	
How close do you feel to each of the following groups:			
My family and friends	0-7; 0 = Not at all close, 7 = Very close	Closeness to People	X
People in my surroundings	0-7; 0 = Not at all close, 7 = Very close	Closeness to People	X
People all over the world	0-7; 0 = Not at all close, 7 = Very close	Closeness to People	X
How much do you feel connected to the physical environment around you?	0-7; 0 = Not at all, 7 = Very much	Environmental Connectedness	X
How much do you feel connected to the social environment around you?	0-7; 0 = Not at all, 7 = Very much	Environmental Connectedness	X
*How many people can you see around you right now?	0, 1-5, 6-10, 11-20, 21+	Number of People Around	X
Was your most recent thought about the past, present (within 5 min before or 5 min after right now), or future, or did it have no time aspect?	Past, Present, Future, No Time Aspect	Temporal Aspect	

Question	Possible Responses	Measure	Analyzed in MS
[If answered 'past'] Was your thought in the past about something that occurred ...	Earlier today, Yesterday, A few days ago, 1-4 weeks ago, 1-12 months ago, More than a year ago, More than 10 years ago, Before you were born	Temporal Aspect	
[If answered 'future'] Was your thought in the future about something that will occur ...	Later today, Tomorrow, A few days from now, 1-4 weeks from now, 1-12 months from now, More than a year from now, More than 10 years from now, More than 50 years from now, After life	Temporal Aspect	
How positive was the thought?	0-7; 0 = Not at all, 7 = Very much	Valence	
How negative was the thought?	0-7; 0 = Not at all, 7 = Very much	Valence	
How exciting was the thought?	0-7; 0 = Not at all, 7 = Very much	Valence	
How spontaneous was your thought?	0-7; 0 = Not at all, 7 = Very much	Valence	
How deep was your thought?	0-7; 0 = Not at all, 7 = Very much	Valence	
How imaginative was your thought?	0-7; 0 = Not at all, 7 = Very much	Valence	
How stressful was your thought?	0-7; 0 = Not at all, 7 = Very much	Valence	
How creative do you feel right now?	0-7; 0 = Not at all, 7 = Very much	State	
How bored do you feel right now?	0-7; 0 = Not at all, 7 = Very much	State	
How impulsive do you feel right now?	0-7; 0 = Not at all, 7 = Very much	State	
How disorderly or orderly is the physical environment around you?	-5-5; -5 = Very disorderly, 5 = Very orderly	Environmental Disorder	
How disorderly or orderly is the social environment around you?	-5-5; -5 = Very disorderly, 5 = Very orderly	Environmental Disorder	
How much do you feel each of these emotions right now:			
Stressed	0-7; 0 = Not at all, 7 = Very much	Negative Affect	
Mentally fatigued	0-7; 0 = Not at all, 7 = Very much	Negative Affect	

Question	Possible Responses	Measure	Analyzed in MS
Insignificant	0-7; 0 = Not at all, 7 = Very much	Negative Affect	
Optimistic	0-7; 0 = Not at all, 7 = Very much	Positive Affect	
In awe	0-7; 0 = Not at all, 7 = Very much	Positive Affect	
Grateful	0-7; 0 = Not at all, 7 = Very much	Positive Affect	
Energetic	0-7; 0 = Not at all, 7 = Very much	Positive Affect	
How much do you feel like you have "gotten away" from your everyday concerns?	0-7; 0 = Not at all, 7 = Very much	Escape	
† Right now, I feel like buying something spontaneously.	0-7; 0 = Not at all, 7 = Very much	Impulsive Buying	
† I would carefully plan my purchases if I were to buy something right now.	0-7; 0 = Not at all, 7 = Very much	Impulsive Buying	
† I would buy things without thinking if I were to buy something right now.	0-7; 0 = Not at all, 7 = Very much	Impulsive Buying	
†Over the course your walk, would you say that time has seemed to move...	Much slower than usual, Somewhat slower than usual, As usual, Somewhat faster than usual, Much faster than usual	Time Perception	

Note. * Question not asked at baseline, only Surveys 1-3. † Question only asked at Survey 3, not Surveys 1 & 2.



Supplemental Figure A1. Bivariate Bayesian linear correlation estimates between different aspects of thought content in the Nature Conservatory (left) and Mall (right). Positive correlations are shown in blue and negative correlations are shown in red. 89% confidence intervals are shown in paratheses.

Supplemental Table A2. Self Vs Others Aspect of Thoughts

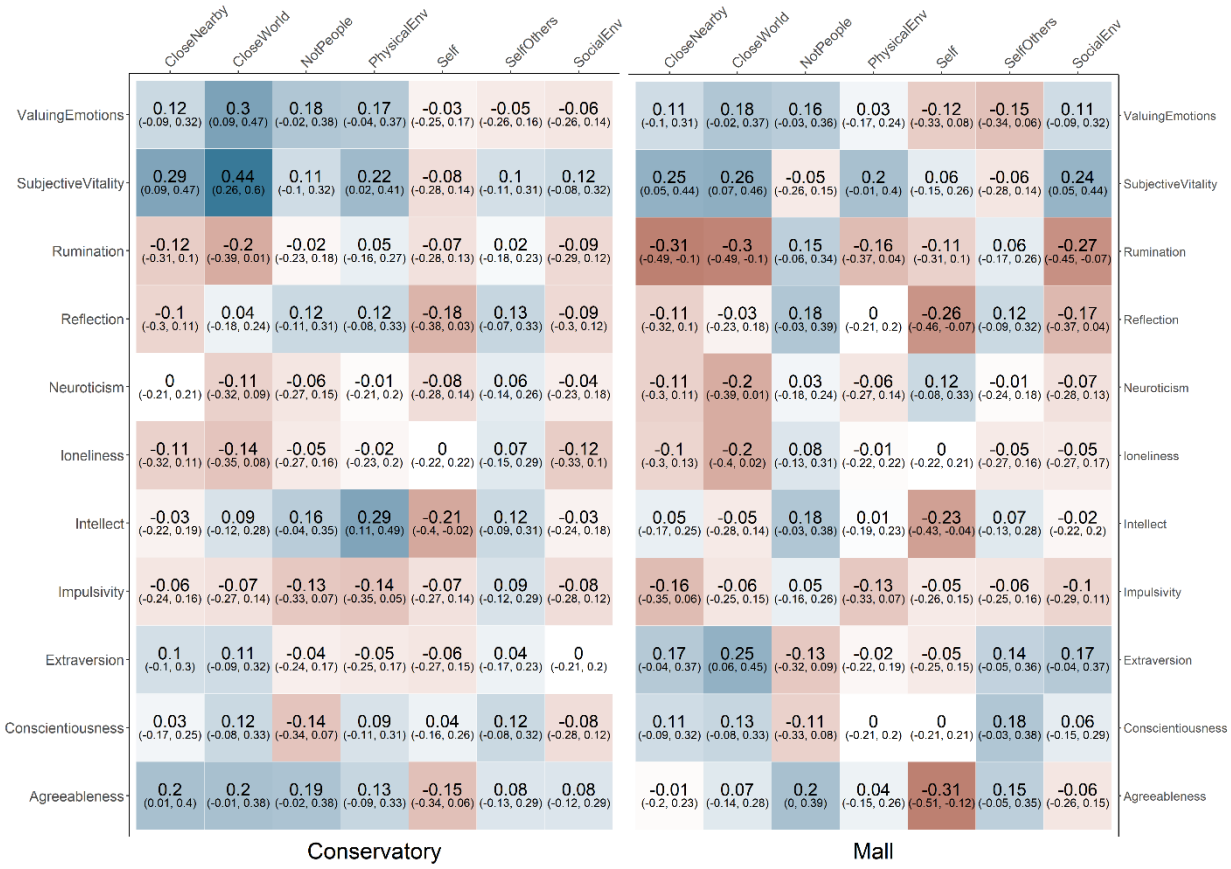
	Self		Not People		Both		Others	
Predictors	*Odds Ratios*	*CI (89%)*	*Odds Ratios*	*CI (89%)*	*Odds Ratios*	*CI (89%)*	*Odds Ratios*	*CI (89%)*
Intercept	0.58	0.39 – 0.82	0.13	0.08 – 0.19	0.43	0.29 – 0.60	0.12	0.08 – 0.17
Conservatory Baseline	1.07	0.67 – 1.59	0.56	0.31 – 0.90	1.47	0.92 – 2.18	1.14	0.65 – 1.79
Mall Baseline	1.13	0.70 – 1.68	0.47	0.25 – 0.75	1.69	1.06 – 2.52	0.97	0.55 – 1.53
Conservatory Survey 1	0.56	0.34 – 0.85	2.34	1.40 – 3.55	1.16	0.71 – 1.74	0.91	0.51 – 1.45
Mall Survey 1	1.62	1.01 – 2.40	1.02	0.59 – 1.58	0.77	0.47 – 1.16	0.91	0.51 – 1.45
Conservatory Survey 2	0.72	0.45 – 1.08	2.17	1.30 – 3.32	0.90	0.55 – 1.34	1.05	0.60 – 1.65
Mall Survey 2	1.13	0.70 – 1.69	1.24	0.73 – 1.92	0.68	0.42 – 1.04	1.52	0.89 – 2.34
Conservatory Survey 3	0.69	0.42 – 1.03	1.42	0.84 – 2.19	1.27	0.79 – 1.89	1.14	0.65 – 1.79
Mall Survey 3	2.16	1.34 – 3.21	0.62	0.34 – 0.99	0.77	0.48 – 1.16	0.90	0.51 – 1.43
Random Effects								
σ^2	3.29		3.29		3.29		3.29	
τ_{00}	1.16 $_{intakeID}$		1.31 $_{intakeID}$		0.97 $_{intakeID}$		0.24 $_{intakeID}$	
N	86 $_{intakeID}$		86 $_{intakeID}$		86 $_{intakeID}$		86 $_{intakeID}$	
Observations	683		683		683		683	

Supplemental Table A3. Closeness to Various Groups of People

	Nearby		Around the World		Family & Friends	
Predictors	*Estimates*	*CI (89%)*	*Estimates*	*CI (89%)*	*Estimates*	*CI (89%)*
Intercept	3.28	2.88 – 3.67	2.75	2.32 – 3.17	6.37	5.90 – 6.83
Conservatory Baseline	0.42	0.04 – 0.82	0.06	-0.31 – 0.42	0.69	0.29 – 1.09
Mall Baseline	0.24	-0.15 – 0.63	-0.17	-0.53 – 0.20	0.37	-0.02 – 0.77
Conservatory Survey 1	0.43	0.03 – 0.82	0.43	0.07 – 0.80	-0.05	-0.45 – 0.35
Mall Survey 1	-0.61	-1.00 – -0.22	-0.56	-0.93 – -0.19	-0.51	-0.91 – -0.10
Conservatory Survey 2	0.34	-0.05 – 0.73	0.47	0.10 – 0.84	-0.06	-0.45 – 0.34
Mall Survey 2	-0.50	-0.88 – -0.11	-0.36	-0.73 – 0.01	-0.39	-0.80 – 0.01
Conservatory Survey 3	0.07	-0.32 – 0.46	0.49	0.12 – 0.85	0.09	-0.31 – 0.49
Mall Survey 3	-0.39	-0.78 – -0.00	-0.36	-0.73 – 0.01	-0.14	-0.54 – 0.26
Random Effects						
σ^2	3.14		2.33		3.60	
τ_{00}	2.12 $_{\text{intakeID}}$		3.12 $_{\text{intakeID}}$		4.14 $_{\text{intakeID}}$	
N	86 $_{\text{intakeID}}$		86 $_{\text{intakeID}}$		86 $_{\text{intakeID}}$	
Observations	683		683		683	

Supplemental Table A4. Connection to Physical and Social Environments

	Physical		Social	
Predictors	*Estimates*	*CI (89%)*	*Estimates*	*CI (89%)*
Intercept	4.67	4.29 – 5.05	2.96	2.58 – 3.34
Conservatory Baseline	-1.50	-1.91 – -1.09	-0.15	-0.54 – 0.24
Mall Baseline	-1.74	-2.15 – -1.34	-0.14	-0.53 – 0.25
Conservatory Survey 1	1.88	1.47 – 2.28	0.22	-0.17 – 0.60
Mall Survey 1	-0.59	-1.00 – -0.19	-0.17	-0.56 – 0.22
Conservatory Survey 2	1.72	1.31 – 2.12	0.31	-0.07 – 0.71
Mall Survey 2	-0.67	-1.07 – -0.26	-0.23	-0.62 – 0.16
Conservatory Survey 3	1.62	1.21 – 2.03	0.31	-0.08 – 0.71
Mall Survey 3	-0.72	-1.14 – -0.32	-0.16	-0.55 – 0.24
Random Effects				
σ^2	3.92		3.11	
τ_{00}	1.69 $_{\text{intakeID}}$		1.77 $_{\text{intakeID}}$	
N	86 $_{\text{intakeID}}$		86 $_{\text{intakeID}}$	
Observations	683		683	



Supplemental Figure A2. Bivariate linear correlations between individual trait measures (rows) and dependent variables (columns) in the conservatory (left) and mall (right). Positive correlations are shown in blue and negative correlations are shown in red. 89% confidence intervals are shown in paratheses.

Supplemental Table A5. Cronbach's alphas for all composite trait measures

Measure	Alpha	95% CI
Subjective Vitality	.82	[.74, .87]
Valuing Emotions	.70	[.57, .78]
Extraversion	.86	[.80, .90]
Agreeableness	.78	[.66, .86]
Conscientiousness	.80	[.71, .86]
Neuroticism	.79	[.69, .86]
Intellect	.80	[.72, .85]
Rumination	.93	[.90, .95]
Reflection	.95	[.92, .96]
Impulsivity	.74	[.61, .80]
Loneliness	.79	[.68, .88]

Influence of reported number of people in sight on thoughts and feelings in Study 1

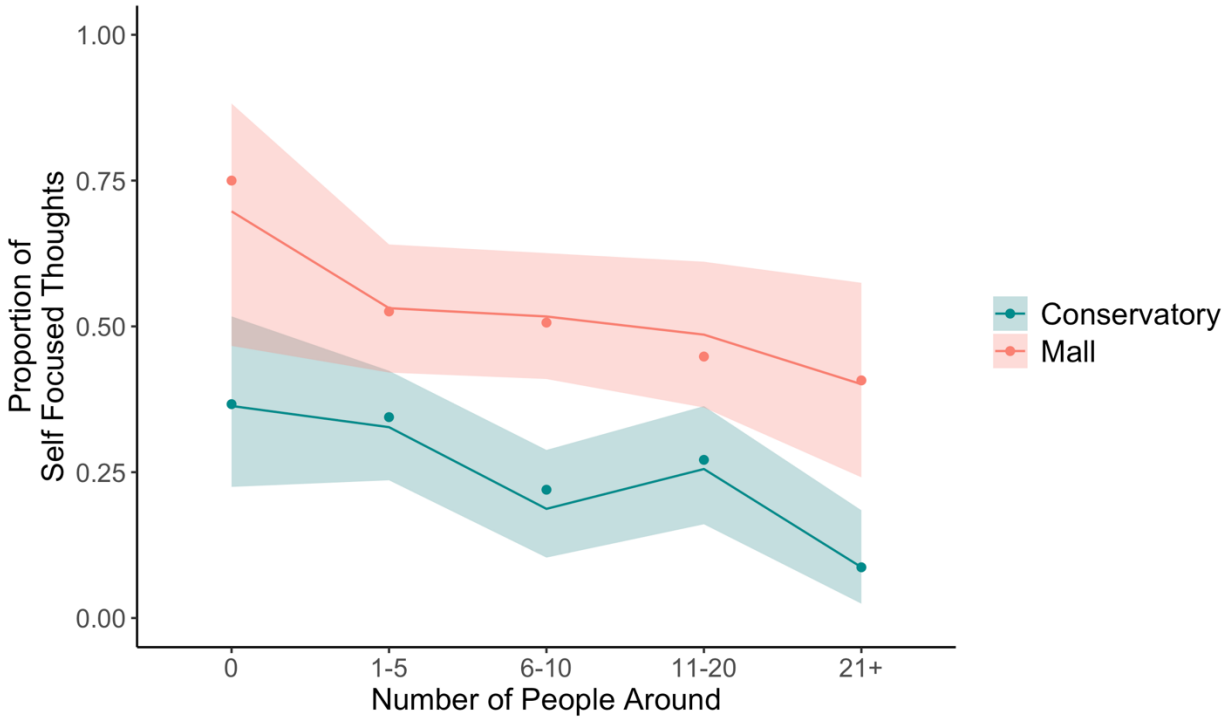
The reported differences in thought content by condition could potentially be explained by the presence of different numbers of people at the time of responding. Thus, we analyzed all our dependent variables as a function of environment, number of people in sight at time of response, and their interaction. Overall, while there were interesting interactive effects between environment and number of people for some of the dependent variables, number of people around did not explain our results. Descriptively, it was more likely for there to be zero or one to six people in sight in the conservatory and more likely for there to be six to 10 people in sight in the mall. There were many reports of having 11-20 or 21 or more people in sight in both locations. See Supplemental Figure 2 for a histogram of number of people in sight by condition.

Supplemental Figure A3. Reported number of people in sight while in the conservatory and mall.

For the responses to the question "Who was your most recent thought about?", the logistic model took this form:

$Response_i \sim \text{Binomial}(1, p_i)$
$\text{logit}(p_i) = 1 + \alpha_{\text{participant[i]}} + \beta 1_{condition[j]} + \beta 2_{people\_around[k]} + \beta 3_{\text{condition*people\_around[l]}}$
$\beta 1_j \sim \text{Normal}(0, 0.5)$, for j = 1-2 (conservatory, mall)
$\beta 2_k \sim \text{Normal}(0, 0.5)$, for k = 1-5 (levels of people in sight)
$\beta 3_l \sim \text{Normal}(0, 0.5)$, for l = 1-10 (interaction of condition x people in sight)
$\alpha_{participant[i]} \sim \text{Normal}(\overline{\alpha}, \sigma_\alpha)$, for $i = 1 - 86$
$\overline{\alpha} \sim \text{Normal}(0, 1.5)$
$\sigma_\alpha \sim \text{Exponential}(1)$

There was a main effect of number of people around on participants reporting thoughts about just themselves (see Supplemental Figure A4), but this did not interact with condition. Participants reported less thoughts about just themselves when there were more people in their surroundings in both locations. For example, the proportion of self-focused thoughts when surrounded by 21 or more people was 0.30 (89% PI [0.03, 0.54]) less than when there was no one in sight at the mall, and 0.28 (89% PI [0.12, 0.44]) less in the conservatory. Thoughts about others, myself & others, and non-interpersonal thoughts were not associated with the number of people in the surrounding area (see Supplemental Figure A7 and Supplemental Table A6).



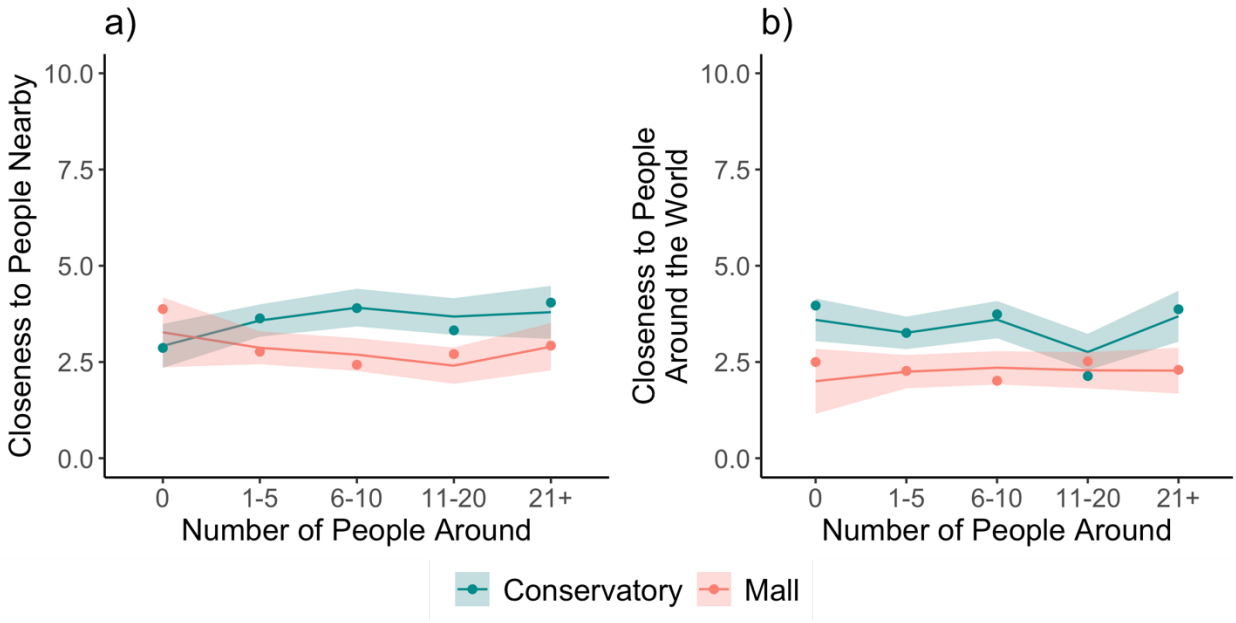
Supplemental Figure A4. Observed and modeled selection of self-focused thoughts, as related to the number of people in sight. Points are observed probabilities from the raw data. The fitted line is the logistic regression model's predicted estimate. The shaded area represents the 89th percentile interval of the posterior distribution.

For questions asking about closeness to different groups of people and feelings of connection to the physical and social environment, the model linear model took the following form:

$$Response_i \sim \text{Normal}(\mu, \sigma)$$
$$\mu_i = 1 + \alpha_{\text{participant[i]}} + \beta 1_{condition[j]} + \beta 2_{people\_around[k]} + \beta 3_{\text{condition*people\_around[l]}}$$
$$\beta 1_j \sim \text{Normal}(0, 2) \text{ , for j = 1-2 (conservatory, mall)}$$
$$\beta 2_k \sim \text{Normal}(0, 2) \text{ , for k = 1-5 (levels of people in sight)}$$
$$\beta 3_l \sim \text{Normal}(0, 2) \text{ , for l = 1-10 (interaction of condition x people in sight)}$$
$$\alpha_{participant[i]} \sim \text{Normal}(\bar{\alpha}, \sigma_\alpha) \text{ , for } i = 1 - 86$$
$$\sigma \sim \text{Exponential}(1)$$
$$\bar{\alpha} \sim \text{Normal}(5, 1.5)$$
$$\sigma_\alpha \sim \text{Exponential}(1)$$

Feelings of closeness to nearby people interacted between condition and number of people around (Supplemental Figure A5). Feelings of closeness to nearby people was higher with a greater number of people around in the conservatory but was lower with a greater number of people around in the mall. For example, when there were 21 or more people around closeness to nearby people was rated 0.87 (89% PI [0.07, 1.68]) points higher than when there was no one in sight at the conservatory. When in the mall, closeness to nearby people was rated highest when in sight of no one and rated lowest when surrounded by 11-20 people, with a 0.87 (89% PI [-0.08, 1.81]) point difference between the two.

Feelings of closeness to people around the world also interacted with number of people around (Supplemental Figure A5). While ratings were relatively stable across different numbers of people around in the mall, there was a drop in closeness to people around the world in the conservatory when participants saw 11-20 people around them. Closeness to people around the world when surrounded by 11-20 people was 0.83 (89% PI [0.25, 1.42]) points lower than no one in sight and 0.93 (89% PI [0.26, 1.60]) points lower than when there were 21 or more people around. Closeness to family and friends did not interact with number of people in the surroundings. See Supplemental Table A7 for full models.

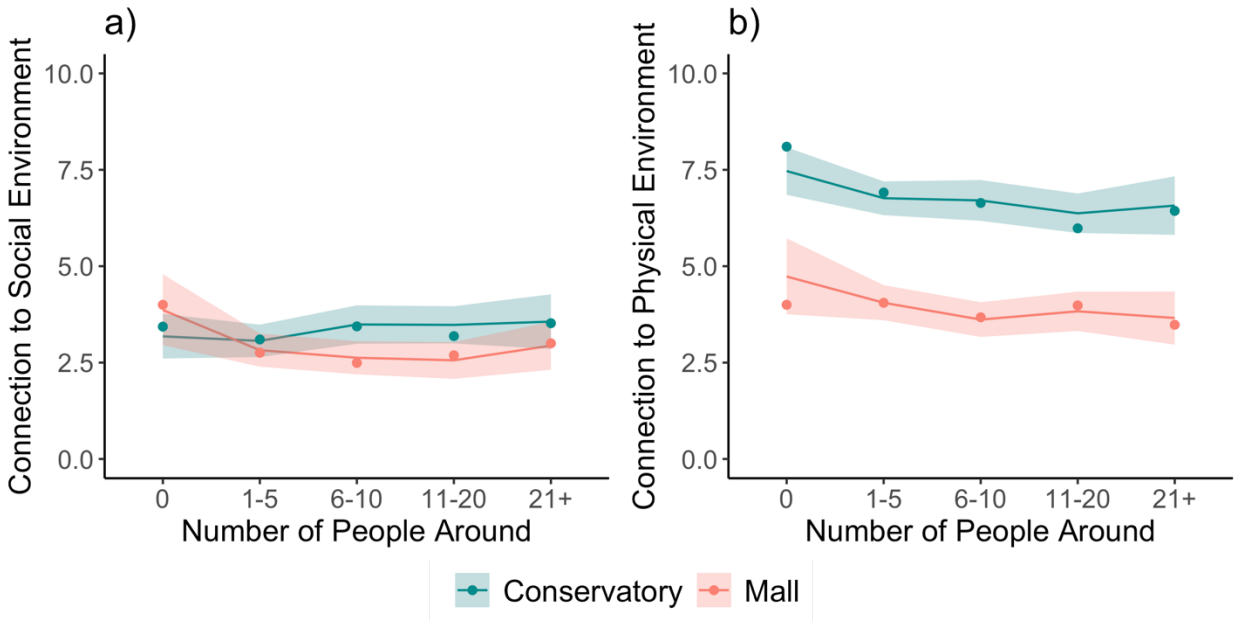


Supplemental Figure A5. Observed and modeled ratings for a) feelings of closeness to people in the surroundings and b) people around the world, as related to the number of people in sight at time of survey. Points are mean observed ratings from the raw data. The fitted line is the linear model's predicted estimate. The shaded area represents the 89th percentile interval of the posterior distribution.

Feelings of connection to the social environment showed no main effect of number of people around but had an interaction between condition and number of people around, such that connection to the social environment was higher in the mall than conservatory when there were no people in sight but dropped to be lower than the conservatory with any number of people around (Supplemental Figure 6). For example, connection to the social environment when there were 21 or more people around was rated 0.92 (89% PI [-0.1, 1.96]) points lower than when there was no one in sight at the mall. See Supplemental Table A8 for full model.

There was a main effect of number of people around on feelings of connection to the physical environment (Supplemental Figure A6), but this did not interact with condition. Participants reported less connected to the physical environment when there were more people in their surroundings in both environments. For example, connection to the physical environment

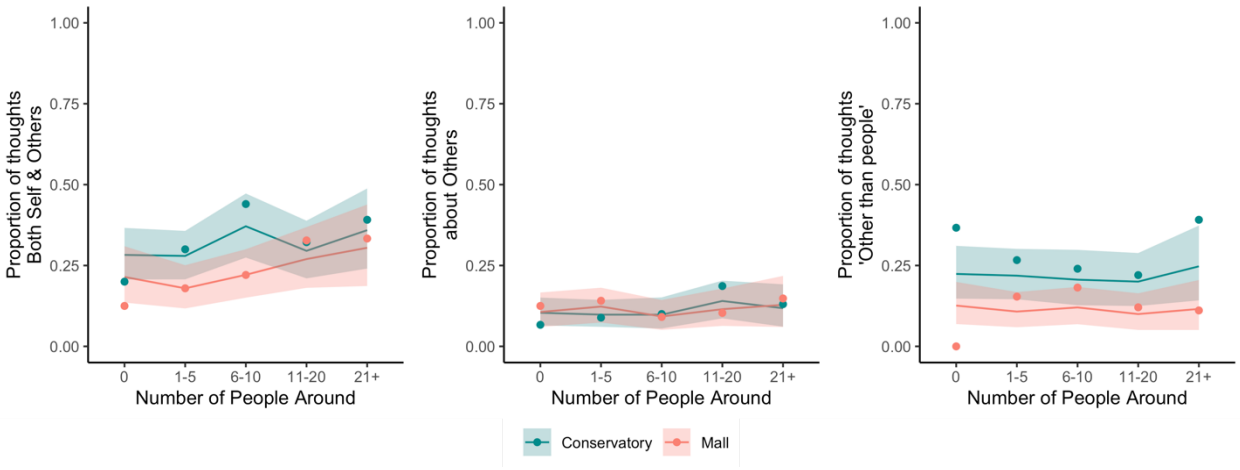
when surrounded by 21 or people was 1.08 (89% PI [-0.05, 2.22]) points lower than when there was no one in sight at the mall, and 0.90 (89% PI [-0.01, 1.80]) points lower in the conservatory. See Supplemental Table A8 for full model.



Supplemental Figure A6. Observed and modeled ratings for feelings of connection to the physical and social environment, as related to the number of people in sight at time of survey. Points are mean observed ratings from the raw data. The fitted line is the linear model's predicted estimate. The shaded area represents the 89th percentile interval of the posterior distribution.

Supplemental Table A6. Associations with Number of People Around for Self vs Other focused thoughts

	Self		**Not People**		**Self & Others**		**Other People**	
Predictors	*Odds Ratios*	*CI (89%)*	*Odds Ratios*	*CI (89%)*	*Odds Ratios*	*CI (89%)*	*Odds Ratios*	*CI (89%)*
Intercept	0.61	0.29 – 1.07	0.29	0.17 – 0.45	0.40	0.26 – 0.58	0.12	0.07 – 0.18
Mall	5.63	1.56 – 13.27	0.51	0.30 – 0.77	0.71	0.44 – 1.05	1.06	0.63 – 1.63
1-5 People	0.95	0.41 – 1.78	1.02	0.59 – 1.59	1.03	0.62 – 1.55	0.99	0.55 – 1.58
6-10 People	0.45	0.17 – 0.91	0.94	0.53 – 1.51	1.57	0.93 – 2.43	0.98	0.52 – 1.62
11-20 People	0.68	0.26 – 1.35	0.91	0.51 – 1.46	1.11	0.65 – 1.73	1.49	0.83 – 2.40
21+ People	0.19	0.04 – 0.46	1.20	0.62 – 2.01	1.50	0.82 – 2.45	1.21	0.61 – 2.05
Mall:1-5 People	0.69	0.16 – 1.71	0.92	0.48 – 1.55	0.86	0.47 – 1.41	1.37	0.70 – 2.31
Mall:6-10 People	1.46	0.32 – 3.71	1.15	0.59 – 1.94	0.74	0.40 – 1.22	1.00	0.50 – 1.73
Mall:11-20 People	0.84	0.18 – 2.13	0.95	0.47 – 1.65	1.37	0.73 – 2.24	0.84	0.41 – 1.44
Mall:21+ People	2.92	0.42 – 8.43	0.85	0.39 – 1.53	1.23	0.60 – 2.14	1.17	0.55 – 2.09
Random Effects								
σ^2	3.29		3.29		3.29		3.29	
τ_{00}	0.93 $_{intakeID}$		1.57 $_{intakeID}$		0.53 $_{intakeID}$		0.15 $_{intakeID}$	
N	85 $_{intakeID}$		85 $_{intakeID}$		85 $_{intakeID}$		85 $_{intakeID}$	
Observations	500		500		500		500	



Supplemental Figure A7. Observed and modeled selection of thoughts focused on both self and others (left), just other people (center) and things other than people (right), as related to the number of people in sight. Points are observed probabilities from the raw data. The fitted line is the logistic regression model's predicted estimate. The shaded area represents the 89th percentile interval of the posterior distribution.

Supplemental Table A7. Associations with Number of People Around for Closeness to Other Groups of People

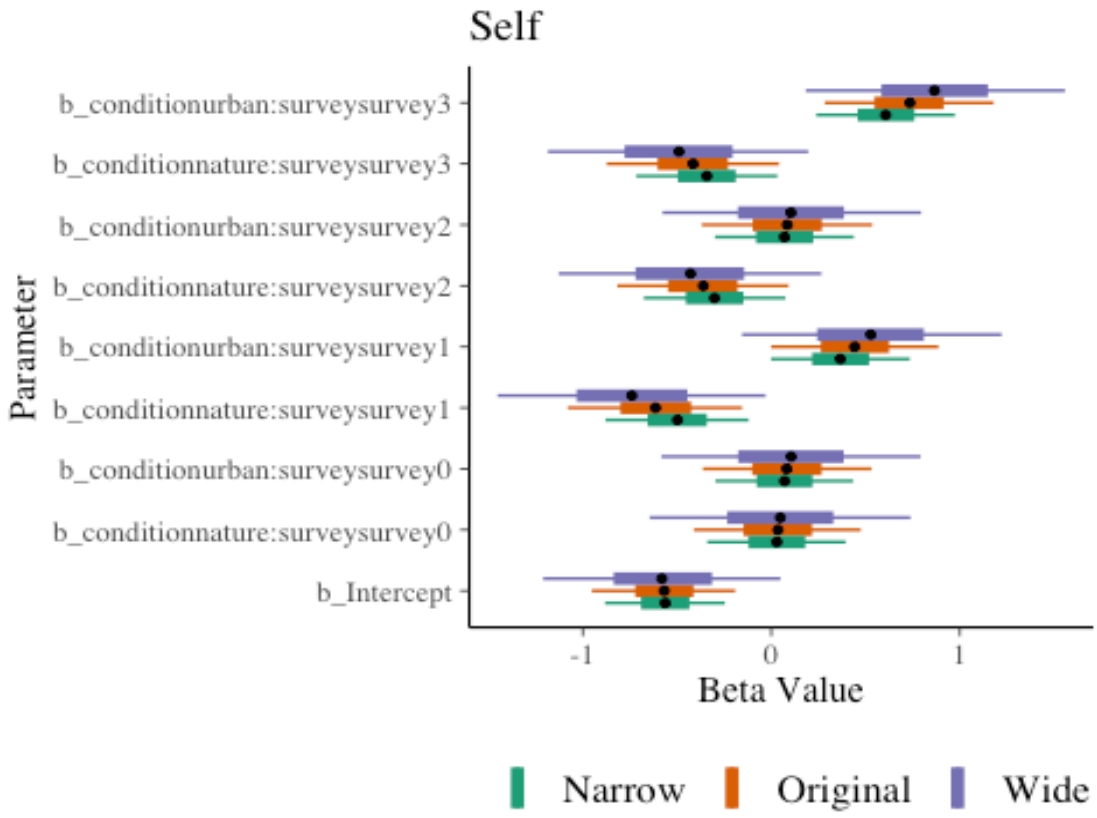
	People Nearby		People Around the World		Family & Friends	
Predictors	*Estimates*	*CI (89%)*	*Estimates*	*CI (89%)*	*Estimates*	*CI (89%)*
Intercept	2.92	2.35 – 3.49	3.59	3.04 – 4.15	6.00	5.37 – 6.65
Mall	0.35	-0.54 – 1.24	-1.59	-2.41 – -0.77	0.22	-0.71 – 1.15
1-5 People	0.66	0.08 – 1.24	-0.34	-0.85 – 0.18	0.47	-0.15 – 1.07
6-10 People	0.99	0.34 – 1.64	0.01	-0.57 – 0.58	0.19	-0.50 – 0.86
11-20 People	0.76	0.11 – 1.41	-0.83	-1.42 – -0.25	0.35	-0.34 – 1.03
21+ People	0.87	0.07 – 1.68	0.09	-0.64 – 0.82	0.24	-0.62 – 1.11
Mall:1-5 People	-1.06	-2.04 – -0.07	0.58	-0.34 – 1.48	-0.89	-1.91 – 0.15
Mall:6-10 People	-1.57	-2.57 – -0.57	0.34	-0.59 – 1.26	-0.65	-1.69 – 0.40
Mall:11-20 People	-1.63	-2.64 – -0.60	1.12	0.18 – 2.04	-0.48	-1.53 – 0.58
Mall:21+ People	-1.25	-2.42 – -0.07	0.18	-0.90 – 1.26	-0.35	-1.57 – 0.87
Random Effects						
σ^2	2.85		2.23		3.19	
τ_{00}	2.62 $_{\text{intakeID}}$		3.49 $_{\text{intakeID}}$		4.84 $_{\text{intakeID}}$	
N	85 $_{\text{intakeID}}$		85 $_{\text{intakeID}}$		85 $_{\text{intakeID}}$	
Observations	500		500		500	

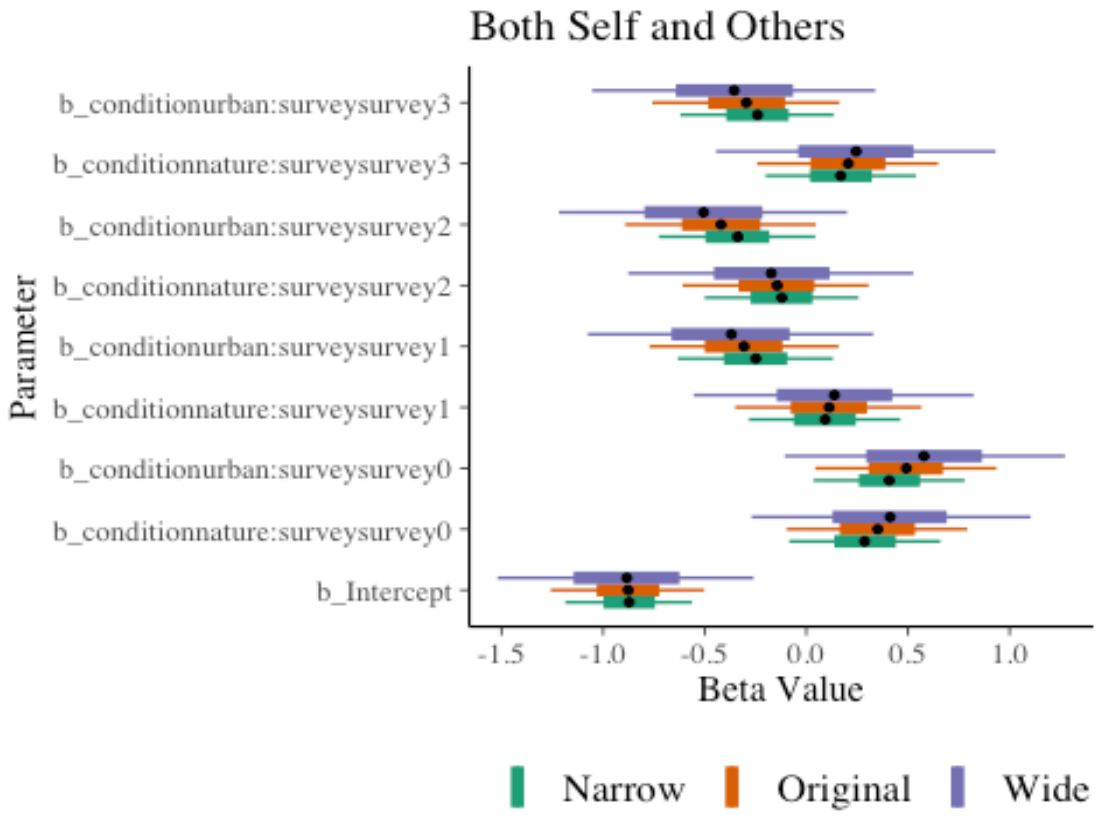
Supplemental Table A8. Associations with Number of People Around for Connection to Environment

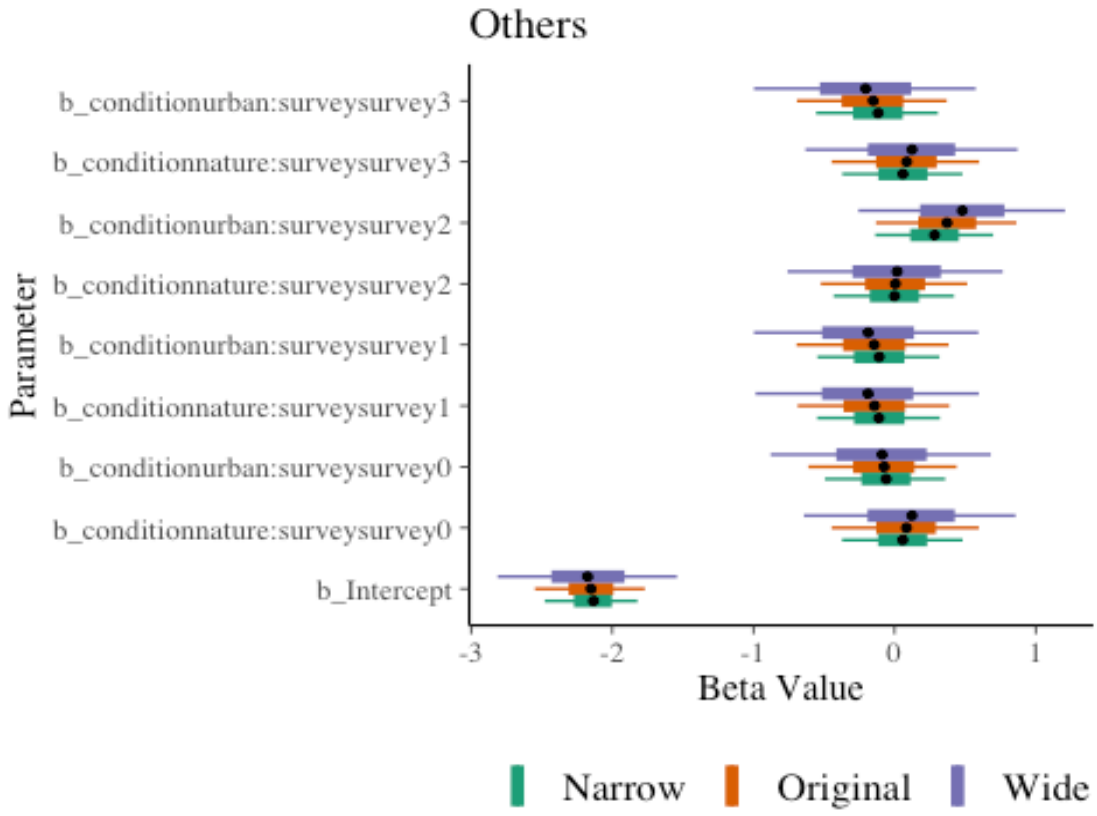
	Physical Environment		Social Environment	
Predictors	*Estimates*	*CI (89%)*	*Estimates*	*CI (89%)*
Intercept	7.47	6.85 – 8.08	3.18	2.61 – 3.76
Mall	-2.74	-3.70 – -1.75	0.68	-0.21 – 1.59
1-5 People	-0.70	-1.35 – -0.05	-0.12	-0.72 – 0.48
6-10 People	-0.76	-1.49 – -0.03	0.31	-0.36 – 0.97
11-20 People	-1.10	-1.82 – -0.37	0.30	-0.37 – 0.96
21+ People	-0.90	-1.80 – 0.01	0.38	-0.45 – 1.21
Mall:1-5 People	0.02	-1.06 – 1.09	-0.92	-1.92 – 0.08
Mall:6-10 People	-0.35	-1.47 – 0.75	-1.55	-2.57 – -0.53
Mall:11-20 People	0.19	-0.93 – 1.31	-1.60	-2.64 – -0.58
Mall:21+ People	-0.18	-1.47 – 1.11	-1.31	-2.51 – -0.12
Random Effects				
σ^2	3.95		3.02	
τ_{00}	2.11 $_{intakeID}$		2.48 $_{intakeID}$	
N	85 $_{intakeID}$		85 $_{intakeID}$	
Observations	500		500	

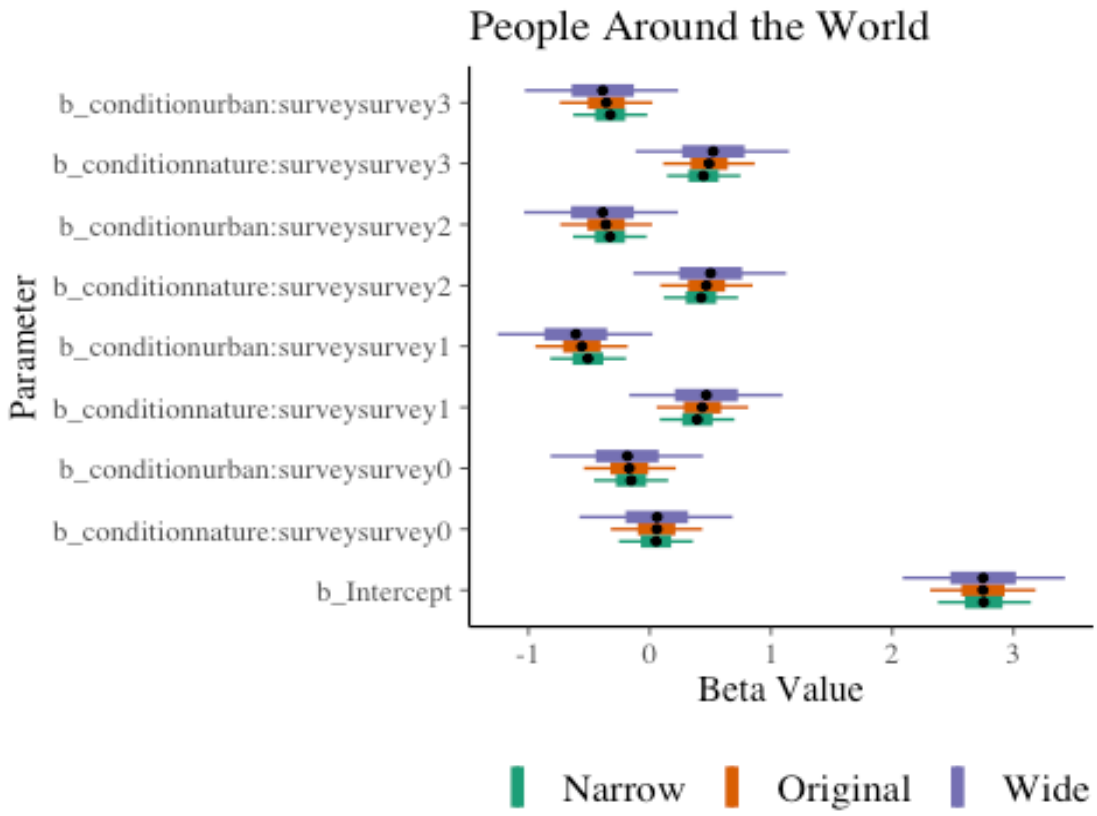
Sensitivity Analyses for Choice of Priors

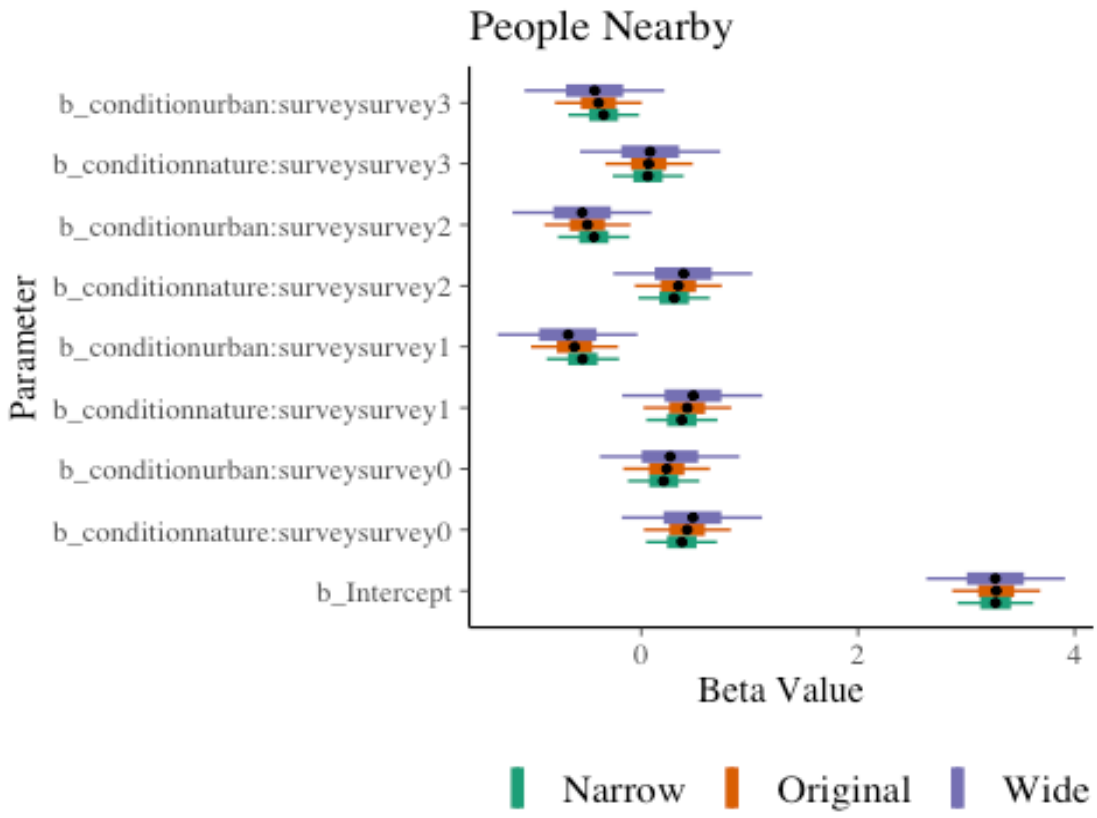
A Bayesian sensitivity analysis tests the robustness of one's results against the choice of priors. To do this, we re-ran our main models with both wider (Normal(0,1)) and narrower (Normal(0, 0.35) regularizing priors to examine how the estimates of our parameters changed. The figures below show how the beta estimates changed based on the choice of priors. While the exact (i.e., point) estimates are slightly larger for the wide priors and smaller for the narrow priors, the credible intervals are similar across all of the models.

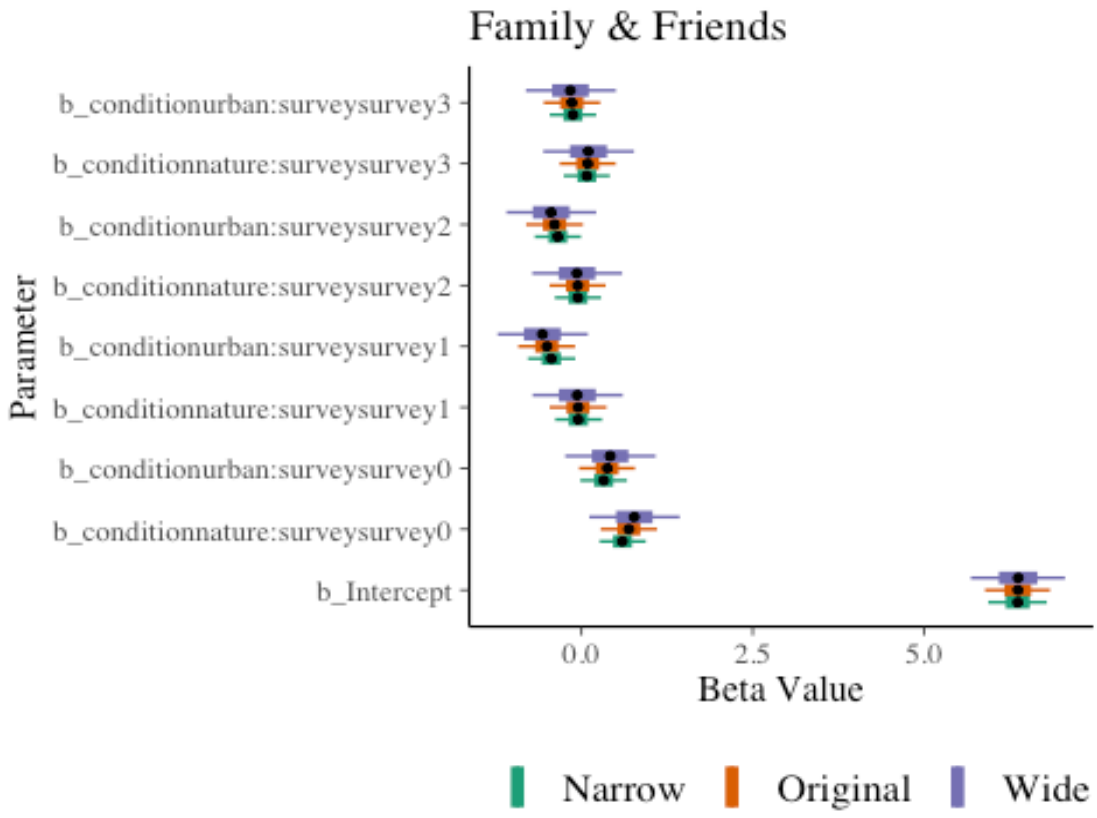

Self
b_conditionurban:surveysurvey3
b_conditionnature:surveysurvey3
b_conditionurban:surveysurvey2
b_conditionnature:surveysurvey2
b_conditionurban:surveysurvey1
b_conditionnature:surveysurvey1
b_conditionurban:surveysurvey0
b_conditionnature:surveysurvey0
b_Intercept
Parameter
-1
0
1
Beta Value
Narrow
Original
Wide

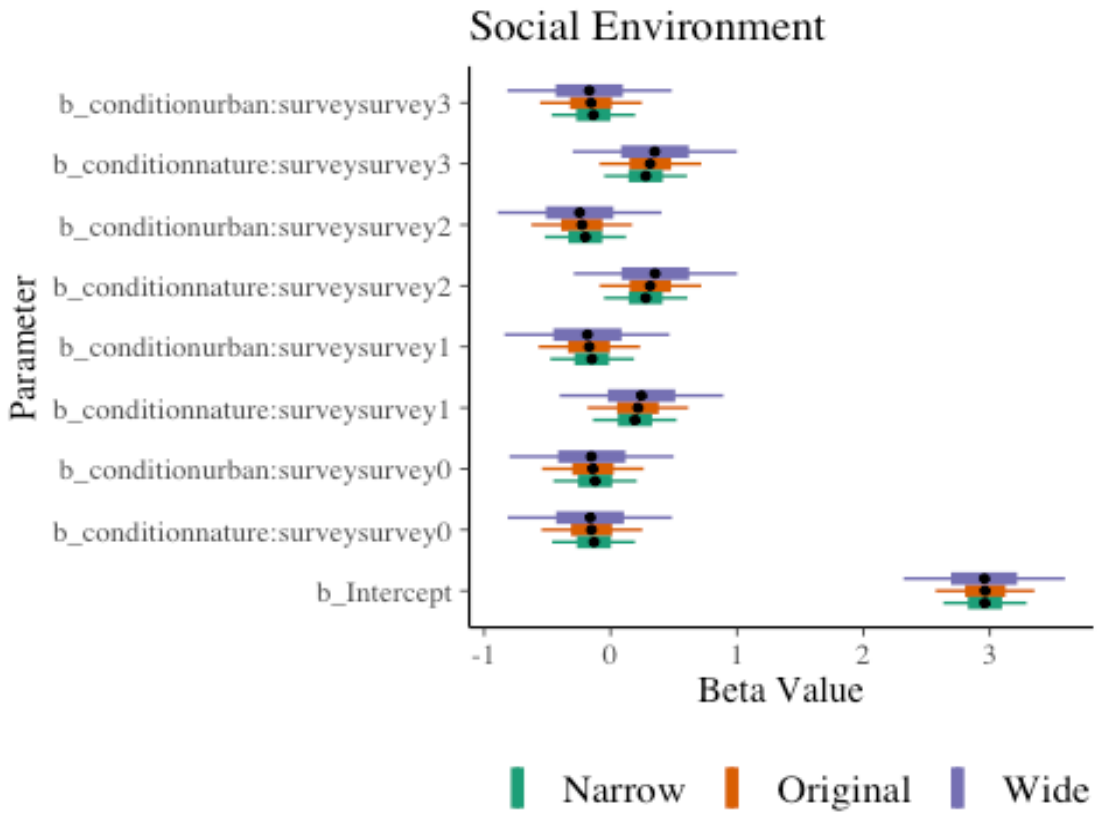

Both Self and Others
b_conditionurban:surveysurvey3
b_conditionnature:surveysurvey3
b_conditionurban:surveysurvey2
b_conditionnature:surveysurvey2
b_conditionurban:surveysurvey1
b_conditionnature:surveysurvey1
b_conditionurban:surveysurvey0
b_conditionnature:surveysurvey0
b_Intercept
Parameter
-1.5
-1.0
-0.5
0.0
0.5
1.0
Beta Value
Narrow
Original
Wide

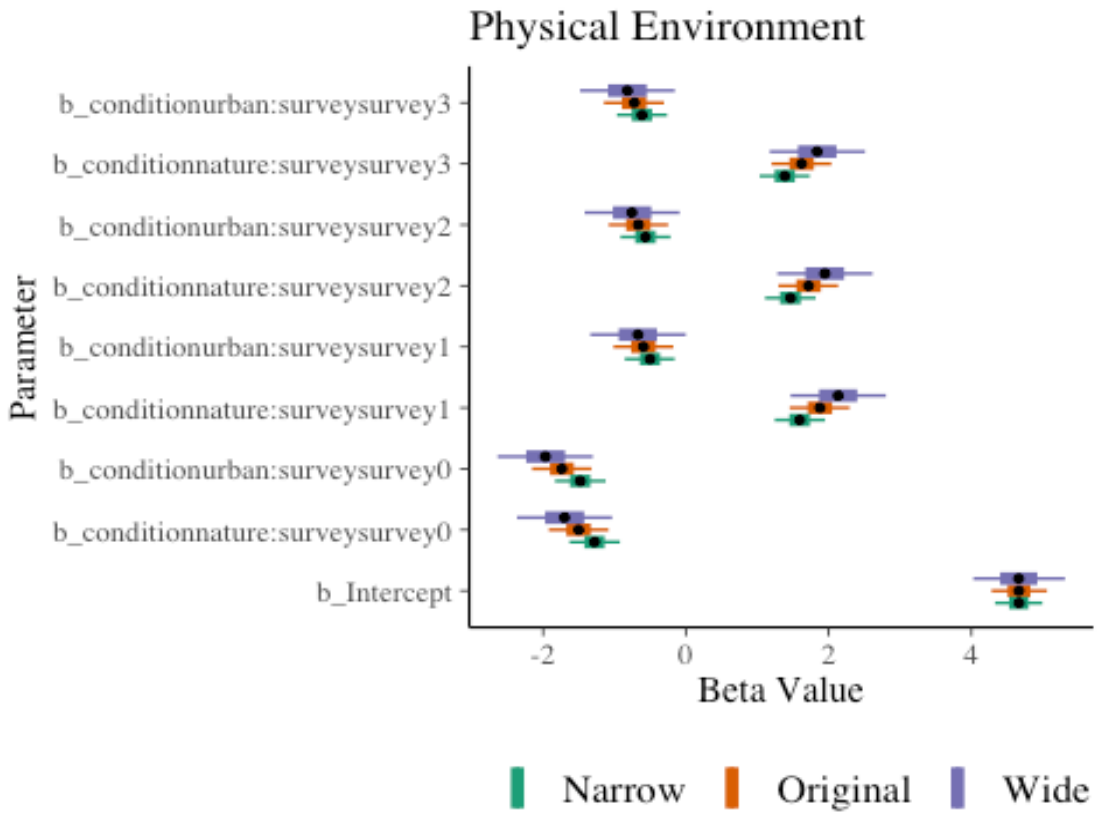

Others
b_conditionurban:surveysurvey3
b_conditionnature:surveysurvey3
b_conditionurban:surveysurvey2
b_conditionnature:surveysurvey2
b_conditionurban:surveysurvey1
b_conditionnature:surveysurvey1
b_conditionurban:surveysurvey0
b_conditionnature:surveysurvey0
b_Intercept
Parameter
-3
-2
-1
0
1
Beta Value
Narrow
Original
Wide

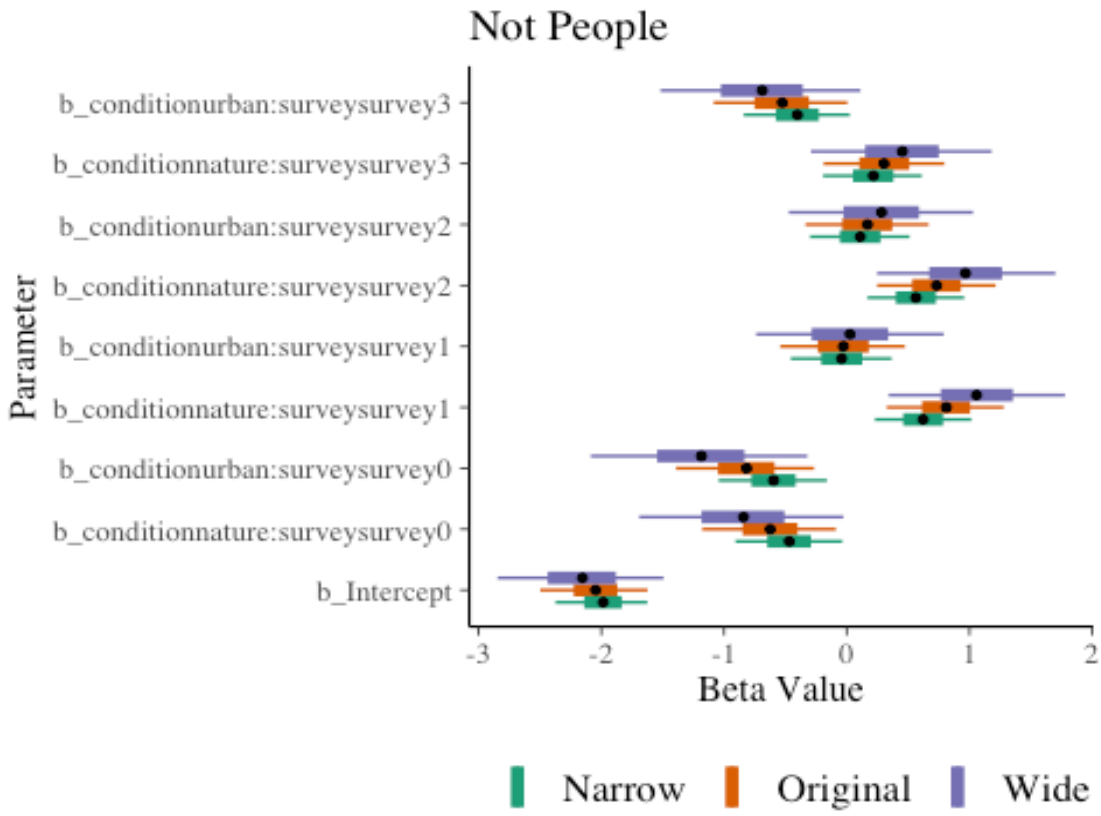

People Around the World
b_conditionurban:surveysurvey3
b_conditionnature:surveysurvey3
b_conditionurban:surveysurvey2
b_conditionnature:surveysurvey2
b_conditionurban:surveysurvey1
b_conditionnature:surveysurvey1
b_conditionurban:surveysurvey0
b_conditionnature:surveysurvey0
b_Intercept
Parameter
-1
0
1
2
3
Beta Value
Narrow
Original
Wide


People Nearby
b_conditionurban:surveysurvey3
b_conditionnature:surveysurvey3
b_conditionurban:surveysurvey2
b_conditionnature:surveysurvey2
b_conditionurban:surveysurvey1
b_conditionnature:surveysurvey1
b_conditionurban:surveysurvey0
b_conditionnature:surveysurvey0
b_Intercept
Parameter
0
2
4
Beta Value
Narrow
Original
Wide


Family & Friends
b_conditionurban:surveysurvey3
b_conditionnature:surveysurvey3
b_conditionurban:surveysurvey2
b_conditionnature:surveysurvey2
b_conditionurban:surveysurvey1
b_conditionnature:surveysurvey1
b_conditionurban:surveysurvey0
b_conditionnature:surveysurvey0
b_Intercept
Parameter
0.0
2.5
5.0
Beta Value
Narrow
Original
Wide


Social Environment
b_conditionurban:surveysurvey3
b_conditionnature:surveysurvey3
b_conditionurban:surveysurvey2
b_conditionnature:surveysurvey2
b_conditionurban:surveysurvey1
b_conditionnature:surveysurvey1
b_conditionurban:surveysurvey0
b_conditionnature:surveysurvey0
b_Intercept
Parameter
-1
0
1
2
3
Beta Value
Narrow
Original
Wide


Physical Environment
b_conditionurban:surveysurvey3
b_conditionnature:surveysurvey3
b_conditionurban:surveysurvey2
b_conditionnature:surveysurvey2
b_conditionurban:surveysurvey1
b_conditionnature:surveysurvey1
b_conditionurban:surveysurvey0
b_conditionnature:surveysurvey0
b_Intercept
Parameter
-2
0
2
4
Beta Value
Narrow
Original
Wide


Not People
b_conditionurban:surveysurvey3
b_conditionnature:surveysurvey3
b_conditionurban:surveysurvey2
b_conditionnature:surveysurvey2
b_conditionurban:surveysurvey1
b_conditionnature:surveysurvey1
b_conditionurban:surveysurvey0
b_conditionnature:surveysurvey0
b_Intercept
Parameter
-3
-2
-1
0
1
2
Beta Value
Narrow
Original
Wide

Appendix B

Supplementary Materials for Study 2

Data QA Checks & Exclusion Criteria

A series of data quality checks were performed at the end of the study period to ensure the validity of the surveys.

Background (Baseline) Survey

In the baseline survey, we checked for duplicate IP addresses to ensure that we did not have the same individuals participating multiple times and we checked to see if the IP addresses were outside of Chicago. If duplicate IP addresses or outside of Chicago IP addresses were found, other data were examined to check the validity of the participants, such as whether the community area and zip code provided were real areas and/or made sense (i.e. zip and community area should be related). We also checked whether the data participants provided during recruitment matched what they provided in the survey.

Park Surveys

For the Park Surveys, an R script was run to flag GPS coordinates that were not within/close to any Chicago parks as specified by the park boundaries shapefile from Chicago's open data portal. If parks were flagged, the GPS coordinates were entered into Google Maps in order to determine proximity to the park. If the GPS coordinates did not seem to reflect the park, the specific park survey data were examined to assess authenticity. This was done by examining the photo of the park participants were asked to upload at the end of the survey (making sure it was indeed a picture of that park that seemed real and not imported from online, showed the park in the correct season, and didn't show up on a cursory google search of that park). Additionally, in the case where the picture was not helpful or missing, participants' answers to what facilities

and attributes of the park they liked were cross checked to see if they overlapped with actual facilities listed on the Chicago Park District website.

Exclusion and Flagging Criteria

Some participants provided clearly fraudulent data, which was identified by several potential mechanisms: the location of one or more surveys indicated they could not have been in Chicago during the time of the study, some participants shared the same IP address as another "participant" and the identity of the participant could not be verified via recruitment (suggesting the same person filled out the survey under a different name), and some participants enrolled in the study without being sent enrollment information (again indicating it was the same person using multiple emails). Per our IRB and consent form, when fraud was detected participants would not be paid. As such, clearly fake participants were not paid and their data from these participants was discarded. These participants were not counted towards the total sample of 426 participants.

However, some participants' data had one or two red flags that indicated they were not fully compliant with the study procedures or might have provided fake data. Additionally, several participants completed park surveys for parks outside the City of Chicago. In this case, participants were flagged as potentially false and excluded from the primary analyses, but were paid for participation.

Additionally, while some participants appeared to provide real data for many study elements, but the validity of specific responses were questionable (i.e., the GPS coordinates didn't correspond with a given park location and picture didn't help verify), these particular surveys were flagged for exclusion from main analyses. Parks surveys that could not be matched to a park in Chicago city proper are not included.

Additional Data Collected During Baseline and Park Surveys not reported in this Study

There were many additional questions answered by participants that are not the focus of this manuscript. A full list of all study variables, including other tasks and surveys, are listed on the project's main OSF page (https://osf.io/pjfcd/).

Park Survey

After providing the name of the park, participants rated it on perceived cleanliness, naturalness, maintenance, safety (now), safety (at night), noisiness, cleanliness of the air, and their preference (like/dislike) for the park. They indicated whether they had visited the park before, and if so, what facilities they normally use, what activities they normally do, what activities they did at their last visit, and what was their favorite activity to do in the park. They were also asked whether they would visit again, why they would or would not, whether they came to the park to fill out the survey or whether they were coming anyway, and now that they were there, would they stay a while. They were asked whether they felt they belonged in the park or not. They were also asked to evaluate the demographic breakdown of others in the park (by gender and age). They were asked what types of social interactions they observed (e.g., people getting along or not). Restorative properties of the park were evaluated using a 4-item version of the Perceived Restoration Scale (PRS) (Berto, 2005). To assess participants' perceived restoration, they were asked how mentally fatigued and mentally refreshed they felt right now. Participants completed the D-FAW state affect questionnaire (Russell & Daniels, 2018). In addition to the adjectives used in the D-FAW (Happy, At ease, Anxious, Annoyed, Motivated, Calm, Tired, Bored, Gloomy, Active), participants rated how Impulsive, Thoughtful, Relaxed, Energized, Irritable, and Compassionate they felt. These adjectives were included based on several theories of how greenspaces may reduce impulsivity ("Impulsive") (Schertz et al., 2022), increase reflection

("Thoughtful"), reduce stress and induce relaxation ("Relaxed") (Ulrich et al., 1991), increase subjective vitality ("Energized") (Ryan et al., 2010), and improve social interactions, potentially by decreasing anger ("Irritable") and increasing prosocial orientations ("Compassionate")(Passmore & Holder, 2017).

Additionally, biodiversity of the park was evaluated using a short version of the scale developed by (Fuller et al., 2007). Lastly, participants were asked to take a photo of the park at the end of the survey. This was used to check that participants were indeed in the park (see QA procedures) and, as many parks are large and have distinct areas, to determine what participants were seeing as they filled out the survey.

Background Survey

Participants also completed a series of questions that assess economic disadvantage (ability to afford food and other essentials such as rent, power, healthcare, etc.), migrant status and experiences (if applicable), and perceptions of their neighborhood. Perceived neighborhood quality and belonging and was evaluated using a subset of questions from the CHART project (Chicago Health and Activity in Real-Time (CHART) | NORC.org) and from the MIDUS project (Brim et al., 1999). Participants were also asked about their typical use (if applicable) of Chicago parks. They were asked "How often do you visit parks in Chicago?", "What kind of activities do you normally go to parks for?" and "What facilities do you care about when you visit parks?". They were also asked about exposure to excessive heat, physical symptoms experienced from heat, and heat adaptation strategies in a series of questions that were adapted from Hayden et al. (2011). Participants also completed the Kirby Delayed Discounting Task (Kirby et al., 1999).

Supplemental Table B1. Association between Naturalness and Connectedness

	Nearby People		**Physical Environment**	
Predictors	*Estimates*	*CI (89%)*	*Estimates*	*CI (89%)*
Intercept	2.58	2.30 – 2.85	2.71	2.50 – 2.93
Naturalness	0.19	0.14 – 0.24	0.42	0.38 – 0.47
Random Effects				
σ^2	1.87		1.71	
τ_{00}	1.67 $_{\text{UniqueID}}$		0.74 $_{\text{UniqueID}}$	
N	300 $_{\text{UniqueID}}$		303 $_{\text{UniqueID}}$	
Observations	1120		1235	

Alternative Model Robustness Checks

Supplemental Table B2. Association between Naturalness and Connectedness (Model w/ Random Intercept for Park)

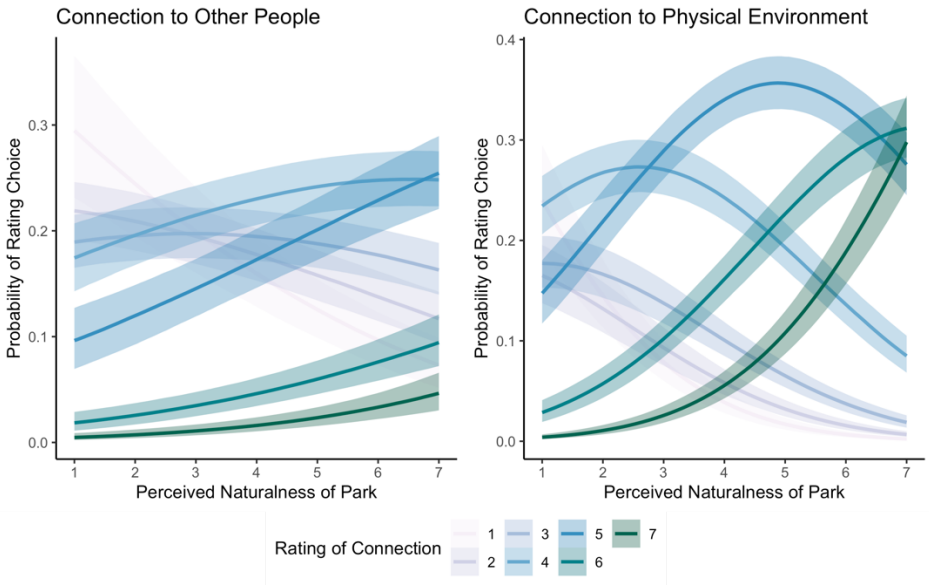
	Nearby People		Physical Environment	
Predictors	*Estimates*	*CI (89%)*	*Estimates*	*CI (89%)*
Intercept	2.50	2.22 – 2.78	2.70	2.47 – 2.92
Naturalness	0.20	0.15 – 0.25	0.42	0.37 – 0.46
Random Effects				
σ^2	1.71		1.57	
τ_{00}	0.17 $_{\text{ParkName}}$		0.15 $_{\text{ParkName}}$	
	1.62 $_{\text{UniqueID}}$		0.72 $_{\text{UniqueID}}$	
N	300 $_{\text{UniqueID}}$		303 $_{\text{UniqueID}}$	
	403 $_{\text{ParkName}}$		443 $_{\text{ParkName}}$	
Observations	1120		1235	

Supplemental Table B1. Association between Naturalness and Connectedness (Model w/ Random Slopes)

	Nearby People		Physical Environment	
Predictors	*Estimates*	*CI (89%)*	*Estimates*	*CI (89%)*
Intercept	2.52	2.25 – 2.79	2.71	2.44 – 2.97
Naturalness	0.20	0.15 – 0.26	0.42	0.37 – 0.48
Random Effects				
σ^2	1.83		1.50	
τ_{00}	1.33 $_{\text{UniqueID}}$		2.80 $_{\text{UniqueID}}$	
τ_{11}	0.03 $_{\text{UniqueID.Naturalness}}$		0.10 $_{\text{UniqueID.Naturalness}}$	
N	300 $_{\text{UniqueID}}$		303 $_{\text{UniqueID}}$	
Observations	1120		1235	

Supplemental Table B4. Association between Naturalness and Connectedness (Model w/ Ordered Categorical Outcome)

	Nearby People		Physical Environment	
Predictors	*Odds Ratios*	*CI (89%)*	*Odds Ratios*	*CI (89%)*
Intercept[1]	0.69	0.54 – 0.85	0.71	0.58 – 0.85
Intercept[2]	1.22	0.97 – 1.52	1.13	0.93 – 1.36
Intercept[3]	2.02	1.61 – 2.51	1.78	1.47 – 2.13
Intercept[4]	3.82	3.02 – 4.77	3.59	2.93 – 4.32
Intercept[5]	8.63	6.71 – 10.92	9.09	7.33 – 11.05
Intercept[6]	15.87	12.15 – 20.26	20.50	16.21 – 25.24
Naturalness	1.17	1.12 – 1.22	1.43	1.37 – 1.48
Random Effects				
σ^2	1.34		0.68	
τ_{00}	2.45		2.33	
N	300 $_{\text{UniqueID}}$		303 $_{\text{UniqueID}}$	
Observations	1120		1235	



Supplemental Figure B1. Predicted Model Estimates when treating Connectedness as an ordered categorical dependent variable.

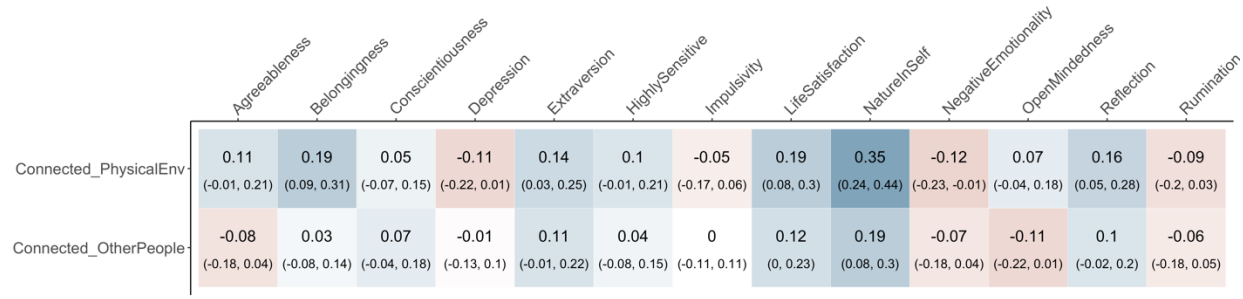


Figure B2. Correlations between personality variables and connection to others and the physical environment. Positive correlations are shown in blue and negative correlations are shown in red. 89% confidence intervals are shown in paratheses.

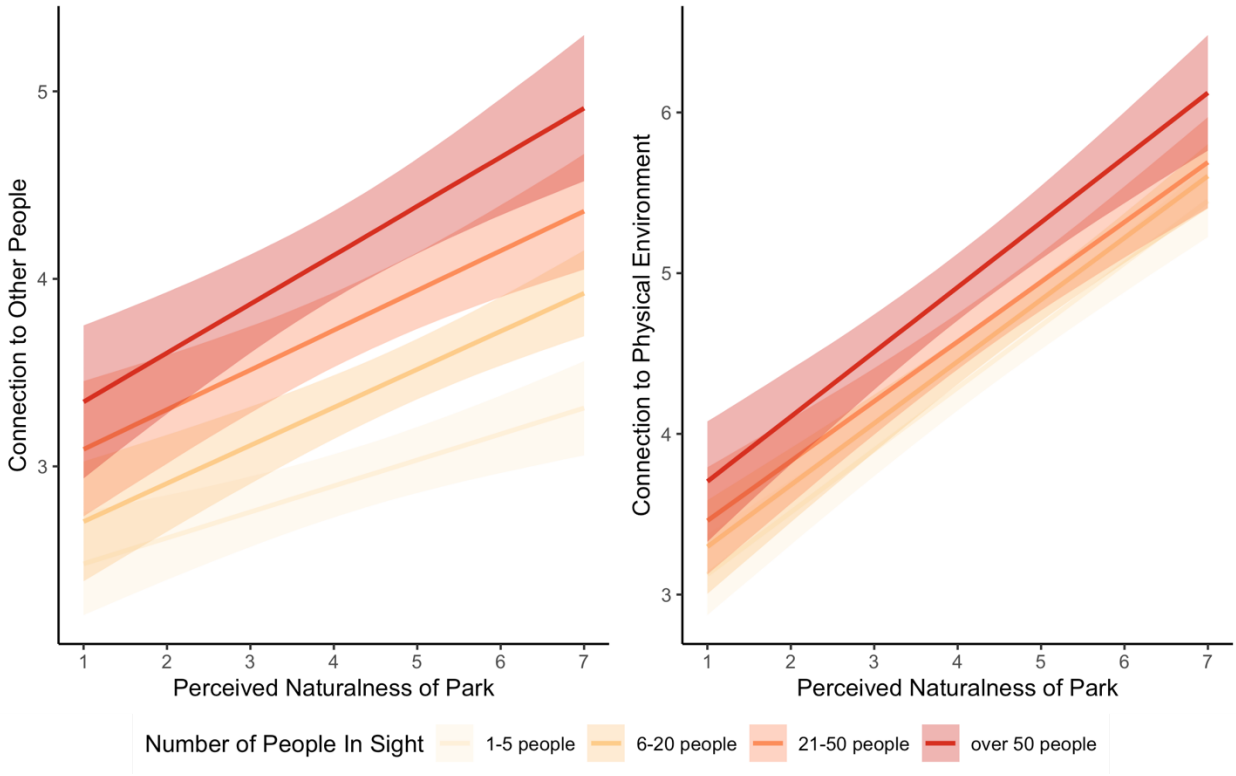
Supplemental Table B5. Cronbach's alphas for composite trait measures

Measure	Alpha	95% CI
Life Satisfaction	.86	[.84, .88]
Extraversion	.72	[.68, .76]
Agreeableness	.70	[.66, .75]
Conscientiousness	.80	[.77, .83]
Negative Emotionality	.80	[.77, .83]
Open Mindedness	.69	[.65, .74]
Rumination	.91	[.89, .92]
Reflection	.87	[.85, .89]
Impulsivity	.83	[.80, .85]
Highly Sensitive Person	.88	[.86, .89]
Belongingness	.93	[.91, .94]
Depression	.87	[.85, .89]

Supplemental Table B6. Interaction between Naturalness and Number of People In Sight

	Nearby People		**Physical Environment**	
Predictors	*Estimates*	*CI (89%)*	*Estimates*	*CI (89%)*
Intercept	2.34	2.01 – 2.67	2.74	2.43 – 3.04
Naturalness	0.14	0.07 – 0.21	0.39	0.32 – 0.45
6-20 People Around	0.16	-0.26 – 0.58	0.18	-0.23 – 0.58
21-50 People Around	0.54	0.08 – 1.00	0.35	-0.09 – 0.80
Over 50 People Around	0.74	0.24 – 1.24	0.56	0.08 – 1.05
Naturalness: 6-20 People Around	0.06	-0.02 – 0.15	-0.00	-0.09 – 0.08
Naturalness: 21-50 People Around	0.07	-0.03 – 0.17	-0.02	-0.11 – 0.08
Naturalness: Over 50 People Around	0.12	0.01 – 0.24	0.02	-0.09 – 0.12
Random Effects				
σ^2	1.75		1.65	
τ_{00}	1.51 $_{\text{UniqueID}}$		0.69 $_{\text{UniqueID}}$	
N	300 $_{\text{UniqueID}}$		300 $_{\text{UniqueID}}$	
Observations	1120		1120	

Unlike in Study 1, we did not see an interaction here between naturalness and number of people in sight for either feelings of connection to other people or the physical environment; see Supplemental Figure BX for a visual representation of the models.



Supplemental Figure B3. Model estimates for the interaction between number of people in sight and perceived naturalness on feelings of connection to other people (left) and the physical environment (right).

Sensitivity Analyses for Choice of Priors

A Bayesian sensitivity analysis tests the robustness of one's results against the choice of priors. To do this, we re-ran our main models with both wider (Normal(0,1)) and narrower (Normal(0, 0.35) regularizing priors to examine how the estimates of our parameters changed. The figures below show how the beta estimates changed based on the choice of priors. We do not observe a change in point estimates or credible intervals based on the priors used.