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Seeing Community for the Trees: Links Between Contact with Natural Environments, Community Cohesion, and Crime

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Abstract

Individuals may be losing touch with nature as their contact with it decreases worldwide. While the consequences for people's personal well-being outcomes are becoming well documented, there is almost no research examining the social correlates of contact with nature. This paper used a large nationally representative sample to link objective (% greenspace) and subjective measurements of contact with nature, community cohesion, and local crime incidence. The perceived quality, views, and amount of time spent in nature were linked to more community cohesion, and in turn the perception of cohesive communities enhances individual well-being outcomes and contributions back to society through higher workplace productivity and environmentally responsible behaviors. Findings also indicated that local nature was linked to lower crime both directly and indirectly through its effects on community cohesion.

Keywords: Nature, well-being, community cohesion, crime, SDT

Seeing Community for the Trees: Links Between Contact with Natural Environments, Community Cohesion, and Crime

Rapid population growth and expanding infrastructure has transformed over half of the Earth's land surface (Hooke & Martin-Duque, 2012). The result is that human contact with nature has declined considerably as people become more urbanized, spend leisure time indoors with technological forms of entertainment, and read children's stories with increasingly urbanized backgrounds (Pew, 2012; Roberts & Foehr, 2008). Recent estimates put 70% of Europeans and half of people worldwide in urban areas, with figures expected to rise in coming years (United Nations, 2009). Theorists have proposed that this trend may be moving individuals toward poorer ties with others and less cohesive societies (Forrest & Kearns, 2001).

A large and growing number of empirical studies provide evidence that contact with nature increases positive emotions (e.g., Tarrant, 1996; Hartig, Evans, Jamner, Davis & Garling, 2003; White et al., 2010), and contributes to physical health (e.g., Hartig, Evans, Jamner, Davis & Garling, 2003; Leather, Pyrgas, Beale, & Lawrence, 1998; Maas, Verheij, Groenewegen, de Vries, & Spreeuwenberg, 2006) and life satisfaction (e.g., Kaplan, 1995; Vemuri & Costanza, 2006), among many other indicators of health and well-being. In addition, people actively seek out nature in order to relax (Chiesura, 2004), sometimes traveling relatively long distances in order to reach natural areas (e.g., Scrinzi et al., 1995). Indeed, a growing field of psychotherapy termed 'adventure therapy' uses contact with nature as part of a larger therapeutic technique, or sometimes as the therapeutic technique itself (e.g., Duncan, Segal, Harper, 2010; Hattie, Marsh, Neill, & Richards, 1997); basic research and clinical applications suggest a non-trivial link between nature and wellness. In addition to these direct effects, nature can act as a buffer against the negative subjective and physiological correlates of stress (e.g., Fuller et al., 2007; Ulrich et al., 1991). Further

research indicates that these positive effects may occur because nature exposure fosters a sense of vitality that is central to well-being and supports coping (Ryan, Weinstein, Bernstein, Brown, & Gagné, 2010). These health benefits are robust enough that living in natural environments may reduce mortality risk and reduce socioeconomic inequalities (Mitchell & Popham, 2008).

Though a considerable literature exists on these individual well-being outcomes of contact with nature, little is known about its *social* consequences. Central to this research is the idea that contact with nature might enhance the quality of social and community interactions because it promotes a sense of connection with the outside world that generalizes to other people. This idea has its roots in the psychological perspective of self-determination theory (SDT: Ryan & Deci, 2000) and a complementary approach from evolutionary science, the biophilia hypothesis (Wilson, 1984; 1993). The biophilia hypothesis posits that all humans have an innate affiliation to other living organisms and organic systems such that people intrinsically connect and relate to natural environments. Later work argues that human affection, aversions, and communication are closely contingent on closeness to nature (Kellert, 2012). The biophilia hypothesis is often explained in evolutionary terms. From this perspective, our ancestors experienced day-to-day life in natural environments, and nature served as the source of food and survival (e.g., Wilson, 2007). Some point to our evolved fear of potentially harmful natural stimuli (e.g., snakes), and lack of inherent fear of potentially harmful modern-day stimuli (e.g., handguns) as further evidence that this is an evolutionarily- and biologically-based instinct (Gullone, 2000), and other research shows humans are drawn to natural environments that were conducive to survival and flourishing (Appleton, 1975; Orians, 1980). In sum, the biophilia hypothesis and supporting research suggest that immersing oneself in natural environments is an inherently satisfying activity, and one that promotes a sense of connection in people regardless of background and location.

SDT further argues that all humans have a basic and innate need for relating and connecting to others or to the world around them (Ryan & Deci, 2000; Kneezel & Emmons, 2006). Relatedness needs are often, but not exclusively, satisfied through interactions with others (Deci & Ryan, 2012). For example, research has suggested that the need for relatedness can be satisfied in the context of certain games, including those providing a mix of human- and computer-controlled characters (Przybylski, Rigby, & Ryan, 2010). More pertinent to this paper, recent work has shown individuals feel close and connected to natural environments after contact with them (Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2008; Weinstein et al., 2009). Important to our reasoning is work informed by SDT, which suggests that the more relatedness people experience, the more they will seek further relatedness; presumably, this snowball effect could result when initial sense of relatedness is satisfied by natural environments and extends to relationships with other people (Moller, Deci, & Elliot, 2010). This psychological work provides a theoretical framework for understanding why natural environments may promote relationships between people – natural spaces foster a sense of relating to the outside world which generalizes to a caring and closeness with other people.

Community Cohesion. Not surprisingly, mutual caring and feelings of connectedness in turn shape people's community interactions (Gilchrist, 2009). This paper therefore explores the idea that community cohesion and the benefits it bestows are promoted by contact with nature. There is some evidence to support this suggestion. A sense of place is closely tied into a sense of community: "when the latent bond of common interest in the place…draws people together and enables them to express common sentiments through joint action" (Wilkinson, 1991, p. 7). From this interactional perspective (Kaufman, 1959, Wilkinson, 1991) the physical space is invested with meanings that affect and are affected by the interactions of residents (see also, Theodori & Kyle, 2013); the physical structure of

space can encourage support and caring that underlie social cohesion or social capital (Patrick & Wickizer, 1995). The simple presence of natural environments can facilitate social experiences, bringing people out of their homes and offices and into communal spaces, but they only do so if natural environments are made accessible. Self-reported connectedness to nature has been linked to higher perceived empathy for others (Mayer & Frantz, 2004). In addition, qualitative interviews and observational data have indicated that natural spaces in urban areas encourage public social interactions (Dines & Cattell, 2006, Sullivan, Kuo, & DePooter, 2004). Experimental work suggests that people exposed to nature for brief experimental procedures using images or plants within a laboratory setting are more likely to give money to others in an economics game and espouse more social goals (Weinstein et al., 2009), yet no one has applied this work to understanding the links between nature and society as a function of longer-term contact. Given that brief but powerful effects observed in laboratory settings may generalize to longer-term behavioral and experiential shifts when individuals are exposed to comparable stimuli in their daily life (e.g., Anderson & Dill, 2000), it is reasonable to expect that observations of changing social behavior after brief periods of contact with nature may translate to impactful changes in social and community experiences when people are exposed to nature in their daily lives.

Crime. The strength of a community extends beyond cohesion, to the levels of crime and aggression. Higher quality community life critically involves lower incidence of crime that feed into perceptions of safety (Raphael et al., 2001). Neighborhoods high in crime are also characterized by community members' distrust, hostility, and lower perceptions of community cohesion (Greenberg, Rohe, & Williams, 1982; Sampson & Groves, 1989; Taub, Taylor, & Dunham, 1984). Furthermore, these relations between strong intra-community bonds and crime occur independent of socioeconomic factors, although these also play a big role in determining crime levels (Skogan, 1989).

Crime rates have been associated with a number of characteristics of the area, including economic deprivation and unemployment (Bursik & Grasmick, 1993; Gould et al. 2002), highly populated urban areas (Danziger, 1976), and higher temperature (Ranson, 2014). Historically, vegetated areas have been associated with greater perceptions of the possibility of crime (e.g., Nasar, 1982). However, some work suggests that more natural surroundings are negatively associated with crime, and proposed this link to be due to nature facilitating residents spending more time outdoors and monitoring their environment (Kuo & Sullivan, 2001). Importantly, these population-level data show that areas of a US city with more nature also have less crime and controls for density of apartment units, apartment vacancy rates, and building height, among other possible confounds.

Other outcomes of social cohesion: Media use, happiness, work performance, environmental concern. Increasingly, findings suggest that the community has an important role in promoting health and a sense of *happiness* (Boutilier et al., 2000; Raphael, 1999; Robert, 1999), and that social cohesion is particularly important in this respect (Wilkinson, 1991). The impact of nature on communities extends across important elements of wellness, to a number of personal reactions and daily behaviors. For example, research has shown that community cohesion increases individuals' general sense of well-being (Bramstone, Pretty, & Chipeur, 2002; Morrow et al., 1999). As social needs are satisfied people also spend less time in solitary *media-use* behaviors that offer an escape from daily life, such as watching television and spending time on the internet (Bickham et al., 2006; Katz & Foulkes, 1962; Katz, 2002); instead they may spend free time with important others. Benefits extend further into *workplace behavior*, and research shows that socially supportive contexts at home, such as community cohesion, predict better work performance (e.g., Bliese et al., 1996; Voydanoff, 2001). The benefits of community cohesion may extend beyond the social and personal sphere to *environmental concern* that benefits global environmental problems, and

research shows that, when individuals live in more cohesive societies, they are more likely to contribute with environmentally friendly behaviors (Roseland, 2000).

Present research

The present research links contact with nature and important covariates with social cohesion outcomes, and by doing so extends previous work in a number of ways. It is the first study to test social correlates of both objective (actual, coded geographic data) and subjective (self-reported) contact with nature in a systematic way. Second, we rely on a community sample randomly selected from a large cohort and weighted to be nationally representative, and therefore can make generalizations across geographic (urban vs. rural) and socioeconomic groups in the population. Third, we control for an extensive list of potential social and personal confounds (e.g., community-level and individual socioeconomic status). Finally, we explore contact as comprised of both exposure (through viewing nature) and engagement with nature (through visiting natural areas). Presumably, individuals surrounded by natural environments may derive little benefit if they perceive nature to be of low quality or inaccessible, or if they do not spend time in natural environments. In the present research we test the links between daily contact with nature around one's home and community and social outcomes. Using a nationally representative sample, we test the hypothesis that daily contact with nature around one's home and community is linked to higher levels of social cohesion and lower levels of crime, which in turn has individual well-being outcomes. Analyses were conducted using two conservative methods: because of the large number of potential predictors tested, model selection techniques (Burnham & Anderson, 2002) were used to objectively identify the most predictive and concise regression models from candidate models based on different hypotheses; this approach is less vulnerable to experimenter bias than conducting many independent analyses, while increasing power to identify key effects.

In addition, a structural equation model was constructed to concurrently assess links between nature, community cohesion, and personal outcomes.

Method

Participants and Procedure

This study was conducted using an online interview administered to participants in the 150,000-person Harris Poll panel of Great Britain. A subset of panelists (15,173) was selected at random from the base sample and was invited by email to take part in the survey; responses were accepted until the survey was closed two weeks later. Data from the weighted responding sample were collected over a 2-week period in late September 2011. This process yielded a cohort of 2079 adults (1040 men and 1039 women) ranging in age from 22 to 65 years (*M* = 43.21 years, *SD* = 11.49 years) who provided the information outlined below. Statistical weightings were performed for age, gender, race/ethnicity, education, region, and household income where necessary to bring them into line with their actual proportions in the population based on UK census data. Participant incomes ranged from less than £10,000 to over £150,000 per year (*M* income = £14,000/year, *SD* = £10,000), and came from across the UK (the areas most highly represented comprised of: South East - 15.8% of participants, London - 12.5%, Northern Ireland & Scotland - 11.1%, North West - 10%; South West - 9.6%). The online survey assessed community predictors, socioeconomic and other demographic standing, subjective contact with greenspace (used as a surrogate for nature), perceived community cohesion, and individual experiences of well-being. Means for major study variables (described individually in the section below), which are split by gender, age, income, and education, are presented in Table 1.

Materials

Primary Model Measures

Objective measure of local nature. We extracted information at the level of wards (the primary unit of UK electoral geography) on their % cover by nature, from the General Land Use Database (GLUD, Office of the Deputy Prime Minister, 2001) for England and the CORINE database the (Coordination of Information on the Environment database, or CORINE; EEA, 2000) elsewhere. Natural cover was defined very broadly to include gardens, parks, woods, meadows, and farmland, mapped to $5m^2$ resolution (Richardson & Mitchell, 2010). Vegetated areas included gardens, parks, woods, meadows, and farmland (separate sources of nature were not quantified). Databases provided a percentage of the land in a given ward that is comprised of nature.

Subjective contact with local nature. Participants reported the extent to which the *view* out of their home windows was 1 "*built-up*" to 10 "*natural"* (*M* = 5.28; *SD* = 2.58). We also measured *accessibility*: "how easy is it to get to 'nature'?" using a scale of 1 "*very difficult*" to 7 "*very easy*" (*M* = 6.13, *SD* = 1.15). To measure quality of nature, participants were asked "how do you perceive the quality of accessible nature?" with a scale from 1 "*terrible*" to 7 "*excellent*" (*M* = 5.37, *SD* = 1.25). Finally, participants reported on "how often do you visit nature" from 1 "*never visit my local nature or any other nature*" to 8 "*every day*" (*M* = 4.13, *SD* = 1.94). These items were subjected to a principal components analysis; all four loaded on a single factor with an eigenvalue of 2.07 (no loading was lower than .63). Items were averaged to create a single construct we termed "nature contact".

Community Cohesion. *Community cohesion* was thought to reflect a sense of relatedness with other people that emerged from exposure to nature (Weinstein et al., 2009). was measured with four items paired with a 5-point (1, *not at all true* to 5, *very much true*) scale, with items: "I care about other people in my neighbourhood", "I feel connected to other people in my neighbourhood", "I feel that people within my neighbourhood are on 'same team'", and "I would help my neighbours if they required 1 hour of my time". We then

calculated the mean of the four items as an overall community cohesion score; reliability was high, α = .88 (*M* = 2.87, *SD* = .98).

Crime. *Crime* statistics were extracted from the United Kingdom's National Archive Database (2012), which records frequency of 12 crimes requiring police intervention taking place over a period of one year (2011). Crimes included violence, endangering life, wounding, harassment, common assault and robbery; all were analyzed together. Crime incidence per ward ranged from 99.3 to 6691.58 for the year (α = .94, *M* number of crimes = 1294.47, *SD* = 1288.46). The most common crimes tended to be violence, criminal damage, and woundings; average occurrence above 1500). For analysis, the crime incidence was $\log_{10}$-transformed to normalize its distribution.

Criterion constructs at the individual level. *Happiness* was measured using the Positive and Negative Affect Scale (Watson, Clark, & Tellegen, 1988). Participants reported on how much they felt each of 20 adjectives reflecting general happiness, with a scale of 1 = *very slightly or not at all* to 7 = *extremely often*. Negative indicators were reversed and all items were averaged (α = .91, *M* = 3.33, *SD* = 6.05). Participants also reported, using an open-ended question, on their *media use*; the number of hours they watch television (*M* = 11.77, *SD* = 10.17) or spend time on the Internet (*M* = 12.43, *SD* = 11.68) in a given week. As well, participants responded to the question "how is your overall performance at work?" in terms of 1 "*worst performance"* to 10 "*best performance"* (*M* = 7.76, *SD* = 1.46). Finally, we measured environmental concern: "How much action do you take, typically, to preserve the environment?" with a scale ranging from 1 "*I take almost no action*" to 5 "*I take a lot of action on a daily basis*" (*M* = 2.53, *SD* = 1.16).

Community-Level Covariates

Socioeconomic (SE) deprivation. We used Indices of Deprivation produced by Communities and Local Government (CLG) to derive a socioeconomic deprivation score for

English participants, supplemented by the Scottish Index of Multiple Deprivation, the NI Multiple Deprivation Measure 2010, and the Welsh Index of Multiple Deprivation for participants outside of England. The Index of Multiple Deprivation was comprised of separate indices for separate domains of deprivation (e.g., ward-level income, employment, health deprivation and disability), which were simply averaged. Scores ranged from .93 to 82.50 (M = 21.09, SD = 14.97).

Population density. Participants were asked to provide their UK postcode data, which was coded using Geoconvert (2012), an online geography matching and conversion tool which allows analysis of UK postcode data. Based on Geoconvert statistics, postcodes were given a number indicating how rural or urban the area, ranging from 1 (*rural*) to 4 (*urban*), with a national mean of 3.67, SD = .73, as an indicator of population density. In addition, statistics on population size were compiled using data taken by the 2011 UK Census. The Census is the most complete source of information for the UK and includes quality assurance indicators (ons.gov.uk). Population size was controlled for in analyses on crime for a measurement of crime incidence as a function of population size.

Unemployment rate was derived from the Office for National Statistics (neighbourhood.statistics.gov.uk), neighbourhood statistics index based on 2011 census data. Unemployment rate was defined as the proportion of active members of the population (defined as those at working age who are seeking or available to work) who are unemployed. Rates ranged from 0% to 2.9% with a national mean of 1.44, SD = 0.49.

Weekly household wages were derived from model-based estimates for households (neighbourhood.statistics.gov.uk, Office of National Statistics). This index estimates income per household per week in pounds sterling, from data identified during the period April 2007-April 2008. This was the latest data available at this time and fitted with the time period

covered in the current study; wages ranged from £350 to £1640 per week (*M* = 669.40, *SD* = 173.05).

Individual Covariates

Socioeconomic standing (SES). Participants were asked "How financially secure do you feel?" with a scale of 1 "*not at all secure*" to 5 "*extremely secure*" (mean responding was 2.70, *SD* = 2.70), and their gross income – total 2010 household income before taxes – was included as an objective indicator of wealth. Finally, we measured education with the item: "Which of the following, if any, is the highest educational or professional qualification you have obtained?" (range from "no formal qualification" to "Masters/PhD or equivalent"). A principal components analysis showed the three scales loaded onto a single factor with an eigenvalue of 1.55 and lowest loading at .63; they were standardized and averaged to create a "socioeconomic standing" composite.

Exploratory additional covariates. We tested two potential confounds that may result from current and previous experiences linked to our primary constructs. First, we measured and control for time socializing. Participants used an open-ended format to report on the hours spent socializing face to face per week (*M* = 5.74, *SD* = 8.46); this construct was used to account for the possibility that more social individuals also reported higher perceptions that their community was cohesive. Second, we measured people's childhood contact with local nature with the question "Thinking back to when you were growing up, do you consider that you grew up in an area that was…" paired with a scale ranging from ranged from 1 ("Mostly surrounded by buildings, i.e., town or city centre") to 3 ("mostly surrounded by uncultivated natural nature (forests, mountains, natural streams, lakes)").

Results

Preliminary Descriptive Analyses

Missing data (< 10% of responses) was estimated with multiple imputations (Rubin, 1987). Preliminary Spearman rank correlations offered a first view of the relations between living conditions and contact with nature. Socioeconomic deprivation was linked to lower objective nature, locally, $\rho = -.41$, $p < .001$, and higher population density, $\rho = .28$, $p < .001$. Individuals living in socioeconomically deprived areas also reported less views of nature, $\rho = -.35$, $p < .001$, lower quality, $\rho = -.20$, $p < .001$, and accessibility, $\rho = -.17$, $p < .001$, of natural environments, and they were less likely to spend time in nature, $\rho = -.12$, $p < .001$, all indicators that comprised the were less likely to spend time in nature, calculated for primary analyses (see Table 2).

Further analyses showed that, not surprisingly, the presence of nature translated to higher perceptions that nature was available. People living in areas with high objective nature reported more views of local nature, $\rho = .51$, $p < .001$, higher quality nature, $\rho = .19$, $p < .001$, and greater accessibility to, $\rho = .13$, $p < .001$, and they spent more time in nature, $\rho = .13$, $p < .001$ (Table 1). Bonferroni corrections for these correlations set a new critical p at .002 (.05/21, across all correlations in Table 1) but all correlations remained significant even after corrections. These correlation analyses examined simple relations between our predictors of interest and community cohesion, but we then focused on more detailed analyses where we conducted controlled for potential covariates and confounds.

Model Selection for Community Cohesion and Crime

We analyzed demographic and nature predictors of community cohesion and crime using multiple regression (ordinary least squares) models within the framework of model selection based on the Akaike Information Criterion (AIC) (Burnham & Anderson, 2002). This widely used analytic approach permits an objective assessment of ideal (defined as the most concise and predictive) regression models, that is free from researcher bias (Burnham &

Anderson, 2002); it is therefore most appropriate when dealing with large number of predictors.

We first established an a priori set of models based on our own hypotheses. For community cohesion, we fitted 15 models and the null model (i.e., the model without any predictors). The 15 defined models systematically tested combinations of individual and community-level covariates and main predictors (objective + subjective contact with nature) based on theory. Thus, we tested competing hypotheses, that (1) only demographics (and not nature) were linked to community cohesion, (2) only contact with nature (and not demographics) was linked to cohesion, (3) both independently explained variance and should be taken into consideration, or (4) none of the predictors accounted for sufficient variance to justify loss of parsimony. See Table 3 for more detail on the models and hypotheses. By including objective and subjective contact with nature in separate models we allowed that each could be independently important, or, alternatively, that the importance of one supersedes the other.

For the crime incidence, we fitted three models as well as the null model. Information on the crime incidence was only available at the ward level, so we used the crime incidence of each ward as the response variable ($\log_{10}$-transformed), and included only our ward-level predictor (i.e., objective nature) and covariates (i.e., population size, population density, socioeconomic deprivation, unemployment rate, and weekly wages) in the analysis. As before, our models tested competing hypotheses that (1) only covariates were linked with crime, (2) local nature accounted for variance in crime, (3) both explained variance independently of each other, or (4) neither explained sufficient variance (also see Table 4).

From the fitted models, we selected best-fitting models using AIC, calculated with the equation: AIC = n log (residual ss/n) + 2k. We computed ΔAIC as a measure of the difference between the highest ranked model (i.e., model with the smallest AIC) and other,

competing models. For these sets of models, Akaike weights (w_i) were calculated. A given w_i can be interpreted as the expected probability of that model being the best one among the full set. Model inference was then made on all models within 95% cumulative Akaike weights (i.e., 95% confidence set of models, Johnson & Omland 2004).

Community cohesion. The model selection exercise suggested the top three models with the smallest AIC represented the 95% confidence set of models, based on the calculated Akaike weights (Table 3 presents results for all models, presented in order of goodness of fit;). Subjective contact with nature, age, gender and SES were included in all the three models and in particular, 95% confidence intervals of the estimated coefficients for subjective nature, age and SES did not overlap with zero (findings are detailed in supplemental table A), indicating that these three factors were particularly important in explaining the variation in community cohesion; see also Table 5 for detailed results of multiple regression model using robust standard errors. The positive coefficient for subjective nature suggests that the level of community cohesion is positively associated with subjective contact with local nature, independent of the effects of age and SES.

Crime. Table 4 presents all the three hypothesis-driven models and Table 5 presents findings for the best model based on AIC; the model with community covariates and objective nature was clearly the best fitting model with $w_i > 0.99$ (see also supplemental Table B for details on all models tested). In the best model, 95% confidence intervals of estimated coefficients did not overlap with zero for population size, socioeconomic deprivation, unemployment rate, weekly wages, and objective nature, indicating that these four factors were important in explaining the variation in ward-level crime incidence. The negative coefficient for objective nature suggests that wards with more objective nature are associated with lower crime incidence.

Exploratory Additional Analyses

To account for alternative explanations for the findings reported above we reanalyzed the top fitting models for community cohesion and crime. First, we ran the model predicting community cohesion controlling for two potential alternative explanations: that individuals who grew up in natural environments would select to place themselves in natural environments and would also have a greater sense of community, and that those who spend more time socializing are more likely to be outside and therefore exposed to nature, and may have a greater sense of community. Second, we reanalyzed the top fitting models for both cohesion and crime for urban and rural areas, separately.

Exploratory covariates. We found there was no link between current sense of community and childhood nature contact, $\beta = -.00$, $t(2072) = -0.20$, $p = .84$, $d = .01$, but those who spent more time socializing were more likely to report a sense of community, $\beta = .07$, $t(2072) = 3.19$, $p < .001$, $d = .14$. Controlling for these potential confounds, we found similar associations between community cohesion and contact with nature, $\beta = .28$, $t(2072) = 12.80$, $p < .001$, $d = .56$, with individual socioeconomic standing, gender and age also being retained as covariates (and together accounting for 12% of variance). Given a previous link has been identified between temperature and crime rates (Ranson, 2014) an exploratory model tested the effects of objective nature controlling for average annual temperature across England. Results showed that temperature did not account for the link identified between objective nature and crime rates (see supplemental temperature analyses for method and findings related to this analysis).

Urban and rural applications. When we re-ran the top fitting model for community cohesion separately for rural and urban respondents we found that, controlling for covariates, contact with nature was linked to more community cohesion for individuals living in both urban, $\beta = .27$, $t(1435) = 19.39$, $p < .001$, $d = 1.03$, and rural, $\beta = .27$, $t(634) = 6.84$, $p < .001$, $d = .54$ communities. An equivalent split analysis for crime incidence – again controlling for

covariates, showed no link between objective nature and crime in rural settings, $\beta = -.10$, $t(282) = -1.65$, $p = .10$, d - .21, though a link was present in urban areas, $\beta = -.13$, $t(870) = -3.84$, $p < .001$, $d = .21$.

Structural Model

To test an integrative model linking nature to community outcomes, as well as exploring the effects community has on individuals we conducted a structural equation model (Kline, 2010), simultaneously testing relations between contact with nature, community cohesion and crime, and individual outcomes (See Figure 1 for the full estimated model). From the model selection results presented above, objective local nature was expected to directly link to lower crime but not to community cohesion. We also expected that a latent factor representing contact with nature (perceived views of nature, perceived quality of nature, and time spent in nature) would directly lead to community cohesion. New to the structural equation model, we set paths to individual outcomes of cohesive communities, namely indicators of well-being: happiness and amount of time spent online and watching television (the latter of these was a negative indicator), and indicators of individual contributions back to the society: work performance, environmental action. Finally, we tested whether nature leads to lower crime *indirectly* by increasing community cohesion. To ensure these effects did not directly result from the personal (age, gender, socioeconomic status [income, education, financial security]) and social covariates (population density, socioeconomic deprivation, local wages, local unemployment) of primary interest, we controlled for these in the model.

Figure 1 presents standardized coefficients (βs) and effect sizes for these data. Results of the model showed that living in more natural areas (from objective coding) was linked to more contact with nature, $b = .02$, $t = 26.71$, $p < .001$. However, contact with nature did not, in turn, directly relate to any individual well-being indicators, though a trend indicated more

contact was linked with somewhat lower media use, $b = -.91$, $t = -1.84$, $p = .07$ (contact with nature and affect; $b = .02$, $t = 0.21$, $p = .54$; contact with nature and environmental action; $b = -.02$, $t = -0.36$, $p = .72$).

Looking at the links with crime, community-level socioeconomic status was linked to lower crime, $b = -112.85$, $t = -8.03$, $p < .001$. Controlling for this, both objective local nature, $b = -7.61$, $t = -2.35$, $p = .02$, and community cohesion, $b = -246.84$, $t = -2.40$, $p = .02$, were linked to lower crime rates in the community.

Finally, the model concurrently examined the effects of nature on community cohesion, and, indirectly, personal indicators of well-being. Findings showed personal socioeconomic status was linked to more community cohesion, $b = .80$, $t = 4.87$, $p < .001$, and that age, $b = .01$, $t = 2.95$, $p = .003$, and gender, $b = .11$, $t = 2.63$, $p = .008$, were also linked to cohesion. Similar to outcomes from regression analyses presented above, and controlling for the effects of demographics, contact with nature was linked to more community cohesion, $b = .20$, $t = 4.83$, $p < .001$. In turn, community cohesion was related to fewer hours spent on media use, $b = -.82$, $t = -3.15$, $p < .001$, higher levels of self-reported happiness, $b = .11$, $t = 8.06$, $p < .001$, greater perceptions that one is higher performing at work, $b = .22$, $t = 6.86$, $p < .001$, and higher engagement in environmental action, $b = .23$, $t = 9.06$, $p < .001$. This model provided adequate fit to the data, CFI = .88, GFI = .96, NFI = .86, RMSEA = .056; with RMSEA and GFI suggesting good fit (Hu and Bentler, 1999; Miles and Shevlin, 1998) and CFI/NFI suggesting just acceptable fit, with values > .90 (Bollen, 1989).

Discussion

A large body of research provides evidence that contact with nature provides benefits for well-being, health, and environmental consciousness (for examples see, Fuller et al., 2007; Leather et al., 1998; Mitchell & Popham, 2008; Ryan et al., 2010; Tarrant, 1996; Vining, 2003). The present work was aimed at broadening our understanding of the

consequences of contact with nature by investigating more fully the role of nature on social rather than personal outcomes, operationalized in terms of community cohesion and local crime.

Our analyses inform previous work in two ways. First, the current findings, using a quantitative approach on a nationally representative sample, support the view that the quality of contact with nature can improve social connections and the well-being of individuals. Subjective experiences of the views of nature from the home, the quality of nature, and the amount of time spent in nature, were linked to perceiving one's community as close and cohesive. Moreover, these effects were in place even when taking into account the socioeconomic standing of individuals and, separately, of their communities. Second, they indicate that increases in well-being due to contact with nature may be due in part because individuals who can contact local nature perceive more cohesive communities. These results support the idea of the broad positive effects of nature being due, at least in part, to enhancing connections with the community. This suggests that the biophilia hypothesis' claim that we are intrinsically drawn and connected to natural environments, and self-determination theory's explanation of the relatedness need and its positive effects, together provide a theoretical underpinning from which to draw greater understanding of the positive effects of nature on social interactions.

Regression models suggested that about 8% of the variance in community cohesion could be explained by subjective experiences of local nature alone (Table 5), a striking finding given individual predictors such as income, gender, age, and education together accounted for only 3% of independent variance; it appears that the role of natural spaces was robust in comparison to other constructs we would expect would influence people's experiences in society.

In documenting social benefits, these findings support and expand on empirical work showing links between nature and more generalized tendencies to prosociality (Mayer & Frantz, 2004; Weinstein et al., 2009). Finally, findings inform the community and place-attachment literatures by supporting an interactional perspective that physical space can shape relationships among community members (Patrick & Wickizer, 1995; Theodori & Kyle, 2013). Although this research offers additional evidence that natural characteristics link with perceptions of closeness, future work could usefully explore the psychological mechanisms by which this relation occurs, for example by defining the meaning that nature has to individuals (Wilkinson, 1991).

In addition, path analyses suggest social cohesion was correlated with personal outcomes that may have improved the day-to-day life of individuals: higher levels of happiness, fewer hours spent on media sources such as television or videogames, better perceived workplace performance, and more environmental action; thus social cohesion was linked to individual well-being and contribution back to society on a number of important dimensions. In fact, when accounting for the indirect effects of nature on personal outcomes through social cohesion, there was no direct path from nature to happiness, productivity, or environmental action. These results indicate that perceiving social cohesion may be an important mechanism by which nature increases well-being and the likelihood that people will contribute to their community. These findings are consistent with suggestions that a community's civic behaviors enhance productivity and wellness of its members (Putnam, 1993).

In both path analyses and model averaging, availability of objective nature local to a participant's community was linked to the level of crime in his or her community. Controlling for key demographic factors, the more nature in one's surroundings, the less crime was reported in an area. After removing variability from covariates, objective nature

accounted for 4% additional variance in crime rates (Table 5). We argue that this is substantive variability given it assessed only quantity and not quality or accessibility, its comparative predictive power alongside powerful predictors such as socioeconomic deprivation (5%), and real world importance placed on crime reductions of around 2-3%. Though not precisely the same, a drop in UK crime of 3% was recorded between 2010 and 2013 and equated to 3.7 million fewer offenses in the country during this period (House of Commons Report, 2014), and 3% drops in crime have supported stricter sentencing decisions (Bell et al., 2014). Exploratory analyses indicated it is particularly important for reduced crime that nature be available in urban settings. Moreover, in path analyses, local nature was also linked to crime incidence indirectly through fostering social cohesion, which substantiates previous research in a US city linking percentages of nature with lower crime incidence (Kuo & Sullivan, 2001). Crime is lower in communities that are mutually supportive and have a high level of organization, and are therefore able to coordinate more local resources for crime prevention (neighbourhood watches, neighbor calls to police after suspicious activity; Brown & Wycoff, 1987; Sampson & groves, 1989); thus, the relational benefits of nature may lead to less actual criminal behaviour, and likely to lower perceptions of crime, though this was not tested here. The positive impact of local nature on neighbours' mutual support may discourage crime, even in areas lower in socioeconomic factors.

In highlighting the relationship between contact with local nature and both community cohesion and crime, this paper has interesting implications for those who plan developments and govern communities. Greater consideration of greenspace provision in developments may help with these societal, as well as individual, outcomes. Our findings that beneficial social indicators are linked to contact with nature in urban as well as rural areas further supports this assertion. Although beyond the scope of this paper, and noting that different approaches are not mutually exclusive, it would be interesting to compare the costs

and benefits of greenspace provision for community cohesion and crime reduction with that of traditional approaches such as policing. This paper provides a necessary preliminary to that: evidence in support of greenspace provision as one potential option for tackling crime reduction.

These findings should be viewed in light of several limitations. First, despite having controlled for a range of possible confounds, our conclusions relied on a correlational method that precluded making causal links. For example, there may be other characteristics of rural living—such as neighbors from a similar ethno-cultural background, or lower neighbor turnover rates—that are responsible for the correlations we observed between nature and community. In future research, experimental methods supported by quasi-experimental designs using real world environments may be well suited to examining these issues and instrumental variable estimation could be test for potential endogeny bias (see Gould et al., 2002 for example). Experimental groups could be asked to interact in natural and non-natural environments to collect data with behavioral as well as self-report indicators of cohesion. To study the effects of long-term contact with nature, school and work groups could be randomly assigned to interact in natural or non-natural environments during retreats and over longer periods of time. Second, despite an otherwise high level of population representation, findings relied on adults ranging in age from 22 to 65 years; this limits generalizability of the present findings and future research should explore the effects on younger and older individuals who may respond differently to natural spaces; given that younger individuals are exposed to more crime (Farrington, 1986) and older individuals experience more loneliness (Lenhoff et al., 1966) it seems plausible that natural spaces are even more important to cohesion and closeness in these groups. In this research we have explored the role that nature, broadly, has on a sense of community but future research should differentiate between types of vegetation which may have distinct effects (for example, gardens, meadows, forests, lakes,

etc.), the links with more or less human-dominated landscapes (for example, gardens vs. woodlands), and whether more biodiversity is important; dissecting the role of different natural environments could help inform more targeted interventions. Finally, future work could usefully explore in more depth the links with workplace productivity and well-being workplace prod teamwork and consequent productivity in businesses located where greenspace has (or has not) been designed into the surroundings, for example.

The present findings offer a new perspective for understanding the links between nature on the social experience. Stringent model testing commonly used in the conservation literature to deal with large numbers of predictors was used to test a small number of clear hypotheses, while controlling for a number of known noise and confounding factors. These showed that perceived quantity of nature and direct contact with high quality nature are linked to higher social cohesion. Our results also identified social cohesion as an important mechanism through which nature links to personal well-being (e.g., happiness, work performance) and socially responsible behaviors (e.g., environmental concern), and they linked quantity of nature to community-level crime incidence. These findings add to our growing understanding of the frequently overlooked benefits that people get from nature (Millennium Ecosystem Assessment, 2005). Some of these so-called ecosystem services – such as the provision of wild-caught fish or timber, or the regulation of climate through carbon sequestration – are relatively tangible and amenable to quantification. However, the apparent benefits of contact with nature on social cohesion, and in turn of social cohesion on crime incidence, individual happiness, and performance in the workplace, are more challenging to tease apart and measure. This paper contributes to raising awareness of their apparent significance, and encourages further exploration of how they arise. We also hope that it stimulates consideration of how best to ensure that nature, at many different levels, can continue to benefit individuals and society into the future.

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Author Note

This research was funded in part by the ESRC (project number RES-064-27-0019). We wish to thank Professor P. Lynn (Institute for Social and Economic Research) for his assistance in survey design and methodology.

Table 1

Means for all study predictors and covariates split by gender, age, income, and education. Crime scores are standardized here because the original scores are large and arbitrary. Wages reflect weekly earnings.

	Gender		Age		Income		Education	
	Men	Women	Younger	Older	Low	High	Low	High
Predictors								
Contact with nature (subjective)	-0.04 (0.7)	0.02 (0.7)	-0.13 (0.7)	0.13 (0.7)	-0.10 (0.8)	0.04 (0.7)	-0.03 (0.7)	-0.00 (0.7)
Contact with nature (Objective)	50.98 (26.1)	53.06 (27.1)	48.12 (25.8)	56.42 (26.8)	50.56 (27.1)	52.82 (26.3)	53.97 (24.8)	50.31 (27.2)
Outcomes								
Community cohesion	2.84 (1.0)	2.90 (1.0)	2.77 (1.0)	2.99 (0.9)	2.82 (1.0)	2.89 (1.0)	2.82 (1.0)	2.91 (1.0)
Crime	-.012 (1.0)	0.0 (1.0)	0.11 (1.1)	-0.12 (0.8)	0.04 (1.0)	-0.02 (1.0)	-0.01 (1.0)	0.01 (1.0)
Community factors								
Socioeconomic deprivation	21.38 (13.9)	20.81 (13.2)	23.32 (14.4)	18.58 (12.1)	24.05 (14.3)	19.46 (12.8)	21.71 (13.9)	20.56 (13.2)
Population density	23.80 (24.5)	23.07 (25.1)	24.87 (25.8)	18.31 (19.7)	23.07 (23.7)	25.62 (30.6)	22.65 (24.1)	28.03 (28.0)
Unemployment rate	1.48 (0.5)	1.42 (0.5)	1.46 (0.5)	1.39 (0.5)	1.45 (0.5)	1.39 (0.5)	1.45 (0.5)	1.42 (0.5)
Wages	664.53 (177.25)	669.78 (180.8)	659.02 (178.0)	696.36 (179.7)	651.41 (168.0)	768.42 (212.0)	659.22 (170.9)	716.68 (217.2)
Individual outcomes								
Happiness	3.35 (0.6)	3.32 (0.6)	3.28 (0.6)	3.39 (0.6)	3.21 (0.6)	3.40 (0.6)	3.31 (0.6)	3.35 (0.61)
Media use	0.99 (0.4)	0.91 (0.4)	0.97 (0.4)	0.94 (0.4)	0.99 (0.4)	0.92 (0.4)	0.96 (0.4)	0.95 (0.4)
Environmental action	3.28 (1.2)	2.35 (1.1)	3.38 (1.1)	2.43 (1.2)	2.52 (1.1)	2.54 (1.2)	2.58 (1.2)	2.49 (1.1)
Performance at work	7.64 (1.5)	7.88 (1.1)	7.52 (1.5)	8.03 (1.4)	7.75 (1.5)	7.77 (1.4)	7.86 (1.5)	7.68 (1.4)

Table 2

Spearman rank correlations between living conditions, subjective and objective qualities of nature, crime, and community cohesion. Analyses are based on n = 2079, all correlations were significant at p < .001 unless indicated with a ^ symbol. Variables 1, 2, 3, 4, and 6 are at the community level. Ind. socioeconomic standing refers to individuals' socioeconomic standing, with higher scores reflecting better standing. Correlations are shown for the individual indicators of contact with nature (Variables 7-10) as well as the composite they comprise (Variable 11).

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1. Socioeconomic deprivation												
2. Population density	.19											
3. unemployment rate	.26	.17										
4. weekly wages	.17	-.08	-.18									
5. Ind. socioeconomic standing	-.15	-.04	-.06	.29								
6. Objective nature	-.36	-.54	-.26	.06	.01^							
7. Perceived views of nature	-.30	-.42	-.15	.10	.08	.50						
8. Perceived quality of nature	-.17	-.19	-.09	.16	.17	.18	.34					
9. Accessibility of nature	-.14	-.12	-.08	.12	.10^	.13	.22	.64				
10. Hours visiting nature	-.10	-.15	-.09	.09	.11	.12	.25	.36	.29			
11. Subjective nature composite	-.25	-.31	-.15	.14	.16	.33	.64	.81	.73	.66		
12. Community cohesion	-.10	-.12	-.06	.04	.14	.12	.23	.25	.15	.25	.31	
13. Crime	.43	.20	.01^	-.18	.02^	-.35	-.27	-.06^	.05^	-.06^	-.16	-.04

Table 3

All models predicting community cohesion ordered by model fit (From best to worst fit). All models based on simple linear regression of factors affecting community cohesion. Models are ranked according to the Akaike Information; the third highest ranking model did not account for sufficient variability in the outcome (delta AIC > 2.0), so was not interpreted. Community cohesion was assessed at the individual level with community and individual level predictors included as potential covariates across 16 theoretically driven models.

Hypothesis for model	AIC	Δ_i	Akaike weights	R^2
1. Individual covariates + subjective nature	5581.11	0.00	0.56	.11
2. Individual covariates + both objective and subjective nature	5582.33	1.22	0.31	.12
3. Individual and community covariates + subjective nature	5585.02	3.91	0.08	.11
4. Individual and community covariates + both objective and subjective nature	5585.96	4.85	0.50	.12
5. Subjective nature	5607.41	26.21	0.00	.10
6. Both objective and subjective nature	5608.21	27.10	0.00	.10
7. Community covariates + subjective nature	5610.72	29.61	0.00	.10
8. Community covariates + both objective and subjective nature	5611.97	30.85	0	.10
9. Individual covariates + objective nature	5727.88	146.76	0	.05
10. Individual and community covariates + objective nature	5729.16	148.05	0	.05
11. Individual covariates + community covariates	5734.25	153.14	0	.05
12. Individual covariates	5746.03	164.91	0	.04
13. Community covariates + objective nature	5788.78	207.67	0	.02
14. Community covariates	5794.12	213.01	0	.02
15. Objective nature	5795.49	214.38	0	.02
16. Null model	5825.05	243.94	0	

Table 4

All models predicting crime ordered by model fit (from best to worst fit). Models are ranked according to the Akaike Information; the second and third highest ranking model did not account for sufficient variability in the outcome (delta AIC > 2.0) so were not interpreted. Crime was assessed at the ward level and predicted by community covariates, only; these were tested across four theoretically driven models to test four predictors.

Hypothesis for model	AIC	Δ_i	Akaike weights	R^2
1. Covariates and Predictor	531.959	0.000	1.000	.29
2. Covariates only	594.496	62.54	0	.25
3. Predictor only	721.338	189.38	0	.16
4. Null model	917.829	385.87	0	

Table 5

Detailed results of top fitting models for community cohesion and crime, separately. Results based on multiple regression analysis. Partial r^2 is the independent variance for each variable after accounting for other predictors defined in the model. *b*s and standard errors for crime were based on raw variable scores (not log transformed) to give more intuitive results; t values are identical to analyses using the transformed variable *p < .05, ***p < .001.

	b	Robust *se*	*t* with robust *se*	*t* with typical *se*	r^2
Predicting community cohesion					
Age	0.01	0.002	4.99***	2.89***	.01
Gender	0.07	0.041	1.71	1.71	.00
SE standing	0.14	0.010	1.40	5.05***	.02
Subjective nature	0.38	0.029	13.10***	12.50***	.08
Predicting crime					
Population size	0.001	0.002	0.77	3.32***	.01
SE deprivation	23.59	3.901	6.04***	9.18***	.05
Population density	62.34	37.622	1.66	1.91	.01
Unemployment rate	-351.7	42.796	-8.22***	-9.90***	.06
Weekly wages	-0.36	0.186	-1.94	-1.65	.01
Objective nature	-9.73	1.593	-6.11***	-8.12***	.04
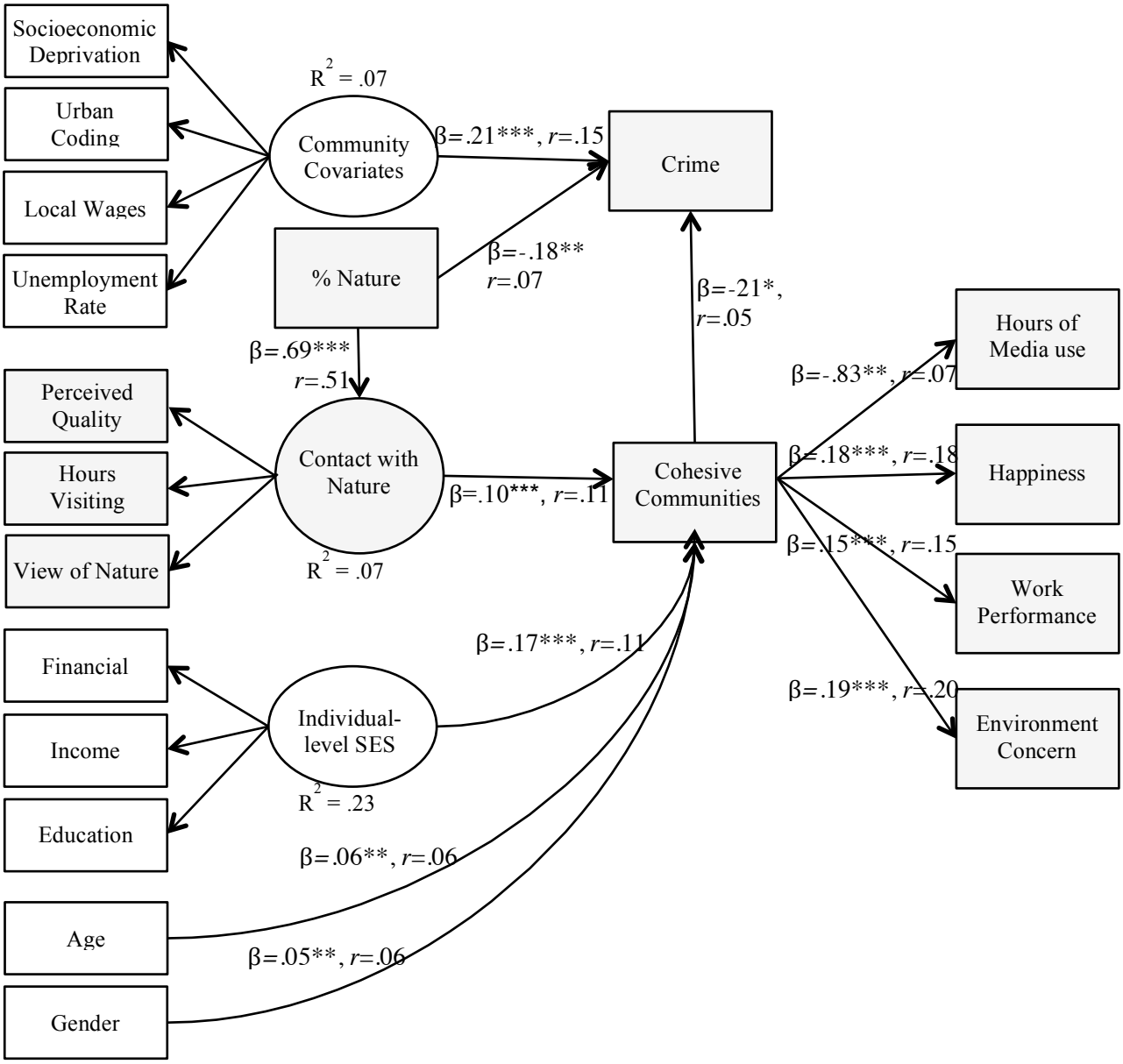
Figure 1. Full structural model. Structural equation model with personal and societal outcomes of community cohesion, including significant links only. Arrows are as drawn in initial model; circles reflect latent (combined or composite variables), whereas squares represent observed variables. Shaded spaces designate primary constructs of interest whereas unshaded spaces refer to covariates. All analyses are correlational and conducted at individual levels. *p < .05, **p < .01, ***p < .001.