

Does perceived restorativeness mediate the effects of perceived biodiversity and perceived naturalness
on emotional well-being following group walks in nature?

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Abstract:

Natural environments are associated with positive health and well-being. However, little is known about the influence of environmental qualities on well-being and the mechanisms underlying this association. This study explored whether perceived restorativeness and its subscales would mediate the effects of perceived biodiversity, perceived naturalness, walk duration and perceived intensity on emotional well-being. Participants ($n = 127$) of a national walking program in England completed pre- and post-walk questionnaires ($n = 1,009$) for each group walk attended within a 13-week period. Multilevel mediation examined the hypothesised indirect effects. Perceived restorativeness mediated the effects of perceived bird biodiversity, perceived naturalness, and perceived walk intensity on positive affect, happiness and negative affect. The effect of walk duration on happiness was also mediated by perceived restorativeness. Perceived walk intensity had a direct effect on positive affect and happiness. Findings have implications for theory development, future biodiversity-health research and practitioners interested in designing restorative environments.

Keywords (6 max): perceived restorativeness; biodiversity; well-being; environmental quality; green exercise; mechanisms

Highlights

- Examined restorativeness as mediator of biodiversity and naturalness on well-being.
- Perceived naturalness and biodiversity had no direct effect on emotional well-being.
- Perceived restorativeness mediated effect of perceived bird biodiversity on emotional well-being.
- Perceived restorativeness mediated effect of perceived naturalness on emotional well-being.

1. Introduction

Interaction with natural environments has diverse health and well-being benefits (Bowler, Buyung-Ali, Knight, & Pullin, 2010; Frumkin, 2001; Hartig, Mitchell, de Vries, & Frumkin, 2014; Irvine & Warber, 2002; Keniger, Gaston, Irvine, & Fuller, 2013). However, little is known about the contribution that different qualities of natural environments have on well-being – and even less is known about the mechanisms through which this relationship occurs. Previous researchers have called for mediation analyses to explain how different environmental qualities affect well-being (Clark et al., 2014; Hartig, 2011; Lovell, Wheeler, Higgins, Irvine, & Depledge, 2014; Sandifer, Sutton-Grier, & Ward, 2015). As the effect of natural environment qualities on well-being is a developing area for nature and health research, this gap is important to address.

In their review of green exercise, Thompson Coon et al. (2011) suggest “future studies might consider the impact of the perceived quality of the environment on mental and physical wellbeing outcomes” (p. 1771). Whilst environmental quality is often discussed in terms of the “aesthetics or attractiveness” of the natural environment (de Vries, van Dillen, Groenewegen, & Spreeuwenberg, 2013) (p. 27), two alternative indicators of environmental quality – ones that begin to acknowledge ecological quality – are the degree of naturalness (Carrus et al., 2013; van Dillen, de Vries, Groenewegen, & Spreeuwenberg, 2012) and level of biodiversity (Lovell et al., 2014) of the environment. To understand how these indicators might affect well-being, one can look to theories of restorative environments which identify salutogenic outcomes from interaction with, and the qualities of, environments that facilitate well-being (Kaplan & Kaplan, 1989; Kaplan, 1995; Ulrich, 1983; Ulrich et al., 1991). The perceived restorative quality of an environment has been associated with both the degree of naturalness (Carrus et al., 2013; Hartig, Korpela, Evans, & Gärling, 1997; Hipp &

Ogunseitan, 2011; Hipp, Gulwadi, Alves, & Sequeria, 2015) and level of biodiversity (Carrus et al., 2013; Carrus et al., 2015; Scopelliti et al., 2012) of that environment – as well as emotional well-being (Hartig et al., 1997; Korpela, Borodulin, Neuvonen, Paronen, & Tyrväinen, 2014; Marselle, Irvine, Lorenzo-Arribas, & Warber, 2015; Sato & Conner, 2013). Thus, perceived restorative quality may play a mediating role in the impact of environmental quality on emotional well-being. This study investigates whether perceived restorative quality mediates the relationship between the quality of the environment (perceived degree of naturalness and perceived level of biodiversity) and emotional well-being following the green exercise activity of outdoor group walks (see Figure 1). Characteristics of a walk – duration and perceived walk intensity – were also tested as predictors.

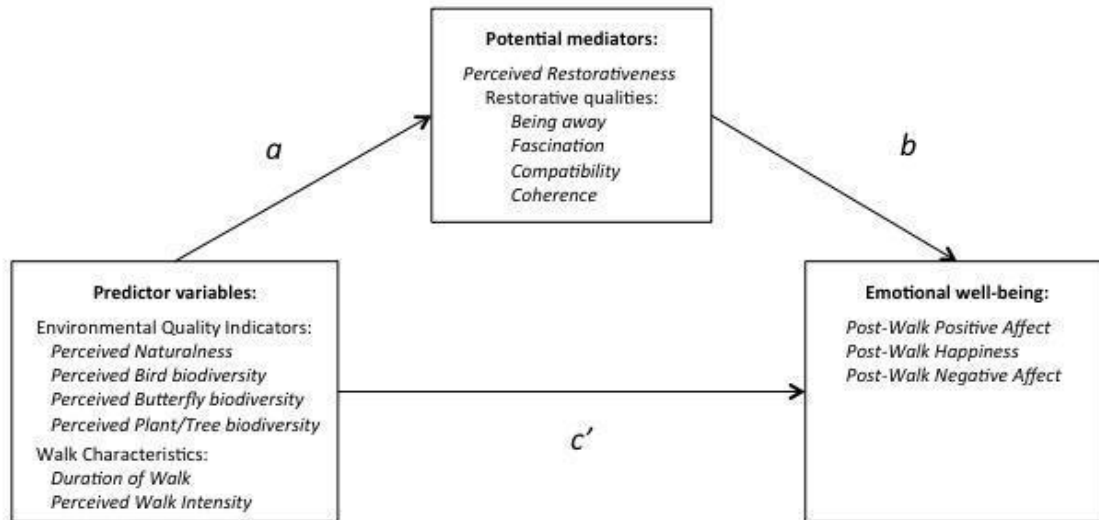


Figure 1. Conceptual diagram of the mediating effect of perceived restorative quality (perceived restorativeness, being away, fascination, compatibility and coherence) on the association between environmental quality indicators (perceived naturalness and perceived biodiversity), walk characteristics (duration and perceived walk intensity), and emotional well-being. *a* = associations between the predictor variables and the potential mediators. *b* = associations between the potential mediators and emotional well-being. *c'* = Direct association between predictor variables and emotional well-being, adjusted for mediators (Figure adapted from Tak et al. (2011)).

1.1 Naturalness and biodiversity of the environment, and well-being

Seventy-three per cent of Britons believe that the environment is important to both personal and national well-being (Office for National Statistics, 2015). The degree of naturalness of an

environment has been found to be associated with greater well-being. Recent reviews highlight that people report greater emotional well-being in natural environments compared to indoor (Thompson Coon et al., 2011) or outdoor, built environments (Bowler et al., 2010). For example, MacKerron and Mourato (2013) found that happiness varied by the type of natural environment in which people were located; compared to continuous urban environments, self-report happiness was greatest in coastal environments and lowest in floodplains and wetlands. Hinds and Sparks (2011) found that the perceived naturalness of an environment was positively associated with greater psychological well-being, specifically ‘more natural’ environments such as forests were associated with greater well-being than ‘less natural’ environments such as urban parks. Perceived naturalness of an environment has also been found to significantly predict a reduction in anxiety following green exercise (Mackay & Neill, 2010).

The measured level of actual biodiversity in the environment has been found to be positively associated with health (Hough, 2014; Jorgensen & Gobster, 2010; Lovell et al., 2014; Wheeler et al., 2015), psychological well-being (Carrus et al., 2015; Fuller et al., 2007) and positive emotions (Cracknell, White, Pahl, Nichols, & Depledge, 2015; Johansson, Gyllin, Witzell, & Küller, 2014). Our review here focuses on perceived biodiversity – an individual’s assessment of the species richness in an environment. People demonstrate a general belief that the perceived biodiversity of flowers, birds, and trees in an urban park improves their well-being (Shwartz, Turbé, Simon, & Julliard, 2014). In Dallimer et al.’s (2012) *in situ* study of riparian green spaces, psychological well-being was found to increase as the perceived species richness of birds, butterflies, trees/plants in the environment rose. In contrast, actual species richness in the environment showed inconsistent relationships; psychological well-being was positively associated with higher levels of bird species richness, but declined with

higher levels of plant/tree biodiversity and was not related to butterfly species richness (Dallimer et al., 2012). That is, perceptions of biodiversity were consistently associated with positive psychological well-being whilst actual biodiversity's influence on well-being was mixed. There is some evidence to suggest that people are able to accurately perceive the level of actual species richness of some environments (Fuller et al., 2007; Lindemann-Matthies, Junge, & Matthies, 2010) although findings by Dallimer et al. (2012) and Schwartz et al. (2014) are contradictory to this. Given the mixed evidence in the literature, self-report measures may be an acceptable alternative method of assessing the impact of biodiversity on well-being, particularly for green exercise studies such as walking where multiple environments may be encountered.

1.2 Theoretical background

Two theories provide useful insight into how natural environments positively influence health and well-being. The stress reduction theory (Ulrich, 1983; Ulrich et al., 1991) states that interacting with nature results in stress recovery – as manifest in reduced physiological arousal and negative affect, and enhanced positive affect. Qualities of the natural environment that facilitate these restorative responses include: moderate complexity and depth; a focal point; deflected vistas; a ground surface conducive for movement; lack of threat; and water (Ulrich, 1983) (p. 105). Biodiversity can be considered a measure of an environment's complexity (Ulrich, 1983) (p. 96).

Attention restoration theory (ART) emphasises restoration of one's ability to concentrate or direct attention (Kaplan, S. & Talbot, J. F., 1983; Kaplan & Kaplan, 1989; Kaplan, 1995). Based on William James' theory of attention (which asserts there are two types, voluntary and involuntary), ART contends that this capacity to focus or direct attention requires cognitive effort, and as such is liable to fatigue. Restoration of directed attention can occur when involuntary attention is engaged – an

attention considered to be effortless, not requiring of cognitive effort. According to ART, four co-acting qualities characterise the experience of a restorative environment: being away, fascination, coherence, and compatibility (Kaplan & Kaplan, 1989; Kaplan, 1995). A restorative environment requires psychological and physical distance from tasks, thoughts, or settings that draw upon directed attention (*being away*). Fascinating stimuli are required to effortlessly attract involuntary attention, which allows for the restoration of directed attention (*fascination*). Environmental stimuli that might draw forth involuntary attention are: “strange things, moving things, wild animals, bright things, pretty things, metallic things, words, blows, blood, etc. etc. etc.” (James, 1892) (p 88). Fascination can be sustained if the stimuli are organized in a coherent way and rich enough to foster the perception of being in a whole other world (*coherence*). The theory also acknowledges that a fit between the environmental setting and one’s purposes and inclinations is required for restoration; a compatible environment allows one to carry out his or her activities without struggle (*compatibility*). Natural environments are theorized to have a high level of these four restorative qualities (Kaplan & Kaplan, 1989; Kaplan, 1995).

While here discussed as distinct theories, integration of the two has been proposed (Kaplan, 1995) Directed attention fatigue can lead to, and may have similar negative emotional consequences as, stress (Hartig & Evans, 1993; Kaplan & Kaplan, 1989; Kaplan, 1995). Support for theory integration between attention and emotion has been found in previous research (Gonzalez, Hartig, Patil, Martinsen, & Kirkevold, 2010; Hartig, Evans, Jamner, Davis, & Garling, 2003).¹ It is this more holistic framework that underpins the current study. In this study, we test whether restorative qualities

¹ Although see Berman and colleagues (Berman, Jonides, & Kaplan, 2008; Berman et al., 2012) for contrary evidence.

identified in ART are the mechanism through which qualities of the natural environment influence emotion, as described in the stress reduction theory.

1.3 Perceived restorativeness as a mediator

The restorative quality of an environment can be measured through validated self-report scales (Berto, 2005; Hartig, Korpela et al., 1997; Laumann, Garling, & Stormark, 2001; Pasini, Berto, Brondino, Hall, & Ortner, 2014). Based on ART's four co-acting qualities, these scales assess an individual's subjective experience of the physical environment as restorative. A restorative experience of the environment may facilitate actual restoration, as described by the stress reduction theory and ART. Thus, perceived restorativeness measures are intermediate in character, occurring between the quality of the environment and its restorative outcomes (Hartig, 2011). Such measures mediate the experience of the environment on actual restoration (Hartig & Staats, 2003; Hartig, Kaiser, & Bowler, 1997). Questions about *how* the external environment comes to affect our internal psychological wellbeing are answered by mediation analyses (Baron & Kenny, 1986). Such mediation analyses are needed to advance understanding of ART (Hartig, 2011; Hartig et al., 2014; Hartig et al., 1997).

1.3.1 Naturalness and perceived restorativeness

A small body of literature has revealed a relationship between naturalness and perceived restorative quality. In a study of American, Swedish and Finnish students, Hartig et al. (1997) found perceived restorativeness scores were higher for natural compared to urban environments. Carrus et al. (2013) identified a significant correlation between perceived naturalness and perceived restorative quality, indicating that environments perceived as more natural were rated as more restorative. Research by Hipp and Ogunseitan (2011) identified similar relational patterns between perceptions of air and water quality and perceived restorativeness of a coastal environment; individuals who

perceived the air and water quality of a coastal park to be healthy were more likely to perceive the coastal environment as restorative. Hipp et al. (2015) found perceived greenness of a university campus was positively associated with perceived restorativeness, as well as the restorative qualities being away, fascination and compatibility. These studies suggest a positive relationship between the degree to which an environment is perceived as natural and one's experience of that environment as restorative.

1.3.2 Biodiversity and perceived restorativeness

Relatively few studies have specifically explored biodiversity and perceived restorativeness. Across those that have, findings are inconsistent. Two studies have shown a significant, positive association between the objectively assessed level of biodiversity of Italian parks and perceived restorative quality (Carrus et al., 2015; Scopelliti et al., 2012), and all four qualities of a restorative environment (Scopelliti et al., 2012). However, another study found small urban green spaces in Copenhagen that were rich in plant and animal species were positively related to the restorative quality coherence, negatively related to fascination, and not related to being away or compatibility (Peschardt & Stigsdotter, 2013). To the authors' knowledge, no investigation of the perceptions of biodiversity in the environment and the experience of the restorative quality of that environment has been conducted to date.

1.3.3 Perceived restorativeness and emotional well-being

Measures of perceived restorativeness have been found to positively correlate with greater emotional well-being in general (Korpela et al., 2014), and positive affect (Hartig et al., 1997; Marselle et al., 2015) and happiness (Marselle et al., 2015) in particular. Perceived restorativeness was also associated with a reduction in negative affect following outdoor group walks (Marselle et al., 2015).

The restorative quality fascination has been found to positively correlate with greater positive affect – but not related to negative affect (Sato & Conner, 2013). In general, these findings support an association between perceived restorativeness and positive aspects of well-being; an association with negative affect requires further investigation.

1.3.4 Perceived restorativeness as a mediator of the relationship between nature and well-being

A handful of studies have specifically investigated perceived restorativeness as a mediator of the relationship between nature and well-being. Two studies found that perceived restorative quality mediated the effects of frequency of nature-based recreation (Korpela et al., 2014) and nature in and around the home (Martínez-Soto, Montero-López-Lena, & Cordova, 2014) on emotional well-being. Frequency of nature-based recreation and the amount of nature in/around the home were both positively correlated with perceived restorativeness, which in turn was positively correlated with emotional well-being. Gonzalez et al. (2010) found the decrease in depression following a farm-based horticultural therapy intervention was mediated by the change in restorative qualities being away and fascination. Compared to being at home, participants reported higher levels of being away and fascination whilst at the farm; the greater the change in being away and fascination, the greater the decline in depression from participating in the intervention. In a study of university students' quality of life, Hipp et al. (2015) found the effect of perceived greenness of the campus on quality of life was mediated by perceived restorativeness and the specific restorative qualities being away, fascination and compatibility. Greater perceived greenness was associated with greater perceived restorativeness, which in turn was associated with higher quality of life. Carrus et al. (2015) found the relationship between actual biodiversity of an environment and self-reported psychological and physical benefit was mediated by perceived restorativeness. Participants in high biodiversity environments perceived

the environment as more restorative than participants in the low biodiversity environments; those who perceived greater restorativeness also expressed greater psychological and physical benefit from the environment.

Two of these studies measured the quality of the natural environment (Carrus et al., 2015; Hipp et al., 2015) – one study measured perceived greenness, the other assessed the actual level of biodiversity. The other three studies assessed nature without an investigation of its quality. Moreover, only one study (Gonzalez et al., 2010) measured the change in well-being following interaction with nature. The role that biodiversity plays in change in emotional well-being is thus under-explored. As such, there is scope for assessing what specific environmental qualities of the environment influence a change in well-being following interaction with nature.

1.4 Walk characteristics: Duration and intensity

Physical exercise itself has been shown to improve mood (Biddle & Mutrie, 2008; Hendrickx & van der Ouderaa, 2008; Mata et al., 2012). As such, it is important to isolate its effect from the natural environment when studying green exercise (Hartig et al., 2011; Hartig et al., 2014; Marselle et al., 2015; Ulrich et al., 1991). In green exercise studies, duration can be a measure of the quantity of a nature experience as well as a measure of physical activity, whilst intensity is considered a measure of physical activity only. Here we review existing literature that specifically examined perceived restorative quality as a mediator of duration and intensity.

Duration of time in nature has been found to be related to greater subjective psychological and physical benefit (Scopelliti et al., 2012), enhanced emotional well-being (Korpela et al., 2014), and higher positive affect (Sato & Conner, 2013) – but not related to negative affect (Sato & Conner, 2013). Moreover, duration of time in nature was positively correlated with perceived restorativeness

(Korpela et al., 2014) and with the specific restorative quality fascination (Sato & Conner, 2013). Mediation analyses have identified that participants who spent more time in nature report greater perceived restorativeness, and those who perceived greater restorativeness also expressed greater psychological and physical benefits from that environment (Carrus et al., 2015; Scopelliti et al., 2012). Of the four restorative qualities, both being away and fascination were found to mediate the effect of duration of time in nature on positive affect; fascination mediated the effect of duration on negative affect – but solely for women (Sato & Conner, 2013).

Moderate or vigorous intensity physical activity can increase post-exercise positive affect (Ekkekakis, 2003). Results from research on the influence of intensity of physical activity in natural environments are however mixed. Barton and Pretty (2010) found green exercise of light or vigorous intensity had the greatest change in post-green exercise emotional well-being (Barton & Pretty, 2010). Mackay and Neill (2010) found perceived intensity of green exercise did not predict a change in anxiety. In an effort to examine physical activity and perceived restorativeness, Norling et al. (2008) developed a ‘perceived restorativeness for activities scale’ (based on the four restorative qualities of ART) to assess the restorative potential of physical activity. The authors found that perceived exercise intensity was positively correlated with compatibility only. To date, no research has investigated whether perceived restorativeness mediates the effect of perceived intensity on well-being.

1.5 Aims & hypotheses

The aim of this study was to examine whether perceived restorative quality would mediate the effect of perceived environmental quality (naturalness and biodiversity) and walk characteristics (duration and intensity) on emotional well-being following an outdoor group walk (see Figure 2).

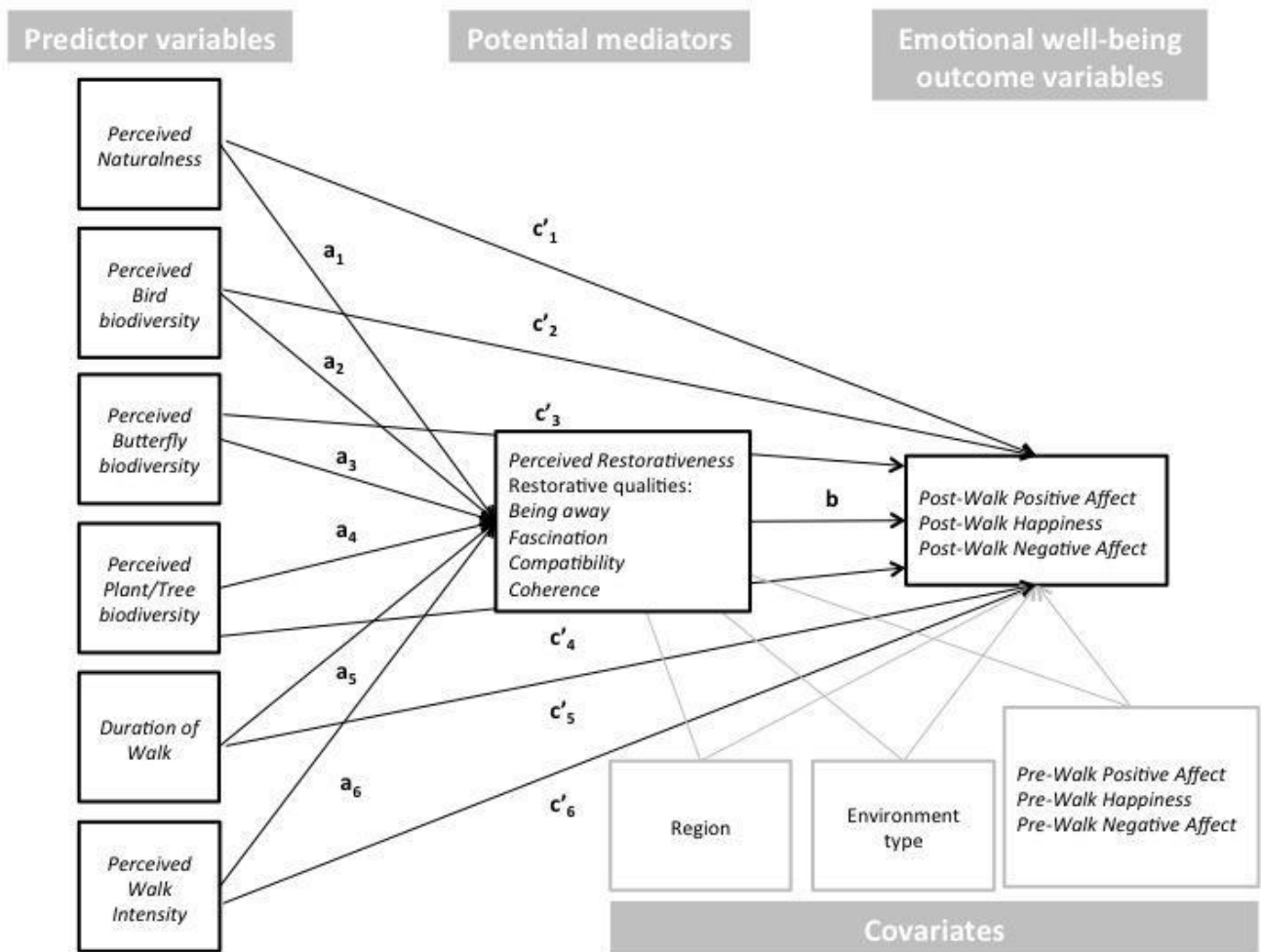


Figure 2. Conceptual diagram of the mediating effects of predictor variables perceived naturalness, perceived biodiversity, walk duration and perceived walk intensity on outcome variables post-walk emotional well-being via potential mediating variables (perceived restorativeness, being away, fascination, compatibility and coherence). *a paths* = Tested associations between the predictor variables and the potential mediators. *b paths* = Tested associations between the potential mediators and emotional well-being outcome variables. *c' paths* = Tested direct associations between predictor variables and emotional well-being outcome variables, adjusted for mediators. Covariates were included in all analyses. The indirect effect (ab) is the product of the *a* and *b* paths.

Based on restorative environment theories (Kaplan & Kaplan, 1989; Kaplan, 1995; Ulrich, 1983; Ulrich et al., 1991) and previous research (Carrus et al., 2015; Gonzalez et al., 2010; Hartig et

al., 1997; Korpela et al., 2014; Martínez-Soto et al., 2014; Sato & Conner, 2013; Scopelliti et al., 2012), the following six hypotheses were tested in a group walk context:

1. Associations between predictor variables and perceived restorativeness will be positive (*a* path). Specifically, greater perceived naturalness (a_1), perceived bird biodiversity (a_2), perceived butterfly biodiversity (a_3), perceived plant/tree biodiversity (a_4), walk duration (a_5) and perceived walk intensity (a_6) would be associated with greater perceived restorativeness.
2. Associations between perceived restorativeness and positive aspects of emotional well-being will be positive (*b* path). Specifically, greater perceived restorativeness would be associated with more positive affect and happiness after a group walk.
3. Associations between perceived restorativeness and negative aspects of emotional well-being will be negative (*b* path). Specifically, greater perceived restorativeness would be associated with a reduction in negative affect after a group walk.
4. There would be a positive indirect effect² of a) perceived naturalness, b) perceived bird biodiversity, c) perceived butterfly biodiversity, d) perceived plant/tree biodiversity, e) walk duration, and f) perceived walk intensity on post-walk positive affect through perceived restorativeness.
5. There would also be a positive indirect effect² of a) perceived naturalness, b) perceived bird biodiversity, c) perceived butterfly biodiversity, d) perceived plant/tree biodiversity, e) walk duration, and f) perceived walk intensity on post-walk happiness through perceived restorativeness.

² The indirect effect of perceived environmental quality and walk characteristics on positive affect and happiness via perceived restorativeness will be positive because the relationship between the *a* path (e.g. the relationship between perceived naturalness and perceived restorativeness) and *b* path (e.g. the relationship between perceived restorativeness and post-walk positive affect) will both be positive.

6. There would be a negative indirect effect³ of a) perceived naturalness, b) perceived bird biodiversity, c) perceived butterfly biodiversity, d) perceived plant/tree biodiversity, e) walk duration, and f) perceived walk intensity on post-walk negative affect through perceived restorativeness.

The above mediation analyses were repeated for each of the perceived restorative qualities being away, fascination, compatibility and coherence.

2. Method

2.1 Participants

Participants were recruited from a larger study investigating the well-being benefits of Walking for Health (WfH) (Marselle, Irvine, & Warber, 2014), a national group walk program which provides free, organised, led health walks throughout England (Walking for Health, 2013a). WfH is one of the largest public health interventions for physical activity in the UK (Fitches, 2011) with 70,000 people attending 3,400 group walks each week (Walking for Health, 2013b). WfH walks are advertised in advance, designed to occur at a predetermined location, duration (10-90 minutes), and a walk intensity “that makes walkers feel warmer, breathe harder and their heart beat faster” (Walking for Health, 2014).

Previous research has found no significant difference on social well-being (Marselle et al., 2014) and Connectedness to Nature (Marselle, 2013) between those who participate in WfH walks and those who do not take part in any group walks. This is relevant for the current study as social interaction is related to greater positive affect and reduced negative affect (Watson, 1988). Similarly,

³ The indirect effect of perceived environmental quality and walk characteristics on negative affect via perceived restorativeness will be negative because the relationship between the *a* path (e.g. relationship perceived naturalness and perceived restorativeness) will be positive and the *b* path (e.g. relationship between perceived restorativeness and negative affect) will be negative.

connection to nature may influence attention to the natural environment and perceived restoration (Tang, Sullivan, & Chang, 2015), as well as positive emotions (Capaldi, Dopko, & Zelenski, 2014).

Inclusion criteria were restricted to individuals aged 55 years or older to reflect the age demographic of the WfH population (Coleman, Kokolakis, & Ramchandani, 2011; Fitches, 2011) and the main study sample (Marselle et al., 2014). One hundred and sixty individuals were randomly selected through stratified sampling. Individuals were stratified by gender and 9 English regions (Office for National Statistics, n.d.). An equal number of men and women were randomly selected within each region, resulting in 9 men and 9 women per region (except London for which all 16 volunteers were selected). Thirty-three participants did not take part in the study. In total, 127 individuals participated. The sample was 55.5% female, with 44.1% of participants aged 55-64 years and 45.5% aged 65-74 years. A total of 1,009 questionnaires were returned during the 13-week study period by the 127 participants, resulting in a median of 7 questionnaires per person (mode = 12) and a range of 1-32 questionnaires.

2.2 Procedure

Participants completed a questionnaire for each WfH group walk attended within a 13-week period (22 August to 14 November 2011). This 13-week period was the ‘intervention’ for a larger research study (Marselle, 2013; Marselle et al., 2014). The two-page questionnaire contained a section to be completed immediately before, and a section to be completed immediately after, the walk (see Appendix A). The data collection procedure was discussed in Marselle et al. (2015). This study received ethical approval from De Montfort University’s Human Research Ethics committee.

2.3 Measures

2.3.1 Outcome variables

Emotional well-being is one of the most common outcomes in studies of nature and health (Bowler et al., 2010; Brown, Johnston, Currie, & Muñoz, 2011; Thompson Coon et al., 2011). Theoretically, it is considered an aspect of well-being that can be restored through interaction with nature (Ulrich, 1983; Ulrich et al., 1991). Importantly, emotional well-being has a demonstrated impact on long-term health, including function and mortality (Moskowitz, Epel, & Acree, 2008; Ostir, Markides, Black, & Goodwin, 2000). Following previous research (Hartig, Mang, & Evans, 1991; Hartig et al., 2003), we measured emotional well-being as positive affect, happiness and negative affect.

Positive Affect and *Negative Affect* were measured with the Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988), which consists of 10 items that assess positive emotions (e.g. *interested, excited*) and 10 items that assess negative emotions (e.g. *upset, guilty*). Before and after the group walk, participants rated how they felt “now” on a 5-point scale (1 = *very slightly or not at all*; 5 = *extremely*). For each subscale, total scores range from 10 to 50; higher scores demonstrate greater positive or negative affect. The PANAS has been used in previous nature and health studies (Berman et al., 2008; Berman et al., 2012; Marselle et al., 2014; van den Berg & Custers, 2011). Calculated internal consistencies for the positive affect (pre-walk PA $\alpha = 0.92$; post walk $\alpha = 0.91$) and negative affect (pre-walk NA $\alpha = 0.87$; post-walk NA $\alpha = 0.82$) subscale were acceptable, and in line with published literature: positive affect ($\alpha = 0.89$) and negative affect ($\alpha = 0.85$) subscales (Crawford & Henry, 2004).

Happiness was assessed with a single item (Abdel-Khalek, 2006). Participants were asked to assess “*How happy do you feel right now*” before and after the group walk on an 11-point scale (0 = *Not happy*; 10 = *Very happy*). Single-item happiness scales have been used in studies of restorative

environments (Hartig et al., 1991; Hartig et al., 2003) and nature and health (Raanaas, Patil, & Hartig, 2010; Raanaas, Patil, & Hartig, 2012).

2.3.2 Predictor variables

2.3.2.1 Indicators of perceived environmental quality

Perceived naturalness of the environment was assessed with a single item. Participants were asked to rate “*How natural would you say the environment you walked in is overall?*” on a 7-point semantic differential scale (1 = *natural*; 7 = *artificial*). The item has been used in previous green exercise research (Mackay & Neill, 2010), restorative natural environments (van den Berg, Jorgensen, & Wilson, 2014), evaluations of soundscape (Kang & Zhang, 2010) and landscape preference (Real, Constantino, & Sabucedo, 2000). This variable was recoded (1 = *artificial*; 7 = *natural*) for the analysis; higher scores indicate greater perceived naturalness.

Drawing on previous research (Fuller et al., 2007), *perceived biodiversity* was assessed with three items. Participants were asked to indicate how many different types of birds or butterflies or plants/trees they would say are in the environment on a 5-point scale (birds: 1 = 0; 2 = 1-4 types; 3 = 5-14 types; 4 = 15-30 types; 5 = more than 30 different types; butterflies: 1 = 0; 2 = 1-4 types; 3 = 5-9 types; 4 = 10-20 types, 5 = more than 20 different types; plants/trees: 1 = 0; 2 = 1-9 types; 3 = 10-99 types; 4 = 100-300 types; 5 = more than 300 types).⁴ Due to low frequencies for the zero response option, the two lowest response categories were combined for each perceived biodiversity variable.

2.3.2.2 Walk characteristics

Walk Duration was a computed variable based on the participant-provided start and finish times of the group walk. *Perceived walk intensity* was assessed with a single item that asked

⁴ Response categories were based on Fuller et al. (2007) with the addition of the initial response option of zero. Fuller et al. (2007) had 4 response categories.

participants to “Please rate the physical intensity of the walk” on a 10-point scale (0 = *Very low*; 10 = *Very high*). This scale was used in previous research of outdoor walking behaviour (Duvall, 2010a).

2.3.3 Mediator

Perceived restorativeness was measured with the 16-item Perceived Restorativeness Scale (PRS) (Hartig et al., 1997) which is comprised of four subscales that assess the four qualities of a restorative environment according to ART: being away (BA), fascination (FA), coherence (COH) and compatibility (COM). BA was measured with two PRS items (e.g. *Spending time here gives me a break from my day-to-day routine*). FA was measured with five PRS items (e.g. *My attention is drawn to many interesting things*). COH was measured with four PRS items, all reverse coded (e.g. *There is too much going on*). COM was measured with five PRS items (e.g. *Being here suits my personality*). The items were placed in random order to reduce question order effects (Siminski, 2008). Participants assessed the extent to which each statement reflected their experience of the walk environment on a 7-point scale (0 = *Not at all*; 6 = *Completely*). All 16-items were summed to create the perceived restorativeness measure; total scores range from 0 to 96 with higher scores indicating greater restorative quality perceived in the environment. Each subscale was also summed; larger values indicate greater experience of the specific restorative quality. The PRS (Carrus et al., 2015; Hipp et al., 2015; Scopelliti et al., 2012) and its subscales (Gonzalez et al., 2010; Hipp et al., 2015; Sato & Conner, 2013; von Lindern, Bauer, Frick, Hunziker, & Hartig, 2013) have been used in previous mediation analyses. The calculated internal consistency of the 16-item PRS scale ($\alpha = 0.90$), and subscales BA ($\alpha = 0.85$), FA ($\alpha = 0.94$), and COM ($\alpha = 0.92$) were acceptable and in line with published literature (Hauru, Lehvavirta, Korpela, & Kotze, 2012): 16-item PRS scale ($\alpha = 0.93$), and subscales BA ($\alpha = 0.84$), FA ($\alpha = 0.85$), COM ($\alpha = 0.93$). The COH subscale was an exception with a low calculated

internal consistency ($\alpha = 0.62$), compared to published ($\alpha = 0.77$) (Hauru et al., 2012).

2.3.4 Covariates

Covariates included English region and environment type in which the walk took place. Participants were allocated to one of nine English regions (Office for National Statistics, n.d.) based on postcode. *Environment type* was assessed with the question: “*What type of environment did you walk in?*”. Participants selected one response from a list of 10 categories that best described that environment. Environment types were reduced to seven categories based on previous research (Marselle, Irvine, & Warber, 2013). Pre-walk positive affect, negative affect and happiness were also considered as covariates.

2.4 Statistical analysis

The 1,009 questionnaires were screened for missing data. Hot Deck imputation (Myers, 2011) was used for missing items; a missing value on one questionnaire was replaced with a value from another questionnaire by the same participant. Imputation was applied to items for all measures, except duration; the final number of analysed questionnaires was 935.

Pearson’s correlation coefficients for repeated measures using median scores (Bland & Altman, 1995) were calculated for all variables (except for duration, which is purely continuous, for which we used the mean).

Multilevel mediation models with multiple causal variables (Bauer, Preacher, & Gil, 2006) were fitted to assess the proposed mediation analyses in our data set. The structure of the study (each participant completed a questionnaire for every group walk attended) meant each participant provided multiple responses about their pre- and post-walk emotional well-being, environment type, and indicators of perceived environmental quality, perceived restorativeness and walk characteristics.

Multilevel modelling (also termed mixed modelling) allowed us to include “both ‘fixed’ and ‘random’ effects” (Fischer et al., 2011) (p. 1001). Fixed effects are the predictor variables of interest. Random effects reflect the hierarchical structure of the data (questionnaires within participants); this improves the analysis by partitioning unexplained variation into systematic variation between respondents and residual variation between questionnaires within respondents.

In the mediation models, perceived naturalness, perceived biodiversity (birds, butterflies and trees/plants), walk duration and perceived walk intensity were the predictor variables. Overall perceived restorativeness and each of the four PRS subscales (BA, FA, COH, COM) were the mediator variables. Three outcome variables were tested for emotional well-being: post-walk positive affect, happiness, and negative affect. Region, environment type and pre-walk emotional well-being were included as covariates. All variables (except region and environment type) were treated as continuous. For region, the reference category was London. The reference category for environment type was urban public space.

Multicollinearity for the predictor variables was assessed following Shieh and Fouladi (2003); no variables demonstrated multicollinearity. Residual plots from these models were analyzed to determine how closely these followed the normal distribution. Duration of WfH walk and perceived walk intensity were tested for a potential diminishing returns effect based upon previous research results (Barton & Pretty, 2010). No transformations were necessary for any of the outcome variables.

All analyses were performed in R (R Core Team, 2015) with the *mediation* package (Tingley, Yamamoto, Hirose, Keele, & Imai, 2014). To calculate the uncertainty estimates for the mediation models, we ran 1000 simulations per model using the quasi-Bayesian Monte Carlo method integrated

in the package, which is based on normal approximation (Imai, Keele, & Tingley, 2010; Preacher & Hayes, 2008).

Results from the mediation analyses were interpreted following Hayes (2009; 2013) who argues for modernizing the traditional interpretation of Baron and Kenny (1986) and advocates for the reporting of the indirect effects and their significance as the most relevant information to be extracted from these models. Statistical significance for the indirect effect was observed as a p -value less than 0.05 and a 95% bootstrap confidence interval (CI) that does not include zero.⁵ Indicators of model fit (e.g. R^2 values, deviance) were not included as they are considered inappropriate for multilevel analysis (McCoach & Black, 2012; Snijders & Bosker, 2012).

3. Results

Mean scores for the outcome, predictor, and the perceived restorativeness mediator variables are reported in Table 1. The mean was higher for post-walk positive affect ($M = 36.28$) and happiness ($M = 7.95$) when compared to the pre-walk values ($M = 30.52$; $M = 6.45$, respectively). There was a reduction in the average value for negative affect after the walk ($M = 10.53$) compared to pre-walk values ($M = 11.74$). Changes in the means were statistically significant for all three variables ($p < 0.001$ for all).

Table 1 also includes correlations between the variables of interest. Perceived naturalness, perceived biodiversity and walk duration were not significantly correlated with all three post-walk emotional well-being variables (see Table 1). Perceived walk intensity was significantly positively

⁵ Statistical significance of the a and b paths was discerned from the CI. However, statistical significance of the a and b paths on their own (in contrast to the indirect effect ab) is not given major relevance in the interpretation of mediation results. Hayes (2013) states that “whether a and/or b is statistically significant is not pertinent to whether the indirect effect is different from zero...it is only their sign that matters” (p 201).

correlated with post-walk positive affect ($r = 0.38, p < 0.001$) and happiness ($r = 0.45, p < 0.001$) but not negative affect ($r = .03, p = .772$). Perceived restorativeness was moderately correlated with post-walk positive affect ($r = 0.60, p < 0.001$) and happiness ($r = 0.43, p < 0.001$) but not correlated with post-walk negative affect ($r = -.06, p = .486$). Perceived restorativeness was also significantly correlated with perceived naturalness, all three perceived biodiversity variables (bird, butterfly and plant/tree) and perceived walk intensity (see Table 1). Following the Baron and Kenny (1986) causal steps approach, these statistically significant correlations imply a mediation model in which perceived naturalness, the three biodiversity variables, and walk intensity indirectly influence post-walk emotional well-being through perceived restorativeness.

Table 1. Means, standard deviations, and correlations¹ between emotional well-being, perceived naturalness, perceived biodiversity, walk duration, perceived walk intensity, and perceived restorativeness.

Correlations between variables													
	M (SD)	1	2	3	4	5	6	7	8	9	10	11	12
1. Pre-Walk Positive Affect	30.52 (7.32)	1.00											
2. Post-Walk Positive Affect	36.28 (6.99)	0.54***	1.00										
3. Pre-Walk Happiness	6.45 (2.10)	0.68***	0.26**	1.00									
4. Post-Walk Happiness	7.95 (1.50)	0.49***	0.62***	0.68***	1.00								
5. Pre-Walk Negative Affect	11.74 (3.63)	-0.16	0.11	-0.39***	-0.20	1.00							
6. Post-Walk Negative Affect	10.53 (1.71)	0.04	0.09	-0.14	-0.12	0.69***	1.00						
7. Perceived Naturalness	5.22 (1.58)	0.01	0.17	-0.02	0.08	-0.00	0.03	1.00					
8. Perceived Birds	NA	0.05	0.06	0.07	0.08	0.01	0.04	0.02	1.00				
9. Perceived Butterflies	NA	-0.01	0.07	0.03	0.09	0.08	-0.06	-0.02	0.55***	1.00			
10. Perceived Plants & Trees	NA	0.05	0.01	0.10	0.03	0.03	0.03	0.08	0.67***	0.46***	1.00		
11. Walk Duration	1.53 (0.97)	-0.04	0.10	-0.00	0.16	0.01	-0.06	0.15	0.20*	0.12	0.19*	1.00	
12. Perceived Walk Intensity	6.07 (1.81)	0.29**	0.38***	0.28**	0.45***	-0.09	0.03	0.30**	0.20*	0.17	0.15	0.11	1.00
13. Perceived Restorativeness	66.91(15.11)	0.32***	0.60***	0.17	0.43***	0.01	-0.06	0.31***	0.34***	0.31***	0.25**	0.16	0.43***

Note. ¹ Pearson’s correlation coefficients for repeated measures calculated using median scores for all variables, except duration for which mean values were considered (relatively similar Spearman rank correlations were found). Higher scores indicate greater: positive affect (range 10–50); negative affect (range 10–50); happiness (range 0–10); perceived naturalness (range 1–7); perceived birds (range 0–4 to 30+); perceived butterflies (range 0–4 to 20+); perceived plants/trees (range 0–9 to 300+); walk duration (range 0.25 to 6 hours); perceived walk intensity (range 0–10); and perceived restorativeness (range 0–96). NA: not applicable. $n = 127$. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$. Table reproduced from “Moving beyond green: Exploring the effect of environment type and indicators of perceived environmental quality on emotional well-being following group walks” by M.R. Marselle, K.N. Irvine, A. Lorenzo-Arribas and S.L. Warber, (2015), *International Journal of Environmental Research and Public Health*, 12(1), p. 116. Copyright 2015 by MDPI under Creative Commons Attribution License 4.0 International.

3.1 Positive Affect

Figure 3 shows the direct effect (c') of perceived naturalness, the three perceived biodiversity variables, walk duration and perceived walk intensity on post-walk positive affect, as well as the

indirect paths (*a* and *b*) for these predictors through perceived restorativeness. Results of these mediation analyses, as well as the mediation analyses with each of the four PRS subscales, can be found in Appendix B.

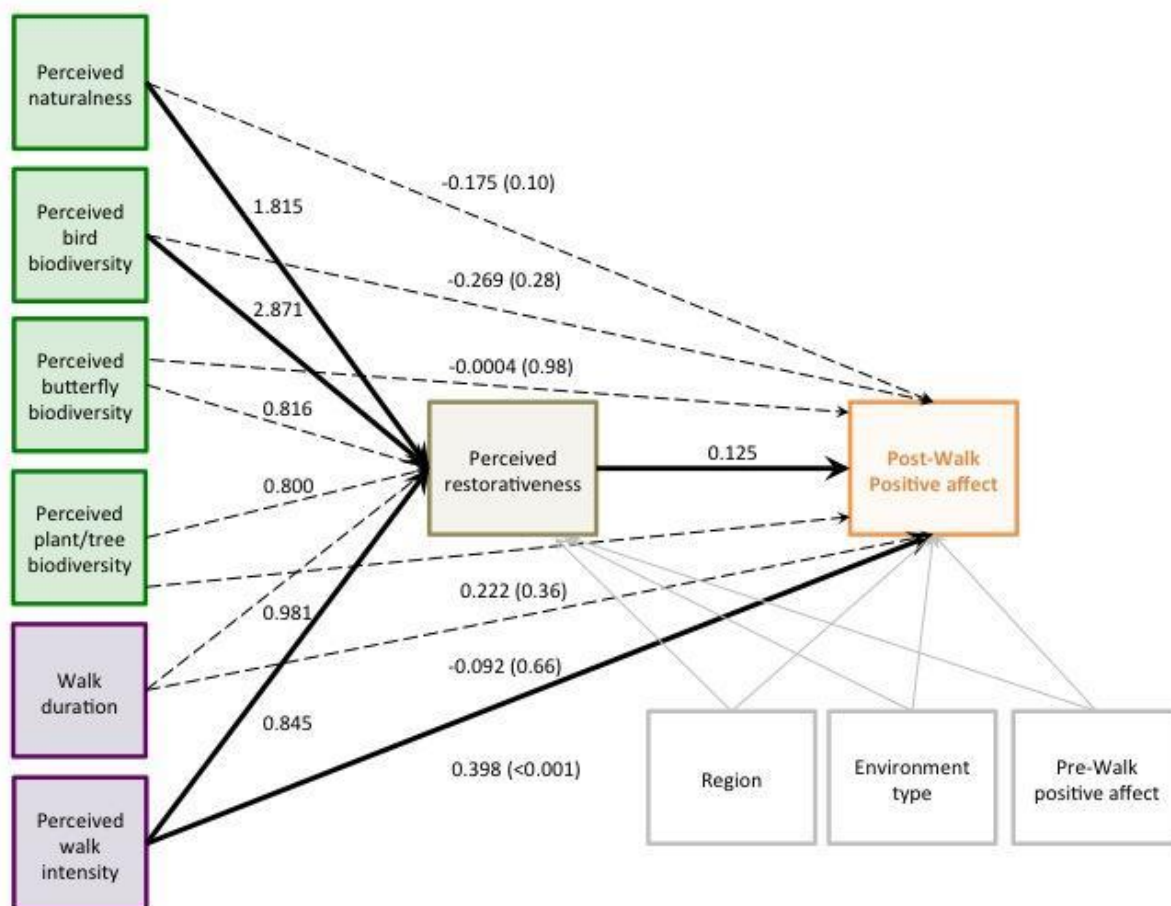


Figure 3. Mediation model of perceived naturalness, perceived bird, butterfly and plant/tree biodiversity, walk duration, and perceived walk intensity as predictors of post-walk positive affect via perceived restorativeness. Unstandardized regression coefficients are reported for the *a*, *b* and *c*' paths. Statistically significant paths are highlighted in bold; nonsignificant paths are portrayed by dotted lines. Values in parentheses for *c*' path indicate p-values.

3.1.1 Associations between predictors and perceived restorativeness (*a* paths)

Associations between environmental quality indicators, walk characteristics and perceived restorativeness partially support Hypothesis 1. All predictor variables were positively associated with greater perceived restorativeness – although only perceived naturalness, perceived bird biodiversity and perceived walk intensity were significant (see Figure 3). Positive associations between predictor variables and PRS subscales were also found (see Appendix B).

3.1.2 Associations between perceived restorativeness and post-walk positive affect (*b* paths)

In line with Hypothesis 2, greater perceived restorativeness was significantly associated with higher post-walk positive affect (see Figure 3). Three of the four PRS subscales – BA, FA and COM – were also positively associated with post-walk positive affect (see Appendix B).

3.1.3 Associations between predictors and post-walk positive affect (*c'* paths)

Only one significant direct effect was found; perceived walk intensity was significantly associated with greater post-walk positive affect (see Figure 3).

3.1.4 Mediation analyses (*ab* paths)

Results were supportive of Hypothesis 4a showing that perceived naturalness positively influenced post-walk positive affect through perceived restorativeness ($ab = 0.22$; $p < 0.001$, CI: 0.15 to 0.30). Of the PRS subscales, BA, FA, and COM significantly mediated the relationship between perceived naturalness and post-walk positive affect (see Appendix B).

The relationship between perceived bird biodiversity and post-walk positive affect was mediated by perceived restorativeness ($ab = 0.36$, $p < 0.001$; CI: 0.20 to 0.52). For the PRS subscales, BA, FA, and COM significantly mediated this relationship (see Appendix B). These findings are supportive of Hypothesis 4b.

Hypotheses 4c and 4d were not supported. We found no indirect effect of perceived butterfly ($ab = 0.10, p = .21$) nor plant/tree ($ab = 0.10, p = .16$) biodiversity on post-walk positive affect via perceived restorativeness. There was no significant indirect effect with each of the four PRS subscales (see Appendix B).

Hypothesis 4e was not supported. The relationship between walk duration and post-walk positive affect was not significantly mediated by perceived restorativeness ($ab = 0.12, p = .05, CI: 0.00$ to 0.25). Within the four PRS subscales, no evidence of mediation was found (see Appendix B).

Hypothesis 4f was supported; perceived restorativeness mediated the relationship between perceived walk intensity and post-walk positive affect ($ab = .11, p < 0.001, CI: 0.06$ to 0.16). Of the four PRS subscales, only FA mediated the relationship between walk intensity and positive affect (see Appendix B).

3.2. Happiness

Figure 4 shows the direct effect (c') of perceived naturalness, the three perceived biodiversity variables, walk duration and perceived walk intensity on post-walk happiness, as well as the indirect paths (a and b) for these predictors through perceived restorativeness. Appendix C details the output from these mediation analyses, as well as the mediation analyses with each of the four PRS subscales.

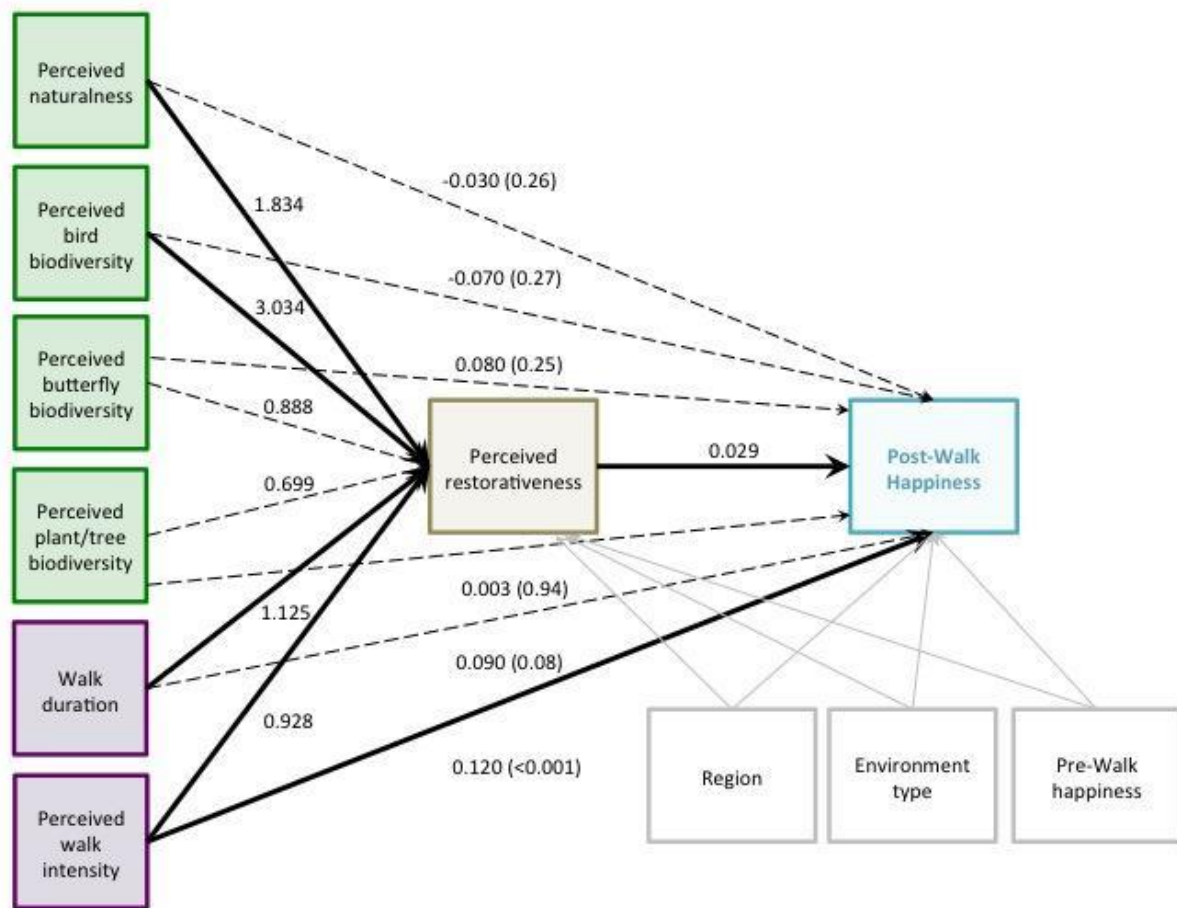


Figure 4. Mediation model of perceived naturalness, perceived bird, butterfly and plant/tree biodiversity, walk duration and perceived walk intensity as predictors of post-walk happiness via perceived restorativeness. Unstandardized regression coefficients are reported for the *a*, *b* and *c'* paths. Statistically significant paths are highlighted in bold; nonsignificant paths are portrayed by dotted lines. Values in parentheses for *c'* path indicate p-values.

3.2.1 Associations between predictors and perceived restorativeness (*a* paths)

Results were partially supportive of Hypothesis 1. All predictor variables were positively associated with perceived restorativeness, but only perceived naturalness, perceived bird biodiversity, walk duration, and perceived walk intensity were statistically significant (see Figure 4). Positive

associations between predictor variables and the four PRS subscale were also found (see Appendix C for further detail).

3.2.2 Associations between perceived restorativeness and post-walk happiness (*b* paths)

Results support Hypothesis 2. Greater perceived restorativeness was significantly associated with higher post-walk happiness (see Figure 4). Within the four PRS subscales, BA, FA and COM were positively associated with post-walk happiness (see Appendix C).

3.2.3 Associations between predictors and post-walk positive affect (*c'* paths)

Only one significant direct effect was found; perceived intensity was significantly associated with greater post-walk happiness (see Figure 4).

3.2.4 Mediation analyses (*ab* paths)

Hypothesis 5a was supported. The relationship between perceived naturalness and post-walk happiness was mediated by perceived restorativeness ($ab = 0.05$, $p < 0.001$, CI: 0.04 to 0.07). Three of the PRS subscales – BA, FA, and COM – significantly mediated this relationship (see Appendix C).

Similar effects were also found for perceived bird biodiversity, which are supportive of Hypothesis 5b. The relationship between perceived bird biodiversity and post-walk happiness was significantly mediated by perceived restorativeness ($ab = 0.09$, $p < 0.001$, CI: 0.05 to 0.13). Within the PRS subscale analyses, BA, FA, and COM significantly mediated the relationship between perceived bird biodiversity and post-walk happiness (see Appendix C).

Neither perceived butterfly ($ab = 0.03$, $p = 0.19$) nor plant/tree ($ab = 0.02$, $p = 0.26$) biodiversity indirectly influenced post-walk happiness through perceived restorativeness. No significant indirect effect with each of the four PRS subscales was found (see Appendix C).

Hypotheses 5c and 5d were not supported.

Results support Hypothesis 5e; the relationship between walk duration and post-walk happiness was mediated by perceived restorativeness ($ab = 0.03$, $p = 0.03$, CI: 0.00 to 0.06). No significant indirect effect via the four PRS subscales was found (see Appendix C).

Hypothesis 5f was supported. Perceived restorativeness mediated the relationship between perceived walk intensity and post-walk happiness ($ab = 0.03$, $p < 0.001$, CI: 0.02 to 0.04). Within the PRS subscales, FA significantly mediated this relationship (see Appendix C).

3.3 Negative Affect

Figure 5 shows the direct effect (c') of perceived naturalness, the three perceived biodiversity variables, walk duration and perceived walk intensity on post-walk negative affect, as well as the indirect paths (a and b) of these predictors through perceived restorativeness. Output from these analyses, as well as the mediation analyses with each of the four PRS subscales, can be found in Appendix D.

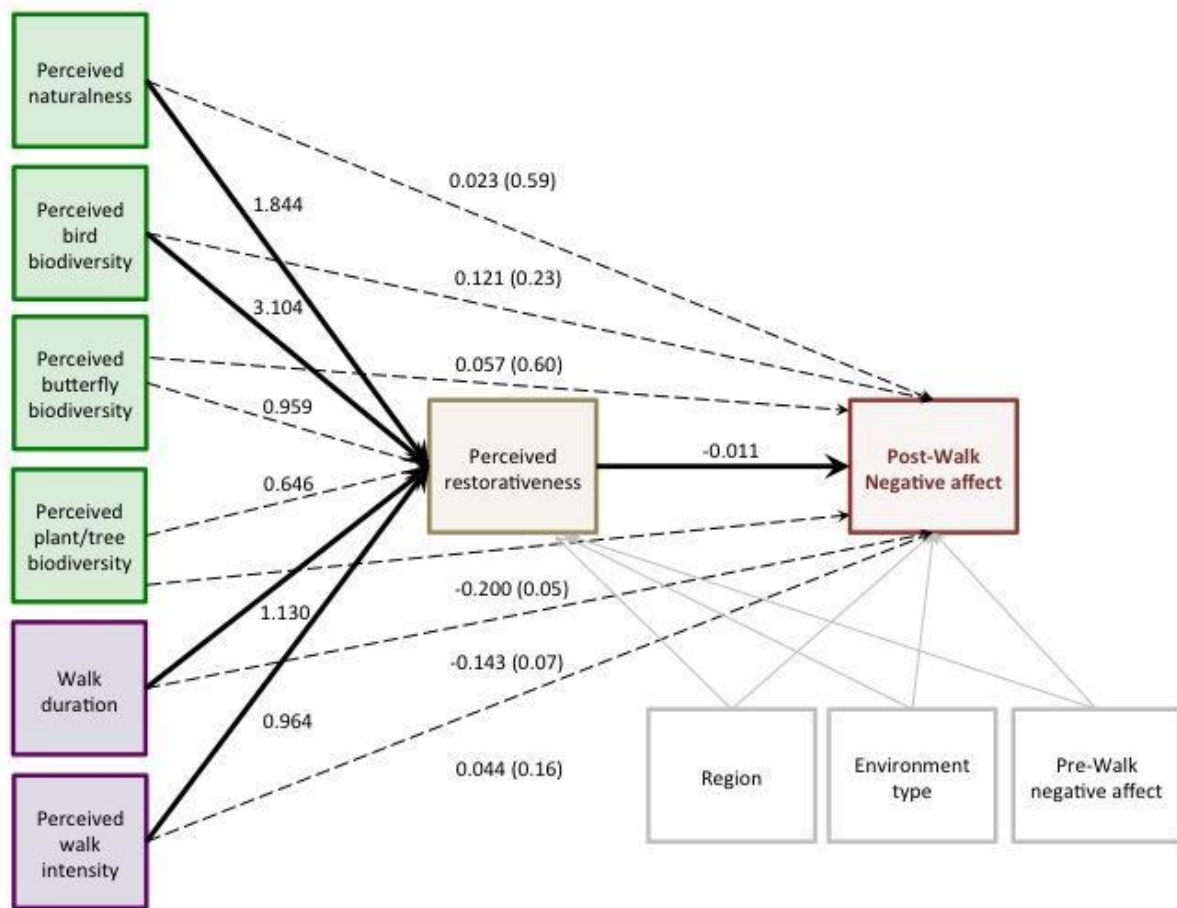


Figure 5. Mediation model of perceived naturalness, perceived bird, butterfly and plant/tree biodiversity, walk duration and perceived walk intensity as predictors of post-walk negative affect via perceived restorativeness. Unstandardized regression coefficients are reported for the *a*, *b* and *c'* paths. Statistically significant paths are highlighted in bold; nonsignificant paths are portrayed by dotted lines. Values in parentheses for *c'* path indicate *p*-values.

3.3.1 Associations between predictors and perceived restorativeness (*a* paths)

Results were partially supportive of Hypothesis 1. All predictor variables were associated with greater perceived restorativeness, although only perceived naturalness, perceived bird biodiversity, walk duration and perceived walk intensity were significant (see Figure 5). For each of the PRS subscales, positive relationships were also found (see Appendix D for further detail).

3.3.2 Associations between perceived restorativeness and post-walk negative affect (*b* paths)

Results support Hypothesis 3. Greater perceived restorativeness was significantly associated with reduced post-walk negative affect (see Figure 5). Negative associations between each of the four PRS subscales and post-walk negative affect were also found (see Appendix D).

3.3.3 Associations between predictors and post-walk positive affect (*c'* paths)

No significant direct effect between the six predictor variables and post-walk negative affect was found (see Figure 5).

3.3.4 Mediation analyses (*ab* paths)

Hypothesis 6a was supported. The relationship between perceived naturalness and post-walk negative affect was significantly mediated by perceived restorativeness ($ab = -0.02$, $p = 0.01$, CI: -0.04 to -0.00). Within the PRS subscales, COM significantly mediated the relationship between perceived naturalness and post-walk negative affect (see Appendix D).

The relationship between perceived bird biodiversity and post-walk negative affect was significantly mediated by perceived restorativeness ($ab = -0.04$, $p = 0.01$, CI: -0.07 to -0.01). Of the PRS subscales, COM also mediated this relationship (see Appendix D). Hypothesis 6b was supported.

Hypotheses 6c and 6d were not supported. Neither perceived butterfly ($ab = -0.01$, $p = 0.14$) nor plant/tree ($ab = -0.01$, $p = 0.24$) biodiversity indirectly influenced post-walk negative affect through perceived restorativeness. No evidence was found of an indirect effect via each of the four PRS subscales (see Appendix D).

Perceived restorativeness did not significantly mediate the relationship between walk duration and post-walk negative affect ($ab = -0.01$, $p = 0.05$, CI: -0.03 to -0.00). No evidence was found of an indirect effect via the four PRS subscales (see Appendix D). Hypothesis 6e was not supported.

Hypothesis 6f was supported. The relationship between perceived walk intensity and post-walk negative affect was significantly mediated by perceived restorativeness ($ab = -0.01$, $p = 0.01$, CI: -0.02 to -0.00). There was no evidence that the four PRS subscales mediated this relationship (see Appendix D).

4. Discussion and Conclusions

Studies that have investigated perceived restorativeness as a mechanism between naturalness, biodiversity, or walk characteristics and human well-being are few. The aim of this study was to examine whether the restorative quality of an environment would mediate the effect of perceived environmental quality (naturalness, biodiversity), and walk characteristics (duration, perceived intensity) on emotional well-being following an outdoor group walk. Multilevel mediation models examined hypothesised indirect and direct effects. Perceived restorativeness quality mediated the effects of perceived naturalness and perceived bird biodiversity on emotional well-being. An indirect effect was identified for walk duration on happiness via perceived restorativeness. Perceived walk intensity had both a direct effect and an indirect effect, via perceived restorativeness, on positive affect and happiness; it had an indirect effect on negative affect through perceived restorativeness.

4.1 Perceived quality of the environment

Perceptions of our two dimensions of environmental quality had no significant association with emotional well-being. The effect of perceived naturalness and perceived biodiversity of birds on post-walk positive affect, happiness and negative affect were however significantly mediated by perceived restorativeness. Thus, perceived naturalness and perceived bird biodiversity only influenced post-walk emotional well-being through their effect on perceived restoration. These mediation results suggest that experiencing the environment as restorative is a necessary step in the relationship between

perceiving an environment's degree of naturalness or level of bird biodiversity and positive emotional well-being. In other words, in this sample, it is not the perception of the environment's naturalness or bird biodiversity that leads to greater emotional well-being, but that perceived naturalness and bird biodiversity offers opportunities for a restorative experience which then contributes to positive emotional well-being.

Previous studies have shown that actual naturalness (Bowler et al., 2010; MacKerron & Mourato, 2013; Thompson Coon et al., 2011) and biodiversity (Cracknell et al., 2015; Johansson et al., 2014) are associated with positive emotional well-being, and with greater perceived restorativeness (Carrus et al., 2013; Carrus et al., 2015; Hartig et al., 1997; Scopelliti et al., 2012). To our knowledge, this is the first study to investigate perceived restorative quality as a mediator of the relationships between perceived naturalness, perceived biodiversity and emotional well-being. Although assessing quality of life rather than emotional well-being, Hipp et al. (2015) found perceived restorativeness mediated the effect of perceived greenness on quality of life. Our bird biodiversity-emotional well-being mediation results are supportive of Carrus et al. (2015) although our study used perceived rather than actual biodiversity and measured emotional well-being instead of psychological and physical benefit.

We also found the restorative qualities of being away, fascination and compatibility mediated the effects of perceived naturalness and perceived bird biodiversity on positive affect and happiness, whilst compatibility mediated these relationships for negative affect. These findings suggest that individuals who walk in environments perceived to be more natural or perceived to contain a greater number of bird species might experience greater post-walk positive emotional well-being because they experienced psychological and physical distance from taxing cognitive content, effortless attention due

to fascinating environmental stimuli, and oneness with the environment. The results correspond with Hipp et al. (2015) who found being away, fascination and compatibility mediated the relationship between perceived greenness and specific quality of life domains. Our results are also supportive of Gonzalez et al. (2010) who found being away and fascination mediated the relationship between actual nature and depression. Cracknell et al. (2015) suggest that the restorative qualities being away and fascination may explain the relationship between actual levels of aquatic biodiversity and positive mood found in their study. Our results here provide some support for their hypothesis, although replication with marine biota would be required.

Neither perceived butterfly nor perceived plant/tree biodiversity directly influenced post-walk emotional well-being. Contrary to expectations, no significant indirect effect of perceived biodiversity of butterflies or plants/trees on emotional well-being variables via perceived restorativeness was also found. We can speculate as to why no significant mediation was found for these two aspects of perceived biodiversity, yet significant mediation was found for perceived birds. First, over the course of the data collection period (22 August to 14 November 2011), the number of actual species of butterflies present in the walk setting likely diminished, and cues of different types of plants and trees may have become reduced as well. This could account for the nonsignificant relationships; species richness cannot influence well-being and perceived restorativeness if it is not perceived. Second, it could be due to a lack of knowledge. Dallimer et al. (2012) found that British participants were better able to identify different types of birds than either butterflies, plants or trees. Third, the perceived biodiversity measures used in this study were designed such that responses from participants could be compared to quantitative ecological survey data on species richness in urban green spaces (Fuller et al., 2007). These biodiversity response categories may have been inappropriate for assessing perceived

biodiversity of butterflies and plants/trees in the wide variety of environment types that span a group walk. It is possible that a single-item, continuous scale (e.g. 0 = *no butterflies*, 10 = *many butterflies*), more similar in format to the perceived naturalness item, may have been a more appropriate measure.

4.2 Walk characteristics

In studies of green exercise, it is important to isolate the effects of physical activity from those of the environment in order to discern the independent effect of nature on well-being (Hartig et al., 2011; Hartig et al., 2014; Marselle et al., 2015; Ulrich et al., 1991). In the current study, we investigated whether characteristics of the walk – specifically duration and perceived intensity – would indirectly influence emotional well-being through perceived restorativeness. Previous research has found that perceived restorativeness mediates the effect of duration of time spent in nature on well-being (Carrus et al., 2015; Sato & Conner, 2013; Scopelliti et al., 2012). To our knowledge, no studies have examined whether there is a mediating relationship with perceived intensity.

In this study, we did not find a direct relationship between walk duration and post-walk emotional well-being. We did find an indirect effect of walk duration on happiness via perceived restorativeness. These findings indicate that spending more time walking outdoors was associated with higher perceived restorativeness, which in turn may have affected levels of happiness after the walk. This is consistent with previous findings (Carrus et al., 2015; Scopelliti et al., 2012) where the effect of duration of time spent in an urban park on psychological and physical benefit was mediated by perceived restorativeness. None of the four PRS subscales mediated the relationship between duration and post-walk happiness. How can perceived restorativeness mediate this relationship when no subscales were significant mediators? Perhaps it is due to the additive nature of the PRS scale; the combination of the small indirect effects for all subscales may have a significant additive effect

resulting in significance. These non-significant mediational results for the PRS subscales are contrary to Sato and Conner (2013) who found being away and fascination mediated the effect of duration of time in nature on positive affect. The difference may be the outcome variable, but also it is unknown what activity was undertaken by participants in Sato and Conner (2013).

With respect to perceived walk intensity, we identified that perceived restorativeness mediated the effect of perceived walk intensity on post-walk emotional well-being. In line with our expectations, we found that individuals who rated the physical intensity of the group walk as higher also reported higher restorative quality scores, and this greater appreciation of the environment as restorative was related to an increase in positive affect and happiness, and a decrease in negative affect after a walk. Furthermore, fascination significantly mediated the effect of perceived walk intensity on positive affect and happiness. Greater perceived intensity from a group walk was associated with greater engagement with a fascinating environment, which in turn was related to more positive emotional well-being following the walk. The mediation of the effect of perceived walk intensity on positive emotional well-being through perceived restorativeness and fascination provides useful insight into physical activity as a restorative experience (Norling, Sibthorp, Suchy, Hannon, & Ruddell, 2010). Samson et al. (2015) found that runners attend to the fascinating aspects of the external environment as a way to distract themselves from pain or physical fatigue. This attention on the external environment, and away from the internal focus on one's fatigue, may contribute to the overall positive experience of high intensity exercise (Samson et al., 2015).

Perceived intensity was also found to directly influence positive affect and happiness, indicating that the perceived physical intensity of a group walk may contribute to an increase in post-exercise positive emotional well-being – independent of perceived restorative quality. This

corresponds with findings from earlier research of the influence of exercise intensity on emotional well-being (Barton & Pretty, 2010; Ekkekakis, 2003). As research has found that walking itself – irrespective of the environment – has a positive effect on post-walk emotional well-being (Berman et al., 2012; Gidlow et al., 2016; Johansson, Hartig, & Staats, 2011; Kinnafick & Thøgersen-Ntoumani, 2014), our findings highlight the importance of assessing duration and intensity variables in green exercise research in order to separate the physical activity effects from that of the natural environment.

4.3 Implications

Understanding the mechanisms through which nature influences health and well-being is a key methodological challenge for nature-health research (Hartig et al., 2014). Previous studies have found perceived restorative quality of the environment to mediate the relationship between interaction with nature and emotional well-being (Gonzalez et al., 2010; Korpela et al., 2014; Sato & Conner, 2013) as well as psychological and physical benefit (Carrus et al., 2015; Scopelliti et al., 2012). This study provides further support for perceived restorative quality as a mechanism through which perceived qualities of the natural environment – naturalness and bird biodiversity – can influence positive emotional well-being. Moreover, our study found that the specific restorative qualities of being away, fascination and compatibility mediated the relationships between perceived naturalness and perceived bird biodiversity on positive affect and happiness, whilst compatibility mediated these relationships for negative affect. Thus, these analyses provide some evidence for the idea that the positive emotional well-being effects of biodiverse and natural environments are dependent on gaining psychological distance, attending to fascinating nature or a person-environment fit with a perceived natural or bird species rich environment. These are important findings, supporting the practical use of restorative qualities in the design of environments (Kaplan, Kaplan, & Ryan, 1998). For example, the experience

of being away, fascination and compatibility with the environment could inform the design of biodiverse environments for positive emotional well-being. Does the design of the environment foster a sense of being away or fascination? How can the design of the environment be compatible for a restoration? Our findings may thus be of interest to urban planners, landscape designers and ecologists who wish to design 'healthy' environments.

The mediation findings emphasize the need to consider the transactional human-environment relationship (Altman & Rogoff, 1987) in investigations of nature and health/well-being. We found perceived bird biodiversity and naturalness of the environment to only have an effect on emotional well-being through one's experience of that environment's restorative qualities. That is, perceived bird biodiversity and naturalness of an environment provide an opportunity for an individual's restorative experience, which leads to positive emotional well-being. This indirect effect, and the results of others' mediation studies (Carrus et al., 2015; Gonzalez et al., 2010; Hipp et al., 2015; Korpela et al., 2014; Martínez-Soto et al., 2014; Sato & Conner, 2013; Scopelliti et al., 2012), suggests a move away from deterministic analyses of environment and health. Future studies should seek to investigate the individual's experience of the environment as restorative as a key step in studies about the influence of nature on human health and well-being.

Our findings raise important considerations for mediation research into the salutogenic effects of biodiversity for human health and well-being. Here we found no direct effect of perceived biodiversity on emotional well-being – but rather an indirect effect via perceived restorative quality. Given the identified role of perceived restorative quality as a potential mechanism, it will be fruitful to move beyond simplistic main effects analyses – where a lack of an identified direct effect may be due to a constrained analytical design rather than no relationship. This is especially important as any

conclusions that biodiversity does not have a direct effect on human health and well-being could have implications for environmental management, conservation efforts, and public policy. Our findings also contribute to other's calls (e.g. Carrus et al., 2015) for the need to understand the mechanisms behind the seminal work of Fuller et al. (2007) and Dallimer et al. (2012) when investigating the relationship between objectively measured and perceived biodiversity and aspects of human well-being.

Finally, we hypothesized, and our data support, an integration of the two restorative environment theories, stress reduction theory and ART. Our analyses found perceived restorative quality was a mechanism through which qualities of the external environment (perceived naturalness and perceived bird biodiversity) came to influence positive affect, happiness, and negative affect. These results provide additional support for an integration of restorative environment theories (Kaplan, 1995; von Lindern et al., 2013). Hartig et al. (2014) recommend future studies should investigate the interplay of stress recovery and attention restoration. To facilitate this, and further explore restorative theory integration, future studies may wish to conduct serial multiple mediator analyses. For example, the effect of environmental quality on emotional well-being could be mediated by perceived restorativeness and stress reduction in a serial fashion (e.g. environmental quality → perceived restorativeness → stress reduction → emotional well-being) (see Hayes (2013) for further information).

4.4 Study limitations

An *in-situ*, non-experimental study of this type will necessarily have limitations. First, the data collection protocol could mean that participants did not necessarily complete the questionnaire immediately before and after the group walk, which has implications for internal validity. Second, as the study took place over the changing seasons from late summer through autumn, the data may reflect

a seasonal effect. Third, power is important for multilevel analyses (Snijders, 2005). A power analysis and estimation of the required sample size should have been conducted prior to data collection to be sure that mediation effects would be detected (Frazier, Tix, & Barron, 2004). However, given our design – one in which the number of questionnaires returned depended on the number of group walks taken by participants – this was not feasible in this study. Fourth, given the presence of multiple simultaneous statistical inferences, caution is recommended when interpreting *p*-values close to the threshold 0.05. Multiple comparisons corrections (e.g. Bonferroni) could be used for further assurance in specific cases. Fifth, the reliance on self-reports for all variables may mean the estimates of association are inflated. Finally, the study's data focuses on the individual's experience within the context of group walks, which might differ from an individual's experience of the environment alone (Duvall, 2010b; Staats & Hartig, 2004; White, Pahl, Ashbullby, Herbert, & Depledge, 2013). The social aspect of the group walk may result in less interaction with the environment (Hynds & Allibone, 2009) and less perceived restorativeness (Johansson et al., 2011; Scopelliti & Giuliani, 2005).

4.5 Future studies

Work remains to investigate whether the four aspects of a restorative experience mediate the effects of environmental quality on stress recovery and attention restoration (Hartig et al., 2014). Such mediation studies may wish to include a measure of attention restoration (e.g. digit span test) as an outcome variable or induce restorative need in participants. Both of these methodological inclusions would ensure greater consistency with ART. Given the known issues with the coherence subscale, future work should include refinement of the subscale in order to more fully understand the theoretical importance of coherence in the nature-health relationship.

Future research could usefully incorporate objective indicators for naturalness, biodiversity, walk duration and walk intensity. Subsequent research could replicate this study with solo walkers, as it is possible that coefficients of the *a* and *b* paths, direct effects (*c*'), and indirect effects (*ab*) found in this study may be stronger for those who are walking alone. Further research may also wish to explore the best 'dose' of biodiversity for perceived restorative qualities; e.g., would a high biodiverse environment be associated with greater fascination, but less coherence? Finally, future studies of biodiversity and well-being may want to investigate mediation models with perceived restorativeness. This type of research would further the understanding of the transactional human-environment relationship.

4.6 Conclusion

As the contribution of natural environment qualities for well-being is a developing area of nature and health research, it is important to understand the mechanisms through which this relationship occurs. The current study found that perceived naturalness and perceived bird biodiversity did not influence emotional well-being directly, but indirectly through their effect on perceived restorative quality. This suggests that it is not the perception of an environment's naturalness and bird biodiversity that contributes to emotional well-being, but that the perception of these environmental qualities provide an opportunity for a restorative experience, which then influences emotional well-being. Perceived restorative quality of the environment may thus be an important mechanism underlying the salutogenic effects of nature. The value of biodiverse environments and their restorative qualities to promote well-being for humans – and non-humans – is relevant for ecologists and urban planners alike. For environmental psychologists, the findings describe the components of a restorative

experience that enhance emotional well-being, support an integration of restorative environment theories and highlight the transactional relationship between environment and person.

Conflicts of Interest

The authors declare no conflict of interest.

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