ONE HEALTH: THE WELL-BEING IMPACTS OF HUMAN-NATURE RELATIONSHIPS

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ONE HEALTH: THE WELL-BEING IMPACTS OF HUMAN-NATURE RELATIONSHIPS

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In recent years there has been a growing body of evidence from fields such as public health, architecture, ecology, landscape, forestry, psychology, sport science, psychiatry, geography suggesting that nature enhances psychological health and wellbeing. Physical activity in the presence of nature, feelings of connection to nature, engagement with nature, specific environmental features (e.g. therapeutic, water and trees) and images of real and virtual nature have all been posited as important wellbeing facilitators. Thus, the association between natural environments and health outcomes might be more complex than initially understood (Pritchard, Richardson, Sheffield, & Mcewan, 2019). Despite the number of studies showing improvements in psychological health and wellbeing through nature-based physical activities or feelings of connection to nature the exact role and influence of the natural environment in this process is still rather unclear (Brymer, Davids, & Mallabon, 2014; Karmanov & Hamel, 2008). Research is also beginning to consider the importance of individual differences, meaning and the person-environment relationship (Freeman, Akhurst, Bannigan & James, 2016; Freeman & Akhurst, 2015) in the development of wellbeing and health outcomes. Furthermore traditional theoretical notions, such as Biophilia, topophilia, restoration theories and stress reduction theories typically used to interpret findings are also being critiqued. Often one of the main barriers for practitioners is the vast array of theories that claim to effectively explain research findings but that tend to be only partially relevant (e.g. for Physical activity or restoration), focus on the characteristics of the person (e.g. nature relatedness) and only some features of the landscape (e.g. therapeutic landscapes).

This special edition therefore brings together cutting edge ideas and research from a wide set of disciplines with the purpose of exploring interdisciplinary or trans-disciplinary approaches to understanding the psychological health and wellbeing benefits of human-nature interactions

Brymer, E., Davids, K., and Mallabon, E. (2014). Understanding the psychological health and well-being benefits of physical activity in nature: an ecological dynamics analysis. *J. Ecopsychol*. 6, 189—197.

Freeman, E., Akhurst, J., Bannigan, K., and James, H. (2016). Benefits of walking and solo experiences in UK wild places. *Health Promot. Int*. doi: 10.1093/heapro/daw036IF1.989

Freeman, E., and Akhurst, J. (2015). "Rethinking notions of therapeutic landscapes: a case study exploring perceptions of a wild place experience (WPE)," in *Explorations: Adventure Therapy Around The Globe, International Perspectives and Diverse Approaches*, eds C. L. Norton, H. Carpenter, and A. Pryor (Champaign, IL: Common Ground Publishing).

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Editorial: One Health: The Well-being Impacts of Human-Nature Relationships

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Editorial on the Research Topic

One Health: The Well-being Impacts of Human-Nature Relationships

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This special edition responds to two interrelated issues confronting humanity today: the health and well-being of populations and the state of the natural environment. Mental Health disorders are on the rise across the world. A report commissioned by Lancet in 2018 estimated that 1.1 billion people are currently affected by adverse mental health issues (Chandra and Chand, 2018; Frankish et al., 2018). At the same time, the planet is being pushed to its limits from the effects of climate change and there is an ongoing biological annihilation (Ceballos et al., 2017). The implications of these issues are not only financial; they threaten the future of human civilization itself (Ceballos et al., 2017) as it depends upon the Earth's natural systems (Whitmee et al., 2015). It is now vital that governments, policy makers and practitioners across all sectors focus efforts on improving the human-nature relationship. Recognition of the importance of finding ways to improve the human relationship with the rest of nature for the well-being of people and the wider natural world is now international and reflected in responses to the United Nations Sustainable Development Goals (goal 3) (Chandra and Chand, 2018; Peacock and Brymer, 2019; Parsons et al., 2019; Sharma-Brymer and Brymer, 2019), "One Health" models of human, environmental and wildlife health (Rabinowitz et al., 2018) and clinical ecology (Nelson et al., 2019).

Some argue that globalization, the rise in technology, population growth, and the perceived diminution of nature's worth for human psychological, emotional and physical health has caused a disconnect between humanity and the rest of nature. As this disconnect continues and potentially grows, the prospects of achieving human well-being within the dominant economic development paradigm weakens. Vital alternative, sustainable, and integrated development paradigms are being developed that aim to re-address the balance between the human system and the Earth system (Rockström, 2015). Fortunately, research in this area continues to grow and we know a great deal more about the human-nature relationship, its benefits and ways to improve it (e.g., Lumber et al., 2017) than we did just a few years ago. The articles in this special edition clearly demonstrate this and provide hope that we will find a better way to relate to the rest of the natural world and consequently to ourselves.

It is now clear that the responsibility for mapping out the future for human health is not merely an issue for medicine and allied health. Perhaps more than any other issue affecting humanity, the future for the health of people and planet depends on multiple disciplines working together. This special edition reflects this notion with perspectives and evidence drawn from psychology, sport science, public health, environmental studies, biology, social science, forestry, education,

occupational health, information technology, built environments, pharmaceutical and medical sciences, zoology, tourism, and philosophy. Researchers herald from the UK, Australia, United States, Finland, Norway, France, and Austria providing a wide, inclusive and multidisciplinary insight to this research area.

All of the papers argue that the human-nature relationship is an important one, one to understand, enhance, and protect. Human health and well-being benefits range from those that enhance flourishing and thriving to those where nature interactions protect against the onset of illness, to those where nature is an effective intervention for ill health. The contexts explored in this special edition are equally diverse and include the workplace (Hyvönen et al.), semi-natural or urban green spaces (Pasanen et al.; Wood et al.; Tracey et al.; Roe et al.) as well as wilder contexts (Niedermeier et al.), which all found nature experiences in these contexts beneficial to improving well-being. Importantly, Barnes et al.; Roe et al.; Schebella et al. and Wood et al. provide wider evidence of the link between the natural environment, biodiversity and well-being, and Hyvönen et al. show that nature should be included in models of workplace well-being. Additionally, there is recognition of the challenges of accessing nature and research on the use of nature-based guided imagery (Nguyen and Brymer) and simulations of natural scenes (Wooller et al.; Calogiuri et al.) find they are effective anxiety and stress management interventions. Roe et al. highlight well, highlight well, however, the need to understand the complexities of stress-management arguing that age and other demographic variables are important to consider.

The special issue supports and notes (e.g., Barnes et al.) the growing evidence that nature is good for well-being. The issue presents specific interventions (e.g., Nguyen and Brymer) and nature as a therapeutic environment (Tracey et al.). However, Barnes et al. and Summers and Vivian show how nature is still an unrecognized health resource despite evidence of the benefits from numerous sources, including large scale national campaigns such as 30 Days Wild which benefits well-being by improving nature connectedness (Richardson and McEwan).

We also see different concepts, theories and therapies considered in attempts to better understand and work with nature. For example, Schweitzer et al. argue that phenomenological and psychoanalytic perspectives offer a richness to understanding experiences, finding that nature is an integral part of the sense of self among people who considered nature as essential to their health and well-being. Stoic and Buddhist traditions are considered by Fabjanski and Brymer who argue mindful attention to natural patterns and rhythms, cognitive interventions and deconstructing and relinquishing anthropomorphic perceptions are key aspects to how nature enhances health and well-being. Acceptance and Commitment Therapy (ACT) was also combined with Adventure Therapy (AT) to explore ways of promoting the well-being of children "at-risk" (Tracey et al.). A review of Ecotherapy (Summers and Vivian) highlights the role of human-ecosystems interaction as a therapeutic device claiming that nature provides a service that is undervalued in ecological literature.

Evidence in this special edition, alongside an increasingly vast array of published work, seems to support a push for a health service built around the integration of human experience with nature (Natural England, 2009), and the need to improve and diversify nature-based provision for social prescribing to suit different contexts, preferences, resources and needs. Caution is rightly encouraged though by van Heezik and Brymer who question the prevalent use of nature as a commodity and reveal the often brushed aside tensions between human-nature relationship work and the need to protect the very thing that keeps us healthy. Often such challenging topics are avoided. Wood et al. and Schebella et al., demonstrate further why such questioning is so essential when they showed that biodiversity underpinned people's choice of favorite places and their perceptions of restorative impacts. Challenges also still exist in understanding mechanisms underpinning the well-being benefits of human-nature relationship (though some research is edging closer e.g., Richardson and McEwan; Lawton et al.) which reflect the need to move beyond the limitations exposed when examining traditional and well-established theories, such as Attention Restoration Theory and Biophilia.

Crucially, we need to understand more about how we can both enhance well-being through nature exposure and experiences, and become stewards of nature, working toward protecting it more effectively, and allowing nature to also flourish—developing a closer, connected relationship with the rest of the natural world. Continuing research in this area in an interdisciplinary and trans-disciplinary way is therefore vital. All too often researchers work within the safety of their own disciplines. Pioneers within this specialism should demonstrate (more often) how to work together across disciplines and showcase the fruits of their work widely and in ways that can be applied.

Despite the breadth of evidence, nature based solutions remain inexplicably absent from the dominant models of health, health behavior change (e.g., Gritti, 2017) and workplace well-being (Richardson et al., 2017). Yet this special issue presents clear evidence of the benefits of human embeddedness within the natural world (e.g., papers by Fabjanski and Brymer and Schweitzer et al.) and the importance of moving forward with a multidisciplinary approach. Both these perspectives (embeddedness and multidisciplinary work) can be seen to underpin the benefits, for example, of nature-based exercise (Wooller et al.) and engagement with nature's beauty (Richardson and McEwan). Research in this special edition demonstrates that the human-nature relationship as it pertains to health and well-being is clearly more nuanced than traditionally understood. How this relationship provides for such a broad impact on psychological health, including increased flourishing and decreases in a broad array of mental illness, needs further exploration. However, what seems clear is that much depends on understanding the relationship between activity, individual characteristics and environmental characteristics.

Future research should focus on two areas. Firstly, there is no human well-being without nature's well-being, and the threats to biodiversity, wildlife and the living planet are present and severe. In order to maximize the opportunities for both humans and nature to thrive, further research is needed to understand *how* the human-nature relationship works and following on from this, how best to improve the human-nature relationship.

This will require investigations that recognize and explore the complexities of the human-nature relationship, acknowledge the role of meaning and meaning-making (Freeman et al., 2016; Freeman and Akhurst, 2018) and respond to this call for further research in a nuanced manner, avoiding reductionist or narrow tendencies. The continuation of interdisciplinary collaboration is therefore vital. Future research that provides a deeper understanding of the human-nature relationship has the potential to aid the development and improvement of these broader efforts. The continuation of current funding that supports these research needs and the expansion of funding opportunities in this area are therefore needed if current crises in health, mental health and our planetary future are to be addressed.

Secondly, there is an urgent need to find ways to improve the human-nature relationship through interventions, campaigns (Richardson and McEwan), activities, curricula, green infrastructure and urban design. Bringing together artists, planners, designers, and researchers to create places that afford a connection to nature. Such research should go beyond understanding to application, creating accessible and effective tools for practitioners from all aspects of human-environment interaction to address the human-nature relationship. An exemplar and catalyst for this movement is provided in the recommendations below.

RECOMMENDATIONS

There will always be a need for further research and understanding, but owing to the crises in well-being and biodiversity a new relationship with nature, where nature and well-being are central determinants of human development, is needed now. Therefore, the research in the special issue can be distilled into a number of recommendations that recognize the importance of human-nature relationships for both human and nature's well-being:

- Everyday experiences of nature matter. Provide green spaces, close to home and work, with opportunities and prompts for people across the lifespan to notice nature and its beauty. See Richardson and McEwan and Roe et al.
- Encourage a broader range of seasonal experiences in nature, of various durations, at various times and calling on insight from a range of approaches to human-nature relationships (e.g., Stoic and Buddhist Traditions; nature connectedness). See Barnes et al.; Fabjanski and Brymer; and Richardson and McEwan.
- Provide habitats for a variety of wildlife. Biodiversity matters for human health. Micro-variables such as birds, plants, wildlife, and native species create a bond between people and natural places. See van Heezik and Brymer and Schebella et al.
- Activity in natural environments is good and better than in other environments. Provide opportunities to encourage walking and exercise in nature in residential and work contexts. Compared to indoor exercise there are additive benefits of a closer relationship with nature and reduced anxiety. See Lawton et al.; Wooller et al.; Hyvönen et al.; and Niedermeier et al.
- Provide nature based therapeutic environments. See Tracey et al. and Summers and Vivian
- For those with limited access to nature, provide imagery and VR alternatives. See Nguyen and Brymer and Calogiuri et al.

Together the articles in this special issue provide one bounded example of how interdisciplinary approaches to appreciating the nuances involved in uniting human and planetary health can help rethink the human-nature relationship and inform the international need for a perspective that positively impacts on the well-being of human beings and our planet. The evidence is clear; the well-being of future populations and the planet depends on a cross sector commitment and an authentic desire to refocus political and practical efforts on effective human-nature relationships.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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ORIGINAL RESEARCH
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Combining Acceptance and Commitment Therapy With Adventure Therapy to Promote Psychological Wellbeing for Children At-Risk

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With high rates of psychological distress reported amongst children internationally, the development and evaluation of new program initiatives is critical in order to meet the challenge of this burgeoning issue. Both acceptance and commitment therapy and adventure therapy are emerging as popular strategies to elevate psychological wellbeing. This small-scale program evaluation focuses on nine upper primary school-aged children enrolled in a specialist school in Australia for children with challenging behavior and/or emotional needs. Participants completed a newly developed 8-week intervention entitled 'ACT in the Outdoors' which combined key principles of both acceptance and commitment therapy and adventure therapy. The program was evaluated via a combination of pre and post participant psychological measures, and post interviews with participants and teachers. The results of this small-scale preliminary evaluation suggest that a portion of the participating children reported improvements in psychological wellbeing and skill development. Improvements appear to be mitigated by attendance and level of psychological wellbeing upon program entry. Based on this premise, the results suggest that more research is warranted to further understand the potential benefit of this innovative interdisciplinary approach.

Keywords: acceptance and commitment therapy, adventure therapy, wellbeing, mental health, at-risk children

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INTRODUCTION

High prevalence rates of psychological difficulties amongst children present as an enduring international problem. The most recent World Health Organization's (World Health Organization [WHO], 2005) inquiry into child mental health affirmed that worldwide, 10–20% of children and adolescents experience mental disorders. This remains a significant issue with WHO's Mental Health Action Plan 2013–2020 (World Health Organization [WHO], 2013) advocating that there should be an international focus on assisting young people to develop a positive sense of identity and the ability to manage thoughts and emotions to enable full active participation in society.

In Australia, the site of the current study, around one in seven children and adolescents aged 4–17 years exhibit a psychological or behavioral disorder with attention deficit hyperactivity disorder, anxiety, depression and conduct disorder the most prevalent (Lawrence et al., 2015). If unresolved, these childhood difficulties negatively impact on children's development and the

attainment of future productive adult lives (World Health Organization [WHO], 2005). Indeed, robust longitudinal studies have confirmed that anxiety and depressive symptoms in childhood and adolescence significantly predict major depression and mood disorders in adulthood (Reinherz et al., 2003; Roza et al., 2003).

The identification and development of effective resolutions for this burgeoning problem warrants attention. The World Health Organization [WHO] (2005) lamented that the construction of both policies and interventions to support child and adolescent mental health lagged behind efforts made for adults. Given the predictive nature of childhood mental health for adult outcomes, work with children and adolescents necessitates greater consideration. Since the World Health Organization [WHO]'s (2005) deposition, two primary bodies of therapeutic work have emerged with children: Acceptance and commitment therapy and outdoor adventure therapy. The current study utilized both of these approaches and thus a review of their definitions, current application and evidence-base will be presented.

Acceptance and Commitment Therapy

Acceptance and commitment therapy (ACT) has arisen as an increasingly popular therapeutic approach and is considered as the 'thirdwave' of cognitive behavioral therapies (Fletcher and Hayes, 2005). Unlike its predecessors, ACT focuses on a person's thinking and behavior to achieve a valued and meaningful life, and thereby reduce psychological distress, rather than centring on the control and removal of symptoms of psychopathology in itself (Simon and Verboon, 2016). The key aim of ACT is to increase one's psychological flexibility, which is defined as the ability to be present in the moment, pursue important values and select behavior that is aligned to these values whilst accepting the presence of unpleasant experiences (Hayes and Strosahl, 2004). ACT identifies six core processes that work together to achieve psychological flexibility: acceptance, defusion, contact with the present moment also known as mindfulness, self-as-context, valuing, and committed action (Hayes et al., 1999). With the significant overlap and intersection among the six core processes, one's mastery of these processes is typically measured by experiential avoidance as a proxy for psychological inflexibility (Murrell et al., 2015). A review of the empirical evidence underpinning ACT concludes that ACT has shown to be effective at improving a range of problems where experiential avoidance is present. Effect sizes are large both immediately following intervention and at follow-up (Ruiz, 2010).

Although the construction of ACT intervention programs for children is gaining momentum, comparatively little ACT efficacy research has been conducted with children, as opposed to adults and adolescents (Barney et al., 2017). Simon and Verboon (2016) contend that key characteristics of ACT position it as an ideal intervention for children. Namely, the cognitive components of ACT are easier to master than that of cognitive behavioral therapy, metaphors are used as a central strategy instead of literal instructions, the focus of ACT suits preventative work which is typically aimed at children, and children appear to be more receptive to strategies such as mindfulness and acceptance than adults (Goodman and Greenland, 2009).

Nonetheless, the evidence base affirming the effectiveness of ACT for children remains scarce (Simon and Verboon, 2016; Enoch and Dixon, 2017) and given the resource-intensive delivery of ACT and the focus on samples with specific characteristics (i.e., with identified psychological needs), studies tend to rely on single-case or small sample, uncontrolled studies (Coyne et al., 2011). Although the inherent nature of these designs reduces the capacity to make inferences about efficacy with children, these small case studies and program evaluations help to build a broader body of knowledge.

For example, following nine 50-min ACT sessions, three children previously diagnosed with obsessive compulsive disorder (10–11 years) evidenced clinically significant reductions in obsessive compulsive symptoms (Barney et al., 2017). Similarly, Murrell et al. (2015) reported that out of nine children (11–15 years) with attention deficit hyperactivity disorder, learning problems and behavioral problems, approximately one-third demonstrated clinically significant changes in behavioral symptoms. Furthermore, Ghomian and Shairi (2014) employed a quasi-experimental design where 10 children (7–12 years) with chronic pain received an ACT intervention. Results revealed that, compared to the control group, participating children reported increased functioning. Finally, the sustained attention of children (6–12 years) who received six sessions of ACT intervention focusing on present moment activities was improved compared to those who did not receive the intervention (Enoch and Dixon, 2017). Less is known though about the impact on psychological wellbeing such as anxiety and depressive symptoms for children.

Adventure Therapy

Together with the rise of ACT, adventure therapy (AT) is gaining momentum as a method to remedy psychosocial difficulties through one's engagement with outdoor activities and experiential learning exercises (Bowen and Neill, 2013). Often used synonymously with a variety of terms, AT is typically underpinned by the following principles: learning through experience; interaction with nature; heightened arousal from perceived risk; focus on positive change for participants; provision of care and support; and group based delivery where group processes themselves form part of the intervention (Gass et al., 2012).

AT presents as a promising approach for developing the psychological wellbeing of children for both its ability to engage children and also documented outcomes in itself. Children demonstrate a preference for outdoor settings, especially those based in nature (Evans, 2006) and AT can offer a more appealing approach to therapeutic intervention (Bowen et al., 2016). That is, children may be reluctant to engage in traditional intervention approaches (Rickwood et al., 2007) that require sitting still, talking, or writing, which dominate therapeutic approaches with adults.

A mounting body of evidence suggests that AT, and associated approaches, can foster short and long-term therapeutic change (e.g., Dickson et al., 2008; Scrutton, 2015; Bowen et al., 2016), although qualitative evaluations tend to deliver more consistent

positive results than quantitative evaluations (Scrutton, 2015). There is a need, however, to conduct further evaluations to produce a robust evidence-base of efficacy, especially for its efficacy with children (Bowen et al., 2016). Research examining the impact of AT for children tends to be based on children without clinical diagnoses, so while the designs and sample sizes permit greater statistical investigation of efficacy than what has been achieved for ACT, the results do not always apply directly to children diagnosed with psychological difficulties. For example, Scrutton (2015) surveyed 360 children (10–12 years) who participated in a residential week of outdoor adventure and compared their pre and post personal and social development with a control group of 115. A small positive effect was witnessed after the intervention, but was not maintained at follow-up. Children who reported poorer personal and social skills initially appeared to gain more from the outdoor adventure experiences.

A randomized controlled trial with 120 senior primary age children demonstrated the efficacy of AT for promoting psychological wellbeing (Li et al., 2013). Children received five 75-min sessions plus one full day of adventure-based training and, in comparison to the control group, reported a reduction in depressive symptoms, lower anxiety levels and higher self-esteem. Furthermore, a recent meta-analysis of AT outcomes (Bowen and Neill, 2013) established an effect size of 0.5 with strongest effects for clinical and self-concept measures. Importantly, age moderated the effectiveness of AT programs with stronger outcomes demonstrated for adult participants. Effect sizes are yet to be determined for children.

In sum, a review of the literature signals the potential efficacy of ACT and AT to promote the psychological wellbeing of children. The current study developed and implemented a new program which comprised principles from both ACT and AT. Although the small scale of the study precludes the evaluation of the additive contribution of combining ACT and AT beyond their individual contributions to psychological wellbeing, it provides a description of the new program and preliminary insight into participant and stakeholder perceptions of impact.

A New Interdisciplinary Approach to Enhance Psychological Wellbeing of Children: *ACT in the Outdoors*

Premised on ACT and AT, the authors constructed a new intervention program entitled *ACT in the Outdoors*. The authors hold complementary expertise including: a registered psychologist with specific ACT training and experience, a specialist in outdoor learning and experiential education approaches, a certified therapeutic recreation specialist with experience in AT, and a certified nature pedagogue specializing in arts-based pedagogies in the outdoors.

Together they delivered each session in outdoor settings, including the beach, park and on nature walks. The children's school teachers also participated in the sessions. The program was conducted over 8 weekly sessions (with the first seven sessions of 1 h duration and the final session of 2 h duration). **Table 1** presents the sequence of concepts and activities (for a full description of the program see Truong et al., 2018).

The Present Study

The present study aimed to provide a preliminary evaluation of the *ACT in the Outdoors* program on the psychological wellbeing of children who presented with challenging behavioral and/or emotional needs. This objective was addressed through interviews with participating children and their school teachers to gather their perspective on impacts, as well as participating children's completion of pre and post quantitative measures.

MATERIALS AND METHODS

Design

The present study implemented a multi-method design (Creswell, 2018) combining the administration of both post-intervention qualitative interviews with participating children and their school teachers, and quantitative pre and post-intervention questionnaires with participating children. Together, these methods provide insight into the perspectives of children and teachers about the impact of *ACT in the Outdoors* on the psychological wellbeing of participants.

Participants

A total of nine children from the *ACT in the Outdoors* program participated in the quantitative component of the study and completed pre and post questionnaires. Participants included eight males and one female with an average age of 11 years 9 months (ranging from 11 years 2 months to 12 years 10 months; five were in Year 5; four were in Year 6). As a result of exhibited behavioral and emotional difficulties, the children were placed in a "School for Specific Purpose" particularly designed to support children with behavioral and/or emotional challenges by offering small class sizes and alternative pedagogies among other strategies. The participants attended this school from 3 to 5 days out of the 5-day school week (with remaining days being completed at their regular local school). Six children identified themselves as Australian; one as New Zealand origin; and two as Aboriginal. Only one student indicated that they spoke a language other than English, namely Spanish. Seven of these children (six males and one female) also participated in a post-intervention interview.

Three teachers from the school (two males and one female) participated in a post-intervention interview. These teachers had detailed knowledge of the children and *ACT in the Outdoors* as they worked with the children at the School for Specific Purpose and accompanied the children during the *ACT in the Outdoors* program.

Materials and Procedure

Approval for the research was received from the University Human Research Ethics Committee and the New South Wales Department of Education. Full parental and personal consent was attained for the participating children, whilst teachers provided full personal consent. Participation in the research was voluntary and when participation was declined, children were still able to fully participate in the *ACT in the Outdoors* program.

TABLE 1 | Sequence of concepts and activities in *ACT in the Outdoors*.

Session	Activities	Focus areas
1	• Circle. Establishment of parameters for interaction; reiteration of school approaches of Safe, Respect, Learner. • Energy rope. • Construction of balancing structures with natural materials. Breathing practices. • Overview of all sessions and anticipated outcomes.	Introduction and practice of mindfulness and contact with the present moment. Contact with place.
2	• Circle and recap on week 1. • Checking in with our bodies in space: stretching, breathing and body awareness. • Helium stick. • Nature walk to identify anger. • Exercises for contextualizing negative thoughts drawn on paper and sand.	Willingness to make space for difficult thoughts. Emotions and behaviors associated with adversity and hardship. Changing the way we respond to difficulties. Recognizing the ephemeral nature of negative thoughts.
3	• Circle with focus on positive reflections. • Checking in with our bodies and emotions. • Oz Tag game with rule changes for reflection. • Writing then destroying words depicting negative emotions in the sand. • Rock skimming (negative thoughts written on rocks).	Being in the moment. Noticing emotions and how they impact on everyday interactions. Breathing to reduce stress and anxiety. Learning to release oneself from difficult thoughts.
4	• Circle: reflection on previous weeks with examples of activities enjoyed or positive thoughts. • Balloon (with negative thoughts inscribed) sling in groups of 3. • Tug of war game. • Chinese finger traps. • Mindfulness activity with a focus on the body and thoughts.	Objectifying thoughts – as separate from the self – my thoughts are not me. Communication, attempting to reach consensus, group action, disassociation from negative thoughts. Identifying how we hook ourselves on negative thoughts. Awareness of responses to no-win situations: fight or flight – or witnessing and letting go.
5	• Circle and energy rope with recap on being safe, respectful and learner. • Breath exercises. • Values cards exercise. • Clay sculptures and storytelling. • Human yurt circle.	Awareness of difficult thoughts, and of energy used in discordant emotions. Living a valued life: identifying personal values and goals. Identifying steps to achieve goals. Working together with group support to stay safe and achieve outcomes.
6	• Circle and energy rope; reflections on values. • Rob the nest game. • Beeswax sculptures, • storytelling and totems. • Values cards exercise. • Breathing and mindfulness.	Working with values. Identifying what it means to live a valued life and what detracts from the valued life. Perspectives on problems. Symbols and totems we can use for reminding us of our values. Developing resilience.
7	• Circle and energy rope; reflection on totems and symbols. • Problem solving with knots, and charcoal drawings. • Developing a plan for implementing problem solving actions. • Minefield game. • Breathing and stretching.	Taking action: practicing techniques to live with emotions and take action toward a valued life. Unhooking from difficult thoughts. Developing trust. Identifying scale of problems, strategies for solving them, weighing of strategies and choosing one for action plan.
8	• Nature hike – with experiential activities. • Circle –safety review and identification of purpose of walk. • B.O.L.D: Breath, Observe, Listen, Decide. • Choice point model exercise – fork in the path. • Values clarification: paper plane at end of walk. • Letter to self regarding following school year. • Cutting of energy rope and making slipknot bracelets for all participants.	Focus on values-guided action: commitment strategies for living a valued life, dealing with setbacks and recognizing progress. Willingness to try something new. Recognizing body and emotions working together and the influence awareness can have on both. Identifying strengths, making decisions and self-compassion. Symbolically committing to actions for a valued life.

Semi-Structured Interviews With Children

Post-intervention interviews were conducted with participating children to gain insight into their perceived changes in psychological wellbeing or skills from before the program to after the program. Questions included: (1) What is your opinion about the weekly sessions? (2) What did you like the most? (3) Which activities did you enjoy, or get the most out of? (4) What could have been improved? (5) Think about what you were like

before you started and what you are like now. Have there been any changes? Please explain (6) What are the main messages or lessons you have taken away from our sessions? (7) How do you apply these principles/lessons at home or at school?

Semi-Structured Interviews With Teachers

The post-intervention interviews with teachers sought to examine similar topics but from the perspectives of the teachers who had close knowledge of the children within their everyday school environment and of their *ACT in the Outdoors* journey. Teachers were asked to comment on any changes they had observed in the children following their participation in the program.

Pre and Post Questionnaires

A battery of pre-existing measures was selected by the researchers to measure children' psychological wellbeing (i.e., anxiety, depression, impairment caused by anxiety, general school self-concept) and skills (i.e., psychological flexibility, mindfulness).

Kessler10

This is a 10-item measure of anxiety and depression symptoms experienced in the past 4 weeks (Kessler et al., 2002). The measure has been used in studies with Australian adolescents and adults. Scores range from 10 to 50 and are classified into four bands: Low: 10–15, Moderate: 16–21, High: 22–29, and Very High: 30–50. The Kessler10 has excellent internal consistency ($\alpha = 0.93$) (Kessler et al., 2002). Lower scores are more desirable.

Children's anxiety life interference scale

This is a 9-item measure used to assess the level of life interference and impairment associated with anxiety (Lyneham et al., 2013) where lower scores are more desirable.

Self-description questionnaire I

This is a measure of multidimensional self-concept with strong reliability and validity (Marsh, 1990). For the current study, the general school factor was administered; it includes ten items about the student's competence and enjoyment of school in general, on a 5 point Likert-type response scale. Higher scores are more desirable.

Avoidance and fusion questionnaire for youth

This is a 17-item child-report measure used to assess psychological inflexibility provoked by cognitive fusion, experiential avoidance, and behavioral ineffectiveness in the presence of negatively evaluated private events (e.g., thoughts, feelings, physical-bodily sensations) (Greco et al., 2008). Lower scores are more desirable.

Child acceptance and mindfulness measure

A 10-item measure of mindfulness which assesses the degree to which children and adolescents observe internal experiences, act with awareness, and accept internal experiences without judging them (Greco et al., 2011). Higher scores are more desirable.

Data Analysis

Interviews were recorded and transcribed verbatim. Guided by the constant comparative method and thematic coding (Creswell, 2012), interview transcripts were reviewed and categories developed based on presented ideas that related to perceived impact. These categories served as the basis to identify common themes across both child and teacher qualitative data sources.

Given the small sample size in the present study, group analyses were not possible. Reliable Change Index (RCI) scores were calculated for each individual's scores on the five quantitative measures to determine pre and post changes at the individual level (see Zahra et al., 2016 for a review). Jacobson and Truax's (1991) standard formula was applied whereby scores greater than 1.96 (95% confidence level) were considered significant.

RESULTS

Interviews

An analysis of the semi-structured interviews with both children and teachers identified that participation in *ACT in the Outdoors* evidenced the following changes for participating children: self-calming through mindfulness, committing to action, enhanced teamwork and ability to trust others, and showing support and respect for others.

Self-Calming Through Mindfulness

The most prominent impact observed by the teachers was the children's ability to calm themselves when feeling anxious, angry, or frustrated. This was discussed by the teachers generally in relation to mindfulness, and more specifically, the breathing exercises introduced and practiced throughout each session of the program. The following quote demonstrates this finding:

I have noticed a change in [one student] and to some degree [another]...took on the strategies and everything and have used them. I've seen [him] use them . . . he does use the calming. . . He just blanks out basically. He blanks out and kind of sits there and does his own thing. He just stares at something and I've asked him about it and he said 'I'm meditating,' which I don't know if he is or if he's just blocked out, but it really seems to calm him down when he does it.

Broadly, mindfulness was identified as a new skill acquired by the majority of the participating children. While the children did not specifically use the term 'mindfulness', there were numerous references to '*taking time out,*' '*calming down,*' '*breathing,*' '*meditation,*' and '*yoga,*' within their recollections of what they learned and their perceived behavioral changes as a result of participating in the program. The following interview exchange with Ned[1] reveals not only what he learned in relation to applying mindfulness strategies, but also provides an example of how he put this new skill into action in his daily school life.

> **Researcher:** What do you think you learned?
> **Ned:** Control my anger because now I'm like I can control my anger.
> **Researcher:** Do you feel like you can recognize when you start to get angry?

[1] Pseudonyms used

> **Ned:** Yeah.
> **Researcher:** And what do you do now?
> **Ned:** Just calm myself now.
> **Researcher:** Okay. How do you calm yourself down?
> **Ned:** Breathing. Do that breath stuff.
> **Researcher:** Can you think of a time that you've done that in the past, since we started our sessions?
> **Ned:** Tuesday.
> **Researcher:** So you started; what happened?
> **Ned:** This [student] was just annoying me so much and then I got to a point and I swore. I didn't even know I swore. I yelled out and I was like so messed, I didn't even know…But to calm myself down I walked outside and I went to have a drink and I took some breaths.

Similarly, when asked about what he learned through his participation in the program, Ryan responded:

> Well it made me behave more better and calmed me down. Like it would teach me how to calm down instead of being all angry and it's better…
> It just made to calm you down, change your actions, make you more better, calm you down, gives you time out, like yoga. Yeah. Makes you behave. Doesn't make you angry. Doesn't make you have thoughts of bad stuff.

While breathing and calming exercises are facets within mindfulness and broader ACT principles, the children's responses indicate that they were particularly beneficial for managing difficult emotions and subsequent negative behavior. Although some children found it challenging or at times boring to participate in these activities, they also identified the value of developing these new skills, with one student commenting that he grew to respect the program over time.

Committing to Action

Core principles of ACT, embodied in *ACT in the Outdoors*, are the identification of values and a commitment to actions that help achieve a life guided by these values. During the interviews, the children identified the positive behaviors they need to commit to in order to achieve their valued life. For example, Nathan stated: "*I do more work. I reckon I listen more…I'm way calmer*." Identified actions mostly involved applying themselves and tempering the aggressive behavior that has been problematic for them throughout their schooling. For example, Ned stated he would like to "*be good and listen to the teachers and just try my hardest*." Nick emphasized the importance of taking his time with school tasks that he finds difficult, and Ryan said that he would advise himself to "*be calm, do my work*" and listen to the teacher.

The children also suggested making an effort to socialize and get along with their peers as a way to improve their school experience. Half of the participants insisted that they would need to curtail their aggressive behavior such as fighting, smashing windows and lashing out at others. Ryan in particular discussed how his aggressive behavior led him to leave his regular school and that he would have to "*calm down*" and "*make a change*" if he wanted his school experience to improve. Ned indicated that he wanted to "*Make some friends. Don't be left out. I don't want to be left out of nothing. Don't embarrass myself…I just want to start a whole new life.*"

Enhanced Teamwork and Ability to Trust Others

Characteristic of AT, many of the program activities required communication and cooperation amongst group members. The teachers commented that such tasks are often challenging for these children and participation in these activities varied. Nonetheless, the development of teamwork and trust in group members was identified by the teachers as a key outcome of *ACT in the Outdoors*. One teacher commented:

> I think that what I've noticed is that – and we've worked on it all year, but it's becoming more and more – that they work as a team, a lot more teamwork and a lot more trust between them.

Similarly, another teacher reflected on the development of children's positive rapport and changing relationships with their school teachers as a result of the program:

> They're seeing us as not so much their bosses and being in charge of them. They're kind of seeing that we're there to help them and the positive push that this program's got has really changed their thoughts toward us and it gives us a lot more base knowledge.

Showing Support and Respect for Others

The importance of trust is interrelated with the ability to show support and respect for others. This emerged as another theme, and in particular, the storytelling activity, which involved clay sculpting, was a significant antecedent event. When asked to identify an activity that had the most impact on students, one teacher shared:

> For me personally it was the clay building. That day was amazing. To see some of the [students] open up and be so honest and there was no competition between stories. It wasn't 'Well I've done this,' 'I've done that,' and 'I've got a worse life than you.' It was just open and honest what they were saying. So yeah, that was a real highlight of the [program] for me was a couple of the [students] talking so openly and honestly…No one took it as a 'Look how bad my life is.' It was more of a 'This is just what's happened to me and I trust you guys enough to tell you.' So the trust in that exercise was amazing.

The level of trust and rapport within the group was viewed positively. The impact of adults putting their trust in the students, as was the case during a trust and obstacle course activity was also viewed as impactful:

> I really loved the minefield activity and I think that the kids really love it when we put our trust in them and it really stood out…when the kids were in charge of our safety and they didn't abuse it. They took it really seriously.

Pre and Post Questionnaires

At least one RCI score was significant for five of the nine participants (see **Tables 2–6**). Two children exhibited

TABLE 2 | Significant reliable change indices, and pre and post scores, for participant 2.

	Pre	Post	RCI
Mindfulness	25	32	−2.56*

**indicates a significant RCI.*

TABLE 3 | Significant reliable change indices, and pre and post scores, for participant 4.

	Pre	Post	RCI
Anxiety and depression	40	20	−3.30*
General school self-concept	10	23	1.98*

**indicates a significant RCI.*

TABLE 4 | Significant reliable change indices, and pre and post scores, for participant 5.

	Pre	Post	RCI
Life interference associated with anxiety	25	6	−3.58*
Psychological inflexibility	30	8	−2.04*

**indicates a significant RCI.*

TABLE 5 | Significant reliable change indices, and pre and post scores, for participant 6.

	Pre	Post	RCI
Anxiety and depression	30	22	−1.98*

**indicates a significant RCI.*

TABLE 6 | Significant reliable change indices, and pre and post scores, for participant 8.

	Pre	Post	RCI
General school self-concept	27	40	1.98*

**indicates a significant RCI.*

significantly improved general school self-concept; two children reported significantly reduced anxiety and depression; one child reported significantly reduced life interference associated with anxiety; one child evidenced significantly improved mindfulness whilst another exhibited significantly reduced psychological inflexibility.

DISCUSSION

This study sought to provide a preliminary evaluation of a new interdisciplinary program entitled *ACT in the Outdoors*, based on a combination of ACT and AT principles, on the psychological wellbeing of primary age children with challenging behavioral and/or emotional needs. The qualitative interviews provide insight about potential impact, as perceived by participating children and their school teachers. Rather than identify changes to psychological wellbeing, both children and teachers recognized that participating children had acquired new skills and new behaviors that may indeed serve as precursors to future improved psychological wellbeing. Changes include: self-calming through mindfulness, committing to action, enhanced team work and ability to trust others, and showing respect for others. The program was buttressed by the inclusion of the school teachers alongside the children and facilitators. Warm and trusting relationships were cultivated between the children and their school teachers which may lead to greater school engagement and a continuation of ACT and AT principles within the school environment.

The pre and post quantitative findings show that five of the nine participating children exhibited a significant improvement in at least one aspect of psychological wellbeing from pre to post intervention. Improvements were in the area of: general school self-concept (two children); anxiety and depression (two children); life interference associated with anxiety (one child); mindfulness (one child); and psychological inflexibility (one child). A closer examination of these significant changes presents some interesting findings that may guide future research and practice. Firstly, it is notable that the five children who exhibited significant changes had attended seven to eight out of eight sessions, whilst those who did not exhibit significant changes only attended five to six out of eight sessions. It appears that significant change may only occur following completion of seven to eight sessions within *ACT in the Outdoors*. Secondly, significant change was witnessed for children who, at pre-test, presented with the highest anxiety and depression; highest life interference associated with anxiety and lowest general school self-concept compared to the remaining children who did not show any significant improvements. It could be hypothesized that *ACT in the Outdoors* may be most effective for children presenting with particularly low levels of psychological wellbeing. These findings mirror previous research which scrutinizes significant change at an individual level rather than group mean differences. For example, Scrutton (2015) found that children who reported poorer personal and social skills initially appeared to gain more from an AT intervention, whilst Murrell et al. (2015) observed that only four out of nine students demonstrated some significant change as a result of an ACT intervention and cited possible feasibility obstacles such as reduced attendance at sessions as undermining impact.

The study design does not permit evaluation of how the combination of ACT and AT may enhance children's psychological wellbeing above and beyond the delivery of ACT or AT alone. It does, however, provide a preliminary evaluation of *ACT in the Outdoors*. Given the novel interdisciplinary approach adopted within this study to address children's wellbeing, the authors make the following observations about combining ACT and AT within nature-based experiences for children with challenging behavioral and/or emotional needs. Firstly, the natural environment served as a key facilitator for the mindfulness activities, teaching breathing exercises and connecting to the present. Similarly, the various movement activities where participants interacted with each other and

nature supported the introduction of metaphors and the reinforcement of ACT principles. Children's engagement in the program was generally assisted by both the outdoor environment and the nature and arts-based activities. Nonetheless, some challenges were experienced which are not uncommon for AT, however, possibly more problematized for children presenting with challenging behavioral and/or emotional needs. At times, the outdoor environment presented distractions (e.g., children wanting to move into the ocean whilst at the beach) and the need to manage physical and emotional safety (e.g., children exhibiting a fear of snakes and being in the bush during the nature walk). Facilitators need to be skilled and prepared to not only deliver ACT and AT but responsive to children's behavior to optimize outcomes for these children in need.

Limitations

This study offers practitioners an innovative new program which seeks to combine ACT and AT, however, the results derived from the evaluation should be interpreted with caution due to limitations in design. Firstly, no comparison of results for a control group or long-term follow-up measure points were possible with the available funding. Therefore, changes experienced by the children cannot be directly related to their involvement in the program. Secondly, the study relied on a small sample size which prevented the testing of significant changes for participants as a group. Furthermore, this study employed self-report measures (with no input from parents or teachers in the children's regular local school), which are susceptible to response bias, rather than objective measures of change in psychological wellbeing. As a result, findings should be considered preliminary. Future research should adopt randomized controlled trial methodologies with larger sample sizes to strengthen the evidence of the efficacy of programs such as *ACT in the Outdoors* which adopt an interdisciplinary approach to boosting children's psychological wellbeing. More importantly, a rigorous experimental design is required to determine the differential impacts of ACT, AT, and ACT combined with AT to advance practice.

CONCLUSION

The current study presents a new program entitled *ACT in the Outdoors* based on the interdisciplinary combination of ACT and AT and delivered this program to children with challenging behavioral and/or emotional needs. The evaluation results, although founded on a small scale inquiry, provide encouraging insight into the possible positive impacts on psychological wellbeing and skill development. More importantly, the results may serve as a catalyst for future research in this emerging area of practice. Given the rise of ACT and AT interventions, randomized controlled studies with larger sample sizes are required to establish evidence of their impact on children's psychological wellbeing. In practice, the present study suggests that there may be a minimum participation level required to achieve significant change, and that this interdisciplinary intervention may be best targeted to children with particularly low levels of psychological wellbeing. Finally, although intervention programs should be conducted by trained facilitators, the researchers encourage the inclusion of children's school teachers to bolster the impact of the intervention for children in their school environment. Such a strategy may extend the impact of the intervention into their daily learning environment as witnessed in this study.

AUTHOR CONTRIBUTIONS

All authors contributed to the study design, *ACT in the Outdoors* implementation and data collection. DT performed the statistical analysis and drafted the manuscript. ST, TG, and KW conducted the qualitative analysis. All authors critically revised the draft manuscript for publication.

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Can Nature Walks With Psychological Tasks Improve Mood, Self-Reported Restoration, and Sustained Attention? Results From Two Experimental Field Studies

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The evidence for restorative effects of contact with nature is vast. Drawing from two well-known theories in Environmental Psychology, Stress reduction theory and Attention restoration theory, restoration can be seen as a sequential, interactive process that begins with physiological relaxation and results in affective and attention restoration and broader life reflection. This interaction between a person and their environment may be facilitated by actively engaging with the environment but this has been understudied. We examined engagement with the environment by asking participants to complete psychological, restoration theory-driven tasks designed to enhance physiological, affective and attention restoration, while walking on nature trails. We conducted two experimental field studies (conceptual replications) in Finland in a coniferous forest (Study 1; n = 128) and an urban park (Study 2; n = 121). The participants walked at their own pace for 4–6 km with or without psychological tasks. Those in the task conditions completed either theory-based restoration-enhancement tasks or alternative tasks that we expected to be less restorative (Study 1: the same tasks in the reverse order; Study 2: awareness-enhancement tasks). The participants completed self-reports on valence, activation, and restoration, and the Sustained Attention to Response Task, before, and after, the walk. We compared the change between measurements using regression models grouped by study conditions, with age, recent stress, difficulties with wayfinding, start time, and navigation method (Study 2 only) as covariates. Valence and self-reported restoration improved after the walk, but there was no additional benefit from the psychological tasks. In both studies, sustained attention consistently improved following different versions of the restoration-enhancement tasks and, to some extent, after a walk without the tasks. Participants who were more stressed experienced greater improvements in valence and self-reported restoration (Study 1) and sustained attention (Study 2). The results support both Stress reduction theory and Attention restoration theory, and imply that some forms of active engagement with the environment can aid

sustained attention but not affective restoration. Future research efforts are needed to replicate these findings and to assess any potential long-term or multiplicative effects of engagement-based tasks, or other strategies that could enhance positive engagement with the environment.

Keywords: natural environments, restorative environments, green exercise, sustained attention, engagement, psychological well-being

INTRODUCTION

Contact with natural environments has consistently been shown to improve psychological and cognitive outcomes (Hartig et al., 2014). A vast amount of past research has focused on contrasting the effects of urban and natural environments (summarized in a systematic review by Bowler et al., 2010) or on the specific qualities of environments that promote affective or attention restoration (for example, Stigsdotter and Grahn, 2011; Gatersleben and Andrews, 2013). The cognitive processes and the quality of interaction with nature leading to a restorative experience have, however, been underexplored (Markevych et al., 2017) although they are key components in the dominant theories explaining the benefits of contact with nature, Attention restoration theory (Kaplan and Kaplan, 1989) and Stress reduction theory (Ulrich, 1983). In particular, we do not know if the benefits of a nature experience are a result of gaining distance from everyday concerns or if they are rather a result of positive engagement with natural elements (Hartig et al., 2014). Preliminary evidence suggests that focusing on the surrounding environment during nature visits is connected to greater recalled restoration, although it is not the only means of experiencing it (Pasanen et al., 2018). Thus, it may be that active engagement and interaction with the surrounding environment is not a precondition for restorative experiences but it may facilitate them.

Attention restoration theory states that the benefits of interaction with nature are largely due to cognitive benefits and "soft," effortless fascination (Kaplan and Kaplan, 1989). The theory identifies four qualities that contribute to a restorative experience. *Fascination* implies that there is something in the surroundings that captures one's attention in a non-depleting, replenishing way (Kaplan and Kaplan, 1989). *Extent* assumes that the environment should have coherent scope such that one feels like being in a whole other world (Kaplan and Kaplan, 1989). *Being away* means being mentally detached from everyday worries and concerns (Kaplan and Kaplan, 1989). Finally, the environment should match one's current needs to support restoration, thus, *compatibility* is important (Kaplan and Kaplan, 1989). In applied research in environmental psychology, these four qualities have often been interpreted as external, physical qualities, even though Attention restoration theory describes them as components of person-environment interaction (Kaplan, 2001). From this interaction perspective, the role of an individual in need of restoration is an active one, as opposed to being a passive recipient of some pre-determined restorative cues. This idea of active engagement in environmental experiences has been implied in Attention restoration theory, although applied research has not emphasized it (Kaplan, 2001).

Supporting the notion of attention restoration, the cognitive benefits of contact with nature have been demonstrated, from exposure times ranging from 40 s to 55 min (Berto, 2005; Berman et al., 2008; Lee et al., 2015; Pilotti et al., 2015). Recent evidence has suggested that some of the associated cognitive benefits can be enhanced by targeting active engagement with the environment. In a study by Lin et al. (2014), participants were shown five pictures of urban streetscape with trees for a total of 100 s, and their directed attention was measured by the digit span backward task before and after viewing the images. The participants who were instructed to pay special attention to the greenery (trees and plants) in the images improved their directed attention more than another group who were instructed to observe the environment in general (Lin et al., 2014). Thus, focusing specifically on natural features seems to enhance attention restoration.

A similar effect of active engagement on improved cognition has been shown over longer periods in intervention studies (Duvall, 2011, 2013; Lymeus et al., 2018). Lymeus et al. (2018) found improved performance in an attention task followed by 5 weeks of restoration skills training in garden settings, compared with conventional mindfulness training in a classroom with no outdoor views. In Duvall's studies (Duvall, 2011, 2013), participants were divided into two 2-week walking interventions: a standard condition with planned walking schedules, and an engagement condition where the participants were additionally given several options for engaging with the environment during the planned walks (so called awareness plans). The participants in the engagement group experienced better attentional functioning and less frustration at the end of the study, whereas there was no similar change in the reference group (Duvall, 2011). These results suggest that engagement may be useful for short-term attentional functioning and day-to-day replenishment of cognitive resources.

In the Stress reduction theory (Ulrich, 1983), interaction with the environment is described to start with physiological and initial affective responses, and continue with more elaborated affective, cognitive, and behavioral changes (Ulrich et al., 1991; Hartig et al., 2003). Stress plays a key role in this theory: affective and physiological restoration presumes that the participant is in an initially stressed, highly aroused state that a natural environment helps to restore (Ulrich, 1983). Accordingly, exposure to natural environments have been suggested to function as a buffer that reduces the negative effects of stress on well-being (Wells and Evans, 2003; Mitchell and Popham, 2008; Hartig et al., 2014). Regarding different aspects of stress markers,

the evidence is stronger for positive affective changes followed by exposure to natural versus built environments compared with physiological stress indicators (Barton and Pretty, 2010; Bowler et al., 2010; McMahan and Estes, 2015). Thus, it is likely that the physiological effects of exposure to a restorative environment not only appear but also diminish quickly (Hartig et al., 2003).

Potential stress-reducing effects of contact with nature may guide stressed individuals to seek natural environments repeatedly (Russell and Snodgrass, 1987; Gulwadi, 2006). This idea of using and choosing environments for coping is incorporated in the concept of *favorite places* (Korpela, 2003). Favorite places combine the ideas of self- and emotion-regulation, place attachment, place identity, and restoration theories (Korpela, 2012). Most identified favorite places are in natural settings or nearby water, and visits to them provide the more self-reported restoration compared with other types of favorite places (Korpela et al., 2010). However, it is currently not known how common it is to use an environment as a means of stress and emotional regulation (Hartig et al., 2014). Some evidence suggests that adults prefer to go to "classic" natural environment when feeling either happy or sad more than to other types of environments such as urban areas, "unsafe" nature, living rooms, and shopping malls (Johnsen and Rydstedt, 2013).

Even though the restorative experiences described in Stress reduction theory and Attention restoration theory are conceptually different, they have been seen as complementary processes that interact with each other (Kaplan, 1995; Markevych et al., 2017). Stress reduction theory assumes that restoration is a response to visual properties in the environment and their preference evaluation, which quickly results in physiological and affective relaxation (Ulrich, 1983). In Attention restoration theory, the first phase of restoration involves 'clearing the head,' that is, removing excessive cognitive residue, followed by recovery of directed attention, facing challenges in one's mind, and finally, more general life reflection (Kaplan and Kaplan, 1989; Korpela and Hartig, 1996). Integrating these perspectives, Hartig et al. (1991) proposed that a restorative experience begins with physiological and attentional recovery, which are followed by affective changes.

TABLE 1 | Descriptive information of the study settings and the participants.

	Study 1	Study 2
Length (km)	6	4
Environment	Coniferous/mixed forest in the countryside	Urban park near the city center
Where were the tasks read from?	Signposts along the trail	Mobile application
Alternative tasks	Same tasks in the reverse order	Awareness-enhancement tasks (Duvall, 2011)
Design	2 × 2 × 2 (pre-post, tasks/no tasks, route direction)	2 × 3 (pre-post, tasks/no tasks/alternative tasks)
Participants (valid)	150 (127)	122 (119)
Mean age [range]	50 [18–81]	40 [18–63]
Women (%)	80	87

Drawing together Attention restoration theory, Stress reduction theory, and favorite place studies, restoration can be seen as a multi-phasic experience in which individuals can have an active role by interacting with an environment that supports their (restoration) needs. Restorative experiences, in turn, can be important for more general well-being (Hartig et al., 2014). In this paper, we explore whether affective and attention restoration could be enhanced by psychological instructions that aim to deepen the different phases of a restorative experience by conducting two experimental field studies.

THE PRESENT STUDIES

To study the restorative effects of instructed interaction with the environments, we conducted two field experiments where participants walked along a nature trail, either with or without psychological tasks (descriptives in **Table 1**). Both studies had two versions of the tasks, one that was hypothesized to be more restorative than the other. The tasks that we hypothesized to be the most restorative were based on restoration theories (Attention restoration theory, Stress reduction theory, and favorite place studies) and their contents followed the different phases of restoration described in the introduction: physiological and affective relaxation, mood-enhancement, building an affective relationship with a place, and general life reflection (Korpela et al., 2017). We labeled these 'restoration-enhancement tasks.' The comparison tasks were either the same tasks in the reverse order, that is, mismatched with the hypothesized phases of restoration (Study 1), or 'awareness-enhancement tasks' inspired by Duvall's studies (Duvall, 2011, 2013; Study 2). The participants completed self-evaluated questionnaires on restoration and mood (valence, activation) and a behavioral task on sustained attention before and after the walk.

We hypothesized that walking the nature trails would provide initial benefits: (1a) enhance restoration and valence and reduce activation, and (1b) reduce errors and shorten and stabilize response times in the sustained attention task (Ulrich, 1983; Kaplan and Kaplan, 1989; McMahan and Estes, 2015). We further hypothesized that the above benefits (1a—b) would differ between the study conditions: (2a) the benefits would be greatest after conducting the restoration-enhancement tasks that follow the theory-driven phases of restoration, (2b) the benefits would be smallest after walking without the tasks (due to less interaction with the environment), and (2c) the benefits for those who conduct the comparison tasks would lie between those two. The studies are conceptual replications of each other, with similar procedures (depicted in **Figure 1**). Study 1 assesses whether any potential restorative effects of conducting the restoration-enhancement tasks depend on the order of the tasks. Is the theory-driven order ideal in terms of experienced restoration after a nature walk? In Study 2, we focus on exploring if the restoration-enhancement tasks have a similar effect as other types of psychological tasks that guide interaction with the environment but do not address restoration in particular. How relevant is the content of the tasks for restorative outcomes? In the next sections, we present the two studies in more detail. At

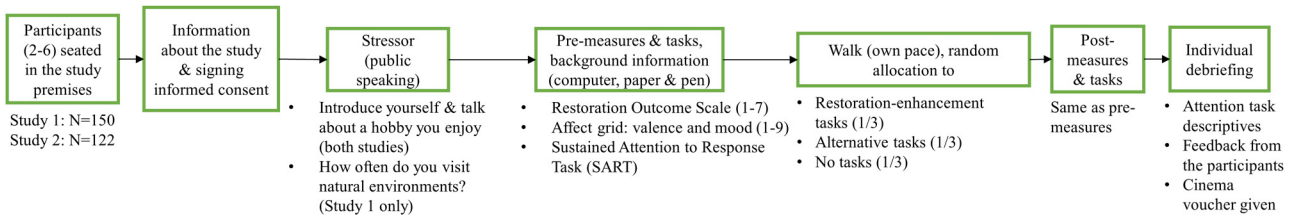

FIGURE 1 | Study procedures.

the end of this paper, we return to a more general discussion on the common themes of the studies.

Study 1 – Coniferous Forest

We began investigating the topic of instructed engagement with the environment during nature visits on a nature trail that had been developed for another project in 2010 (Korpela et al., 2017). For the present study, the trail was equipped with signposts containing the theory-based restoration-enhancement tasks aimed to strengthen affective and attention restoration. We were specifically interested in (1) whether these psychological tasks would aid restoration in general, compared with a walk without tasks, and (2) if the effects of these tasks were stronger when conducted in a theoretically and empirically determined order that mirrored the phases of a restorative experience (physiological, affective, cognitive), compared with the reverse order. Conducting the tasks in the reverse order provided a strong theoretical test, and it was relevant from practical perspective, as the circular route containing the signposts could just as easily be walked in the opposite direction in real life. As the signposts were built into the ground, we assigned four separate groups of participants to walk the route in both directions, with and without the restoration-enhancement tasks.

Materials and Methods

The study site

The 6-km-long circular trail was located in Ikaalinen, a small municipality in Pirkanmaa, Finland. The before and after measurements were taken at meeting rooms at Ikaalinen Spa, a commercial wellness center that provides both recreational and rehabilitation services. The scenery along the route varied, although it was predominantly a typical Finnish natural environment with lakes, some residential houses, a large sandpit, and forests that were both unpleasant (recently clear-cut forest) and pleasant (a scenic viewpoint by a lake). By the Corine Land Cover 25 ha (2012) classification, approximately 3.2 km of the trail was situated within a 'coniferous forest,' 1.2 km (beginning and end around the spa) of the trail were classified as 'industrial or commercial units' (with a lake on the side), 1.1 km as 'mixed forest' (with the scenic viewpoint), and 0.5 km as 'fields.'

On average (measured by median and mode), it took 103 min to walk the route, with a range of 65–155 min. The route contained several crossings where the participants were guided by yellow ribbons and printed instructions, containing both pictures and written guidance. Originally, the route with the signposts was marked with arrows that guided visitors to walk in the clockwise direction.

Participants

Altogether 150 volunteers participated in 35 sessions (**Table 1**). Contrary to our initial plan, we could not recruit visitors at the spa and consequently, the majority of participants signed up after reading about the study in a regional newspaper and via the project's Facebook page. Other recruitment means included a local newspaper, e-mail invitations to local companies, and advertisements at supermarkets in nearby areas. The study was called 'Forest walk study,' and the participants were given information about the procedure and the type of measures (e.g., an attention task) but no specific information about the experimental conditions. We conducted one pilot study with volunteer psychology students (n = 6) who received no compensation for participation, and a second pilot (n = 6), after which the procedure was significantly clarified. Of the remaining 144 participants, a further 15 were excluded due to the following criteria: not walking the instructed route (n = 7), problems with the procedure during one study session (n = 6), impaired senses (n = 1), and personal withdrawal (n = 1). For five participants, the attentional task was either not valid or missing. Ten sessions were canceled due to bad weather. The final sample consisted of 129 participants.

For the majority of the sample (92%), the route was new. Many participants showed a special interest in natural environments (we explored this indirectly in the social stressor task, described in Section "Procedure"). In the whole sample, the participants reported visiting nature 3.9 times per week on average, which is more than the national mean of 2−3 times per week (Sievänen and Neuvonen, 2011).

Procedure

The procedure is illustrated in **Figure 1**. The participants came in groups of 2−6 people, mainly from the surrounding municipalities in the region. They were seated in a meeting room in front of a desk with a laptop, a pen, and an envelope that contained the written tasks. First the researchers (most commonly two project workers) introduced themselves, the study, and the procedure, after which the participants signed the informed consent. Further information about the experiment was then detailed. The participants were asked not to talk aloud during the measurements and to refrain from using mobile phones during the study.

We conducted the experiments during the holiday season (May−September 2016) when stress levels may be lower than usual (de Bloom et al., 2010). To induce a mildly stressed state that could potentiate restorative effects (Ulrich, 1983), we started with a social stressor task, after which the participants completed the self-reported questionnaires and the behavioral measurements. When they were finished, the participants left the room in their own pace and they were given verbal and written instructions for the walk one by one outside the study room. The participants were instructed to walk by themselves. Before and after the walk, the participants could help themselves to some fruit, fresh juice, and water. After the walk, the respondents returned to the study room to complete the tasks in the same order as before the walk. At the end of the session, we showed each participant descriptive statistics of their attention task results, asked for feedback on the study, and gave everyone a cinema voucher. The procedure took approximately 2.5−3 h per person.

In addition to the measures reported in this paper, the participants completed self-reported measures of empathic feelings and vitality and a behavioral task of frustration tolerance, but these are reported elsewhere due to space constraints and different theoretical reasoning. The study was carried out in accordance with the recommendations for "Responsible conduct of research and procedures for handling allegations of misconduct in Finland 2012" by the Finnish advisory board on research integrity (TENK). The protocol was approved by the Ethics Committee of the Tampere Region. All subjects gave written informed consent in accordance with the Declaration of Helsinki.

Study conditions

To control for any effects of weather, the participants were randomly allocated to different walking conditions each study day: 1/3 were assigned to a walk with the restoration-enhancement tasks completed in the designed, theory-based order (which we will call 'clockwise order' because they walked the route in the clockwise [C] direction), 1/3 were assigned to a walk with the restoration-enhancement tasks completed in the reverse order (hence, they walked the route in the reverse [R] direction), and the rest to a walk without tasks, of which one half (1/6 of the sample) walked the clockwise (C) and another half (1/6) the reverse (R) route. The participants in the 'no task' conditions walked the route in opposite directions to account for any potential environmental differences, and the initial idea was to combine these conditions for the analyses.

The psychological instructions

The instructions on the signposts were based on Stress reduction theory (Ulrich, 1983; Ulrich et al., 1991), Attention restoration theory (Kaplan and Kaplan, 1989), and favorite place studies (Korpela et al., 2008; Korpela and Ylén, 2009). Integrating these theories, a restorative experience has been suggested to start with physiological relaxation, followed by affective and mood-enhancing responses, and advance to building an affective relationship with the place and reflection on one's current situation in life (Korpela et al., 2017). Thus, the first three signposts related to physical relaxation and observing the environment (for example, "[. . .] Keep looking around and let yourself be enchanted by your surroundings. Keep breathing peacefully."), the next two to favorite place identification and reminiscence ("Find your favorite place in this area [. . .] Choose a detail by which you may remember this place, perhaps for years."), and the final two to clearing the mind and life reflection ("Look around for something representing you or your current situation in life [. . .] Are you gaining new thoughts?").

Pre- and post-walk measures

Self-reported restoration was measured with the 6-item Restoration Outcome Scale (ROS; Korpela et al., 2008; see also Hartig et al., 1998; Staats et al., 2003). The scale is a self-evaluation of attention restoration (one item: "I feel alert and able to concentrate"), relaxation and calmness (three items, for example, "I feel restored and relaxed"), and clearing one's thoughts (two items, for example, "My thoughts are clear"). Participants rated their current state on a 7-point rating scale ranging from "Describes my experience..." 1 = not at all to 7 = completely. We calculated the mean summary score of the responses in both pre- and post-measurements (Cronbach's $\alpha = 0.85$ and 0.89, respectively).

Mood was measured with a two-dimensional affect grid (Russell et al., 1989) in which the participants are asked to evaluate their mood by marking a single cross in a 9×9 grid. The axes reflect core affects, *valence* (horizontal axis) and *activation* (vertical axis; Russell et al., 1989; Västfjäll and Gärling, 2007).

Sustained attention was measured using the Random version of the Sustained Attention to Response Task (SART), a test of sustained attention (Robertson et al., 1997). In the SART, participants respond to the digits 1–9, presented in a random order (each shown 25 times in five different font sizes) on a screen for 4.3 min. They were instructed to press the space bar whenever they saw any digit (Go) except the digit 3 (No-Go). The participants were asked to pay equal attention to speed and response accuracy. The stimulus was shown for 250 ms, followed by a mask (a white cross within a circle) for 900 ms. We used the source code provided by Stothart (2015) in the open-source software PsychoPy (Peirce, 2009), in which we translated the instructions into Finnish. The participants were seated approximately 40 cm from the screen of a Dell Latitude laptop, although they were free to move further or closer during the experiment. Both pre- and post-tests were preceded by a practice round with 18 digits where the participants received immediate feedback on the accuracy of the response (correct/incorrect).

The SART provides a number of sustained attention measures. Commission errors – the number of responses made to the No-Go digit '3', reflect response accuracy, controlled attention (Manly et al., 2003), and response inhibition (Johnson et al., 2007). Omission errors − the number of non-responses to a Go digit − had a median of 1 and thus, there was little variation to examine and we excluded the measure from the analyses. The mean and standard deviation (SD) of response time (RT) were calculated after excluding responses to the digit '3' and RTs < 100 ms. SDRT reflects the stability of the response style, with larger variability indicating more attentional lapses

(Robertson et al., 1997; Manly et al., 2003; Smilek et al., 2010). The sequence of 225 RTs per participant was further analyzed using a Fast Fourier Transform (FFT) based on the method described in Johnson et al. (2007). Two dependent measures were derived from these FFT analyses – the slow (SFAUS) and fast (FFAUS) frequency areas under the spectra. For the SFAUS, the RT data were analyzed over the entire task. For the FFAUS, the RT data were analyzed in a first half versus second-half analysis. The SFAUS is a measure of all sources of variability in RT slower than 0.0772 Hz, which is derived from the Fixed version of the SART and represents one cycle of a presentation of the digits 1–9 (Johnson et al., 2007), and it measures gradual change in speed of responding over the course of the task. The FFAUS is a measure of all sources of variability faster than 0.0772 Hz, representing trial-to-trial variability in responding, and it measures moment-to-moment variability in responding.

Covariates

Stress in the past 4 weeks, which potentiates restoration effects (Ulrich, 1983), was measured by 10-item Perceived Stress Scale (Cohen et al., 1983), of which we calculated the summary score (Cronbach's $\alpha = 0.84$). *Age* was asked in full years. Older samples have been found to experience greater affective changes after nature exposure (McMahan and Estes, 2015) but we also hypothesized that older participants may find the lengthy route more exhausting, which could be reflected in lower restorative changes. For the majority of participants, the *start time* was at 10.30 am but it varied from 10 am to 4 pm to accommodate as many participants as possible. Time of day can, however, influence the level of alertness and task performance (Monk and Leng, 1982). We coded the start times as −1 = morning (10 − 10.30 am), 0 = midday (12 am − 1 pm), and 1 = afternoon (3 − 4 pm). As a *post hoc* measure, we recorded if the participants reported *problems with wayfinding* during the walk. Having to focus on navigation in a new environment requires mental effort which can reduce any potential restorative effect (both attentional and affective; Gatersleben and Andrews, 2013). We also recorded walk duration, weather, temperature, gender, and the number of hours slept the night before but these were not related to the outcomes in either of the two studies (**Appendices A, B, D, E**).

Data analysis

The *a priori* sample size was calculated as a 3 × 2 between-group repeated measures MANOVA with several correlating dependent variables, with a power of = 0.95 and alpha = 0.05. In this type of design, a medium effect size of 0.25 would be detected with a sample size of 165 participants (Gpower 3.1 software; Faul et al., 2007). However, as the final number of valid cases was lower than we aimed for, the following analyses have less statistical power than we expected to have.

Prior to the actual analysis, we checked that there were no differences between the groups at baseline in any of the outcomes with a one-way analysis of variance (ANOVA) in SPSS version 24 (provided in **Appendix C**). We also checked for differences in the outcomes between the two 'no task' groups that walked the route in different directions. Our initial plan had been to combine these two groups but as there were differences between them, we kept them separate in the analyses. However, we interpreted the results related to them with caution due to their smaller sample size.

We compared the change between pre- and post-measurements with multigroup regression analysis using Mplus version 7.4. The data was continuous but non-normally distributed so the MLR estimator was used (Muthén and Muthén, 1998/2012). The grouping was based on the direction of the route (clockwise/reverse), and completing the restoration-enhancement tasks was an explanatory variable (for simplicity, however, we present these estimates in the results as the difference between within-group intercepts, that is, the estimated within-group means). To retain more power in the analyses, we pre-selected those covariates that correlated significantly ($p < 0.05$) or showed a significant mean difference (in ANOVA) in at least one of the outcomes in either Study 1 or Study 2 (if applicable; these analyses are provided in **Appendices A, B, D, E**). Continuous covariates were centered and ordinal/dichotomous covariates were recoded so that their midpoint was at 0. In the initial models, the covariates were assumed to have a similar effect in both groups. If the standardized residuals for the covariates were large ($>|1.96|$), we relaxed this assumption and retained the modified model if the overall model fit improved.

In addition to the residuals, we checked how the models fit with the data and compared the models with the following criteria: a non-significant χ^2-test, Satorra–Bentler corrected χ^2 difference-test (for model comparison), smaller values for information criteria (Akaike's Information Criteria [AIC], Bayesian information criteria [BIC], and sample-adjusted BIC), Comparative Fit Index (CFI) and Tucker-Lewis Fit Index (TLI) ≥ 0.95, the Root Mean Square Error of Approximation (RMSEA) ≤ 0.05, and the Standardized Root Mean Square Residual (SRMR) ≤ 0.08 (Tucker and Lewis, 1973; Bentler, 1990; Browne and Cudeck, 1992; Hu and Bentler, 1999; Satorra and Bentler, 2010; Kline, 2016). To check for influential outliers we examined Cook's distances in the first models for each block of outcomes, and if they exceeded 1.00 (Tabachnick and Fidell, 2014), the analyses were re-run without the most influential cases by excluding them one by one. If excluding an influential outlier improved the model fit, we retained the improved model.

To account for correlations between related outcomes but to retain more power in the analyses, we analyzed the outcomes in blocks of three: (1) self-reported measures (restoration, valence, and activation); (2) traditional SART measures (commission errors, RT, and SDRT); (3) refined SART variability measures (FFAUS in the 1st and 2nd halves of the tests, and SFAUS).

Sensitivity analyses

If applicable, we ran two types of sensitivity analyses for the final models: (1) for those models where we deleted influential outlier(s), we re-ran the final models with those outliers, (2) for the model with refined SART variability measures, we re-ran the models excluding participants whose mean RT was > 500 ms. RTs > 500 ms are generally considered slow in SART studies with adult participants and slower RTs can be connected to inflated FFAUS and SFAUS, which, in turn, may bias the model estimates.

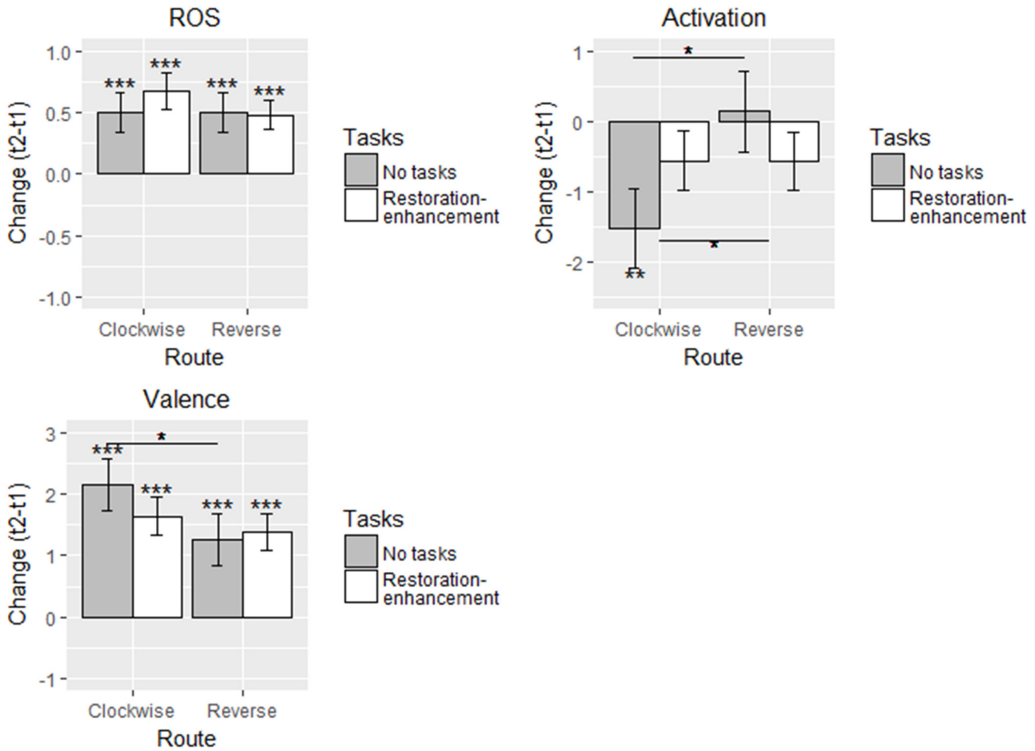

FIGURE 2 | Adjusted means in different conditions for the self-reported measures in Study 1 (n = 129). Solid line: statistically significant between-group difference. *p < 0.05, **p < 0.01, ***p < 0.001.

We ran these second sensitivity analyses to assess whether the results for FFAUS and SFAUS were influenced by respondents with slow mean RTs.

Results

Self-reported restoration and mood

Participants in all conditions reported greater restoration after the walk but there were no differences between the conditions (supporting hypothesis 1a but not 2a−c; **Figure 2** and **Table 2**). The estimated change varied, on average, between 0.48 and 0.67 units on the original 1−7 scale. Similarly, in terms of estimated valence, hypothesis 1a but not 2a−c gained support, as the participants reported feeling, on average, 1.27−2.16 units more pleasant after the walk in all conditions. Activation, in turn, did not change in most groups which was against our hypotheses 1a and 2a−c. The exception were the participants in the 'no task' (C) condition who felt 1.52 units calmer after the walk.

The change in restoration was greater for younger and more stressed participants (**Table 2**). Having a problem with wayfinding was connected to a more negative change in both self-reported restoration and a less positive mood (**Table 2**). Start time was not connected to changes in the self-reported measures.

The model explained self-reported restoration best (R^2's 0.20−0.21), followed by valence (0.11) and activation (0.04). The model fit well with the data and no influential outliers were excluded or large residuals freed (**Table 2**).

Sustained attention – traditional measures

The participants who either walked without tasks or conducted the restoration-enhancement tasks in the reverse order made 1.49 − 2.57 less commission errors after the walk (**Figure 3** and **Table 3**), supporting hypothesis 1b in these groups. The trend was the same for the participants who conducted the restoration-enhancement tasks in the clockwise order, although the estimate (−1.22) was not statistically different from zero (**Table 3**). Similarly, SDRT reduced significantly in the condition with the reversed restoration-enhancement tasks, and the trend was to the same direction in both 'no task' conditions (showing partial support for hypothesis 1b but not 2a−c). With mean RT, there were no significant changes before and after the walk in any of the conditions (contrary to hypothesis 1b) but there was an unexpected interaction effect between route and tasks. Conducting the tasks was associated with increased mean RT compared with not conducting them in the clockwise route, whereas in the reverse route, conducting the tasks was associated with decreased mean RT compared with not conducting them (**Figure 3**). All these results were in contrast with our hypotheses 2a−c because they indicated the least benefits from conducting the restoration-enhancement tasks in the clockwise order.

Age, stress in the past week, or start time were not significantly connected to changes in the outcomes but reporting problems with wayfinding was (**Table 3**). Those who reported problems with wayfinding made almost three more commission errors and had a significantly faster mean RT after the walk (**Table 3**).

TABLE 2 | The results for multigroup regression models for the self-reported measures in Study 1 (*n* = 129).

		Self-reported restoration				Valence				Activation			
		b	*SE*	*p*	β (C/R)	*b*	*SE*	*p*	β (C/R)	*b*	*SE*	*p*	β (C/R)
Mean difference, estimated	(1) Restoration-enhancement tasks (C)	0.67***	0.15	0.00	0.84	1.64***	0.30	0.00	0.99	−0.56	0.42	0.19	-0.23
	(2) Restoration-enhancement tasks (R)	0.48***	0.12	0.00	0.66	1.39***	0.30	0.00	0.84	−0.56	0.41	0.17	-0.28
	(3) No tasks (C)	0.50***	0.16	0.00	0.63	2.16***	0.42	0.00	1.30	−1.52**	0.57	0.01	-0.62
	(4) No tasks (R)	0.50***	0.17	0.00	0.69	1.27***	0.42	0.00	0.76	0.14	0.57	0.77	0.07
	Task × route interaction (difference '1–3' – '2–4')	−0.19	0.26	0.47		0.64	0.57	0.26		−1.66*	0.83	0.05	
Covariates	Stress	0.24*	0.11	0.03	0.17/0.19	0.38	0.30	0.21	0.13	−0.29	0.36	0.42	-0.07/-0.08
	Start time	0.03	0.11	0.75	0.03/0.04	0.23	0.23	0.33	0.09/0.11	−0.24	0.32	0.45	-0.07/-0.10
	Age	−0.01	0.00	0.05	-0.15/-0.18	−0.01	0.01	0.57	-0.05	0.00	0.01	1.00	0.00
	Wayfinding problems	−0.70**	0.23	0.00	-0.28/-0.31	−1.25*	0.56	0.02	-0.24	−0.08	0.56	0.88	-0.01
R^2 (C/R)		0.20/0.21				0.11/0.11				0.04/0.04			

χ^2 = 7.89 (df = 15, p = 0.93), RMSEA < 0.001, CFI = 1.00, TLI = 1.28, SMRM = 0.04. Grouping is based on walking direction: C, clockwise; R, reverse route; figures separated by "/" if they differ between the groups.
** p < 0.05, **p < 0.01, ***p < 0.001.*

The variances explained were nearly 0.09 for changes in commission errors, 0.12−0.13 for changes in mean RT, and 0.05−0.07 for changes in SDRT. The model with two freed parameters fit the data well (**Table 3**).

Sustained attention – refined variability measures

In the refined SART variability measures, there were several influential outliers and even after deleting the four most influential ones, the standard errors of the intercepts were large (**Figure 4** and **Table 4**). The participants had similar amounts of FFAUS in the first half of the tasks (against hypotheses 1b and 2a−c), whereas in the second half only the group who conducted the restoration-enhancement tasks in the reverse order showed reduced FFAUS (partially supporting hypothesis 1b; **Figure 4** and **Table 4**). Similarly, this group performed the SART with less SFAUS throughout the whole test after the walk, whereas the other groups showed no change. Our hypothesis 1b was, therefore, supported in only one group, and this group was not the one we hypothesized (2a) to show the greatest improvements.

Those who participated later in the day (and walked the clockwise route) performed the SART with more FFAUS in the 2nd half of the test, whereas problems with wayfinding were connected to reduced SFAUS after the walk (**Table 4**). Stress and age were not connected to the refined SART variability measures (**Table 4**).

The variances explained were low for the FFAUS in the 1st (0.03−0.06%) and the 2nd half (0.02−0.07), merely exceeding the minimum recommended R^2 for practically significant effect of 0.04 (Ferguson, 2009). For the SFAUS, the model explained 0.08−0.12 of the change between the measurements. Altogether four outliers were deleted and two parameters freed to obtain a good fit with the data (**Table 4**).

Sensitivity analyses

In the first sensitivity model for the refined SART variability measures including the 4 outliers deleted from the final model, the model fit was extremely bad in terms of all assessed criteria (for example, CFI = 0.438) and thus we found it meaningless to assess its results. In the second sensitivity model excluding those whose mean RT was > 500 ms, the intercept estimates of SFAUS and FFAUS in the 2nd half were no longer statistically significantly different from 0 for the group who conducted the restoration-enhancement tasks in the reverse order (however, the trend was the same). Therefore, the result that conducting the tasks in the reverse order, but not in clockwise order, improved sustained attention in terms of reduced variability was only partly supported in this analysis.

Discussion

Our first main result was that self-reported restoration and valence improved in all conditions but this was not connected to conducting the psychological tasks. Activation remained mostly similar. The second main result was that overall, sustained attention performance, as measured by the number of commission errors, improved after the walk, whereas the speed and stability of responding did not change substantially. Unexpectedly, the participants who completed the restoration-enhancement tasks in the reverse order improved their sustained

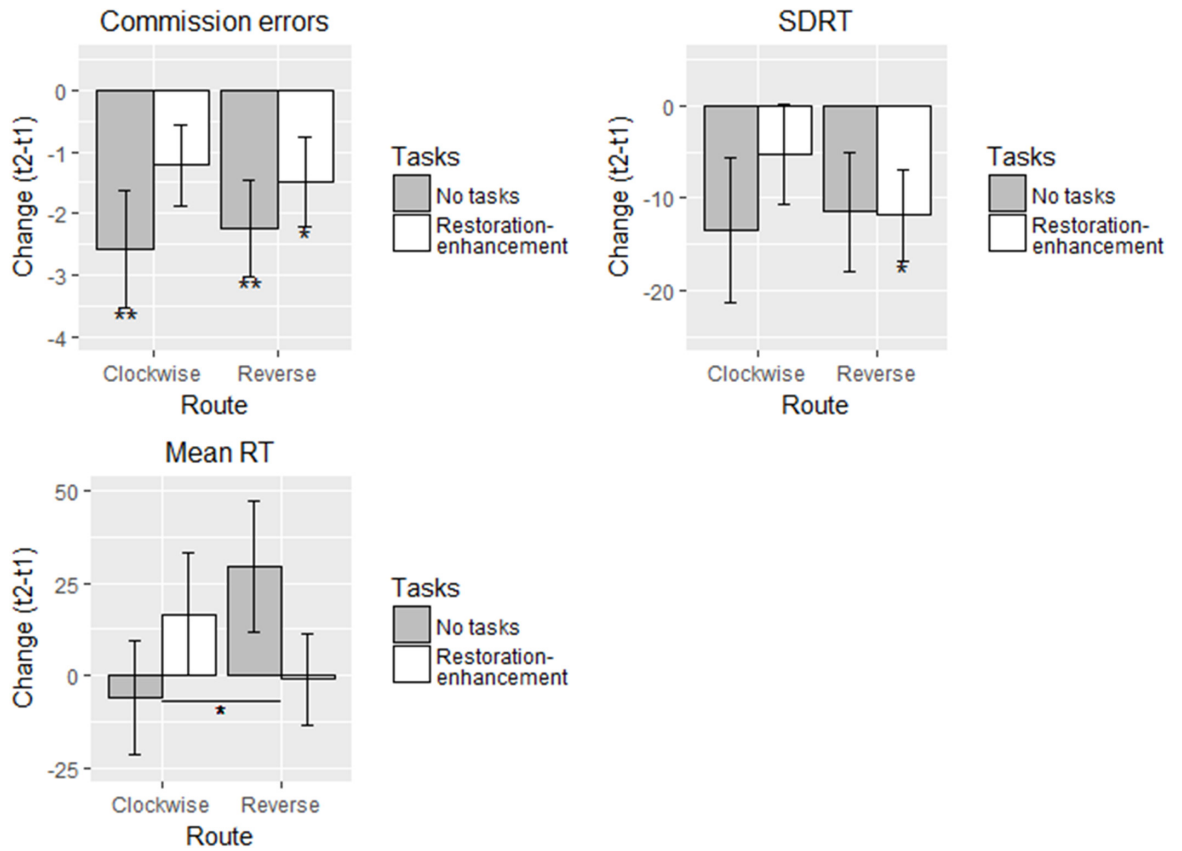

FIGURE 3 | Adjusted means in different conditions for the traditional SART measures in Study 1 (n = 125). Solid line: statistically significant between-group difference. *p < 0.05, **p < 0.01, ***p < 0.001.

attention performance (evaluated by reduced commission errors and RT variability) most consistently, whereas those who conducted the tasks in the clockwise order showed no changes in sustained attention. In both 'no task' conditions, sustained attention improved only in terms of commission errors. Thus, comparing the two conditions where the restoration-enhancement tasks were conducted in different orders, it appeared that the reverse order was more ideal for attention restoration than the hypothesized, theory-driven order. Based on this consistent finding, we modified the contents of the restoration-enhancement tasks for Study 2.

One limitation of this study was that wayfinding was difficult for some. Those who reported problems with wayfinding (n = 15) systematically reported lower levels of restoration and valence after the walk. They also responded more impulsively in their sustained attention task, meaning that they performed the SART with consistently faster RTs, combined with an increased number of commission errors and reduced variability (probably due to the fast speed of responding). The fact that the trail included several crossings (which, nevertheless, were marked with yellow ribbons) and required looking at a map to spot the signposts irritated some participants. Furthermore, taking an incorrect turn and having to return was a nuisance for some, although some found minor wandering around in a new environment inevitable. Most, nevertheless, thought that the trail was well marked and easy to follow.

Another limitation was that the route was different depending on the direction of the walk, which could have affected the results for several reasons. Firstly, when walking the clockwise route, the unpleasant parts of the trail (recent clearings) were toward the end of the walk, whereas in the reverse direction the end was intact coniferous forest. Recently clear-cut forests are generally regarded as unpleasant compared to intact forests or forests that have been cut less invasively (Silvennoinen et al., 2002). In addition to being visually unpleasant, some participants verbally reported feeling upset about the ecological consequences of these clearances. These kinds of reactions to the environment may have shown in their post-walk measurements. Secondly, as the signposts were numbered, the participants who completed the instructions in the reverse order could infer that they were doing them in an "incorrect" order so they were not completely blind to the study conditions. Thirdly, the trail was originally designed to be walked in the clockwise direction and thus, it was marked with arrows and was more intuitive to follow that way. Even though we marked the whole trail with yellow ribbons for this study, we chose not to use arrows pointing in the reverse route to avoid confusion, and it is probable that there was more wayfinding involved when walking the reverse route.

TABLE 3 | The results for multigroup regression models for the traditional SART measures in Study 1 (n = 125).

		Commission errors				Mean RT (ms)				SDRT (ms)			
		b	*SE*	*p*	β (C/R)	*b*	*SE*	*p*	β (C/R)	*b*	*SE*	*p*	β (C/R)
Mean difference, estimated	(1) Restoration-enhancement tasks (C)	−1.22	0.66	0.07	−0.30	16.64	16.29	0.31	0.20	−5.28	5.46	0.33	−0.17
	(2) Restoration-enhancement tasks (R)	−1.49*	0.73	0.04	−0.37	−0.86	12.35	0.94	−0.01	−11.86*	5.00	0.02	−0.44
	(3) No tasks (C)	−2.57**	0.94	0.01	−0.63	−5.83	15.31	0.70	−0.07	−13.44	7.77	0.08	−0.43
	(4) No tasks (R)	−2.24**	0.77	0.00	−0.56	29.21	15.31	0.10	0.41	−11.44	7.77	0.08	−0.42
	Task × route interaction (difference '1–3'-'2–4')	−0.61	1.47	0.68		−52.55*	25.10	0.04		−8.59	10.88	0.43	
Covariates	Stress	−0.92	0.64	0.16	−0.13	30.06/−5.20	19.56/12.44	0.12 /0.68	0.20/−0.04	−5.20	4.79	0.28	−0.09/−0.11
	Start time	−0.40	0.47	0.39	−0.07/−0.08	9.17	10.28	0.37	0.07/0.10	−2.91	3.87	0.45	−0.06/−0.09
	Age	−0.02	0.02	0.44	−0.06/−0.07	0.23	0.44	0.61	0.04/0.05	−0.19	0.19	0.32	−0.08/−0.11
	Wayfinding problems	2.91**	0.98	0.00	0.23/0.24	−57.44*	22.73	0.01	−0.22/−0.26	−15.15	8.60	0.08	−0.16/−0.18
R^2 (C/R)		0.09/0.09				0.12/0.13				0.05/0.07			

*χ^2 = 2.87 (df = 13, p = 1.00), RMSEA < 0.001, CFI = 1.00, TLI = 1.25, SMRM = 0.02. Grouping is based on walking direction: C, clockwise; R, reverse; figures separated by "/" if they differ between the groups. Parameters freed across groups: RT regressed on stress, covariance between commission errors and SDRT. *p < 0.05, **p < 0.01, ***p < 0.001.*

For all the above reasons, the finding that the tasks improved, to some degree, sustained attention performance when they were completed in the reverse order is particularly interesting. We speculate that this may partly have to do with the contents of the final tasks and their congruence with the environment. In the clockwise route, the final task related to general life reflection which may induce all kinds of emotional responses, not solely positive ones (for example, rumination). This type of negative emotional response, especially when combined with the unpleasant scene, may have been the reason for reduced sustained attention restoration; a similar pattern was not found when walking the same route without the tasks. In the reverse route, although more difficult to follow, the end of the trail was more visually pleasant and the final task focused on physical and psychological relaxation. These factors could have induced a more fascinated and calm state and thus, according to attention restoration theory (Kaplan and Kaplan, 1989), lead to better sustained attention when walking this route.

Based on this field experiment, there was no evidence that favored completing the restoration-enhancement tasks in the designed, theory-driven order, although there seemed to be no negative effects of doing these tasks either. It is important to also note that we inspected only short-term effects. For example, reflection may not be restorative in the short-term but it can have a longer-term impact on well-being. To assess any potential longer-term effects on general well-being is, however, outside the scope of this study. Relatedly, we studied single nature visits that may not reveal the full potential of these kind of tasks. For some, it may take more time to "learn" to do the tasks, or more repetition to experience any added benefits on affective or attention restoration (Lymeus et al., 2018).

We would like to note that our participants were more nature-oriented than the general population (evaluated by the number of weekly nature visits). Participation alone required 2.5–3 h, and for most it took much longer because they traveled to the study site from other municipalities in the region. The motive to participate seemed, for many, related to an interest in visiting a new natural environment and/or research on the topic of natural environments. The fact that we found few differences between the participants who completed or did not complete the psychological tasks could also be related to the sample being nature-oriented. Some of the participants in the 'no task' conditions said that they had been disappointed because they were instructed not to do the tasks, but that they compensated by focusing on other, pleasant features during the walk (such as spotting new plant species and picking berries and mushroom while walking). It is plausible to assume that some nature-oriented people already know how they like to explore a new (natural) environment and that they are more prone to find elements there that they find interesting and engaging.

Study 2 – Urban Park

In Study 1 we found that self-reported restoration and valence improved after a forest walk in all groups, regardless of the tasks, whereas for sustained attention, conducting the restoration-enhancement tasks in the reversed order seemed the most beneficial. The aims for Study 2 were to conceptually replicate

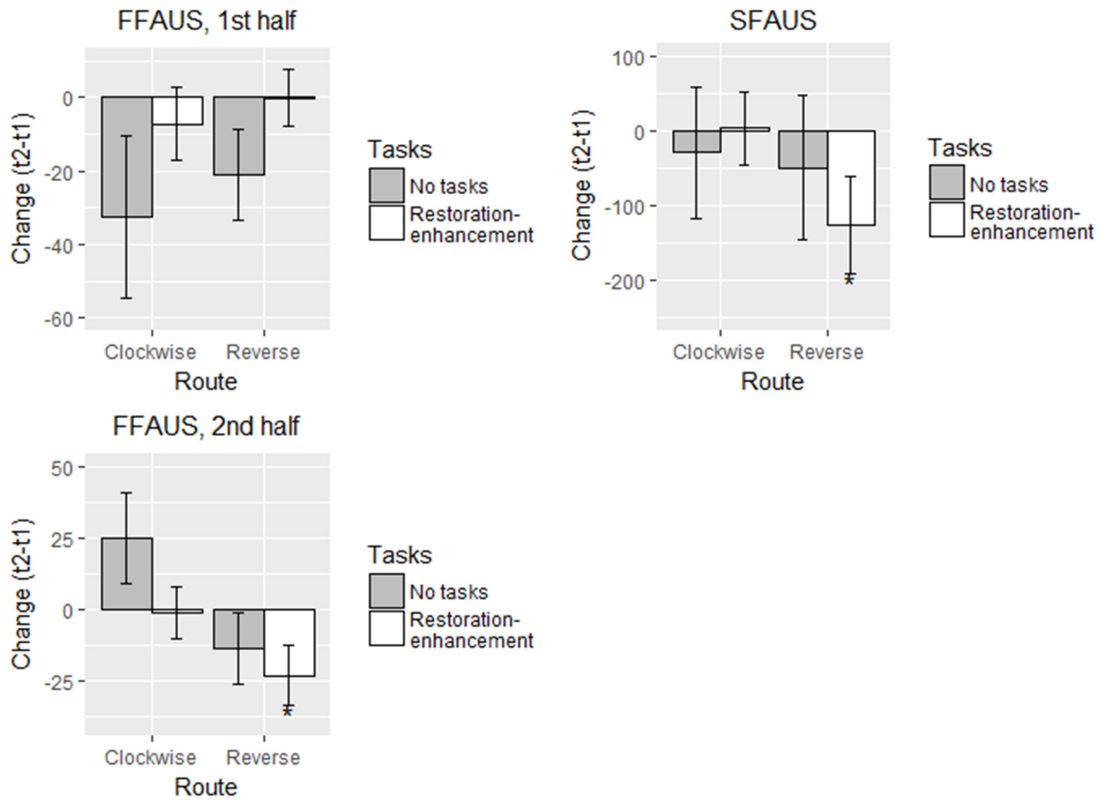

FIGURE 4 | Adjusted means in different conditions for the refined SART variability measures in Study 1 (n = 118). Solid line: statistically significant between-group difference. *$p < 0.05$, ** $p < 0.01$, ***$p < 0.001$.

Study 1, addressing its major limitations, and to investigate the effects of urban nature. The hypotheses were the same as in Study 1 (see The Present Studies).

Materials and Methods

Unless otherwise stated, the method was same as in Study 1.

Study site

The selected 4-km-long trail was within a popular, well-maintained urban park. The area is commonly referred to as Hatanpää arboretum, as it is a habitat for a vast amount of different tree, bush, and plant species, both native and exotic (City of Tampere, 2017). The park comprises three approximately equal-sized, joined parks, and the selected route went through each of these. The first part of the route went along a lake, and the return route went through the middle of the park. There were few crossings along the route and thus, wayfinding was easier than in Study 1. The surface of the route was mainly flat gravel-paved walkway. All parts of the park are located next to a hospital and a built-up residential/industrial/commercial area and thus, the Corine land cover 25ha (2012) data classifies this area as 121 'Industrial or commercial units.' The measurements were taken at a small office room in a nearby mental health service center, approximately 300 m away from the beginning of the trail. A major improvement to Study 1 was that the environment was the same for everyone as all participants walked the same route in the same direction. This way we could exclude the possibility that differences in wayfinding, aesthetics, or vegetation could influence the results.

Participants

A total of 122 working-age people participated in the study in 31 sessions. Initially many more signed up but due to bad weather we had to cancel 13 sessions throughout the summer. Participants were recruited via the project's Facebook page, by sending invitations to local e-mail lists, by placing posters in notice boards around the city center, and by an online event calendar maintained by the leading regional newspaper. To avoid having a more-than-average nature-oriented sample, we named the study "Walking study" (cf. Study 1 was named "Forest walk study"). Contrary to Study 1, we placed a restriction on age so that all participants would be aged between 18 and 64 years, for clearer generalization and prevention of potential problems with the smart phones. In the adverts, in addition to giving relevant information about the study, we stated that we were looking for volunteer participants who were aged 18–64 years; able to walk 4 km at a slow pace; able to use computers and smart phones; did not use medication that affected their concentration, heart, or psyche; and did not participate in Study 1. In the final sample, one participant was excluded because they conducted only half of the assigned tasks along the trail. The self-reports were missing from two participants and the attention task from one.

TABLE 4 | The results for multigroup regression models for the refined SART variability measures in Study 1 (n = 118).

		FFAUS, 1st half				FFAUS, 2nd half				SFAUS			
		b	*SE*	*p*	β (C/R)	*b*	*SE*	*p*	β (C/R)	*B*	*SE*	*p*	β (C/R)
Mean difference, estimated	(1) Restoration-enhancement tasks (C)	−7.21	9.98	0.47	−0.09	−1.19	8.96	0.89	−0.02	3.51	48.72	0.94	0.01
	(2) Restoration-enhancement tasks (R)	−0.15	7.52	0.98	0.00	−23.23*	10.57	0.03	−0.42	−125.97*	64.06	0.05	−0.34
	(3) No tasks (C)	−32.48	22.20	0.14	−0.42	24.92	15.86	0.12	0.41	−29.36	87.85	0.74	−0.11
	(4) No tasks (R)	−21.05	12.27	0.09	−0.43	−13.97	15.86	0.26	−0.25	−49.81	87.85	0.61	−0.14
	Task × route interaction (difference '1–3' – '2–4')	−4.36	26.98	0.87		16.86	24.55	0.49		−109.03	128.90	0.40	
Covariates	Stress	−7.45	9.20	0.42	−0.06/−0.09	5.02	8.67	0.56	0.05	45.65	36.32	0.21	0.09/0.07
	Start time	−14.53/9.98	10.19 /6.34	0.15 /0.12	−0.13/0.17	18.74*/−3.92	8.13/6.93	0.02 /0.57	0.20/−0.06	−16.36	45.82	0.72	−0.04
	Age	−0.06	0.31	0.84	−0.01/−0.02	0.09	0.37	0.81	0.02/0.03	−1.17	1.75	0.50	−0.06 /−0.05
	Wayfinding problems	−4.15	19.90	0.84	−0.02/−0.03	−19.55	22.48	0.39	−0.10/−0.12	−272.82*	118.34	0.02	−0.29/−0.24
R^2 (C/R)		0.03/0.06				0.07/0.02				0.12/0.08			

*χ^2 = 9.70 (df = 13, p = 0.72), RMSEA < 0.001, CFI = 1.00, TLI = 1.27, SMRM = 0.04. Grouping is based on walking direction: C, clockwise; R, reverse; figures separated by "/" if they differed between the groups. 4 outliers deleted; parameters freed across groups: FFAUS (both halves) regressed on start time. *p < 0.05, **p < 0.01, ***p < 0.001.*

Within the participants, visits in the area in the past 6 months varied between 0 and 320, with a mean of 8 visits (median 1). Nature-relatedness, measuring subjective connection with nature, was on average on a moderate level (3.68 on a 1−5 scale, with higher values indicating greater nature-relatedness; Nisbet and Zelenski, 2013).

Procedure

In contrast with Study 1, the stressor task was more neutral to avoid a priming effect for nature enjoyment/orientation. The participants were asked to introduce themselves and talk about a hobby they enjoyed. Two project workers guided all experiments.

We gave the participants smartphones (Lenovo A Plus) where they used the mobile application ActionTrack (license provided by the City of Tampere) which gave an audio signal whenever they were close to a "signpost." The application controlled the order of the tasks so that they could not be completed in a different order than planned, and it allowed us to manipulate the contents of the tasks and to maintain blinding to the study conditions. Using this application required no physical manipulation of the environment, as participants could see the route, the direction of the next task, and their location the whole time they were outdoors. As a back-up, all participants received a paper map with detailed instructions. We instructed them to mainly navigate with the mobile application but if there were problems with it or if they found it disturbing, they could use the paper map and instructions.

The experiment took approximately 2 h per participant, of which the walk duration was 1 h (range between 44 and 97 min). An addition to Study 1 was also that the participants' pulse was measured the whole time with GPS sports watch (Polar V800) and a heart rate sensor at the chest (Polar H7 belt), and they gave saliva samples before and after the walk. Thus, they were instructed to refrain from heavy exercise and alcohol use 24 h prior to the study, and from using caffeine, food, and nicotine 2 h before the study. In the midpoint of the route, all participants were asked three questions via the mobile phone. These additional measures will be reported elsewhere due to space constraints.

The study was carried out in accordance with the recommendations for "Responsible conduct of research and procedures for handling allegations of misconduct in Finland 2012" by the Finnish advisory board on research integrity (TENK). The protocol was approved by the Regional Ethics Committee of the Tampere University Hospital catchment area. All subjects gave written informed consent in accordance with the Declaration of Helsinki.

The psychological instructions

We took into account that in Study 1, the theory-driven restoration-enhancement tasks did not seem to bring added value to any of the affective or attention outcomes when they were conducted in the order they were designed. Instead, these tasks in the reverse order were related to better sustained attention. We noted that in the reverse order, the relaxation tasks became the last and may have affected the respondents positively at the end of the experimental walk. Moreover, in the hypothesized order,

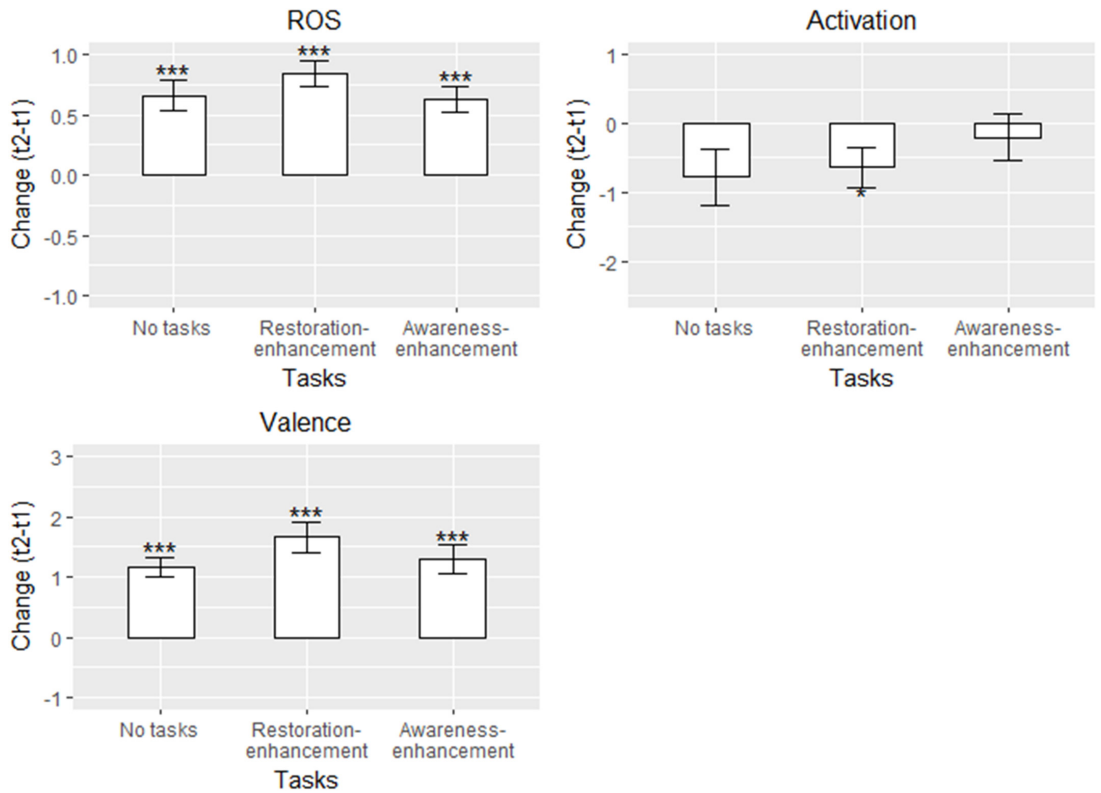

FIGURE 5 | Adjusted means in different conditions for the self-reported measures in Study 2 (n = 118). Solid line: statistically significant between-group difference. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

the task of reflecting on one's life was the last and could prime the respondents positively but also negatively, producing rumination and decrease in restoration. Thus, we updated these restoration-enhancement tasks so that they still evolved according to the restoration theories and made sense narratively but so that both beginning and end focused on affective and physiological relaxation. Tasks 1−5 remained exactly as in Study 1, but we modified Tasks 6 and 7. For Task 6, we combined the parts of Tasks 2 and 3 that related to being away and mood enhancement, and the final Task (7) was a short version of Task 1. Overall, then, the first three tasks focused on relaxation and mood enhancement, followed by identifying a favorite place (Task 4), mood relief and mindset recognition (Task 5), forgetting worries and mood enhancement (Task 6), and relaxation in the end (Task 7).

For the control task condition, we chose tasks similar to those used in Duvall's intervention study (Duvall, 2011, 2013). These alternative tasks focused on different senses (4 tasks) and taking on a new role through which one observes the environment (a magician, a photographer, and a small child; 3 tasks). We matched these tasks to the environment so that, for example, a task instructing one to focus on the sense of smell was located close to the well-maintained rose garden. Like the restoration-enhancement tasks, these 'awareness-enhancement' tasks were based on the idea of strengthening engagement and interaction with the environment (Duvall, 2011). The critical difference was that the restoration-enhancement tasks directly aimed to induce a more restored state, both physiologically (for example, "let your shoulders relax") and psychologically ("feel your mood improve"), whereas the awareness-enhancement tasks focused on engagement and sensory experiences without specifically addressing restoration.

Study conditions

As shown in **Figure 1**, the participants were randomly assigned to three different conditions: a walk without tasks (1/3 of the participants), a walk with the updated theory-driven restoration-enhancement tasks (1/3), and a walk with the awareness-enhancement tasks (1/3).

Pre- and post-walk measures and covariates

The self-reported and attention measures were the same as in Study 1. For the ROS, the reliabilities, measured by Cronbach's α's, were 0.87 before and 0.89 after the walk. The unadjusted means for each outcome before and after the walk are provided in **Appendix F**.

Covariates were the same as in Study 1 with one addition and some modifications. Based on the changes in the procedure and experiences from Study 1, instead of relying on verbal reports, we asked about the ease of *wayfinding* in the electronic questionnaire after the walk (on a 1−4 scale) and about *navigation method* (1 = 'mainly with the provided smart phone,' 2 = 'with both

TABLE 5 | The results for multigroup regression models for the self-reported measures in Study 2 (n = 118).

		Self-reported restoration				Valence				Activation			
		b	*SE*	*p*	β	*b*	*SE*	*p*	β	*b*	*SE*	*p*	β
Mean difference, estimated	(1) No tasks	0.66***	0.13	0.00	0.92	1.17***	0.16	0.00	1.13	−0.78	0.41	0.06	−0.32
	(2) Restoration-enhancement tasks (U)	0.84***	0.11	0.00	1.35	1.66***	0.25	0.00	1.06	−0.64*	0.29	0.03	−0.37
	(3) Awareness-enhancement tasks	0.63***	0.11	0.00	0.94	1.29***	0.24	0.00	0.97	−0.20	0.33	0.55	−0.10
Covariates	Stress	0.16	0.11	0.14	0.12/0.12 /0.15	0.16	0.22	0.46	0.09/0.05 /0.08	0.03	0.37	0.93	0.01/0.01/0.01
	Start time	−0.16	0.17	0.33	−0.10/−0.11/−0.09	0.02	0.26	0.93	0.01/0.01 /0.01	−0.65	0.39	0.09	−0.11/−0.16 /−0.13
	Age	0.00	0.01	0.80	0.02/0.03 /0.02	−0.02	0.01	0.10	−0.20/−0.14/−0.15	−0.01	0.01	0.56	−0.04/−0.06 /−0.05
	Navigation method (smart phone – map)	0.12/−0.27 /−0.24	0.14/0.15 /0.12	0.36/0.06 /0.05	0.13/−0.31/−0.27	−0.17	0.15	0.26	−0.12/−0.08/−0.10	−0.24	0.24	0.32	−0.07/−0.10 /−0.10
	Ease of wayfinding	0.02	0.11	0.89	0.01/0.02/0.01	0.03	0.22	0.88	0.02/0.02/0.01	0.42	0.36	0.24	0.09/0.17/0.11
R^2 (conditions 1/2/3)		0.04/0.12/0.11				0.08/0.04/0.05				0.03/0.06/0.04			

*χ^2 = 26.36 (df = 34, p = 0.82), RMSEA < 0.001, CFI = 1.00, TLI = 1.73, SMRM = 0.08. Grouping is based on the study condition; figures separated by "/" if they differed between the groups. U, updated from Study 1. Parameters freed across groups: ROS regressed on navigation method. *p < 0.05, **p < 0.01, ***p < 0.001.*

smartphone and the paper map,' 3 = 'mainly with the paper map'). *Stress* in the past 4 weeks (Cohen et al., 1983) had, again, a good reliability (α = 0.83). We also asked in the electronic questionnaire if the participants were *afraid* at any point during the walk and if they encountered anything *unusual* that may have influenced their experience (Gatersleben and Andrews, 2013), followed by an open-ended question, but they were rare or not related to the outcomes (**Appendix E in Supplementary Material**).

Data analysis

The data analyses were the same as in Study 1 (see Data Analysis) except that the multigroup models were fitted to three groups according to the study conditions.

Results

Self-reported restoration and mood

As in Study 1, participants in all conditions reported greater restoration and increased valence after the walk, and there were no between-group differences (**Figure 5** and **Table 5**). These findings support our hypothesis 1a but not 2a—c. The estimated changes in self-reported restoration were 0.63—0.84 units, and in valence 1.17—1.66 units. Activation reduced for participants in the 'no task' and the updated 'restoration-enhancement tasks' conditions (−0.78 to −0.64 units), although this change was statistically significant only in the 'restoration-enhancement task' condition (thus, the data showed partial support for hypothesis 1a; **Table 5**). In the 'awareness-enhancement tasks' condition, no changes in activation were apparent.

Stress, start time, age, and ease of wayfinding were not connected to the changes in the self-reported outcomes (**Table 5**). Using the paper map instead of smart phone was connected to a smaller change in self-reported restoration in the conditions where participants conducted tasks (**Table 5**).

Altogether, the R^2s were lower than in Study 1, although in self-reported restoration and valence they mainly exceeded 0.04, the recommended minimum cut-off for practical significance (Ferguson, 2009). In activation, R^2s varied between 0.03 and 0.06. The model fit was good with one parameter freed (**Table 5**).

SART – traditional measures

Participants in the 'no tasks' and 'restoration-enhancement tasks' conditions made 1.57 — 1.99 less commission errors after the walk compared with before (**Figure 6** and **Table 6**), whereas for those in the awareness-enhancement tasks condition, the trend was in the same direction but not significant (partially supporting hypothesis 1b). Mean RT slowed on average by 27 ms for the 'no task' group, whereas no changes were apparent in the other conditions, contrasting hypothesis 1b but supporting hypothesis 2b. For SDRT, against all our hypotheses, none of the groups showed change between the measurements.

Those who had experienced more stress in the past 4 weeks made less commission errors (in the 'no tasks' condition only) and responded faster after the walk compared to before (all conditions; **Table 6**). Start time was associated with most of the measures of sustained attention: those who participated in the afternoon made more commission errors in all groups, responded

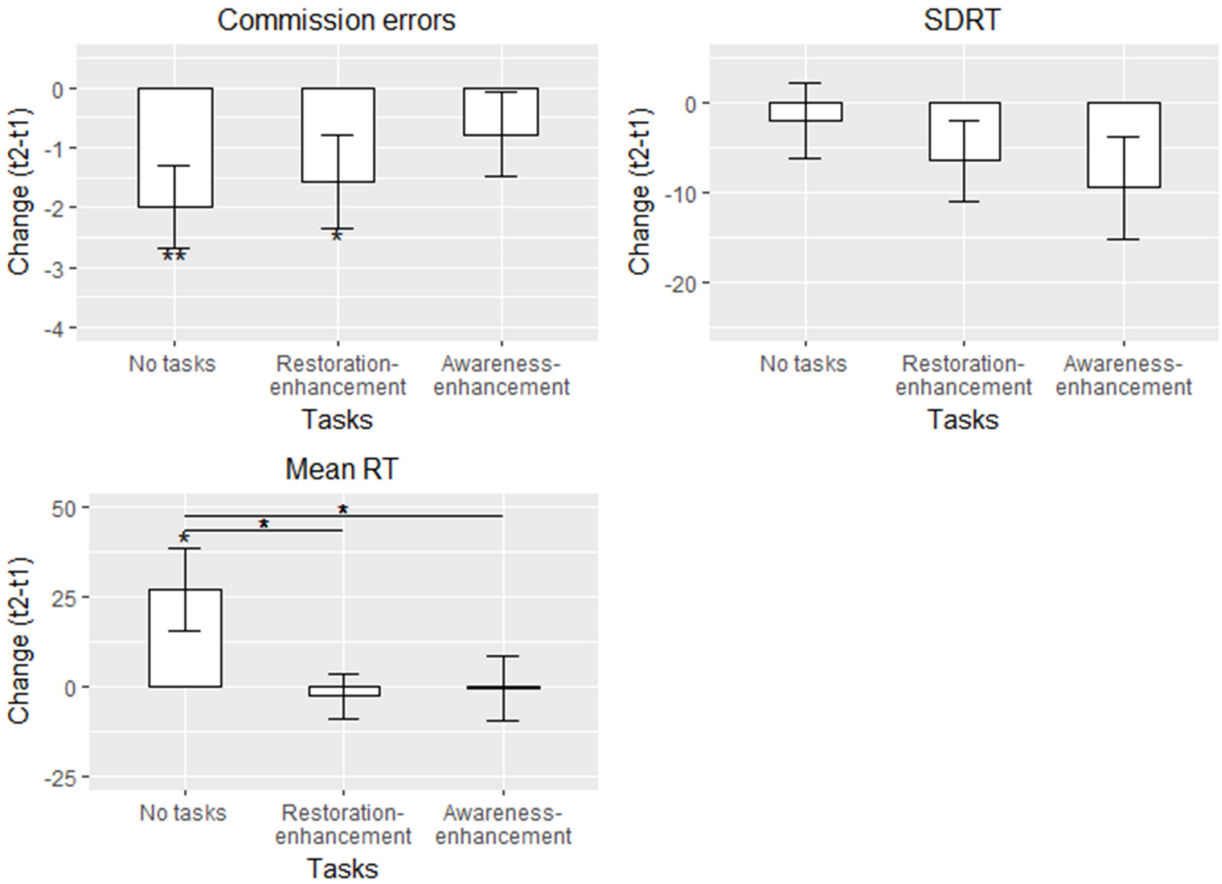

FIGURE 6 | Adjusted means in different conditions for the traditional SART measures in Study 2 (n = 116). Solid line: statistically significant between-group difference. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

faster (in two conditions), and there was less variability in their response times (in the 'no tasks' condition) after the walk (**Table 6**). Using the map instead of the smart phone for navigation was connected to an increased number of commission errors (all groups) and to a speeding of mean RT (in the 'restoration-enhancement tasks' condition). Age was not connected to the changes in the outcomes.

The variances explained were consistently highest in the 'no task' condition (0.20−0.24) and lower and more variable in the other conditions, yet exceeding the 0.04 threshold for practical significance. Initially, the model fit was very bad but improved after freeing seven parameter estimates across the groups (**Table 6**).

SART – refined variability measures

In the first half of the SART, against hypotheses 1b and 2a − c, no changes in FFAUS were apparent after the walk in any of the conditions (**Figure 7** and **Table 7**). In the second half, the participants in the 'no tasks' condition performed the task with less FFAUS; the trend was similar for participants who conducted the updated restoration-enhancement tasks but there was more variability within the group (showing partial support for hypothesis 1b but contrasting hypotheses 2a−c; **Table 7**). In terms of SFAUS, no changes occurred within or between the groups (against all hypotheses).

Age, navigation method, and ease of wayfinding were not connected to the changes in the refined SART variability measures. Participants who were more stressed performed the second half of the SART with less FFAUS after the walk (**Table 7**). Similarly, later start time predicted less FFAUS in the first half of the test.

Variances explained varied between 0.05 and 0.16 in FFAUS, exceeding the threshold for practical significance, but in SFAUS, the R^2s were poor (0.004−0.08). As in Study 1, the model for these outcomes had several large outliers, 3 of which were deleted (**Table 7**). In addition, 2 parameters were freed across groups.

Sensitivity analyses

In the sensitivity model for the traditional SART measures including the outlier deleted from the final model, the greatest difference to the final model was that more stress in the past 4 weeks was connected to lower SDRT. No substantial differences in other estimates, their significance levels or in the conclusions drawn from them were apparent.

Similarly, in the sensitivity model for the refined variability measures including the 3 outliers deleted from the final model,

TABLE 6 | The results for multigroup regression models for the traditional SART measures in Study 2 (n = 116).

		Commission errors				Mean RT (ms)				SDRT (ms)			
		b	***SE***	***p***	β	***B***	***SE***	***p***	β	***B***	***SE***	***p***	β
Mean difference, estimated	(1) No tasks	−1.99**	0.70	0.00	−0.47	27.04*	11.53	0.02	0.46	−1.91	4.22	0.65	−0.08
	(2) Restoration-enhancement tasks (U)	−1.57*	0.79	0.05	−0.32	−2.58	6.28	0.68	−0.06	−6.43	4.45	0.15	−0.27
	(3) Awareness-enhancement tasks	−0.78	0.71	0.27	−0.18	−0.26	8.95	0.98	−0.01	−9.41	5.71	0.10	−0.30
Covariates	Stress	−1.75*/ 2.51 /49	0.77 / 1.38 /0.77	0.02/ 0.07/0.53	−0.23/ 0.25/0.07	−16.03*	7.83	0.04	−0.15 / −0.17/−0.20	−8.73*	4.48	0.05	−0.20/ −0.18/−0.17
	Start time	2.74**	0.85	0.00	0.27/ 0.22/0.24	−61.86***/ −33.67*/ −14.47	12.81/ 14.33/13.25	0.00/ 0.02/0.28	−0.45 / −0.30 /−0.11	−24.01** / −1.61/0.94	7.62/ 5.97/12.31	0.00/ 0.79/0.94	−0.41 / −0.03/0.01
	Age	−0.01	0.04	0.78	−0.03/ −0.02/−0.03	−0.43/ 0.79/ −0.97	0.69/ 0.53/0.61	0.53/ 0.14 /0.12	−0.08/ 0.19/−0.20	−0.38 / 0.36/−0.28	0.36/ 0.31/0.36	0.30/ 0.25/0.44	−0.17/ 0.17/−0.09
	Navigation method (smart phone - map)	1.30**	0.48	0.01	0.23/ 0.17 /0.23	4.83/ −25.36**/ 5.96	7.83/ 8.99/8.68	0.54/ 0.01/0.49	0.06 / −0.36 /0.09	−3.16	2.95	0.28	−0.09/ −0.08/−0.08
	Ease of wayfinding	−0.67	0.72	0.35	−0.08/ −0.09/−0.08	9.93	6.95	0.15	0.08/ 0.15 /0.10	4.50	3.70	0.23	0.09 /0.13/0.07
R^2 (conditions 1/2/3)			0.23/0.09/0.13				0.20/0.16/0.06				0.24/0.07/0.04		

*χ^2 = 20.08 (df = 22, p = 0.58), RMSEA < 0.001, CFI = 1.00, TLI = 1.03, SMRM = 0.06. Grouping is based on the study condition; figures separated by "/" if they differed between the groups. U, updated from Study 1. 1 outlier deleted; parameters freed across groups: RT and SDRT regressed on age and start time, RT regressed on navigation method, commission errors regressed on stress, covariance between RT and SDRT. *p < 0.05, **p < 0.01, ***p < 0.001.*

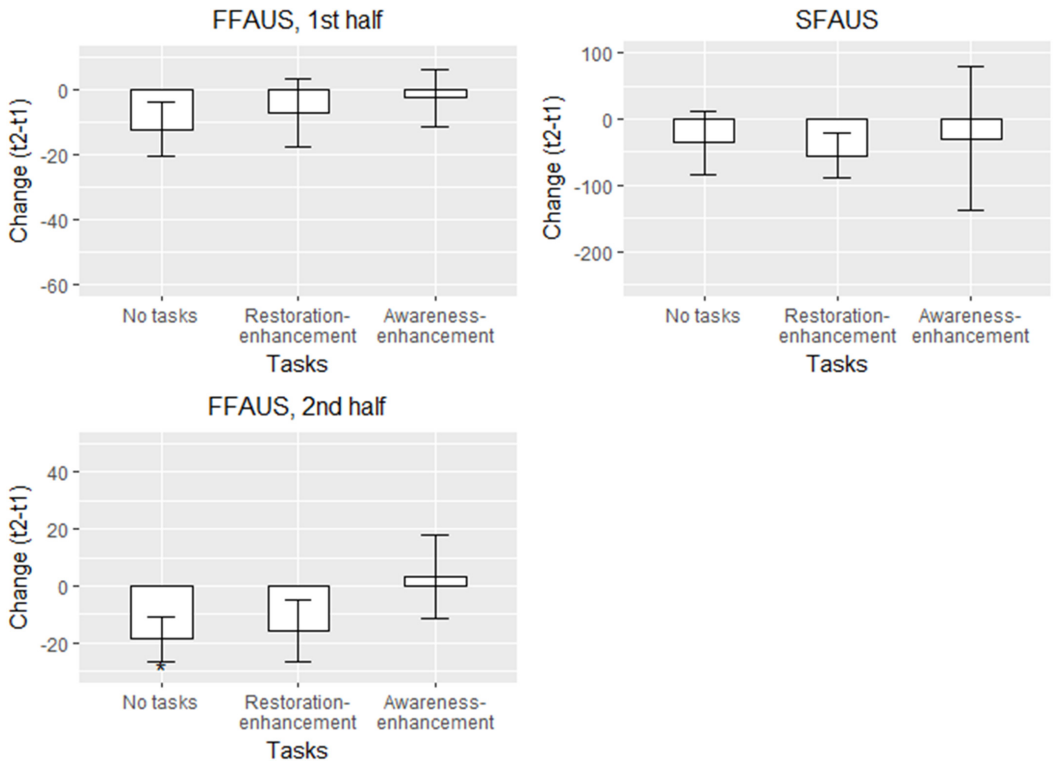

FIGURE 7 | Adjusted means in different conditions for the refined SART variability measures in Study 2 (n = 113). Solid line: statistically significant between-group difference. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

the only substantial difference to the reported model was that more stress predicted less FFAUS also in the 1st half of the test. In the second sensitivity model excluding the participants whose mean RT was > 500 ms, the only substantial difference to the final model was that the participants who conducted the restoration-enhancement tasks showed lower FFAUS in the 2nd half. This result strengthens our conclusion that sustained attention improved in this condition.

Discussion

Consistent with Study 1, self-reported restoration and valence increased after the walk in all conditions. In addition, participants were generally more relaxed after the walk compared to before. No differences between the three groups were found on these self-reported measures, however. In terms of sustained attention performance, the participants who conducted the updated restoration-enhancement tasks made less commission errors after the walk but there was no change in their mean RT or SDRT. This indicates an improvement in response accuracy, attention control, and response inhibition following restoration-enhancement but no effect on their speed or variability in responding. For those who conducted the awareness-enhancement tasks, no changes in sustained attention performance were detected. The participants who did not conduct the tasks made less commission errors but their mean RT slowed significantly more than in the other conditions. They also showed less moment-to-moment variability in responding (FFAUS) in the 2nd half of the SART after the walk. Thus, like Study 1, in terms of sustained attention, conducting the restoration-enhancement tasks resulted in greatest improvements in sustained attention performance, followed by walking without tasks.

Although using the smart phones instead of reading the tasks from signposts improved the procedure from Study 1, some found the smart phones disturbing. Being irritated about having to use the smart phone and resorting to using the map could explain why using the paper map was consistently associated with lower self-reported restoration and increased number of SART commission errors (and, in some groups, faster response time). As we instructed the participants to primarily navigate with the smart phones, unless they found it disturbing, it is plausible that using the paper map was a result of being irritated during the walk. Relatedly, the participants who conducted tasks had to use the smart phone inevitably more throughout the walk: they viewed the tasks' locations, listened to the signals, and read the tasks from the screen. Having to use the smart phone more could have hindered the quality of interaction with the environment, however, our results indicate no such case. The responses between the 'no tasks' and 'restoration-enhancement tasks' conditions were, in fact, very similar with few exceptions.

Both stress and start time were connected to attention restoration but in opposite ways. Later start time was consistently related to more impulsive responding during the SART, that is, faster responding and making more commission errors.

TABLE 7 | The results for multigroup regression models for the refined SART variability measures in Study 2 (n = 113).

		FFAUS, 1st half				FFAUS, 2nd half				SFAUS			
		b	***SE***	***p***	β	***b***	***SE***	***p***	β	***b***	***SE***	***p***	β
Mean difference, estimated	(1) No tasks	−12.26	8.26	0.14	−0.29	−18.71*	7.81	0.02	−0.39	−35.73	48.18	0.46	−0.16
	(2) Restoration-enhancement tasks (U)	−7.15	10.32	0.49	−0.11	−15.81	10.78	0.14	−0.23	−55.58	33.44	0.10	−0.28
	(3) Awareness-enhancement tasks	−2.55	8.72	0.77	−0.05	3.08	14.64	0.83	0.04	−29.77	107.98	0.78	−0.06
Covariates	Stress	−15.88	10.37	0.13	−0.21 /−0.12/−0.20	−25.77*	12.66	0.04	−0.31/ −0.18/−0.20	−52.55	48.73	0.28	−0.14 /−0.13/−0.06
	Start time	−27.29*	11.59	0.02	−0.26/ −0.17/−0.20	6.11	14.57	0.68	0.05 /0.04 /0.03	−38.73/ 90.54/12.57	59.36/ 66.77/111.53	0.51/ 0.18/0.91	−0.07/0.19 / 0.01
	Age	−0.46	0.47	0.33	−0.12/−0.08/−0.09	−0.43	0.51	0.40	−0.10/−0.07/ −0.06	−1.48	2.36	0.53	−0.07/−.08 /−0.03
	Navigation method	0.81	6.85	0.91	0.01/ 0.01/0.01	−15.25/ −12.47/23.09	8.23/ 15.45/15.83	0.06/ 0.42/0.15	−0.24/ −0.12/0.22	12.72	27.98	0.65	0.04/0.04/ 0.02
	Ease of wayfinding	5.91	9.12	0.52	0.07/ 0.07/0.06	3.91	9.18	0.67	0.04/0.04 / 0.02	29.53	36.21	0.42	0.07/ 0.11/0.03
R^2 (conditions 1/2/3)		0.09/0.05/0.06				0.16/0.05/0.08				0.03/0.08/0.004			

*χ^2 = 26.36 (df = 34, p = 0.82), RMSEA < 0.001, CFI = 1.00, TLI = 1.73, SMRM = .08. Grouping is based on the study condition; figures separated by "/" if they differed between the groups. U: updated from Study 1. 3 outliers deleted; parameters freed across groups: FFAUS (2nd half) regressed on navigation method and SFAUS regressed on start time. *p < 0.05, **p < 0.01, ***p < 0.001.*

This could be explained by the circadian rhythm and attention fatigue during the day (Riley et al., 2017), as usually those who participated later came directly after work. Being more stressed in the past 4 weeks was also connected to responding faster but making less commission errors and having less moment-to-moment attentional slips toward the end of the sustained attention test. Thus, the results indicate that participants who were more stressed experienced more sustained attention restoration during the nature walk whereas sustained attention was not restored after participating later during the day (and possibly after work).

It is important to note that even though we found no evidence that the awareness-enhancement tasks improved attention restoration, they were used very differently than in Duvall's original studies (Duvall, 2011, 2013). In these studies, the participants could choose which tasks to use and when; they could change the tasks frequently between or within their walks, or keep on doing the same task during multiple walks. Duvall's intervention (Duvall, 2011, 2013) covered several nature walks during 2 weeks, and it is possible that some restorative effects reported in these interventions may develop over longer time periods because participants may need more time to learn and become used to the tasks (Lymeus et al., 2018).

DISCUSSION

Overall Discussion (Studies 1 and 2)

Our experimental field studies support the established findings that various types of nature visits enhance positive mood but the effects on attention restoration are more nuanced (McMahan and Estes, 2015; Ohly et al., 2016). Although our studies varied in exposure time and environmental quality, the self-reported mood-related outcomes, valence and restoration, showed a similar, positive change. This is in line with meta-analyses summarizing experimental studies on nature exposure (Barton and Pretty, 2010; McMahan and Estes, 2015). Sustained attention improved overall in terms of reduced commission errors; this can indicate less mindlessness and fewer attentional slip-ups in 'real life' (Robertson et al., 1997). The fact that there were fewer differences between self-reported outcomes compared to sustained attention corroborates findings from Lin et al. (2014). In both our studies, the greatest improvements in sustained attention were experienced when the participants conducted the restoration-enhancement tasks ending with instructed relaxation. Less clear, however, is the longevity of these effects, and potential benefits over repeated walks. Repeated exposure to, and engagement with, a natural environment could provide added restoration via place attachment and favorite place establishment (Korpela et al., 2010). We have seen encouraging results showing the attention benefits of repeatedly engaging with the environment via different types of engagement strategies (Duvall, 2011; Lymeus et al., 2018). Whether the psychological tasks examined in our studies could provide similar benefits over a longer course is a matter for future research. Furthermore, as our studies integrated components of different restoration mechanisms (attention restoration, stress reduction, and place attachment), future research investigating the relative contributions of these components in providing restorative outcomes would be worthwhile.

The finding that both mood and sustained attention improved after a nature walk not only supports Stress reduction theory and Attention restoration theory but also the idea that the processes they describe are co-occurring (Kaplan, 1995; Markevych et al., 2017). This was further supported by the strong role of stress prior to, and during, the experiment in explaining both changes in affective and attention restoration. The role of environmental engagement in enhancing restorative benefits of nature exposure, on the other hand, is less clear. We found evidence that restoration-enhancement tasks, aimed to guide interaction with the environment, can aid sustained attention but no indication that it could enhance affective restoration. Furthermore, there was no evidence (in Study 1) that to promote sustained attention, the tasks should follow the theory-based sequence with life reflection at the final stage, or that tasks focusing on engagement without addressing restoration would benefit sustained attention (Study 2; cf. Duvall, 2011). The fact that the contents and the order of the tasks and their congruence with the environment mattered in terms of sustained attention highlights the sensitive and complex nature of person-environment interaction (Kaplan and Kaplan, 1989). Our understanding of these complexities might benefit from qualitative future investigation. Furthermore, although our results suggest that engagement with the environment can be a relevant facilitator of attention restoration, it is, naturally, possible that other type of tasks or forms of engagement could promote both attention and affective restoration more effectively, or, consistently.

Our studies were conducted in the field with a focus on creating a realistic nature visit. It is expected that people respond to these types of psychological tasks differently, and in both our studies, participants could complete them in a way they preferred. Concurrently, this means that we had little control over how 'well' the tasks were conducted, how much time was spent on the tasks, or on the quality of the environmental interaction that the tasks aimed to enhance. To better understand restoration process and the relative contributions of each component in the restoration process – physiological, affective, attentional – it would have been useful to have a measure to assess interaction with the environment during the walk, and not just the restorative outcomes following it. However, examining person-environment interaction without disturbing this interaction could be challenging, and it remains a topic for future studies to explore. Similarly, the fact that the participants could walk at their own pace improved the external validity of the experiment but, at the same time, we could not control for events during the walk (Abrahamse et al., 2016). Had the participants walked in groups, the presence of others, the group size, or inability to walk at one's typical pace may have also affected the experiment in a more positive or negative way (e.g., Staats and Hartig, 2004).

Because the two studied paths differed in environmental type, length, and signing, we conducted no analyses comparing the effects between the studies. Overall, however, the effects of these two similar experiments were to the same direction in all our

measures. This gave us more confidence to draw conclusions, especially when conclusions from the individual studies had to be made with caution due to lower-than-planned sample sizes and, consequently, less power in the statistical analyses. The fact that the findings were similar in the two studies accords with a number of studies and meta-analyses that have found no difference between the restorative effects of wild and maintained natural environments, or otherwise different types of natural environments (Barton and Pretty, 2010; McMahan and Estes, 2015; Rogerson et al., 2016).

Finally, it is important to note that our results may not apply to the general population. Although the samples had the benefit of being more diverse than the commonly used student samples, the participants were mostly female and likely more nature-oriented than the general population. To obtain more diverse samples, similar future studies could try different recruitment methods (such as targeting employees near the study sites) and providing more incentives (such as raffles or more extensive feedback) for participation. Another issue with the samples were drop-outs due to last-minute cancelations and bad weather. The cancelation rates were smaller in Study 2 that, compared to Study 1, was shorter, more easily accessible by public transport, and used an online-calendar for signing up in the study; all these features probably contributed to lower sample attrition and could be recommended for future studies.

CONCLUSION

Our studies focused on the concept of active engagement with the environment, previously receiving scant empirical attention, advancing our theoretical and practical understanding of the restorative environments field. We examined this by designing, and testing, the effects of restoration-enhancement tasks along nature trails. The present studies indicate that these tasks can have a beneficial influence on sustained attention, whereas self-reported restoration and valence appear to improve after a nature walk regardless of conducting tasks. The studies also provide tentative evidence that the effects on sustained attention are sensitive to the tasks' contents: conducting tasks can either hinder or facilitate performance in a sustained attention task compared with regular nature walks without tasks. These findings are in line with both Stress reduction theory and Attention restoration theory, and support the idea that these two theories about attention and affective restoration describe complementary processes (Kaplan, 1995; Markevych et al., 2017).

Most Finnish people regularly spend time in nature, and the most common recreational activity in nature is walking (Sievänen and Neuvonen, 2011). It is also common to visit natural settings for stress reduction purposes and to experience restoration from such visits (Pasanen et al., 2018). Our studies indicate that some aspects of restoration during nature walks could be enhanced by encouraging active engagement with the environment. We already have tentative evidence that self-reported restoration evaluations are similar across visits to nature trails with the same tasks in other European countries (Korpela et al., 2017). Transferring these tasks to other countries and routes is low-cost and requires little-to-no physical environmental modification, and promoting their use has, thus, potentially wider benefits. Moreover, conducting restoration-enhancement tasks or other engagement strategies during a nature walk is free for the public, and it may facilitate interaction with the surrounding environment, especially in cases where natural settings are less optimal, uninteresting or cannot be easily redesigned (cf. Duvall, 2011). Ideally, the tasks could support nature visitors' everyday attention restoration, enhance motivation to visit restorative (natural) settings, and educate or sensitize people who are not familiar with interacting with nature. Restoration-enhancement tasks are, in conclusion, a promising avenue for enhancing the benefits of nature experiences.

AUTHOR CONTRIBUTIONS

This study was originated by KK, who designed and planned the experiments with TP. TP collected the data with a research assistant, conducted the statistical analyses, and wrote the majority of the paper. KJ calculated the variables for FFAUS and SFAUS. KK, KL, and KJ critically revised the manuscript several times. All authors contributed to data interpretation and gave final approval to the version to be published.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2018.02057/full#supplementary-material

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Profiles of Nature Exposure and Outdoor Activities Associated With Occupational Well-Being Among Employees

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This research addresses the profiles of nature exposure and outdoor activities in nature among Finnish employees ($N = 783$). The profiles were formed on the bases of nature exposure at work and the frequency and type of outdoor activities in nature engaged in during leisure time. The profiles were investigated in relation to work engagement and burnout. The latent profile analysis identified a five-class solution as the best model: *High exposure* (8%), *Versatile exposure* (22%), *Unilateral exposure* (38%), *Average exposure* (13%), and *Low exposure* (19%). An Analysis of Covariance (ANCOVA) was conducted for each well-being outcome in order to evaluate how the identified profiles related to occupational well-being. Participants with a *High, Versatile,* or *Unilateral exposure* profile reported significantly higher work engagement in the dimensions of vigor and dedication than did the participants with a *Low exposure* profile. The participants with the *High exposure* profile also reported lower burnout in the dimensions of cynicism and professional inadequacy than the participants with the *Low exposure* profile. Nature exposure during the workday and leisure time is an under researched but important aspect in promoting occupational well-being.

Keywords: nature exposure, outdoor activities, work engagement, burnout, employees

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INTRODUCTION

Contact with the natural environment (e.g., park walks during the workday) and nature elements (e.g., indoor plants) can have beneficial effects on general and work-related well-being, as well as on work attitudes (e.g., Brown et al., 2014; Gray and Birrell, 2014; de Bloom et al., 2017; Sianoja et al., 2017; see reviews by Korpela et al., 2015; Horr et al., 2016). Also, physical activities in natural environments during leisure time can contribute to employee well-being as was noted in a 1-year follow-up study among employees (Korpela et al., 2017). The present research builds on such previous research by incorporating nature exposure at work and including not only the frequency but also the type of outdoor activities engaged in within natural environments during leisure time. In this research, the term "natural environments" refers to green and natural areas such as parks, forests, fields, marshes, beaches, waters, playgrounds, and playing fields.

Using a person-centered approach (e.g., Wang et al., 2013; Bergman and Lundh, 2015), we aimed to identify subgroups of employees characterized by their frequency of nature exposure during working hours and leisure time and the type of outdoor activities they engage in during their visits to natural environments. We were able to identify employee profiles, categorized to be as homogenous as possible within each profile and as heterogeneous as possible between the profiles in terms of employees' nature exposure and outdoor activities in natural environments. This kind of approach is meaningful, since, in reality, people have access to various types of nature exposure and activities concurrently. We further investigated the differences between the subgroups of employees to find out which are the least and most beneficial employee profiles in terms of occupational well-being. Our research seeks to address the question of what occupational well-being benefits are associated with nature exposure and outdoor activities in natural environments, and who benefits most (Bowler et al., 2010). The results are applicable in occupational health services promoting occupational well-being and designing nature-based interventions that target occupational well-being.

The Effects of Natural Environments on Well-Being

We considered the effects of natural environments on occupational well-being within the context of the Attention Restoration Theory (ART; Kaplan and Kaplan, 1989; Kaplan, 1995, 2001) and Stress Recovery Theory (SRT; Ulrich, 1983, 1993; Ulrich et al., 1991). ART (e.g., Kaplan and Kaplan, 1989) focuses on the cognitive processes involved in information processing. Individuals use directed attention in organizing cognitive stimuli, for instance, in problem solving. According to ART (e.g., Kaplan, 2001), directed attention is a limited resource and vulnerable to fatigue. If directed attention is fatigued, the attentional restoration is suggested to be supported by certain environments that have restorative qualities. In line with ART, restoration is more likely to happen when an individual becomes fascinated and the attention is effortlessly drawn to an interesting element in the environment. Thus, the directed attention can replenish and the individual experiences attentional restoration. In addition to fascination, there are three other central elements in nature contributing to attentional restoration: having the sense of being away, the extent to which the environment allows one to engage, and compatibility between oneself and the environment.

The physiological and affective changes observed in natural environments are explained by the Stress Recovery Theory (SRT; Ulrich, 1983; Ulrich et al., 1991). Natural environments impact stress recovery on several levels that can play a key role in occupational well-being. Natural environments speed up physical recovery via releasing muscle tension and reducing blood pressure, heart rate and salivary cortisol (e.g., Kim et al., 2009; Lee et al., 2011; Tsunetsugu et al., 2013). Natural environments promote positive changes in affect and emotions (see a review by Pretty et al., 2007; Bowler et al., 2010). That is, natural environmental factors can facilitate stress recovery through autonomic nervous system changes that increase relaxation (Gladwell et al., 2012) and positive mood (e.g., Bowler et al., 2010). These theories are relevant in explaining restoration and recovery processes among employees since modern working life demands them to process extensive and complex information that burdens attention for long periods of time resulting in cognitive strain. Work environments also create psychosocial stressors (e.g., time pressure and performance expectations), resulting in the reduction of occupational well-being (e.g., Siegrist et al., 2009; Paškvan et al., 2016). Opportunities for restoration and recovery can therefore contribute to better occupational well-being among employees. In turn, when stress recovery fails, employees may experience an increase in job-related burnout.

Restoration has been shown to be more efficient in natural than in built environments (e.g., Ulrich et al., 1991; Kaplan, 1995; Herzog et al., 2002; Berman et al., 2008; Aspinall et al., 2015). A favorite place in a natural rather than in built environment can increase affect regulation, promoting positive states and stress recovery (e.g., Korpela and Ylén, 2009; Korpela et al., 2010). The restorative effects are observed when viewing or being physically active in natural environments (Elings, 2006; Stigsdotter et al., 2011; Tyrväinen et al., 2014). Natural environments, in fact, contribute to well-being beyond physical activity (Ulrich and Parsons, 1992; de Vries et al., 2003; Grahn and Stigsdotter, 2010). Research provides evidence that natural environments are not only restorative after exposure to stress and attention fatigue but also positively impact generally healthy individuals (Frumkin, 2001; Nielsen and Hansen, 2007). Natural environments can, for instance, increase physical activity- and exercise-related benefits, trigger deep reflection and strengthen the nature connection (see a review by Brymer et al., 2010). Nature exposure and outdoor activity can be used as means for the employees' psychological self-regulation toward recovery from work strain and improvement of occupational well-being and health.

The Present Study

In this research, we propose that employees' level of nature exposure is related to their occupational well-being. Nature exposure during the workday was taken into account since employee well-being benefits have been observed in relation to such exposure during work (Lottrup et al., 2012; Gilchrist et al., 2015; Sianoja et al., 2017). For example, employees who took a daily 15-min park walk during their lunch break over a 2-week trial reported increased vitality, decreased fatigue and decreased blood pressure after each break in the afternoons (de Bloom et al., 2017; Torrente et al., 2017). On an individual level, on the days they took the park walk, they showed decreases in end-of-workday stress and fatigue as well as better concentration at work compared to days when they took lunch breaks without a walk through the park (Sianoja et al., 2017). In addition, nature exposure during leisure time can contribute to employees' vitality and stress recovery (Korpela and Kinnunen, 2011; Korpela et al., 2017).

We also took into consideration the types of activities that employees engaged in during leisure time, ranging from being in and enjoying nature to more physical activities of jogging or skiing. There is mixed evidence regarding the relationship

between the type of outdoor activity and well-being. Some previous studies show that well-being effects of green exercise are not related to the type, intensity or length of the activity (Pretty et al., 2007). However, exceptions have been reported; for example, a longitudinal study (Korpela et al., 2017) reported that physical exercise in nature was more effective than some other, less intense activities, such as gardening. It could be that those employees who spend more time in natural environments also generally engage in more varied activities (e.g., gardening, spending time at a summer cottage, walking, skiing, picking berries) than those employees who visit natural environments only infrequently (e.g., enjoying the scenery and photography). These considerations and previous findings call for further studies and we have consequently taken into account the heterogeneity of the outdoor activities in nature.

The first research question we posed relates to whether there are distinctive profiles of nature exposure and outdoor activity in nature. Due to the exploratory nature of the person-centered analyses, we could not set firm hypotheses regarding the number of profiles or their respective levels of exposure and heterogeneity of activities. However, as we aimed to reach a large and heterogeneous sample of employees, we expected to find more than one profile such as relating to various frequencies of exposure and different activities. It is likely that the identified profiles would differ quantitatively from each other. For example, there could be a profile that reflects less frequent nature exposure at work and during leisure time as well as less varied activities in nature. It was also deemed reasonable to assume that there would be a profile that relates to more frequent nature exposure at work and during leisure time in addition to more varied activities in nature. These expectations were based on previous research that has shown that employees differ in their levels of nature exposure and participation in outdoor activities in nature (Gilchrist et al., 2015; Korpela et al., 2015). It was also thought possible that the profiles would differ from each other qualitatively, meaning that they might show different combinations of nature exposure and outdoor activities in nature. For example, while an individual's nature exposure may be high, only certain physical activities may be pronounced in his or her profile (e.g., daily walks with a dog).

The second research question focused on investigating whether the profiles would relate to occupational well-being. Previous research has indicated that exposure to a natural environment at work or during leisure time relates to employee well-being, such as vitality (Korpela et al., 2017) and mental well-being (Brown et al., 2014; Gilchrist et al., 2015). We focused on well-being at work measured by burnout and work engagement, since these two aspects of occupational well-being have not been included in previous studies in conjunction with nature exposure. These aspects measure work-related mental states, which are important in working life as modern employees are expected to work longer, extending their careers (e.g., being engaged at work but not to the point of burnout).

The psychological syndrome of burnout is typically described as exhaustion, cynicism, and reduced professional efficacy caused by prolonged job stress (e.g., Maslach et al., 1996; Maslach and Leiter, 2008). The core component of the syndrome, exhaustion, refers to the depletion of emotional and physical resources from doing one's work. Cynicism describes a negative or distant attitude toward one's work in general, and it can be characterized as dysfunctional coping through which employees detach themselves from their work. Reduced professional efficacy represents feelings of incompetence and ineffectiveness in regard to both the social and non-social aspects of occupational achievements. Work engagement, in turn, aims to capture employees' positive work-related states of vigor, dedication, and absorption at work (e.g., Schaufeli et al., 2006; Bakker and Demerouti, 2008). Vigor describes high energy and mental resilience toward work. Dedication refers to the employee's feelings of pride, meaningfulness and enthusiasm about the work. The absorption component describes being fully concentrated and immersed in work, as well as losing the sense of time while working. We also controlled for psychosocial stressors in the work environment in the form of employee efforts and rewards (Effort–Reward Imbalance model, ERI; e.g., Siegrist et al., 2009), which have been shown to relate to both work engagement and burnout (Kinnunen et al., 2008; Feldt et al., 2013).

In sum, we have set the following hypotheses based on previous research on nature exposure and outdoor activities in nature, as mentioned earlier:

H1: We expect to find distinctive profiles of nature exposure and outdoor activity in nature that are characterized by different frequencies of nature exposure and a heterogeneity of outdoor activities in nature.

H2: Employees with a profile characterized by less frequent nature exposure and less varied outdoor activities in nature will report low occupational well-being.

H3: Employees with a profile characterized by more frequent nature exposure and more varied outdoor activities in nature will report high occupational well-being.

MATERIALS AND METHODS

Data Collection and Participants

This research was conducted to investigate the relationship between visits to natural environments and occupational well-being among employees. The data were collected with an electronic survey, which included questions regarding employees' frequency and duration of visits to natural environments, their engagement in different types of outdoor activities in nature, occupational well-being, and demographic and work characteristics. The electronic link to the online survey was e-mailed to 3,260 employees of 13 public and private sector organizations between May and November 2016. The organizations were recruited directly, including the largest organizations in Central Finland and the Tampere region, with the help of two large occupational health services who forwarded the invitation for taking part in the study to the selected client organizations. The response rate was 24% ($N = 783$). Our study was carried out in accordance with the recommendations of the University of Jyväskylä's Ethics Committee and was given a research permit by the Tampere

District Hospital. The registration number of the research permit is 430.

Of the participants, 78% were female, the average age was 47 years (SD = 10 years, range 21–70 years), and 65% of the participants had children. The participants' educational level was rather high as 56% held a university degree. Of the participants, 91% had full-time work and 76% worked regular daytime hours. Altogether, 17% of the participants were employed in a supervisory position. Of the participants, 35% were employed in a municipality, working in various public sector services. Other participants worked in various organizations, including social and health services (24%), education (21%), logistics and travel (12%), and design and engineering services (8%). The distribution of the participants in regard to their accessibility and exposure to nature is presented in **Table 1**.

TABLE 1 | Percentages for variables describing participants' nature exposure and accessibility to nature areas.

Nature exposure and accessibility	%
Frequency of nature visits during leisure time (1–7)	**Summer/winter**
Never	0/1
Less than monthly	1/6
1–3 times per month	4/10
Once a week	7/14
2–3 times per week	18/26
4–6 times per week	26/18
Daily	44/25
Duration of nature visits during leisure time (1–6)	**Summer/winter**
Less than 15 min	1/3
15–30 min	6/15
30 min to 1 h	31/43
1–1.5 h	31/26
1.5–2 h	18/9
Over 2 h	13/4
The distance to the nearest nature area from home (1–6)	
Less than 100 m	64
100–300 m	24
300–500 m	6
500–1000 m	4
1–2 km	1
Over 2 km	1
Frequency of visits to nature area at work (1–6)	
No visit	67
Less than monthly	12
Monthly	4
Weekly	9
Almost daily	5
Daily	3
Length of commute via nature (1–5)	
None	37
Less than 500 m	21
500–1,000 m	16
1–1.5 km	9
Over 1.5 km	17

Measures

Frequency of Nature Visits at Work and Leisure Time

Frequency of nature visits at work and leisure time was measured with two separate questions. At the beginning of the survey, the participants were informed that our definition of green and nature environments includes areas such as parks, forests, fields, meadows, marshes, rocks, fells, beaches, waters, playgrounds, and playing fields. The first question related to nature visits during leisure time: "How often do you visit green and nature environments?" The participants indicated the frequencies of their visits separately for the summer season (May to September) and winter season (October to April) on a scale from *never* (1) to *daily* (7). Similarly, the second question related to the frequency of nature visits at work: "Do you spend time outside in green and nature environments at work?" The response scale ranged from *never* (1) to *daily* (6). The different response options are shown in **Table 1**.

Outdoor Activities in Nature

Outdoor activities in nature were enquired about with the question: "How do you normally use green and nature environments?" The participants selected the types of activities in nature they normally engage in from a given list of 16 activities (0 = *no*, 1 = *yes*) (Sievänen and Neuvonen, 2011). The list included a range of activities that described being in nature (e.g., enjoying scenery, relaxing, and dwelling), exercising in nature (e.g., walking and jogging, cycling, skiing), going on nature trips and travels (e.g., spending time at a summer cottage, boating), and the use of nature's resources (e.g., picking berries and mushrooms, hunting and fishing).

Work Engagement

Work engagement was measured with the 9-item Utrecht Work Engagement Scale (Schaufeli et al., 2006; Seppälä et al., 2009). The dimensions of vigor (e.g., "At my work, I feel bursting with energy"), dedication (e.g., "I am enthusiastic about my job") and absorption (e.g., "I feel happy when I am working intensely") were all measured with three items. The rating scale ranged from *never* (1) to *daily* (7). The Cronbach's alphas were: vigor α = 0.89, dedication α = 0.91, and absorption α = 0.86. The three dimensions of work engagement were included separately in the analyses.

Burnout

Burnout was measured with the Bergen Burnout Inventory with nine items (BBI−9; Salmela-Aro et al., 2011) whose factorial invariance has been supported across organizations and measurement times (Feldt et al., 2014). The dimensions of exhaustion (e.g., "I am snowed under with work"), cynicism (e.g., "I feel dispirited at work and I think of leaving my job"), and inadequacy (e.g., "I frequently question the value of my work") were all measured with three items. The rating scale ranged from *totally disagree* (1) to *totally agree* (6). The Cronbach's alphas were: exhaustion α = 0.69, cynicism α = 0.85, and inadequacy

$\alpha = 0.80$. The three dimensions of burnout were included separately in the analyses.

Covariates

The following demographic characteristics were included in the analyses: age (continuous), gender (0 = female, 1 = male), education (0 = no university degree, i.e., low education; 1 = university degree, i.e., high education), and having children (0 = no, 1 = yes). The following work factors were also included: being a supervisor (0 = no, 1 = yes), working a regular day shift (0 = no, 1 = yes), working hours per week (continuous), being in full-time work (0 = no, 1 = yes), and having a white-collar job (0 = no, 1 = yes).

Additional work-related factors of effort and reward were used as covariates. Participants evaluated their job stressors with the Effort-Reward Imbalance Scale (ERI scale; Siegrist et al., 2009). The original, longer version of the ERI scale has been validated in Finland (Rantanen et al., 2013). Our study's participants evaluated their efforts with three items (e.g., "I have constant time pressure due to a heavy workload") and rewards with seven items (e.g., "I receive the respect I deserve from my superiors"). The response scale ranged from *totally disagree* (1) to *totally agree* (4). The Cronbach's alphas were: effort $\alpha = 0.69$, and reward $\alpha = 0.79$.

Further questions regarding nature exposure and accessibility were included in the survey: the duration of the nature visits during leisure time in summer and winter, the distance to the nearest natural area from home, and the length of the commute via nature. These variables did not contribute to the variability between participants and therefore were not included in the Latent Profile Analysis. Instead, these variables were taken into consideration as covariates in the Analyses of Covariance, since they related to well-being measures with the exception of the length of the nature visits during leisure time in the summer, which was not shown to be a significant covariate.

Analyses

Pearson correlation coefficients were calculated to show the relationships between the nature-related variables and dimensions of work engagement and burnout. Latent Profile Analysis (LPA) was used to identify different subsamples of employees in regard to their nature exposure and outdoor activities in nature. The profiles were identified with the three questions specified earlier, that is, the frequency of nature visits during leisure time in summer and winter, the frequency of nature visits at work, and the types of outdoor activities in nature environments during leisure time. The analysis was performed using the Mplus statistical package (Version 7.3) with maximum likelihood estimation (MLE).

Deciding the number of profiles was based on several fit indices (Jung and Wickrama, 2008). First, the Bayesian Information Criterion (BIC), the Vuong-Lo-Mendell-Rubin (VLMR) test, the Lo-Mendell-Rubin test (LMR), and the Bootsrapped Likelihood Ratio Test (BLRT) were calculated. The lower the BIC values are, the better the model is. In the VLMR, LMR and BLRT, $p < 0.05$ indicates that k profiles are sufficient compared to $k + 1$ profiles. Second, a good solution was seen to be indicated when there was successful convergence, a high entropy value (range 0–1) and at least 1% of the participants in a profile. The third and most important criterion was that the identified profiles are meaningful.

We conducted the following analyses. First, the identified profiles were compared with *t*-tests (continuous variables) and χ^2-tests (categorical variables) in regard to demographic, work- and nature-related factors. Second, separate Analyses of Covariance (ANCOVAs) were run for each well-being outcome in order to evaluate how the identified profiles are related to occupational well-being (i.e., vigor, dedication, absorption, exhaustion, cynicism, inadequacy). In these analyses, only the statistically significant covariates were included in the final models. In other words, first all the covariates related to demographic characteristics, work-related factors and nature-related factors (listed in the Measures section) were included in the models, and then, one by one, all of the statistically non-significant covariates were removed.

RESULTS

Descriptive Results

Table 2 depicts the intercorrelations between the nature-related factors and dimensions of work engagement and burnout. More frequent visits to nature environments during summer and winter, as well as shorter distances from home to nature environments, related to higher vigor, dedication and absorption. Also, longer visits to nature environments during the winter and longer commutes via nature related to higher vigor and absorption. More frequent visits to nature environments at work only related to dedication. Of the nature-related factors, only more frequent visits to nature environments at work related to lower burnout on the dimension of cynicism. The length of the visits to nature environments during summer was not related to any of the occupational well-being indicators.

Identifying Profiles of Nature Exposure and Outdoor Activities

Table 3 presents the results of the LPA analyses for alternative multi-group solutions (1–5). The six-profile solution did not converge, despite the modifications to the number of random starts and starting values. Of the alternative profiles, the BIC, VLMR, and LMR supported a five-profile solution. Entropy was higher in the two-profile solution but acceptable in every solution. In the five-profile solution, the smallest profile included 8.4% of the participants. Thus, the solution with five profiles best fulfilled the statistical criteria and was selected.

In **Figure 1**, three of the variables in the LPA model are illustrated (i.e., frequency of nature visits during leisure time in summer and winter, and frequency of nature visits at work). These variables are standardized as they were measured with different scales. As can be seen in **Figure 1**, the frequency of the nature visits in summer and winter is the highest in Profile 1, the lowest in Profile 5, and at an average level in Profile 4. The frequency of nature visits at work is the highest in Profiles 1 and 4. In addition to the three profiles that show only differences in their levels of nature exposure, two other profiles (2–3) were identified. **Table 4** shows that the profiles differed in

TABLE 2 | Pearson correlation coefficients for nature-related variables and indicators of occupational well-being.

Variables	1	2	3	4	5	6	7	8	9	10	11	12
NATURE-RELATED FACTORS												
1. Frequency of visits in winter (1 =Never−7 =Daily)[A]												
2. Frequency of visits in summer (1 =Never−7 =Daily)[A]	0.77***											
3. Duration of visits in winter (1 =Less than 15 min−6 =Over 2 h)[B]	0.16***	0.07*										
4. Duration of visits in summer (1 =Less than 15 min−6 =Over 2 h)	0.02	0.08*	0.62***									
5. Distance to nature area (1 =Less than 100 meters−6 =Over 2 km)[B]	−0.24***	−0.25***	−0.02	0.01								
6. Frequency of visits to nature area at work (1 =No visit−6 =Daily)[A]	0.19***	0.14***	0.05	0.05	−0.08*							
7. Length of commute via nature (1 =None−5 =Over 1.5 km)[B]	0.22***	−0.23***	0.12**	0.08*	−0.10**	0.10*						
OCCUPATIONAL WELL-BEING												
Vigor (1–7)	0.16***	0.13***	0.10**	0.04	−0.10**	0.06	0.09*					
Dedication (1–7)	0.13***	0.12**	0.06	0.01	−0.08*	0.09*	0.08	0.77***				
Absorption (1–7)	0.09*	0.09*	0.09*	0.04	−0.10**	0.05	0.08*	0.69***	0.72***			
Exhaustion (1–6)	−0.03	−0.03	−0.02	0.02	0.01	0.03	−0.04	−0.43***	−0.32***	−0.22***		
Cynicism (1–6)	−0.05	−0.05	−0.02	0.00	0.04	−0.08*	−0.05	−0.66***	−0.68***	−0.54***	0.55***	
Inadequacy (1–6)	−0.04	−0.04	0.00	0.03	0.05	−0.05	−0.05	−0.59***	−0.58***	−0.45***	0.53***	0.81***

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. [A]Nature-related variable included in the LPA. [B]Nature-related variable used as a covariate in the ANCOVAs.

TABLE 3 | The results of latent profile analyses of nature exposure and outdoor activity.

# of profiles	Log-likelihood	BIC	VLMR *p*-value	LMR *p*-value	BLRT *p*-value	Entropy	Proportions, *n* (%)
1	−11194.19	22534.96	–	–	–	–	783 (100)
2	−10774.93	21829.72	0.000	0.000	0.000	0.830	213 (27.2) 570 (72.8)
3	−10482.60	21378.31	0.000	0.000	0.000	0.894	179 (22.9) 143 (18.3) 461 (58.9)
4	−10328.24	21202.86	0.000	0.000	0.000	0.828	172 (22.0) 144 (18.4) 161 (20.6) 306 (39.0)
5	−10197.31	21074.25	0.001	0.001	0.000	0.856	171 (21.8) 150 (19.2) 99 (12.6) 297 (37.9) 66 (8.4)
6	Did not converge						

terms of demographic, work- and nature-related variables. The participants in Profiles 1, 2, and 3 visited nature environments in summer significantly more often than did the participants in Profiles 4 and 5. Furthermore, the participants in Profile 5 visited nature environments in winter significantly less often than did all of the other participants. The participants in Profile 1 visited nature environments at work more often than did all of the other participants; and furthermore, participants in Profile 4 visited nature environments at work more often than did the participants in Profiles 2, 3, and 5.

The participants in Profiles 2 and 3 are similar in regard to these three variables: they visited nature environments during leisure time more often than did the average of the sample, but the frequency of their nature visits at work was less than was the case for the average of the sample. The reason why the LPA identified Profiles 2 and 3 as separate is due to the fact that the participants in these profiles differ in their patterns of activities in nature environments (see **Table 5**). In Profile 2, the participants were active in nature environments in various ways: they spent time in nature in a number of different ways, such as enjoying the scenery, relaxing, gardening, sunbathing, and swimming. They exercised in nature by walking and jogging, cycling, and skiing. They also spent time in their cottage, went boating, and picked berries and mushrooms. In contrast, in Profile 3, the most

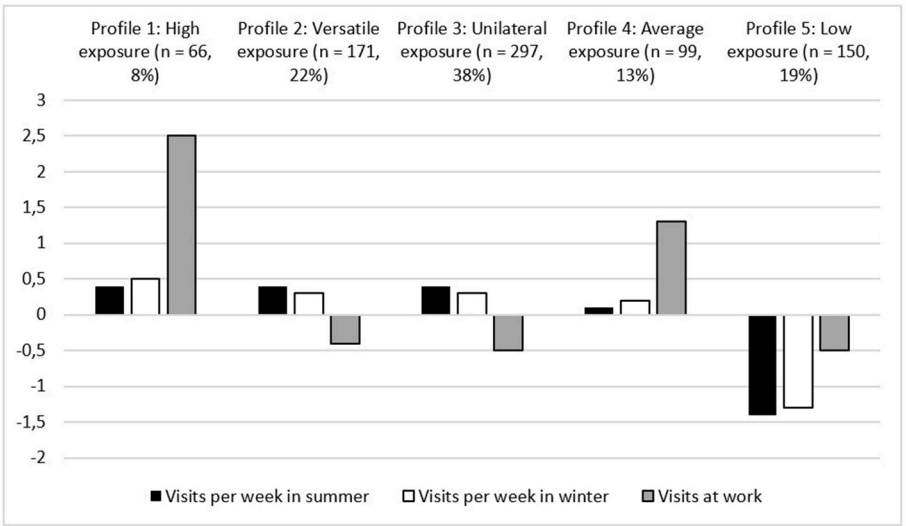

FIGURE 1 | The five-profile solution of the LPA showing the frequency of nature of visits per week in summer and winter during leisure time and the frequency of visits at work.

common activities were enjoying the scenery and nature, and walking and jogging. Moreover, the participants in Profiles 1, 4, and 5 were also rather narrow in their activities, since they mainly enjoyed the scenery and nature, relaxed, walked, and jogged.

Based on these results, the profiles can be described as follows: Profile 1 = *High exposure* (n = 66; 8%), describing frequent nature visits at work and during leisure time; Profile 2 = *Versatile exposure* (n = 171; 22%), describing frequent nature visits and versatile activity during leisure time combined with less frequent nature visits at work; Profile 3 = *Unilateral exposure* (n = 297; 38%), describing frequent nature visits but unilateral activity during leisure time combined with less frequent visits at work; Profile 4 = *Average exposure* (n = 99; 13%), describing average frequency of nature visits at work and during leisure time; Profile 5 = *Low Exposure* (n = 150; 19%), describing less frequent nature visits at work and during leisure time.

Profiles of Nature Exposure and Activity in Relation to Occupational Well-Being

Tables 6, **7** present the results related to the ANCOVAs: specifically, the estimated marginal means for the profiles in regard to occupational well-being factors (**Table 6**) and the final ANCOVA models with only statistically significant covariates (**Table 7**). The profiles differed in vigor, dedication, and cynicism after the statistically significant covariates were taken into account, explaining 1–3% of the variance in the well-being variables. In addition, the differences between the profiles were marginally significant in relation to professional inadequacy.

In order to reduce the number of pairwise comparisons, only the low exposure profile was compared to the other profiles (instead of comparing all profiles to each other). The participants in the high exposure profile reported higher vigor ($\beta = 0.63$, $p < 0.001$), dedication ($\beta = 0.71$, $p < 0.001$) and absorption ($\beta = 0.43$, $p < 0.05$), and lower cynicism ($\beta = -0.47$, $p < 0.001$) and inadequacy ($\beta = -0.40$, $p < 0.01$) than did the participants in the low exposure profile. Moreover, the level of vigor was lower in the low exposure profile compared to that of the participants in the versatile nature exposure profile ($\beta = 0.52$, $p < 0.001$) and unilateral exposure profile ($\beta = 0.33$, $p < 0.001$). The participants in the low exposure profile also reported lower levels of dedication compared to the participants in the versatile exposure profile ($\beta = 0.44$, $p < 0.001$), the unilateral exposure profile ($\beta = 0.31$, $p < 0.01$) and the average exposure profile ($\beta = 0.35$, $p < 0.05$). In the Bonferroni corrections, the p-value is multiplied by the number of pairwise comparisons. In this case, we have four pairwise comparisons. The p-values under 0.01 remain under 0.05 and p-values under 0.05 remain under 0.1 when Bonferroni corrections are calculated. The only occurrence of $p < 0.05$ was for the difference between the participants in the low exposure and high exposure profile regarding absorption, as well as for the difference between the participants in the low exposure profile and average exposure profile regarding dedication. These p-values may become marginally significant when Bonferroni corrections are taken into account.

Additionally, the versatile and unilateral exposure profiles were compared to see whether the diversity of the outdoor activities plays a role in well-being. However, these two profiles did not differ in regard to any of the well-being variables (results not reported here).

DISCUSSION

Our present research findings offer a valuable step forward from previous studies by having utilized a person-centered approach to identify profiles of nature exposure and outdoor activity in nature among a range of Finnish employees. As expected in our hypotheses, there was heterogeneity in the levels of nature exposure and outdoor activities in nature,

TABLE 4 | Comparison of the profiles: either the percentage or mean is presented with the related statistical testing.

	Profiles					Statistical test
	High exposure	Versatile exposure	Unilateral exposure	Average exposure	Low exposure	
VARIABLES IN THE LPA (RANGE; SD)						
Frequency of visits in summer (1–7; 1.22)	6.42	6.40	6.42	6.03	4.18	$p < 0.001$; 1, 2, 3 > 4, 5
Frequency of visits in winter (1–7; 1.53)	5.89	5.67	5.62	5.39	3.07	$p < 0.001$; 1, 2, 3, 4 > 5
Frequency of visits at work (1–6; 1.42)	5.39	1.20	1.13	3.70	1.13	$p < 0.001$; 1 > 4 > 2, 3, 5
DEMOGRAPHICAL CHARACTERISTICS						
Gender						$p < 0.001$
Female	83.3	78.9	80.8	85.9[A]	64.7	
Male	16.7	21.1	19.2	14.1	35.3[A]	
Education						$p = 0.001$
Low	69.7[A]	38.8	42.2	44.4	43.3	
High	30.3	61.2	57.8	55.6	56.7	
Children						$p = 0.047$
No	39.4	26.3	37.4	33.3	41.3	
Yes	60.6	73.7[A]	62.6	66.7	58.7	
Age in years	44.09	50.66	47.48	44.60	46.55	$p < 0.001$; 2 > 1, 3, 4, 5
WORK-RELATED FACTORS						
Supervisor						$p = 0.016$
No	89.4	78.9	81.1	92.9[A]	80.8	
Yes	10.6	21.1	18.9	7.1	20.0	
Regular day shift						$p < 0.001$
No	42.4[A]	13.5	18.5	52.5[A]	19.3	
Yes	57.6	86.5[A]	81.5[A]	47.5	80.7	
Full-time work						$p = 0.333$
No	7.6	10.5	10.4	4.0	8.0	
Yes	92.4	89.5	89.6	96.0	92.0	
White-collar worker						$p < 0.001$
No	83.3[A]	47.6	60.9	77.8[A]	54.7	
Yes	16.7	52.4[A]	39.1	22.2	45.3	
Working hours/week	37.84	39.69	39.01	38.89	39.77	$p = 0.403$
Effort	2.86	2.98	2.86	2.85	2.86	$p = 0.224$
Reward	2.32	2.45	2.43	2.48	2.43	$p = 0.393$
NATURE-RELATED FACTORS						
Duration of visits in winter (1–6; 1.06)	3.44	3.60	3.27	3.33	3.04	$p < 0.001$; 2 > 3, 5
Distance to natural area (1–6;.92)	1.32	1.40	1.53	1.48	1.95	$p < 0.001$; 5 > 1, 2, 3, 4
Length of commute via nature (1–5; 1.48)	2.62	2.87	2.41	2.78	1.96	$p < 0.001$; 5 < 1, 2, 4; 2 > 3

[A] *This class is over-represented in this profile.*

which was captured by five profiles of nature exposure and outdoor activity in nature. Our hypothesis regarding the relationship of the profiles of nature exposure and outdoor activity in nature with occupational well-being received support, since the profiles were associated with burnout and work engagement.

Favorable Profiles of Nature Exposure and Outdoor Activity in Nature in Relation to Occupational Well-Being

The participants in the high, versatile and unilateral exposure profiles reported on average 4–6 weekly visits to nature environments in the summer months and 2–3 weekly visits

TABLE 5 | Percentages per profile of participants engaging in each of the different outdoor activities in nature environments during leisure time (activities in which over 50% of participants in each profile engaged are marked in bold).

Outdoor activity	High exposure	Versatile exposure	Unilateral exposure	Average exposure	Low exposure
BEING IN NATURE					
Enjoy scenery and nature	**88**	**93**	**82**	**95**	**79**
Relaxing and dwelling	**73**	**84**	50	**71**	**54**
Sunbathing and swimming	39	**71**	28	48	43
Gardening	41	**70**	38	43	25
Photographing, painting or observing nature	33	33	22	28	16
EXERCISE IN NATURE					
Walking and jogging	**88**	**100**	**87**	**90**	**75**
Cycling	49	**77**	41	38	35
Skiing	33	**71**	28	34	24
Walking and playing with children	46	47	23	34	18
Walking with my pet	41	30	43	37	7
Playing	15	18	5	11	8
NATURE TRIPS AND TRAVELS					
Spending time at cottage	35	**63**	24	35	35
Boating	27	**58**	8	27	15
Camping	17	37	8	24	7
THE USE OF RESOURCES IN NATURE					
Picking berries and mushrooms	**59**	**92**	50	49	39
Hunting and fishing	14	28	6	16	15

TABLE 6 | Estimated marginal means (and standard errors) of well-being outcomes for the profiles (see **Table 7** for covariates used).

	Profiles					*F*-test
	High exposure	Versatile exposure	Unilateral exposure	Average exposure	Low exposure	
Vigor	6.01 (0.13)	5.89 (0.08)	5.71 (0.06)	5.57 (0.11)	5.37 (0.09)	$F_{(4,743)} = 6.59$, $p < 0.001$
Dedication	6.34 (0.13)	6.06 (0.08)	5.93 (0.06)	5.97 (0.11)	5.62 (0.09)	$F_{(4,775)} = 6.08$, $p < 0.001$
Absorption	6.04 (0.14)	5.81 (0.09)	5.69 (0.06)	5.67 (0.12)	5.61 (0.09)	$F_{(4,746)} = 1.99$, $p = 0.093$
Exhaustion	2.69 (0.10)	2.81 (0.06)	2.80 (0.05)	2.82 (0.08)	2.82 (0.07)	$F_{(4,767)} = 0.31$, $p = 0.870$
Cynicism	1.87 (0.11)	2.19 (0.07)	2.18 (0.05)	2.15 (0.09)	2.33 (0.07)	$F_{(4,775)} = 3.16$, $p = 0.014$
Inadequacy	2.17 (0.12)	2.41 (0.08)	2.44 (0.06)	2.40 (0.10)	2.57 (0.08)	$F_{(4,775)} = 1.96$, $p = 0.099$

in the winter months during leisure time. These participants visited nature environments in the summer more frequently than did the participants in the average and low exposure profiles. Furthermore, these participants differed in the frequency of their nature visits from the overall one-fifth of the participants who belonged to the profile of low exposure, who visited nature environments during leisure time once a week in the summer and 1–3 times during the month in the winter, on average. It is therefore an encouraging finding that about 68% of participants belonged to the profiles of high, versatile, and unilateral nature exposure profiles, which can be considered as favorable profiles regarding nature exposure and outdoor activity in nature. These profiles can also be considered as favorable profiles in terms of occupational well-being, since these participants reported higher work engagement in the dimensions of vigor and dedication than did the participants in the profile of low exposure.

Participants in the versatile exposure profile visited natural environments during leisure time and at work as frequently as did the participants in the unilateral exposure profile, but there were differences in the range of their activities in nature environments. Participants who had versatile activities spent time on being in nature (e.g., enjoying scenery and nature, relaxing and dwelling), exercising in nature, engaging in nature trips and travels, and utilized resources of nature such as by picking berries and mushrooms. The participants with unilateral activity typically engaged in less varied activities: enjoying and being in nature as well as walking. However, participants in both profiles were similar from the perspective of occupational well-being.

The association between the profiles and occupational well-being was highlighted in relation to the vigor and dedication dimensions of work engagement. The participants in the profiles of favorable nature exposure and outdoor activity in nature reported higher vigor and dedication compared to the

TABLE 7 | The final results of six separate analyses of covariance with significant covariates: parameter estimates (Unstandardized B) are reported in order to show the direction of the relationship.

	Vigor	Dedication	Absorption	Exhaustion	Cynicism	Inadequacy
DEMOGRAPHICAL COVARIATES						
Age in years	–	–	–	–	–	–
Male	−0.34***	−0.29**	−0.29**	–	–	–
High education	−0.15*	–	–	–	–	–
Having children	–	0.21**	–	–	−0.13*	−0.18*
WORK-RELATED COVARIATES						
Supervisor position	0.30***	–	–	–	–	–
Regular day shift	–	–	0.25**	–	–	–
Full-time work	–	–	–	–	–	–
White-collar worker	–	–	–	–	–	–
Working hours	–	–	–	0.02***	–	–
Effort	−0.14*	–	0.17*	0.81***	0.24***	0.23***
Reward	0.98***	1.06***	0.95***	−0.52***	−1.03***	−1.34***
NATURE-RELATED COVARIATES						
Duration of visits in winter during leisure time	0.13***	–	0.09*	–	–	–
Distance to natural area	−0.11*	–	−0.15**	–	–	–
Length of commute via nature	–	–	–	–	–	–
PROFILES						
High exposure	0.63***	0.71***	0.43*	-0.12^{ns}	−0.47***	−0.40**
Versatile exposure	0.52***	0.44***	0.19^{ns}	-0.01^{ns}	-0.15^{ns}	-0.15^{ns}
Unilateral exposure	0.33**	0.31**	0.08^{ns}	-0.02^{ns}	-0.15^{ns}	-0.13^{ns}
Average exposure	0.19^{ns}	0.35*	0.06^{ns}	0.00^{ns}	-0.18^{ns}	-0.17^{ns}
Low exposure (reference)	–	–	–	–	–	–
Adjusted R^2	0.29	0.24	0.20	0.38	0.31	0.38
η^2 (profiles)	0.03***	0.03***	0.01	0.00	0.02*	0.01

Profile 5 was selected as the reference category.

*$^{ns}p > 0.10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. Non-significant covariates were removed from the final model.*

participants in the low exposure profile. These findings are in line with various research showing the well-being effects of natural environments (e.g., van den Berg et al., 2015). The findings also parallel recent longitudinal research on employees, in which physical activity in nature during leisure time was found to contribute to their vitality (Korpela et al., 2017). Our research provides further evidence that more frequent visits to natural areas can be linked with positive motivational work-related states. On the basis of the ART (Kaplan, 1995) and SRT (Ulrich et al., 1991), nature environments may improve concentration and promote positive affect that presumably play a part in employees' resources for experiencing vigor and dedication at work.

The relationships between the profiles and burnout was less prevalent. The participants belonging to the high exposure profile reported lower cynicism and inadequacy than did the participants in the low exposure profile. In fact, the participants in the high exposure profile reported on average the lowest burnout in all dimensions of burnout and in conjunction with the highest work engagement.

The participants in the high exposure profile are of particular interest, since they differed in the frequency of their nature visits at work from the other participants in the favorable profiles of nature exposure and outdoor activity in nature (the profiles of versatile and unilateral exposure). The participants in the high exposure profile reported being exposed to nature environments on average almost daily during their workday. These results suggest that more frequent exposure to natural environments at work can have beneficial associations with occupational well-being. However, it should be noted that a high frequency of professional nature visits does not necessarily lead to well-being benefits, since participants in the average exposure profile reported only higher dedication in comparison to the participants in the low exposure profile (see below).

The participants in the high exposure profile were more likely to have a lower education, a blue-collar position, and to work irregular day shifts. The other participants in the favorable nature exposure profiles (the profiles of versatile and unilateral exposure) were more likely to work regular day shifts. In addition, the participants in the versatile exposure profile were more likely to be white-collar workers. Based on these results, the participants who work in typical office jobs could gain a further boost to their occupational well-being by having access to more exposure to nature during their workday. This suggestion is supported by previous studies, which have shown that spending more time outdoors during work has beneficial associations with

employee well-being (e.g., Gilchrist et al., 2015), such as through the effects of increased vitality and decreased fatigue as well as blood pressure after a park walk during the lunch break (de Bloom et al., 2017; Torrente et al., 2017).

The Profiles of Average and Low Nature Exposure in Relation to Occupational Well-Being

The results of our study also revealed a profile representing an average level of nature exposure. These participants visited nature environments during leisure time on average less often in the summer than did the participants in the favorable profiles of exposure and outdoor activity in nature, but more often than did the participants in the low exposure profile during the winter. The participants in this profile of average exposure were similar to the participants in the profile of high exposure in terms of the demographic characteristics. They were more likely to be women and working in irregular day shifts in blue-collar, non-supervisory positions. Also, their work entailed nature exposure more frequently than was the case with the participants in the versatile, unilateral, and low exposure profiles.

Overall, the participants in the average exposure profile reported an average level of occupational well-being as well as higher dedication than did the participants in the low exposure profile. On the basis of our findings, it is possible that the participants in the average exposure profile would benefit from more regular nature exposure during leisure time in order to promote higher-than-average occupational well-being. However, their shift work may restrict their possibility to do that.

It is worth noting that the participants in the average exposure profile reported visiting nature areas during work (similar to the participants in the high exposure profile). On the basis of previous empirical findings on forestry professionals (Von Lindern et al., 2013) and restoration theories (e.g., Kaplan and Kaplan, 1989), it could be that gaining a sense of being away may be difficult when the nature visits are work-related. The work-related nature experience may be different in quality and not as restorative as experiences during leisure time. To understand the differing well-being effects and somewhat contradictory findings concerning work-related nature experiences, more research on the relationship between professional nature exposure and well-being benefits is clearly needed. In particular, the elements of fascination and being away in restoration require further research in relation to the frequency of professional nature exposure. Different frequencies may, for example, offset or amplify experiences of being away and fascination in different ways, and could thus lead to added or diminished well-being benefits.

Participants in the low exposure profile, in turn, were more likely to be male, and they reported the lowest work engagement and highest burnout, on average. Our findings also show that these participants had the longest distance to travel to get from home to natural environments. The longer distance from home may restrict the accessibility to nature environments, which is a consideration that is in line with previous research indicating that a longer distance from home to nature environments reduces the number of nature visits (Neuvonen et al., 2007). From this perspective, it is recommendable to increase especially such individuals' exposure to nature. The proximity of nature environments and their accessibility depends not only on an individual's decisions but also on regional and environmental supply and planning. Ideally, nature environments should be located near enough to residential and work environments to act as a resource for health and general as well as occupational well-being.

It is interesting that the participants of all the profiles reported enjoying nature and natural scenery, being and relaxing in nature. Exercise included mainly walking and jogging. Furthermore, the participants in the low exposure profile reported outdoor activities in nature such as enjoying the scenery and nature, as well as walking and jogging. However, engaging in these outdoor activities reasonably regularly seems to be needed to achieve higher levels of well-being, especially vigor and dedication. This finding is in line with a previous study (e.g., de Vries et al., 2003), in which increasing physical activity was not the only explanation for health benefits of nature environments. The well-being effects of a nature environment itself can be significant to some extent, but increased physical activity increases the odds for better well-being.

Study Limitations and Conclusions

Our study is subject to several limitations that should be acknowledged before making inferences based on these findings. First, owing to the relatively low response rate, the representativeness of the sample needs to be considered. It is possible that the participants who responded to the survey were more inclined to nature visits. Those participants who failed to respond, in turn, may be utilizing natural environments to a lesser extent. Therefore, the profile of low exposure may have incorporated a larger proportion of employees if the response rate had been higher.

Second, the relationships between nature exposure and occupational well-being should be investigated with a longitudinal, gender-balanced sample of employees in order to get a more representative picture of different development paths. It is possible that those employees who have better occupational well-being also have more resources enabling them to engage in outdoor activities more frequently. Therefore, on the basis of this cross-sectional study, inferences regarding causal relations of nature exposure and outdoor activity with occupational well-being cannot be made. Third, the study is based on questionnaire data, and thus additional objective data (e.g., register-based sickness absence) should be collected in order to avoid the limitations of self-report data and same-source bias. In terms of future directions, it would also be valuable to investigate how nature experiences differ in association with the workplace vs. leisure time, since nature exposure in association with work appeared to play a role in the profiles of nature exposure in this study.

In conclusion, these findings highlight how employees' levels of nature exposure and outdoor activities in nature can contribute to their work engagement and burnout. Frequent opportunities for nature exposure at work as well as during

leisure time can be related to higher vigor and dedication, and in turn lower cynicism and professional inadequacy. In line with the theories on the restorative effects of nature environments (e.g., Ulrich et al., 1991; Kaplan, 1995), employees may seek to engage in various activities in nature to regain their cognitive and psychological resources. However, the current results extend far beyond the restorative environment theories by showing that the relation of nature exposure to occupational well-being exists on a more general experiential level than the short-term effects of stress and attention restoration described by the ART and SRT. It is conceivable that, for example, changes in vigor and dedication require not only recovery of cognitive and emotional resources, but also active emotion- and self-regulation (Korpela et al., 2015).

AUTHOR CONTRIBUTIONS

KH has designed the research work, collected the data and contributed to the analyses and interpretation of the findings. She has drafted and revised the work and approved the submitted version. She is accountable for all aspects of the work. KT has designed the research work, performed the analyses and written the results section of the paper. She has drafted and revised the work and approved the submitted version. KS has designed the research work, collected data and contributed to writing the introduction and discussion sections of the paper. She has drafted and revised the work as well as approved the submitted version of the paper. KK has designed the research work, contributed to data collection, analyses and interpretation of the findings. He has drafted and revised the work and approved the submitted version. TF has designed the research work, contributed to data collection, analyses and interpretation of the findings. She has also drafted and revised the work and approved the submitted version. UK has designed the research work, contributed to data collection, analyses and interpretation of the findings. She has drafted, revised and approved the work.

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Prevalence of Mental Health Problems and Factors Associated with Psychological Distress in Mountain Exercisers: A Cross-Sectional Study in Austria

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Knowledge about potential protective factors against mental health problems is highly needed. Regular physical activity (PA) in an outdoor environment, like mountain exercising, might reduce psychological distress. Therefore, the aims of the present study were to assess the prevalence of mental health problems in mountain exercisers and to detect factors associated with psychological distress. In a cross-sectional design, we collected self-reported data of 1,536 Austrian mountain exercisers. The prevalence of mental health problems and psychological distress (Kessler Psychological Distress Scale), the level of PA International Physical Activity Questionnaire, and affective valence during PA (Feeling Scale) were obtained. Stepwise multiple linear regression analysis was conducted to assess factors influencing psychological distress. The prevalence of mental health problems in Austrian mountain exercisers was 14%. Health-enhancing PA level and higher affective valence during PA were significantly associated with lower psychological distress. Minimal PA level was not significantly associated with lower psychological distress compared to inactive PA level. Marital status, education, alpine association membership, and body mass index did not show a significant influence on psychological distress. The prevalence of mental health problems seems to be lower in Austrian mountain exercisers compared to the European population. A health-enhancing PA level and affective valence increasing forms of PA were shown to be associated with lower psychological distress. Results might lead to interventional studies focusing on the potential of outdoor PA, e.g., mountain exercise, as an adjunct treatment in people at risk or with mental health problems.

Keywords: depression, anxiety, physical activity, exercise, affective responses

INTRODUCTION

There is a high prevalence of mental health problems in European countries: with 38% of the European citizens, 164.8 million persons suffer from a mental health problem each year (Wittchen et al., 2011). Mental health problems are also associated with higher prevalence in risk factors for chronic diseases (Prince et al., 2007). This leads to a large burden for affected persons, but also

to enormous expenses of the public health care system. The direct healthcare costs for anxiety disorders in Europe accounted for more than eight billion € in the year 2010 (Gustavsson et al., 2011). However, this number does not include the costs of other frequent mental health problems (e.g., mood disorders, psychotic disorders, American Psychiatric Association, 2000) or indirect costs of mental health problems (e.g., disability benefit claims). The percentage of disability benefit claims related to mental health problems increased from 10% of all disability benefit claims in 1995 to 35% in 2013 (OECD, 2015). In Austria, the combined direct and indirect costs for mental health problems account for 3.6% of the gross domestic product (OECD, 2015).

Given this large economic burden of mental health problems, cost-effective interventions for prevention and treatment are urgently needed. There is empirical evidence that regular physical activity (PA) can serve as an effective preventive behavior as well as an intervention for mental health problems (Cooney et al., 2013; Mammen and Faulkner, 2013). Despite this, more than 65% of the European population do not meet the criteria for health-enhancing PA (Sjöström et al., 2006). Health-enhancing PA is defined by approximately 1.5 to 2 h of being active throughout the day based on standard scoring criteria of the International Physical Activity Questionnaire[1]. Alongside the physiological benefits, there is a vast knowledge about mood improvement through PA. Affective valence, defined as the degree of pleasure (or displeasure) in a specific situation (Ekkekakis et al., 2008), may have a bidirectional effect. On one hand, affective valence can be influenced positively by PA with moderate intensity (Ekkekakis et al., 2008; Deslandes, 2014). On the other hand, affective valence plays a key role in maintaining PA (Williams et al., 2008; Rhodes and Kates, 2015), i.e., forms of PA leading to a higher affective valence are more likely to be maintained. Being physically active in an outdoor environment seems to have synergetic effects on affective valence compared to being active indoors (Pretty et al., 2005; Barton and Pretty, 2010; Thompson Coon et al., 2011; Frühauf et al., 2016; Niedermeier et al., 2017). Consequently, especially outdoor PA might affect the maintenance of PA positively and might have the potential to reduce the prevalence of mental health problems (Mammen and Faulkner, 2013).

In alpine areas, mountain exercising, a form of outdoor PA, which plays a key role in PA behavior (Bourdeau et al., 2002). In 2005, nearly 45% of the Austrian population above the age of 15 years was practicing (mountain) hiking or climbing/mountaineering, which are the most prominent representative mountain sport disciplines (Kuratorium für Verkehrssicherheit, 2005; Statistik Austria, 2016). Additionally, mountain exercise is performed by millions of tourists, who are regularly visiting mountainous regions. In 1999, more than 40 million of mountain tourists were estimated in the entire Alps (Burtscher, 1999). Repeated bouts of mountain hiking with moderate intensity showed positive effects on mental health related psychological parameters, both in healthy participants and in patients with metabolic syndrome (Schobersberger et al., 2010; Niedermeier et al., 2017). Furthermore, mountain exercising might also be used in patient populations with mental health problems. Recently, mountain hiking has been effectively used as a treatment option for suicide patients and was recommended as an adjunct to conventional therapy (Sturm et al., 2012).

Overall, mountain exercise as a frequently conducted form of PA in alpine regions may have relevant potential in the prevention and treatment of mental health problems, but at this stage of research, more knowledge based on epidemiological data about potential protective effects of this special form of PA is warranted. Therefore, the aims of the present study were (a) to assess the prevalence of mental health problems in mountain exercisers and (b) to detect potential factors associated with psychological distress in mountain exercisers. We hypothesized that a high level of PA and high affective valence during PA might be associated with lower psychological distress in mountain exercisers.

MATERIALS AND METHODS

Design

The study was conducted in a cross-sectional design. The study protocol was approved by the Board for Ethical Questions in Science of the University of Innsbruck in accordance with the Declaration of Helsinki (No. 25/2015, date: 17.06.2015).

Sample and Procedure

We collected the data via web-based questionnaire. Information about psychological distress, PA level, health status, affective valence to PA, quality of life and socio-demographic data was collected in 49 questions. The questionnaire was distributed by the largest Austrian Alpine Association to ensure collecting a representative sample of mountain exercisers and via electronic networks of the Paracelsus Medical University web site to recruit mountain exercisers without membership in an Alpine Association. Incentives related to mountain sports were provided to increase the participation of mountain exercisers.

Inclusion criteria were permanent residence in Austria, age 18 years and above, and being mountain exerciser. To our knowledge, there is no clear definition of mountain exercise or mountain sports in literature. However, the largest Austrian mountain sports association summarizes "the vast diversity of modern mountain sports" (Austrian Alpine Association, 2002) and includes the following disciplines: hiking and trekking, climbing via ferratas, classic mountaineering, winter mountaineering (ski or snowboard), all types of climbing (bouldering, climbing on artificial objects, crag climbing, continuous climbing, bigwall/aid climbing, alpine climbing, adventure climbing, sport climbing, super-alpine climbing, expedition climbing). A participant was considered as a mountain exerciser, when the participant was exercising in at least one of the disciplines. Because of the low prevalence of bigwall/aid climbing, super-alpine climbing, and expedition climbing in the Alpine region, we did not ask for these types of mountain exercise.

[1] http://www.ipaq.ki.se

Initially, there were data of 2,270 subjects (female: 47%), of which 99% (2,244/2,270) were defined as mountain exercisers. Out of 2,244 mountain exercisers (female: 47%), 15% (336) have been excluded because of non-Austrian permanent residence, 1% (15) due to age less than 18 years, 16% (357) due to missing data in covariates ($n = 302$ in PA, $n = 50$ in monthly income, $n = 5$ in affective valence during PA). The final data set consisted of 1,536 mountain exercisers with complete data in all relevant variables.

Measurements

Psychological Distress and Prevalence of Mental Health Problems

The level of non-specific psychological distress was assessed by the Kessler Psychological Distress Scale (K10, Kessler et al., 2002). On the 10-item scale, participants had to rate how often they felt distressed on 5-point Likert scale from "none of the time" (0) to "all of the time" (5) in the last 30 days. All items were summed up to get a total score ranging from 10 to 50. Higher scores indicate a higher level of psychological distress. The K10 showed excellent internal consistency (Cronbach's $\alpha = 0.93$) and good convergent validity ($r = 0.76$ to 0.99, Kessler et al., 2002). Internal consistency in the present sample was high (Cronbach's $\alpha = 0.84$).

The level of psychological distress shows a strong relationship to mental health problems (Kessler et al., 2002). Consequently, the K10 was used both as a screening tool for mental health problems and as an assessment for the level of psychological distress. The K10 shows good discrimination abilities between cases with mental health problems and non-cases according to the Diagnostic and Statistical Manual of Mental Disorders 4th edition (American Psychiatric Association, 2000) and was shown to be superior compared to other screening scales (Cornelius et al., 2013). The Receiver Operating Characteristic for the discrimination showed values of 0.87 to 0.88 and 0.86, respectively (Kessler et al., 2002; Hides et al., 2007). In accordance to previous studies, subjects with a K10 total score of 10–19 were defined as likely to be well and subjects with K10 total score of 20 and above as likely to have mental health problems (Australian Bureau of Statistics, 2001; Vasiliadis et al., 2015).

Self-rated Physical Activity

The level of PA was assessed with the short form of the International Physical Activity Questionnaire consisting of 11 items (IPAQ[2]). Participants were asked to rate the frequency and duration of vigorous, moderate, and walking activity during the last 7 days as well as the sitting time per day. Even though there was some controversy about the validity of the IPAQ (Hallal and Victora, 2004; Lee et al., 2011), the IPAQ is widely used in national surveys (Guthold et al., 2008; Bauman et al., 2011; Kopp et al., 2015) and Craig et al. (2003) concluded that the IPAQ showed acceptable validity values ($r = 0.8$).

The IPAQ allows calculating both a continuous score (energy expenditure in multiples of the basic metabolic rate) and a categorical score [inactive, minimally active, and health enhancing physically active (HEPA)]. These categories were based on standard scoring criteria[2].

Affective Valence during Physical Activity

The German version of the Feeling Scale (FS) was used to operationalize affective valence (Hardy and Rejeski, 1989). The bipolar, single item scale consists of 11 answer possibilities ranging from "very good" (+5) to "very bad" (−5) with a neutral answer possibility. The FS was exclusively designed for measurements of affective valence during PA. Discriminant validity was reported for perceived exertion including other development information (Hardy and Rejeski, 1989). Convergent validity was assessed previously with the Self Assessment Manikin and ranged from $r = 0.41$ to 0.88 (Van Landuyt et al., 2000).

Momentary assessed affective valence during PA showed a large variability due to both intra-individual differences (Unick et al., 2015; Sudeck et al., 2016) and due to different environments (Pretty et al., 2005; Barton and Pretty, 2010; Thompson Coon et al., 2011; Ekkekakis, 2015; Frühauf et al., 2016). In this study, affective valence was assessed in general (i.e., beliefs about affective valence, Robinson and Clore, 2002). Two separate questions were used to assess affective valence for indoor PA (e.g., Volleyball, Squash, and Badminton) and outdoor PA (e.g., mountain hiking, climbing, Ski touring). Consequently, the mean value of beliefs about affective valence indoors and outdoors was used to operationalize affective valence during PA. If the subjects were not physically active indoor, only the value for outdoor PA was used.

Covariates

The following covariates were collected because of their potential association with psychological distress and mental health problems: sex (male, female), age group in years (18–39, 40–59, 60 and above), body mass index (BMI) in kg/m^2 (<18.5, 18.5–24.9, 25.0–29.9, 30.0 and above), marital status (no partnership, married/de facto partnership), education (non-college level, college level), membership in Alpine association (yes, no), income group in €/month (<1300, 1300–1799, 1800–2800, >2800) and health related quality of life (HRQoL). HRQoL was assessed by the EQ-5D-5L (EuroQol Group, 1990). The EQ-5D-5L is a 5-item-questionnaire and covers five dimensions of quality of life: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. The response mode consists of a 5-point Likert-scale. An index for all dimensions combined is calculated ranging from lowest quality of life (0.000) to highest quality of life (1.000). The EQ-5D-5L showed acceptable convergent validity values, $r = 0.43$ to 0.61 (Janssen et al., 2013).

Statistical Analyses

All statistical analyses were performed using SPSS v. 23 (IBM, New York, NY, United States). To assess relevant associations to psychological distress, the total sample was divided in two groups. One group was defined as likely to be well (K10: 10–19) and one group was defined as likely to have mental health problems (K10:

[2]http://www.ipaq.ki.se/

20 and above) (Australian Bureau of Statistics, 2001; Vasiliadis et al., 2015). Prior to multiple linear regression analysis, all variables were tested on differences in the two groups to assess relevant predictors of psychological distress. Due to non-normal distribution of the variables (as assessed by Shapiro–Wilk test), Mann–Whitney *U* test was used to find differences between the two groups for metric variables. For categorical variables, χ^2-methods were used. Bonferroni correction was applied due to multiple testing on differences. Consequently, *p*-values less than 0.005 were considered as significant for Mann–Whitney *U* test and χ^2-test.

Stepwise multiple linear regression calculations were used to model psychological distress (dependent variable). Step 1 included all relevant demographic covariates differing between the two groups. In step 2, HRQoL was added. In step 3, the PA level was added. The final step 4 included all previous variables and the affective valence during PA.

As expected in a non-clinical sample (Andrews and Slade, 2001), the values of psychological distress were considerably skewed, and so were the values of HRQoL and affective valence during PA. In the regression model, the residuals were not normally distributed. Consequently, the variables psychological distress, HRQoL and affective valence during PA were log-transformed.

The level of significance was set at $p < 0.05$ (two-tailed). Data were presented as median, interquartile range (Mdn, IQR) and percentage (frequency) unless otherwise stated.

RESULTS

Prevalence of Mental Health Problems and Group Differences

The overall prevalence of mental health problems in mountain exercisers was 14% (221). The 9% (144) were categorized as likely to have mild or moderate mental health problems. The 5% (77) were categorized as likely to have severe mental health problems. **Table 1** shows the frequencies of the covariates' categories in subjects who were likely to be well and subjects who were likely to have mental health problems, respectively. Subjects who were likely to have mental health problems showed a significantly higher amount of women, of younger participants, of participants with low income, and a lower amount of HEPA people.

The variables HRQoL and affective valence during PA showed small, but significant differences between the two groups. HRQoL was significantly lower in subjects who were likely to have mental health problems (Mdn: 0.909, IQR: 0.089) compared to subjects who were likely to be well (Mdn: 1.000, IQR: 0.090), $p < 0.001$. Affective valence during PA was significantly lower in subjects who were likely to have mental health problems (Mdn: 3.5, IQR: 1.5) compared to subjects who were likely to be well (Mdn: 4.0, IQR: 1.5), $p < 0.001$.

Marital status, education, membership in an alpine association, and BMI group did not significantly differ in the two groups and were therefore excluded from the linear regression.

Regression Analysis of Psychological Distress

Table 2 shows the results of the four steps of the linear regression. All models were statistically significant. The final model explained 18% of the variance, $F(10,1525) = 33.84$, $p < 0.001$. Protecting sociodemographic factors against psychological distress were being male, being older, and a higher monthly income. Higher HRQoL, higher level of PA, and higher affective valence during PA were associated with lower psychological distress.

DISCUSSION

Major Findings

To the best of our knowledge, this was the first study to show the prevalence of mental health problems in the specific population of mountain exercisers. The major findings in this study were, that (1) being male, older age, higher income, higher activity level, higher HRQoL and higher affective valence during PA were associated with lower psychological distress. (2) Psychological distress was not significantly associated with membership in alpine association and weight status. (3) The prevalence of mental health problems in mountain exercisers seems to be lower compared to the European population.

Associations with Psychological Distress

Sex and income were significant sociodemographic covariates to psychological distress, which is consistent with the existing literature (Lipton et al., 2000; Prince et al., 2007; Wittchen et al., 2011; OECD, 2015). Also in mountain exercisers, being male is associated with lower psychological distress. Our results also confirmed previous findings in national and international surveys (Atlantis and Ball, 2007; Wittchen et al., 2011) that the prevalence of mental health problems and high psychological distress was dependent on the income of the participants.

Weight status was not shown to be a significantly associated to psychological distress in our sample, which is contrary to previous findings (Lipton et al., 2000; Atlantis and Ball, 2007; OECD, 2015). Atlantis and Ball (2007) were able to show higher rates of medium and high psychological distress in underweight and obese people. It might be concluded, that in mountain exercisers psychological distress is independent of weight status. However, this conclusion has to be treated with caution, because there were only few cases of underweight/obesity in the present sample of mountain exercisers (combined $n = 89$). It might be a more convincing conclusion that the percentage of underweight/obese people is low in mountain exercisers. Indeed, the prevalence of underweight/obesity (6%) was low compared to the Austrian population (17%) (Statistik Austria, 2016). When the prevalence of medium/high psychological distress was compared in acceptable (BMI: 18.5–24.9 kg/m^2) and overweight category (BMI: 25.0–29.9 kg/m^2), our results are consistent with Atlantis and Ball (2007) who did not report a difference in these two groups.

TABLE 1 | Subject characteristics in the total sample and between participants who were likely to be well and who were likely to have mental health problems.

Variable	Total sample ($n = 1536$)	Likely to be well ($n = 1315$)	Likely to have mental health problems ($n = 221$)	P^3
Sex, female	703 (46%)	574 (44%)	129 (58%)	<0.001
Marital status, partnership	446 (29%)	382 (29%)	64 (29%)	0.978
Education, college	776 (51%)	662 (50%)	114 (52%)	0.835
Membership in Alpine association, yes	1342 (87%)	1155 (88%)	187 (85%)	0.183
Age group, years				
18–39	693 (45%)	567 (43%)	126 (57%)	
40–59	600 (39%)	519 (39%)	81 (37%)	
60 and above	243 (16%)	229 (17%)	14 (6%)	<0.001
BMI[1] group, kg/m^2				
<18.5	39 (3%)	33 (3%)	6 (3%)	
18.5–24.9	1118 (73%)	949 (72%)	169 (76%)	
25–29.9	329 (21%)	287 (22%)	42 (19%)	
30 and above	50 (3%)	46 (3%)	4 (2%)	0.412
Income, €/month				
<1300	270 (18%)	204 (16%)	66 (30%)	
1300–1799	296 (19%)	240 (18%)	56 (25%)	
1800–2800	474 (31%)	427 (32%)	47 (21%)	
>2800	496 (32%)	444 (34%)	52 (24%)	<0.001
Activity level				
Inactive	188 (12%)	149 (11%)	39 (18%)	
Minimally active	438 (29%)	356 (27%)	82 (37%)	
HEPA[2]	910 (59%)	810 (62%)	100 (45%)	<0.001

[1]*BMI, Body mass index;* [2]*HEPA, health enhancing physically active;* [3]*p, p-value of* χ^2*-test.*

Interestingly, there was no significant difference in psychological distress between inactive and minimally active mountain exercisers. Only when PA level was increased to HEPA category there was a significant psychological distress reducing effect. This finding strengthens the recommendation (also from a mental health point of view) to increase PA level in physically inactive and minimally active persons to HEPA category.

Another important finding was that higher affective valence during PA was associated with lower psychological distress. When the standardized regression coefficients of affective valence during PA and income were compared it can even be concluded that affective valence during PA is nearly equally important as income. It has been shown previously that affective valence during PA play a major role in both starting a PA program (Gollwitzer, 1996; Hall et al., 2002; Ekkekakis et al., 2004, 2010) and maintaining a physically active behavior (Williams et al., 2008; Rhodes and Kates, 2015). The present study provides further evidence that it is important to focus on affective valence during PA and to promote PA that shows positive effects on affective valence.

We expected membership in an alpine association would be associated with lower psychological distress due to social support provided by regular activities in alpine associations, which could not be confirmed in our study. Other authors were able to show a stress-buffering effect of social support (Bovier et al., 2004) and a reduction in depressive symptoms due to voluntary group membership (Rietschlin, 1998). It might be concluded that the degree of social support is comparable in alpine association members and in the peer groups of non-members. Psychological distress in mountain exercisers might be more depending on the social support during mountain exercise *per se* and less on membership. However, this speculation has to be proved in future studies.

Comparison of Mountain Exercisers with General Population

The prevalence of mental health problems in mountain exercisers was lower (14%) compared to values of 38% (total population European Union, Wittchen et al., 2011), 20% (working population Europe, OECD, 2015), and 25% (Germany, Bijl et al., 2003; Kessler et al., 2009). When mountain exercisers were compared to the Austrian Health Survey (representative study for the Austrian population) in the significant covariates, mountain exercisers showed a younger age (median age group: 40 to 44 years vs. 45 to 49 years, Kopp et al., 2015). Since younger age was related to higher scores in psychological distress, this should result in an even larger rate of mental health problems in the sample of mountain exercisers. However, this difference might be compensated by a different percentage of female population (46% vs. 54%, Kopp et al., 2015). It has been shown previously that women show higher rates of mental health problems (Wittchen et al., 2011). There were also small differences in the BMI and in the monthly income. Mountain exercisers showed a smaller mean BMI (23 vs. 25 kg/m^2) and a higher median monthly income (1800–2300€ vs. 1501–1800€). No differences in marital status were observed (29% vs. 29% partnership). The PA levels showed comparable percentages in the three categories inactive (present study: 12% vs. Austrian population 17%), minimally active (29%

TABLE 2 | Stepwise linear regression results for psychological distress.

Variable	*n*	Psychological distress Median (IQR[1])	β[2]	*T*	*P*[3]	R^2 corr. [4]	ΔR^2 corr. [5]
STEP 1							
Sex							
Female	703	15 (5)	1				
Male	833	14 (4)	−0.09	−3.70	<0.001		
Age group, years							
18–39	693	15 (5)	1				
40–59	600	14 (4)	−0.15	−5.81	<0.001		
60 and above	243	13 (4)	−0.25	−9.38	<0.001		
Income, €/month							
<1300	270	16 (5)	1				
1300–1799	296	15 (5)	−0.03	−1.02	0.306		
1800–2800	474	14 (5)	−0.14	−4.07	<0.001		
>2800	496	14 (4)	−0.17	−5.05	<0.001	0.09	
STEP 2							
HRQoL[6]			−0.21	−8.69	<0.001	0.15	0.06
STEP 3							
Activity level							
Inactive	188	15 (6)	1				
Minimally active	438	15 (5)	−0.01	−0.25	0.806		
HEPA[7]	910	14 (5)	−0.10	−2.86	0.004	0.15	0.01
STEP 4							
Affective valence			−0.15	−6.43	<0.001	0.18	0.03

[1] *IQR, interquartile range;* [2] *β, standardized regression coefficient;* [3] *p, p-value of t-test;* [4] R^2 *corr., variance explained by the model (corrected value);* [5] ΔR^2 *corr., change in variance explained by the model (corrected value);* [6] *HRQoL, Health Related Quality of Life;* [7] *HEPA, Health Enhancing Physically Active.*

vs. 27%), and health-enhancing physically active (59% vs. 66%, Kopp et al., 2015).

Limitations

The following limitations have to be considered when interpreting the findings of the present study: Firstly, we cannot exclude a selection bias in the present study. It is known from other studies that the outcome in mental health determinants differs between responders and non-responders (de Winter et al., 2005). Since, we provided incentives related to mountain sports when the questionnaire was completed, we hoped to increase the participation of mountain exercisers with low confidence. Secondly, the explained variance of the final model was low. It remains doubtful if all relevant variables were included in the model. Consequently, we put more attention on the comparison of the associate variables of psychological distress and less attention on the total model. Thirdly, we did not use a clinical measurement of mental health problems (e.g., diagnostic interview, Kessler and Ustün, 2004). Even though the Kessler Scale for Psychological Distress is a widely used screening tool for mental health problems (Mitchell and Beals, 2011; Vasiliadis et al., 2015), the prevalence rates of mental health problems may be not reliable in the present study. Fourthly, due to the cross-sectional design, no comparison of the results could be done with a control group doing indoor PA or being sedentary. Furthermore, we are not able to answer the question about a possible causal effect of the level of PA and affective valence during PA on psychological distress. It remains unclear whether the level of PA affects psychological distress, whether psychological distress affects the level of PA or whether there are mutual influences of the different variables. Prospective studies in the mountain exerciser population are needed to clarify these effects.

CONCLUSION

The present study showed that being physically active in HEPA category and experiencing high affective valence during PA seem to be associated with lower psychological distress in mountain exercisers. Obtained results should lead to prospective longitudinal studies focusing on the prevention of mental health problems by outdoor PA on one hand as well as testing the potential of mountain PA as an adjunct treatment in people with mental health problems on the other hand. Furthermore, the results could be helpful for health professionals for PA recommendations for the prevention of mental health problems by including outdoor exercise as an interesting alternative to traditional indoor exercises.

AUTHOR CONTRIBUTIONS

All authors contributed to the study design. AH performed the data collection. MN performed the statistical analysis and

drafted the manuscript. All authors critically revised the drafted manuscript and provided final approval of the version of the manuscript for publication. All authors agree to be accountable for all aspects of the work ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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The Relationship between the Physical Activity Environment, Nature Relatedness, Anxiety, and the Psychological Well-being Benefits of Regular Exercisers

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Research from a variety of scientific fields suggests that physical activity in nature and feelings of connection to nature enhance psychological health and well-being. This study investigated the psychological health and well-being impact of the physical activity environment for those already undertaking the recommended weekly amount of physical activity. This topic is important for the design of health and well-being environments and interventions involving physical activity. Participants (N = 262) aged 18–71 years (M = 34.5, SD = 13.1) who met the UK physical activity guidelines completed the Nature Relatedness Scale, the trait section of the State Trait Inventory for Cognitive and Somatic Anxiety and the Psychological Well-Being Scale. Analysis via Multivariate ANOVA indicated that participants who engaged in outdoor physical activity reported significantly lower somatic anxiety levels and higher Nature Relatedness experience (NRexp). Significant results were not evident for wellbeing. Hierarchical regressions revealed that the psychological well-being facet of autonomy, NRexp, and outdoor physical activity predicted lower somatic anxiety, whereas indoor physical activity predicted higher somatic anxiety. Results indicate that somatic anxiety is lower for outdoor physical activity participation, and that outdoor activity, in conjunction with autonomy and NRexp, predicts lower anxiety levels. The findings extend previous work by demonstrating the impact of the physical activity environment on anxiety levels, as well as the contribution of outdoor physical activity and well-being facets to the previously established Nature Relatedness-anxiety relationship.

Keywords: anxiety, natural environment, nature relatedness, physical activity, well-being

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INTRODUCTION

In recent years, there has been a growing body of evidence suggesting that time spent in the presence of nature improves psychological health and well-being (Pretty, 2004; Bowler et al., 2010; Shanahan et al., 2016). For example, Chang and Chen (2005) found that window views of nature and indoor plants were related with low anxiety related behaviors. Tension and anxiety increased when window views of nature and indoor plants were removed. Weinstein et al. (2009) found

that exposure to natural environments enhanced caring behaviors and psychological well-being. Mitchell (2013) found an association between regular use of natural environments for leisure activities and a lower risk of mental health issues. However, the association between natural environments and health outcomes might be more complex than initially understood (Ward Thompson and Aspinall, 2011; Mitchell, 2013). Much of the previous research measured short-term benefits of physical activity interventions in natural environments and little is known about the previous physical activity habits of participants. This study aimed to investigate the psychological health and well-being impact of the physical activity environment for those already undertaking the recommended weekly amount of physical activity.

The Role of Physical Activity in Nature

The benefits of physical activity in nature, such as walking in forests, gardening, and outdoor activities have been well-documented (Pretty et al., 2007; Page, 2008; Ryan et al., 2010; Pasanen et al., 2014; Passmore and Howell, 2014). Physical activity in nature has been associated with enhanced mood (Hartig et al., 2003), improvements in attentional capacity (Berman et al., 2008), and cognitive capacity (Berman et al., 2012). For example, Ryan et al. (2010) determined that the presence of nature while walking mediated vitality. Pretty et al. (2007) found that physical activities such as horse riding, walking, cycling, fishing, and conservation activities in nature led to significant improvements in self-esteem and total mood disturbance. Hartig et al. (2003) found that when compared to walking in urban areas walking in the presence of nature enhanced positive emotional and cognitive outcomes. Passmore and Howell (2014) investigated the effect of a 2-week physical activity in nature intervention on eudemonic (meaning and self-realization) and hedonic (pleasure attainment and pain avoidance) well-being. They found that both eudemonic well-being and hedonic tone were enhanced after the 2-week intervention. Mayer et al. (2009) undertook a study comparing a 15-min walk in a natural setting with a similar walk in an urban setting. Emotional well-being was enhanced by exposure to actual nature, compared to urban settings.

While many studies that have examined the psychological health and well-being benefits of physical activity in nature have focused on the enhancement of positive outcomes, some studies have considered the benefits of green exercise for the reduction of psychological discomfort such as stress and anxiety. Anxiety has been categorized as consisting of two distinct facets. State anxiety describes the temporary anxiety experienced when in direct relationship to immediate perceptions of threat. Trait anxiety is a relatively durable characteristic that underlies the intensity of and tendency for state anxiety responses (Spielberger and Reheiser, 2009). High trait anxiety can determine state anxiety occurrences. Studies that have examined the relationship between anxiety and green exercise have focused on the benefits of short bouts of green exercise on state anxiety and found that the greenness of the environment while exercising was more likely to be related to reductions in state anxiety than exercise on its own (Mackay and Neill, 2010). Regular exercise has also been associated with lower trait anxiety (Paluska and Schwenk, 2000) and as a result researchers have proposed that participation in regular green exercise is likely to be related to low levels of trait anxiety (Pretty et al., 2007; Martyn and Brymer, 2016). Studies have also found that nature can help manage and reduce the effects of stress, which if chronic might lead to anxiety (Vyas et al., 2004). For example, studies have shown that even one bout of physical activity in a natural environment can have long-term benefits for stress (Park et al., 2010; Korpela et al., 2014; Takayama et al., 2014). These studies suggest that nature can reduce the potential long term, harmful effects of chronic stress and interfere with the potential for stress to lead to anxiety.

However, despite the number of studies showing improvements in psychological health and well-being through nature-based physical activities the exact role and impact of the natural environment in this process is still rather unclear (Karmanov and Hamel, 2008; Kjellgren and Buhrkall, 2010; Keniger et al., 2013; Brymer et al., 2014; Yeh et al., 2016b). For example, Martens et al. (2011) investigated the influence of wild compared to tended forest environments and found that well-being, positive affect and negative affect showed stronger positive changes in the tended forest condition. This would suggest that benefits obtained from physical activity in nature have a ceiling effect where more accessible natural environments are more appropriate for enhancing positive affect and well-being than wild environments. Loureiro and Veloso (2014) found that for regular exercisers a combination of outdoor and indoor exercise was significantly associated with positive affect and well-being, suggesting that, for regular exercisers, the greatest influence on psychological wellbeing might be physical activity. Kerr et al. (2006) compared laboratory and natural settings on the emotions of recreational and competitive runners and found that both conditions facilitated equivalent beneficial effects. Kerr et al. concluded that the importance of the exercise environment for regular exercisers might be overstated.

Research has demonstrated that even one bout of physical activity at moderate levels has a considerable benefit for psychological health and well-being (Ekkekakis et al., 2000). As most studies assessing the benefits of green environments for exercise have not ascertained if participants were currently meeting physical activity recommendations it is feasible that the findings reflect take up of physical activity and nature provides a pleasant environment whereby participants are able to regulate physical activity at moderate to pleasant levels. Nature, like music, might just be one of many possible ways to distract attention toward pleasant stimuli (Yeh et al., 2016a). And, like music, individual differences in the recipient might impact on the efficacy of nature as an intervention. Indeed, one size may well not fit all; for example, it might be that the benefits found in studies to date are influenced by the participants' psychological make up. One possibly important factor is their experiences of connectedness to nature (Martyn and Brymer, 2016).

The Role of Connection to Nature

A strand of research exploring the health benefits of nature is beginning to show that individual differences in affective, cognitive, and experiential connections with the natural world

influence the benefits found (Zelenski and Nisbet, 2012). For example, Zhang et al. (2014) found a positive relationship between individual experiences of connectedness to nature and life satisfaction and high self-esteem. Research conducted by Cervinka et al. (2011) found a relationship between psychological well-being and feelings of connectedness to nature. They also found a significant positive correlation between connectedness to nature and vitality. Martyn and Brymer (2016) found that connection to nature (Nature Relatedness) was significantly correlated with lower levels of overall anxiety, state cognitive anxiety, and trait cognitive anxiety. Furthermore, Martyn and Brymer (2016) demonstrated that Nature Relatedness (specifically Nature Relatedness experience) significantly predicted lower anxiety levels, thereby establishing an important link between Nature Relatedness and anxiety. However, physical activity was not examined as a contributing factor here. The results from these studies suggest that an individual's engagement with and connection to nature might be an important factor when studying the effects of physical activity in natural environments. A study undertaken in Portugal with regular exercisers found that well-being benefits for those who combine outdoor and indoor exercise were predicated on feelings of connectedness to nature (Loureiro and Veloso, 2014). As previously outlined, outdoor physical activity may produce positive psychological responses, however an individual's experience of connection to the natural world might be a key factor in this relationship. No study has, however, simultaneously assessed the effects of connection to nature and outdoor physical activity in relation to psychological health outcomes.

The current study aimed to investigate the role of the physical activity environment in relation to connection to nature, positive psychological health, and anxiety for regular exercisers. Additionally, this study aimed to extend the work of Martyn and Brymer (2016) by assessing the contribution of the exercise environment to the established Nature Relatedness-anxiety relationship. There were two hypotheses: (1) Individuals who regularly undertake nature-based physical activity will have higher levels of well-being and lower levels of trait anxiety than those who regularly undertake physical activity in indoor environments (2) Nature Relatedness (NR) and outdoor physical activity will positively impact on well-being and/or anxiety levels.

METHOD

Participants

Participants ($N = 262$) consisted of 102 men and 160 women, aged 18–71 years ($M = 34.5$, $SD = 13.1$). The inclusion criteria for the study were that participants were adults (19–64 years) and that they met the physical activity guidelines recommended by the UK Chief Medical Officer (150 min of physical activity per week). Recruitment involved sending a standard email asking for volunteers to participate in a research study looking into the psychological experiences gained from being physically active in different environments through social media (e.g., facebook) and professional networks (e.g., linkedin, the student services of the university of the first author) in the U.K. and internationally. Participants were recruited based on their regular exercise habits rather than their relationship to the natural world. Participation was not linked to compensation. This study was carried out in accordance with the recommendations of the Manchester Metropolitan University ethics procedure, approved by the Manchester Metropolitan University ethics committee with written informed consent from all participants. All participants gave written informed consent in accordance with the declaration of Helsinki. All participants acknowledged that they were over 18 and provided their consent before completing the online survey.

Materials

An online survey was developed using a recognized free web-based survey development tool. The survey included a section on demographics, questions about physical activity choices, the environment in which this activity takes place as well as validated measures of psychological health and well-being. The physical activity questions asked participants to state their main physical activity and the environment questions asked (1) an open question that asked participants where they undertook their chosen physical activity, and (2) whether the environment was central to their physical activity of choice. Three environment options were provided and participants were asked to choose one of the three options: indoors, outdoors where nature is incidental to the experience (incidental meaning that the natural world was not essential to the experience), or outdoors where nature is central to the experience (central meaning where the natural environment is essential and important to the experience).

Three existing quantitative scales were utilized, the Nature Relatedness Scale (NRS) (Nisbet et al., 2009), the trait section of the State Trait Inventory for Cognitive and Somatic Anxiety (STICSA) (Ree et al., 2008) and the Psychological Well-Being Scale (PWB) (Ryff, 1989). The NRS is a 21-item scale that measures individuals' affective, cognitive, and physical relationship with the natural world. The NRS consists of three subscales: an 8-item subscale "self" which measures personal connection to nature, a 7-item subscale "perspective" which measures external worldviews of nature, and a 6-item subscale "experience" which measures physical familiarity with nature (Nisbet et al., 2009). Each subscale uses a 5-point Likert scale ranging from 1 (*disagree strongly*) to 5 (*agree strongly*). The total score is calculated by averaging all 21 items (after reverse scoring appropriate items), whereby higher scores indicate a stronger connection with nature. Nisbet and Zelenski (2013) found NR to be correlated with behavior, environmental scales, and frequency of time in nature, thus supporting the reliability and validity of the NRS. Cronbach's alpha indicated satisfactory internal reliability for the NR total scale, $\alpha = 0.87$. For the subscales, alpha was satisfactory for nature relatedness experience (NRexp; $\alpha = 0.70$) and nature relatedness self (NRself; $\alpha = 0.87$). Alpha was lower than 0.7 for nature relatedness perspective (NRpers; $\alpha = 0.60$), but this can still be considered marginal reliability (Hair et al., 2006).

The trait half of the STICSA comprises of a 21-item scale with each item rated on a 4-point Likert scale, ranging from 1 (*not at all*) to 4 (*very much so*). The STICSA produces a score from 42 to 168 whereby higher scores indicate higher anxiety (Ree et al., 2008). The scale assesses an individuals' general mood state and predicts the situations in which different individuals will display heightened state anxiety (Ree et al., 2008). Within

the trait anxiety scale, anxiety is then further categorized as two subscales comprising of 11 somatic items and 10 cognitive items. Trait somatic anxiety refers to physical symptoms that are generally experienced, such as feeling dizzy, tense, and suffering from a fast heartbeat. Trait cognitive anxiety refers to general feelings of worry, concern and intrusion of unpleasant thoughts. Cronbach's alpha reported satisfactory internal consistency for the total STICSA ($\alpha = 0.90$), for somatic trait anxiety (SOManx; $\alpha = 0.81$), and for cognitive trait anxiety (COGanx; $\alpha = 0.89$).

The Psychological Well-Being Scale developed by Ryff (1989) is a 42-item scale with each item rated on a 6-point Likert scale, ranging from 1 (*strongly disagree*) to 6 (*strongly agree*). The questionnaire is designed to assess how people perceive aspects of their own functioning, e.g., do they feel that what they do in life is meaningful (Abbot et al., 2006). The scale consists of six separate dimensions: autonomy, environmental mastery, personal growth, positive relations with others, purpose in life, and self-acceptance (Ryff, 1995). Each dimension represents a distinct facet of psychological wellbeing. Cronbach's alpha reported satisfactory internal reliability for autonomy ($\alpha = 0.73$), personal growth ($\alpha = 0.70$), positive relations ($\alpha = 0.75$), purpose in life ($\alpha = 0.70$), and self-acceptance ($\alpha = 0.86$). Environmental mastery was lower than 0.7 ($\alpha = 0.60$), but this can still be considered marginal reliability (Hair et al., 2006).

Statistical Analysis

Specific analytic strategies were employed to address the study hypotheses. Firstly, descriptive statistics were computed to examine means, standard deviation, and assumptions among the study variables. Next, the aim was to assess whether individuals who regularly undertake nature-based physical activity have higher levels of well-being, lower anxiety, and higher nature relatedness than those who regularly undertake physical activity in indoor environments (hypothesis one). Three separate MANOVAs were employed; the first focused on anxiety outcomes (COGanx and SOManx), the second assessed wellbeing outcomes (autonomy, environmental mastery, personal growth, positive relations, purpose in life, self-acceptance), and the third assessed nature relatedness (NRself, NRpers, and NRexp) in relation to types of physical activity environment (indoor, outdoor incidental, and outdoor central). Prior to analysis, five participants were removed from the dataset due to extreme scores (i.e., z scores less than −3.25 and/or greater than 3.25; Tabachnick and Fidell, 2001) leaving a final sample of 257. Initial analysis using the Kolmogorov-Smirnov test revealed that the data were not normally distributed. Given this test can be overly sensitive with relatively large samples (Peat and Barton, 2005), skewness and kurtosis were also examined with some values falling beyond the recommended interval of −2 to +2, indicating skewed data (Byrne, 2010). To compensate for this feature of the data, bootstrapping was employed which involved resampling and replacing the original dataset 1,000 times prior to rerunning the MANOVAs. Bootstrapping is often used in research situations with non-normal data and has been shown to be effective for generating accurate confidence intervals for means (see Wang, 2001). The bias-corrected method was used to adjust parameter estimates, standard errors, and effect sizes.

To examine whether Nature Relatedness (NR) and outdoor physical activity positively impact on anxiety and/or well-being (hypothesis two), a series of hierarchical regressions were employed following examination of zero-order correlations. The hierarchical format was constructed in a way that extends the previous work of Martyn and Brymer (2016); specifically, by including NR factors of NRself, NRpers, and NRexp in the first stage of the regression as predictors of anxiety (COGanx and SOManx). In the second stage, physical activity environment was included (using dummy coding), and in the third stage facets of well-being were included (autonomy, environmental mastery, personal growth, positive relations, purpose in life, self-acceptance). Incorporating physical activity environment and well-being facets in latter stages of the analysis enabled an assessment of whether these variables meaningfully contributed to the established NR-anxiety relationship by Martyn and Brymer (2016). Well-being facets were examined in relation to NR and anxiety at the correlation stage. To account for non-normality when computing the correlations and hierarchical regressions, bootstrapping was employed with 1,000 resamples.

RESULTS

Table 1 presents descriptive statistics of the subscales for NR, STICSA, and well-being, as well as summary statistics of physical activities the participants engaged in. Of the final sample, the indoor group comprised 92 participants (38 men, 54 women) with an age range of 17–70 ($M = 33.86$, $SD = 12.86$). The outdoor incidental group consisted of 71 participants (32 men, 39 women) with an age range of 18–63 ($M = 36.85$, $SD = 13.44$). The outdoor central group comprised 94 participants (30 men, 64 women) with an age range of 18–71 ($M = 33.04$, $SD = 12.63$). Higher NR was evident for outdoors central physical activity compared with indoors and outdoors incidental physical activity. Compared with a sample of 305 university students (Martyn and Brymer, 2016), participants scored generally lower across environment groups for NRself (outdoors central $M = 3.34$, outdoors incidental $M = 3.16$, indoors $M = 3.17$, compared with $M = 3.74$). For NRpers, sample scores were comparable with Martyn and Brymer (2016) for both outdoors groups (outdoors central $M = 3.92$, outdoors incidental $M = 3.83$, compared with $M = 3.98$), but were lower for indoors ($M = 3.73$). Similarly, for NRexp, sample scores were comparable for both outdoors groups (outdoors central $M = 3.67$, outdoors incidental $M = 3.56$, compared with $M = 3.70$), and were lower for indoors ($M = 3.37$).

Higher anxiety levels were evident generally for indoors physical activity, whereas lower anxiety scores were evident for outdoors incidental. Compared with normative data of the STICSA ($N = 278$; Grös et al., 2007), participants scored similarly on COGanx for all environment groups (outdoors central $M = 19.12$, outdoors incidental $M = 17.12$, indoors $M = 19.30$, compared with $M = 17.20$). Participants scored lower on SOManx in the outdoors incidental group compared with normative data ($M = 15.95$, compared with $M = 17.10$), but this

TABLE 1 | Descriptive statistics for scales, physical activity type, and physical activity duration for each environment group ($N = 257$).

Variable	Outdoors central ($n = 94$)			Outdoors incidental ($n = 71$)			Indoors ($n = 92$)		
	M	*SD*	95% BCa CI	*M*	*SD*	95% BCa CI	*M*	*SD*	95% BCa CI
NR Total	3.62	0.62	3.49, 3.74	3.50	0.61	3.35, 3.65	3.42	0.61	3.31, 3.53
NRpers	3.92	0.58	3.80, 4.03	3.83	0.62	3.68, 3.98	3.73	0.61	3.62, 3.84
NRself	3.34	0.84	3.16, 3.50	3.16	0.92	2.95, 3.40	3.17	0.83	3.02, 3.34
NRexp	3.67	0.72	3.49, 3.82	3.56	0.62	3.41, 3.70	3.37	0.81	3.22, 3.53
Total (S)TICSA	36.19	10.44	34.02, 38.13	33.08	9.03	30.99, 35.51	37.47	10.05	35.34, 39.58
COGanx	19.12	7.10	17.61, 20.52	17.12	5.94	15.79, 18.57	19.30	6.96	17.96, 20.63
SOManx	17.06	4.72	16.11, 17.93	15.95	3.97	15.05, 16.97	18.17	4.61	17.24, 19.10
Autonomy	29.57	5.70	28.38, 30.64	30.36	5.55	29.06, 31.64	29.44	6.15	28.12, 30.67
Environmental mastery	29.05	4.92	28.02, 30.08	30.43	4.44	29.39, 31.45	29.52	4.22	28.67. 30.32
Personal growth	34.31	4.78	33.39, 35.25	33.66	5.54	32.32, 34.95	33.80	4.51	32.87, 34.72
Positive relations	32.62	5.72	31.49, 33.83	33.38	5.83	31.94, 34.75	32.66	5.35	31.59, 33.79
Purpose in life	30.97	5.17	29.90, 32.08	31.40	5.60	30.11, 32.70	31.82	5.23	30.71, 32.95
Self-acceptance	29.72	6.95	28.33, 31.10	30.38	6.12	28.92, 31.85	29.50	7.26	27.88, 31.12
Main physical activity/sport			Running (35% of group)			Running (44% of group)			Gym exercise (32% of group)
Exercise duration of main activity (mins per week)			120+ minutes (61% of group)			120+ minutes (65% of group)			120+ minutes (62% of group)
Exercise duration of main activity (years)			1–2 years (20% of group)			1–2 years (31% of group)			1–2 years (28.3% of group)

M, Mean; SD, Standard Deviation. 95% BCa CI, Bias-corrected and Accelerated confidence interval based on 1,000 bootstrapped samples; NR Total, Nature Relatedness Total; NRpers, Nature Relatedness perspective; NRself, Nature Relatedness self; NRexp, Nature Relatedness experience; STICSA, State Trait Inventory for Cognitive and Somatic Anxiety; COGAnx, trait cognitive anxiety; SOManx, trait somatic anxiety.

was not the case for outdoors central ($M = 17.06$) or indoors ($M = 18.17$).

Wellbeing scores did not appear to be markedly different across the three physical activity environments, and were similar to normative data (Widdowson et al., 2016). In relation to physical activity, the main activity reported for the indoor group (62%) was gym exercise (including weight training, powerlifting, circuit training, gym classes). For the outdoor incidental and outdoor central groups, the main physical activity was running, with a higher frequency reported for the outdoor incidental group (44% compared with 35%). The majority of participants across the activity environments reported engaging in their main activity for more than 120 min per week. Responses for the duration of the main activity ranged from a minimum of 5 months (weight training; indoor group) to 35 years (horse riding; outdoor central). Interestingly, shorter durations were typically reported for indoor main activities compared with outdoor main activities.

Hypothesis One: Nature Relatedness, Anxiety, and Well-being as a Function of Different Physical Activity Environments

Application of MANOVA with bootstrapping revealed a significant main effect of activity on anxiety, Wilks' $\lambda = 0.95$, $F_{(4, 506)} = 2.84$, $p = 0.024$, $\eta_p^2 = 0.02$ (small effect size). Levene's test was non-significant for COGanx and SOManx ($p = 0.150$ and $p = 0.127$ respectively), as was Box's M ($p = 0.085$), indicating the variance-covariance matrices are homogenous (Stevens, 2002). Tests of between-subjects effects revealed significant differences for activity and SOManx, $F_{(2, 254)} = 4.92$, $p = 0.008$, $\eta_p^2 = 0.04$ (small effect size). Bootstrap estimates, using indoor physical activity as a reference category, indicated that participants engaging in outdoor incidental physical activity had significantly lower SOManx than participants engaging in indoor physical activity, BCa 95% CI of −3.42 to −0.99, $p = 0.002$. No significant difference was observed for outdoor central physical activity compared with indoor physical activity.

MANOVA with bootstrapping reported no significant main effect of activity on wellbeing facets, Wilks' $\lambda = 0.95$, $F_{(12, 498)} = 1.08$, $p = 0.373$, $\eta_p^2 = 0.02$. In addition, no significant between-subjects effects were observed for activity and well-being facets. Levene's test was non-significant for all well-being variables, as was Box's M ($p = 0.051$). Bootstrapping estimates are not reported given the absence of a main effect. MANOVA with bootstrapping revealed a significant main effect of activity on NR, Wilks' $\lambda = 0.94$, $F_{(6, 504)} = 2.38$, $p = 0.028$, $\eta_p^2 = 0.03$ (small effect size). Levene's test was non-significant for all NR variables, as was Box's M ($p = 0.116$). Tests of between-subjects effects revealed significant differences for activity and NRexp, $F_{(2, 254)} = 3.82$, $p = 0.023$, $\eta_p^2 = 0.03$ (small effect size). Bootstrap estimates, with indoor physical activity as a reference category, indicated that participants engaging in outdoor central physical activity had significantly higher NRexp than participants engaging in indoor physical activity, BCa 95% CI of 0.07 to 0.50, $p = 0.016$. No significant difference was observed for outdoor incidental physical activity compared with indoor physical activity for NRexp.

TABLE 2 | Correlation coefficients for scales and subscales with accompanying 95% BCa CI ($N = 257$).

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. NR total		0.69** [0.61,0.76]	0.82** [0.77,0.87]	0.89** [0.86,0.91]	−0.19** [−0.32,−0.06]	−0.16** [−0.29,−0.03]	−0.18** [−0.29,−0.07]	0.09 [−0.03,0.19]	0.09 [−0.02,0.19]	0.02 [−0.11,0.13]	0.01 [−0.13,0.13]	0.06 [−0.07,0.18]	0.07 [−0.05,0.19]
2. NRpers			31** [0.18,0.44]	0.48** [0.38,0.57]	−0.08 [−0.20,0.04]	−0.08 [−0.21,0.06]	−0.06 [−0.16,0.06]	−0.03 [−0.15,0.09]	−0.03 [−0.12,0.07]	−0.03 [−0.15,0.09]	−0.02 [−0.12,0.10]	−0.04 [−0.14,0.09]	0.01 [−0.11,0.12]
3. NRself				0.71** [0.63,0.78]	−0.22** [−0.35,−0.09]	−0.18** [−0.30.−0.04]	−0.23** [−0.35,−0.11]	0.13* [0.01,0.25]	0.11 [−0.01,0.23]	0.05 [−0.08,0.18]	0.01 [−0.11,0.16]	0.09 [−0.05,0.21]	0.09 [−0.03,0.22]
4. NRexp					0.17** [−0.29,−0.05]	−0.15* [−0.26,−0.02]	−0.17** [−0.27,−0.05]	0.10 [−0.01,0.21]	0.10 [−0.01,0.22]	0.02 [−0.01,0.13]	0.01 [−0.11,0.13]	0.09 [−0.05,0.21]	0.06 [−0.05,0.19]
5. Total (S)TICSA						0.89** [0.85,0.92]	0.83** [0.77,0.87]	−0.48** [−0.57,−0.38]	−0.49** [−0.59,−0.37]	−0.34** [−0.45,−0.22]	−0.35** [−0.48,−0.23]	−0.40** [−0.51,−0.28]	−0.63** [−0.69,−0.54]
6. COGanx							0.55** [0.45,0.65]	−0.48** [−0.57,−0.38]	−0.47** [−0.58,−0.35]	−0.32** [−0.43,−0.20]	−0.35** [−0.47,−0.23]	−0.39** [−0.51,−0.26]	−0.66** [−0.73,−0.59]
7. SOManx								−0.35** [−0.45,−0.25]	−0.38** [−0.49,−0.26]	−0.27** [−0.39,−0.14]	−0.26** [−0.38,−0.15]	−0.30** [−0.43,−0.19]	−0.39** [−0.49,−0.29]
8. Autonomy									0.48** [0.36,0.59]	0.46** [0.35,0.56]	0.35** [0.23,0.46]	0.36** [0.24,0.47]	0.51** [0.42,0.60]
9. Environmental mastery										0.47** [0.34,0.59]	0.55** [0.44,0.65]	0.64** [0.55,0.72]	0.65** [0.56,0.74]
10. Personal growth											0.54** [0.42,0.64]	0.65** [0.56,0.73]	0.62** [0.52,0.70]
11. Positive relations												0.57** [0.47,0.65]	0.61** [0.52,0.68]
12. Purpose in life													0.67** [0.58,0.74]
13. Self-acceptance													

*NR Total, Nature relatedness total; NRexp, Nature relatedness experience; NRself, Nature relatedness self; NRpers, Nature relatedness perspective; STICSA, State Trait Inventory for Cognitive and Somatic Anxiety; COGAnx, trait cognitive anxiety; SOManx, trait somatic anxiety. *$p < 0.05$, **$p < 0.001$.*

Hypothesis Two: Nature Relatedness, Type of Physical Activity, and Well-being as Predictors of Anxiety

Correlations between NR total, NR subscales, STICSA total, STICSA subscales, and well-being facets were examined using the bivariate bootstrap technique to compensate for non-normality (Rasmussen, 1987). The results for each correlation are shown in **Table 2**. Significant negative correlations were found between NR total, NRexp and NRself with anxiety outcomes. In addition, all well-being facets significantly negatively correlated with anxiety outcomes. Only the autonomy wellbeing subscale was significantly positively correlated with NR, specifically NRexp, $r_{(255)} = 0.13$, BCa 95% CI of 0.01 to 0.25, $p = 0.044$.

Assumptions of collinearity, homoscedasticity, independence of errors, and absence of outliers were assessed prior to the hierarchical regression analyses, with no notable issues. The first hierarchical regression with bootstrapping examined NR (Stage 1), indoor physical activity (Stage 2), and well-being facets (Stage 3) as predictors of SOManx. Stage 1 reported an R^2 of 0.05, accounting for 5% of the variance in anxiety. The model was, however, significant, $F_{(3, 253)} = 4.56$, $p = 0.004$. Stage 2 significantly improved on Stage 1 by including indoor physical activity ($F_{change} = 5.05$, $p = 0.026$) and accounted for 7% of the variance in anxiety. Including well-being facets at Stage 3 significantly improved the predictive power of the regression ($F_{change} = 9.57$, $p < 0.001$), with the model accounting for 24.6% of the variance in anxiety. Bootstrap estimates revealed that at Stage 3, indoor physical activity significantly predicted higher SOManx ($B = 1.24$, BCa 95% CI of 0.17 to 2.33, $p = 0.024$), and the autonomy facet of well-being significantly predicted lower SOManx ($B = -0.12$, BCa 95% CI of –0.24 to –0.02, $p = 0.026$). Interestingly, prior to Stage 2, NRexp significantly predicted lower SOManx ($B = -1.35$, BCa 95% CI of –2.39 to –0.21, $p = 0.012$).

The second hierarchical regression with bootstrapping examined NR (Stage 1), outdoor central physical activity (Stage 2), and wellbeing facets (Stage 3) as predictors of SOManx. As with the first hierarchical regression, Stage 1 accounted for 5% of the variance in SOManx ($R^2 = 0.05$). The inclusion of outdoor central physical activity at Stage 2 did not significantly contribute to the regression model ($F_{change} = 0.06$, $p = 0.80$). Inclusion of wellbeing at Stage 3 significantly improved the regression overall ($F_{change} = 9.50$, $p < 0.001$) and the final model explained 23% ($R^2 = 0.23$) of SOManx. Bootstrap estimates revealed that at Stage 3, NRexp significantly predicted lower SOManx ($B = -1.06$, BCa 95% CI of −1.94 to −0.91, $p = 0.036$), and the autonomy facet of well-being significantly predicted lower SOManx ($B = -0.13$, BCa 95% CI of −0.23 to −0.03, $p = 0.024$).

The third hierarchical regression with bootstrapping examined NR (Stage 1), outdoor incidental physical activity (Stage 2), and well-being facets (Stage 3) as predictors of SOManx. Stage 1 accounted for 5% of the variance in SOManx ($R^2 = 0.05$). Inclusion of outdoor incidental physical activity at Stage 2 significantly contributed to the regression model ($F_{change} = 6.95$, $p = 0.009$), with the model accounting for 8% of variance in SOManx ($R^2 = 0.08$). Inclusion of well-being at Stage 3 significantly improved the regression ($F_{change} = 9.12$, $p < 0.001$) and the final model explained 25% ($R^2 = 0.25$) of SOManx. Bootstrap estimates at Stage 3 revealed that outdoor incidental significantly predicted lower SOManx ($B = -1.27$, BCa 95% CI of −2.42 to −0.14, $p = 0.024$). NRexp significantly predicted lower SOManx ($B = -0.99$, BCa 95% CI of −1.93 to −0.10, $p = 0.045$), and the autonomy facet of well-being significantly predicted lower SOManx ($B = -0.12$, BCa 95% CI of −0.24 to −0.02, $p = 0.025$) (see **Table 3**).

The hierarchical regression analyses examining NR, types of physical activity, and well-being in relation to COGanx did not document any significant effects at Stage 1 or

TABLE 3 | Hierarchical regression predicting somatic anxiety from NR subscales, outdoor incidental physical activity (dummy coded), and well-being subscales ($N = 257$).

Variable	Step 1			Step 2			Step 3		
	B	*SE (B)*	BCa 95% CI	*B*	*SE (B)*	BCa 95% CI	*B*	*SE (B)*	BCa 95% CI
NRpers	0.13	0.47	−0.89, 1.05	0.18	0.47	−0.78, 1.02	−0.11	0.44	−1.01, 0.79
NRexp	−1.35*	0.50	−2.27, −0.28	−1.23*	0.49	−2.15, −0.21	−0.99*	0.48	−1.93, 0.10
NRself	−0.09	0.41	−0.85, 0.66	−0.22	0.40	−0.98, 0.50	−0.03	0.42	−0.82, 0.67
Outdoor incidental physical activity				−1.63*	0.58	−2.77, −0.42	−1.27*	0.54	−2.42, −0.14
Autonomy							−0.12*	0.05	−0.24, −0.02
Environmental mastery							−0.14	0.09	−0.34, 0.06
Personal growth							−0.01	0.07	−0.15, 0.12
Positive relations							0.01	0.07	−0.13, 0.12
Purpose in life							−0.01	0.08	−0.19, 0.16
Self-acceptance							−0.13	0.07	−0.26, 0.01
R^2	0.05			0.08			0.25		
F	4.56*			5.24**			7.98**		
Fchange				6.95*			9.12**		

*NRexp, Nature relatedness experience; NRself, Nature relatedness self; NRpers, Nature relatedness perspective; BCa CI, Bias-corrected and Accelerated confidence interval based on 1,000 bootstrapped samples. *p < 0.05, **p < 0.001.*

Stage 2 for NR and types of physical activity. Overall, the MANOVA outcomes indicate firstly that participants who engaged in outdoor physical activity (particularly incidental) had significantly lower SOManx than participants engaging in indoor physical activity. Additionally, participants engaging in outdoor central physical activity had significantly higher NRexp than participants engaging in indoor physical activity. The hierarchical regressions indicate that autonomy, NRexp, and outdoor physical activity (particularly incidental) predicted lower SOManx, whereas indoor physical activity predicted higher SOManx. These results extend previous work in the area, by revealing the added contribution of types of physical activity and well-being facets to the previously established NR-anxiety relationship.

DISCUSSION

This study had two main aims; the first was to investigate the impact of the physical activity environment on well-being and trait anxiety for regular exercisers. The second aim was to investigate the relationship between nature relatedness, trait anxiety, and psychological well-being in regular exercisers. There were two hypotheses: (1) Individuals who regularly undertake nature-based physical activity will have higher levels of well-being and lower levels of trait anxiety than those who regularly undertake physical activity in indoor environments, and (2) Nature Relatedness (NR) and outdoor physical activity will positively impact on well-being and/or anxiety levels. The findings partially support the first hypothesis, indicating that individuals who regularly engaged in outdoor-based physical activity had lower levels of somatic anxiety in comparison with individuals who took part in indoor-based physical activity. However, the difference between the exercise environment where nature was central to the experience and the indoor environment was apparent but not significant. In relation to hypothesis two, the findings indicate that although the activity environment was not influential relative to wellbeing facets, and only autonomy was meaningful in relation to NR; NRexp, autonomy, and outdoor physical activity predicted lower somatic anxiety, whereas indoor physical activity predicted higher somatic anxiety.

Taken together this study provides further evidence that feeling experientially connected to nature is related to some aspects of psychological well-being and low somatic anxiety. This study also suggests that for individuals who meet UK physical activity guidelines for regular physical activity the presence of the natural world might not be a central determinant for self-reported levels of trait anxiety or psychological well-being. How an individual feels toward the natural world and exercising outdoors (even if nature is not central to the experience) seems to be more important.

In relation to hypothesis one, the results show that for regular exercisers there were no differences in overall trait anxiety levels, and cognitive anxiety levels or psychological well-being levels, across all physical activity environments. There was, however, differences in somatic anxiety levels. Although previous research has reported that physical activity in the natural world conveys significantly greater psychological benefits than indoor physical activity (e.g., Passmore and Howell, 2014), the findings in this study suggest that for individuals who undertake regular physical activity the immediate exercise environment has minimal influence on wellbeing levels, but can help to lower somatic anxiety.

Psychological wellbeing levels for all participants in this study were in line with population norms. Regular physical activity has been associated with positive psychological well-being (Penedo and Dahn, 2005). A meta-analysis conducted by Penedo and Dahn (2005) concluded that all types of exercise are beneficial for a range of physical and psychological well-being outcomes. Regular physical activity has been associated with greater levels of life satisfaction, increased quality of life outcomes and increased happiness as compared to non-exercisers (Stubbe et al., 2007). Previous research examining the wellbeing benefits of nature-based exercise has most often focused on short-term green exercise interventions with participants who may not have been regular exercisers. This study indicates that for those who regularly exercise the immediate exercise environment does not seem to be a key determinant for well-being benefits. Results from this study are similar to those found by Kerr et al. (2006) who determined that for regular runners the exercise environment was minimally related to well-being outcomes. However, the rich sensory experience afforded by the natural environment might still act as a welcome distraction or motivator for those who struggle to maintain regular exercise or for those wishing to start regular exercise.

Regular physical activity has also long been associated with lower levels of overall trait anxiety irrespective of confounding factors such as age and gender (Petruzzello et al., 1991; Scully et al., 1998; De Moor et al., 2006). On average trait anxiety levels for total trait anxiety, cognitive anxiety, and somatic anxiety were comparable to normative anxiety scores for this cohort and considerably lower than clinical populations. Average scores for somatic anxiety were significantly lower for the outdoor incidental group. This is most likely because the cohort in this study were regular exercisers. Regardless of the type of anxiety measure utilized (trait or state, self-report, or behavioral), or irrespective of the exercise regime undertaken (intensity, time, type), research has consistently reported a link between lower anxiety scores and regular participation in physical activity (Landers and Petruzzello, 1994; Anderson and Shivakumar, 2013). The anxiolytic effects of regular exercise for trait anxiety are stronger and longer lasting than many traditional therapeutic processes (Anderson and Shivakumar, 2013). This is particularly the case for trait somatic anxiety as regular exercise is said to mimic many of the physiological responses to anxiety (e.g., rapid heart rate, sweating, tense, or weak muscles and feeling hot) rendering them less potent (Anderson and Shivakumar, 2013). However, the significantly lower scores recorded for the outdoor incidental group and the lower (but not statistically significant) scores for the outdoor central group might be related to being comfortable exercising in all weathers and conditions. It is possible that exercising outdoors is associated with being more comfortable

with uncomfortable somatic and sensory experiences. As with well-being, the natural environment might still facilitate motivation and act as a distractor that encourages continued participation and therefore the anxiolytic benefits of regular exercise.

Hypothesis two was partially supported in that there were negative correlations between NRtotal, NRexp, and NRself and trait anxiety, and positive correlations between NRexp and the autonomy subscale for psychological wellbeing. The subscale measuring external worldviews on nature (NRpers) was not correlated with well-being or anxiety. NRexp and autonomy were significantly related with lower anxiety levels. Another point of particular interest was that even though anxiety levels for this cohort were similar to normative, non-clinical values there were still significant negative correlations between overall trait anxiety and overall nature relatedness, and between trait cognitive anxiety, trait somatic anxiety, and NRtotal, NRexp, and NRself.

Furthermore, NRexp, autonomy, and the outdoor physical activity environment (specifically incidental) predicted lower somatic anxiety but not cognitive anxiety. These findings are in partial agreement with previous results described by Martyn and Brymer (2016) who found NRexp predicted lower anxiety (albeit cognitive), thereby establishing a link between NR and anxiety. The current study furthers understanding of this relationship by demonstrating the additional effect of the outdoor physical environment and feelings of autonomy. While regular outdoor physical activity might be beneficial for predicting lower trait anxiety, feeling part of nature, and physically comfortable in nature might have an augmenting impact. Exercising in nature all the time may not be essential if a participant feels part of nature providing a participant can exercise outdoors. The differences between the findings for NRexp, trait cognitive and trait somatic anxiety evident from this study in comparison with Martyn and Brymer (2016) might be because cognitive and somatic anxiety have different antecedents. Cognitive anxiety is more related to worry and concern whereas somatic anxiety is linked to the physical symptoms of anxiety such as butterflies in the stomach. Activities that are more related to reduced cognitive anxiety are most likely cognitive in nature such as thought reframing. Those activities most likely to facilitate low somatic anxiety are most likely oriented around using the body, such as yoga and physical activity. Somatic anxiety infers bodily discomfort such as raised heart rate, sweating and muscular changes. As noted earlier, NRexp reflects a physical familiarity with the natural world even those aspects that are not comfortable such as being out in all weathers, wilderness camping, mosquitoes, death, and decay (Nisbet et al., 2009). This would suggest that high NRexp equates to a high propensity for enduring bodily discomfort and as such the somatic response to anxiety might be less problematic.

The results concerning autonomy are interesting, and autonomy may be predictive of lower anxiety because this characteristic is synonymous with feelings of control. Indeed, research has consistently identified that feelings of control are linked with lower anxiety across various subpopulations (e.g., Fischer and Boer, 2011). In addition, recent research has shown that autonomy is predictive of improved mental health outcomes among individuals who engage in leisure-based physical activity (Denovan and Macaskill, 2016), thereby suggesting that autonomy potentially enhances the beneficial effects of physical activity on mental health outcomes, which may have occurred for the participants in this study.

Concerning the negative correlation between anxiety and NRself, NRself reflects the appreciation that as individuals we are part of nature. Nature is perceived to be spiritually rewarding. Recent studies are finding strong relationships between spiritual beliefs and lower anxiety scores (e.g., Boscaglia et al., 2005). People high in the NRself subcategory view themselves as part of nature and as spiritually connected to nature. This might explain the relationship between NRself and lower trait anxiety. Practical and clinical implications for this could be to attempt to enhance individuals' relation with nature, in order to heighten their psychological well-being levels.

For this cohort, connection to nature is related to lower anxiety and being physically comfortable exercising outdoors seems to be important. As it is often the physical relationship with nature that instigates feelings of connection to nature (Martyn and Brymer, 2016), exercising where nature is related to the experience (even incidentally) likely enhances the effects of nature connectedness (NRexp) on anxiety levels.

LIMITATIONS

Before concluding, the authors acknowledge that the study utilized a cross-sectional design. Therefore, findings relating to the observed predictive relationships between NR and physical activity with anxiety provide only correlational evidence. Although literature and this study's findings support the direction of the observed relationships, it is important for future research to carry out longitudinal assessments to more fully examine causal relations among the variables. Furthermore, this study used self-report measures, which can be associated with issues including shared method variance and response bias. Lastly, this study used a self-selecting sample. As a result, it is possible that the study largely attracted participants who were interested in nature and were regular exercisers.

CONCLUSION

Results from this study challenge the current thinking that the immediate environment in which exercise takes place is the most important factor for the psychological wellbeing outcomes produced. Instead, findings from regular exercisers in this study suggest that psychological wellbeing is similar across all exercise environments. However, both the exercise environment and the relationship an individual has with the natural environment are important with regards to anxiety levels, and feeling connected with nature and physically comfortable in nature is strongly related to autonomy and lower somatic trait

anxiety. Future studies should aim to determine the direction of the NR and trait anxiety relationship. The findings reported here regarding the relationship between NR, trait anxiety and psychological wellbeing (specifically autonomy) do offer the intriguing possibility that designing interventions to enhance NR might also be useful for improving well-being and reducing anxiety.

AUTHOR CONTRIBUTIONS

EB research design, theoretical focus, data analysis, and article development. EL Research design, data collection, data analysis, article development. PC theoretical focus, article development, analysis. AD data anlysis, theorerical perspectives, and article development.

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MINI REVIEW
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Characterizing Nature and Participant Experience in Studies of Nature Exposure for Positive Mental Health: An Integrative Review

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A growing number of studies demonstrate significant associations between nature experiences and positive mental health outcomes (e.g., improved mood, decreased stress). However, implementation of this research by practitioners in fields such as urban design or public health has been limited. One reason for this is that it remains unclear what elements of nature and types of participant experience are consistently associated with mental health benefits. As a result, decision-makers who aim to enhance mental health in cities have little guidance about which elements of nature and types of experiences in natural areas may lead to positive mental health outcomes. We reviewed 30 studies with 41 distinct exposures in nature that elicited positive mental health benefits and characterized the elements of nature found at these sites, as well as aspects of participants' experience. Elements of natural areas considered include: forest, managed grass, and water as dominant land cover types, specific water features (e.g., small ponds, fountains) and built features (e.g., trails, paths). The majority of the studies we reviewed assessed the experiences of individuals (vs. in groups) participating in walks during warmer seasons. Most studies did not describe the "nature of the nature" associated with positive mental health outcomes. We contacted authors and used Google Earth imagery to reconstruct the specific natural elements, landscape typology, and site adjacencies present in past studies. We recommend specific ways researchers could better and more transparently document important elements of nature and participant experience in study design and reporting that will enhance the planning and design relevance of their work.

Keywords: environmental psychology, nature-exposure, mental health, urban design, public health

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INTRODUCTION

Urbanization has been associated with increased rates of mental illness in cities worldwide (Okkels et al., 2017). In response, there is a growing interest and urgency in understanding how the urban environment impacts human health and well-being (Hartig et al., 2014; Shanahan et al., 2015; Frumkin et al., 2017). Broadly, natural spaces have been associated with a wide range of health

benefits, such links have been consistent and generally well-understood (van den Bosch and Sang, 2017). Evidence from environmental psychology using a variety of methodologies (including self-report, psychophysiological assessments, and others), have demonstrated that contact with nature enhances positive affect, self-esteem, and cognitive functioning (Barton and Pretty, 2010; Zelenski and Nisbet, 2014; Bratman et al., 2015a; among others). These effects have also been demonstrated to occur across a wide range of demographic groups and sub-populations (Faber Taylor and Kuo, 2011; Ward Thompson et al., 2012; Beyer et al., 2014; Wu et al., 2015). Despite this no studies have yet to connect the nature of the nature to mental health outcomes. As such, specific findings from research on the mental health benefits of nature have yet to be implemented by practitioners such as landscape architects, urban planners, and public health officials, in part because it remains unclear what elements of nature exposure or types of nature experiences and landscapes provide mental health benefits (Gomez-Baggethun and Barton, 2013).

Interdisciplinary research and applied work often requires insights or integration that require alternative approaches and new types of data collection. Our work is unique in that we take an applied perspective on past work on the mental health benefits of urban nature that reveal key shortcomings that are needed to translate research to actionable design solutions for designers and planners. Charged with implementing nature-based solutions and enhanced nature-based design features in the urban context, designers and planners rely on evidence-based research to advance programmatic and policy goals for cities. Outcomes for achieving improved mental health are accessible to the designer and planner, but only when research clearly identifies the components, qualities, and features of landscapes and cityscapes experienced by participant's. Adoption of research in this area by the design profession requires enhanced descriptions of the qualitative features, environmental conditions, and quality of the nature as experienced by participants. Terminology used by designers can easily be incorporated when describing the experience of participants in studies in nature. Examples of where such design language could be incorporated include: enhanced definitions of landcover types, quantifying the density of vegetative cover, describing proximity to other features like rock outcroppings, wildlife habitat, built structures, and offering dimensions of trails and paths and their surface types. Our aim was to evaluate how much of the current body of mental health research on urban nature could be put into practice in the design of streetscapes, urban parks, or other public spaces. This requires knowing something about the "nature of the nature" that was previously found to have positive associations with mental health benefits.

METHODS

Literature Review

We sought to identify and characterize the elements of natural environments and participants' experiences in them by reviewing relevant nature-exposure studies that demonstrate a positive mental health benefit. We conducted an integrative review of the literature to assess common elements, locations, and features used in nature-exposure research. We compiled a database of nature-exposure studies that demonstrated positive mental health outcomes to assess what types of green spaces have demonstrated these benefits.

We systematically reviewed reference lists from all relevant meta-analyses and review papers that investigated the mental health impacts of urban nature exposure and were published by 2016 (these were: Barton and Pretty, 2010; Bowler, 2010; Thompson Coon et al., 2011; Bratman et al., 2012; Keniger et al., 2013; Hartig et al., 2014; Kuo, 2015; McMahan and Estes, 2015; van den Berg et al., 2015). We supplemented the resulting list of studies with nature-exposure research known to our team but not yet included in existing meta-analyses or reviews (these additional studies included: Beil and Hanes, 2013; Bratman et al., 2015a,b; Ochiai et al., 2015; Korpela et al., 2016; Scopelliti et al., 2016; Wilson et al., 2016).

After compiling relevant reference lists and studies, we removed duplicates and included studies that met the following five criteria:

(1) Conducted original, primary research on participants' response to nature using tests of affect (e.g., mood), cognitive function (e.g., memory) or other validated well-being metrics;
(2) Tested responses to a real-life nature exposure, as opposed to *simulated* nature exposure (e.g., via videos or photographs) or methods that included aggregate measures of nature (e.g., relative greenness);
(3) Found positive results from nature exposure, given our interest in understanding the types of nature exposure that *benefit* mental health;
(4) Provided enough information for us to identify the geographic location of the nature exposure; and
(5) Was published or available in English.

After screening studies for these criteria, we identified 41 unique nature-exposure experience locations worldwide (**Figure 1**) based on 30 peer-reviewed and published studies (for full reference list of studies included, see **Supplementary Table S1**). We synthesized information, after abstraction, about the methods and nature-exposure sites in each paper for our analysis.

Indicator Selection

Insights from an interdisciplinary team with expertise in environmental psychology, ecosystem services, ecology, human dimensions of natural resource management, urban planning, and landscape architecture helped generate a list of potentially relevant indicators that could characterize the diversity of general study elements, study sites and participant experiences in nature-exposure studies (**Table 1** includes a full list of the variables characterized). The selected indicators spanned four broad categories:

(1) Study design (e.g., number of participants, participant groupings, and response variable);

FIGURE 1 | Nature-immersion exposure locations. Locations of 41 distinct nature-exposures, visualized at a global scale and then by region in **(A–E)**, as follows: **(A)** corresponds to the Western United States region; **(B)** to the Eastern United States and Canada; **(C)** to Bogota, Colombia; **(D)** to Japan; and **(E)** to Europe. Explore the full map in more detail at: http://bit.ly/natureexpsitesmap (Basemap data 2018 Google, SK telecom, ZENRIN).

(2) Participant experience characteristics (e.g., social context, duration, type of activity, seasonality);
(3) Geographic location (e.g., park name, country, region);
(4) Landscape features (e.g., land cover types, trails, water, built park amenities, and built disamenities such as busy roadways).

Data Collection and Analysis

We collected location information and populated selected exposure site variables first through included information present in each study. In cases where we could not determine exact locations from the information provided in-text, we first contacted authors for clarification, maps of routes that participants took, or additional photographs of the site. Then additional detailed supplementary information about site adjacencies and exposures were identified and analyzed using tools such as: satellite imagery, spatial measurement tools, Street View or panoramic eye-level imagery along roads and some pedestrian paths, and user-submitted geotagged photographs from Google Maps, Google Street View, and Flickr.com respectively. Landcover types were assessed using a visual estimate if one landcover type covered more than half of the study area, we recorded it as the dominant landcover. If no single landcover type covered more than half of the study area, the dominant landcover type was listed as "mixed." Water features were identified if a water element was present, this provides additional specificity compared to water categorized as landcover type. Urban density was assessed using an estimated relative physical density of built structures and dwelling units within a 1-mile radius around the edges of the natural area; analysts visually coded this indicator in categories of low (less than five buildings), medium (between five and 20 buildings), and high (more than 20 buildings) density. We also collected information related to study response variables, methods, and participant populations, these variables were not included in our analysis due to being out of scope for the current work as well as the generally broadly positive effects of nature on mental health across diverse demographic groups, however, this information is included in our **Supplementary Table S1**.

RESULTS

Table 1 summarizes study characteristics, type and duration of nature exposure, and physical characteristics of the natural setting used in each experiment. Almost three-quarters (73.2%) of the studies did not include both a map and photos of the nature-exposure locations in addition to lacking a robust description of the exposure site. This means that most studies largely did not report the type, size, scale, diversity, or composition of the nature that may have been experienced, nor the type of constructed amenities within green space (such as trails or benches) experienced by study participants. The following results therefore contain a combination of in-text provided and additional data using the tools described in the previous section. Those exposures where nature-exposure locations could be determined were distributed across natural areas of various sizes, ranging from small parks (6 ha on average) to large parks (837 ha on average), with two outliers of very large wilderness areas (137,500 ha averaged). Specific features of nature itself were relatively consistent with most exposures containing trails

TABLE 1 | Summary indicators of nature-immersion exposure.

Summary indicators: *Study and exposure characteristics*	**Results***	**Summary indicators: *nature characteristics***	**Results***
Park or nature area size *(ha)*	Small (<20 ha): mean = 6 ha; *n* = 12 or 29.3% Medium (20–100 ha): mean = 44 ha; *n* = 13 or 31.7% Large (100–5,000 ha): mean = 837 ha; *n* = 10 or 24.4% Very Lg. (>5,000 ha): mean = 137,500 ha; *n* = 2 or 5.9% Unspecified: *n* = 4 or 9.8%	**Urban density** *(i.e., physical density of buildings within a 1-mile radius)*	High = 27 (65.9%) Medium = 7 (17.1%) Low = 7 (17.1%)
No. of participants *(people, count)*	Mean = 44 people (*n* = 41) Minimum = 4 Maximum = 112	**Dominant land cover**	Forest = 20 (48.8%) Managed grass = 15 (36.6%) Grassland = 2 (5.9%) Water = 2 (5.9%) Mixed = 2 (5.9%)
Duration** *(mean)*	Mean = 63 min (*n* = 29) Minimum= 10 min Maximum = 360 min	**Large built structures** *(e.g., picnic pavilion, welcome center)*	Yes = 29 (70.7%) No = 12 (29.3%)
Social context	Alone = 19 (46.3%) In a group = 11 (26.8%) Variable = 9 (22.0%) Unspecified = 2 (5.9%)	**Small built structures** *(e.g., benches, picnic 's, playgrounds)*	Yes = 32 (78%) No = 9 (22.0%)
Activity	Walking = 22 (53.7%) Sitting = 4 (9.8%) Variable = 10 (24.4%) Other = 5 (12.2%)	**Trails**	Yes = 37 (90.2%) No = 4 (9.8%)
Season	Summer = 13 (31.7%) Spring = 7 (17.1%) Fall = 5 (12.2%) Winter = 2 (5.9%) Multiple = 2 (5.9%) Unspecified = 12 (29.3%)	**Outdoor sports facilities** *(e.g., basketball, soccer field, ice rink)*	Yes = 9 (22%) No = 32 (78%)
Map included	Yes = 10 (24.4%) No = 30 (73.2%) Provided by request = 1 (2.4%)	**Water features**†	Built = 9 (22%) Natural = 14 (34%) Both built and natural = 3 (7%) No water features = 13 (32%) Unknown = 2 (5%)
Photo(s) included	Yes = 10 (24.4%) No = 30 (73.2%) Provided by request = 1 (2.4%)		
Outcome variable(s)***	Affect/mood = 37 (90.2%) Cognitive function = 11 (26.8%) Physiological = 13 (31.7%) Other = 7 (17%)		

**Presented in frequency of occurrence, unless otherwise noted. **n = 29; exposures with multi-day (outliers), variable, or unspecified duration were not included in the calculation. ***Percentages are calculated related to the total number of exposures (n = 41), studies can include multiple outcome variables. †Two unknown exposures are due to the exact walking path being unknown and taking place in very large wilderness areas.*

(90.2%) as well as both large and small built structures, 70.7 and 78% respectively. The presence of water features was more varied however and split between built (*n* = 9), natural (*n* = 14), or no water features of either type (*n* = 13). Almost one third (29.3%) of the studies did not provide any information regarding the season the exposure took place in. The warmer seasons where individuals are most likely to be outside (summer 31.7%, spring 17.1%) were more frequently used than cooler seasons (fall 12.2%, winter 5.9%). Participants were frequently walking during the exposure (53.7%), with few sitting (9.8%), or doing more vigorous activities such as hiking or biking (12.2%). Notably, response variables that measured affect/mood were the most common. The average duration of a nature exposure was just over an hour (63 min), with a wide range between a minimum duration of 10 min, and a maximum of 360 min. Most often participants experienced nature-exposures alone (46.3%) rather than in a group (27.8%). Full results for each exposure included in the review are available in **Supplementary Table S1**.

DISCUSSION

Within many of the studies on the benefits of nature experience, descriptions of the elements of nature associated with mental

health benefits are understudied and underreported. We sought to understand how well nature-exposure studies characterized these elements. This integrative-review of nature-exposure studies elucidated three main categories of findings which are discussed in more detail in the following sections.

(1) Identification of the key elements of nature which elicited mental health benefits that individuals may have been exposed to.
(2) Identification of common participant experience elements (individually, walking, summertime, etc.).
(3) Identification of the common broader contextual elements surrounding exposure sites that individuals may have been exposed to.

Key Elements of Urban Green Space

Our review identified specific elements that were present in the majority of studies that found positive mental health benefits. Almost universally green spaces contained a trail of some kind, either gravel/dirt or paved. This is not unusual given that paths help direct flow, and guide individuals through a space, or to a place within a space and are a common design element (Lynch, 1960). Both small and large built structures were present in most green spaces and afforded some type of amenities to the natural spaces. It should be noted however that it's unclear in the descriptions of participants experiences within studies whether any of the participants used such amenities, which should be included in future work. Valuable to designers and planners would be to understand whether additional amenities or features can support or enhance an individual's willingness to extend the duration of their exposure to nature, and whether or not it enhances or detracts from the experience. Most green spaces did not contain a formal sports area within them.

From existing evidence it's unclear whether such formalized, generally single-use forms of urban green space elicit similar benefits as other forms of nature as they potentially don't share many of the elements found in the current review that are associated with such benefits (Francis et al., 2012). Another common aspect that was common to the majority of green spaces was the presence of water features either built or natural. This would be consistent with previous work whereby water features promoted greater well-being (Völker and Kistemann, 2011).

Finally, green spaces that elicited mental health benefits could be found across a gradient in terms of sizes ranging from a small 1 ha city park to a 159,000 ha wilderness area. As urbanization intensifies globally, the impact of smaller pocket parks and even streetscaping in the form of planters and street trees could be critical elements for improving mental health for urban residents. A small amount of recent studies investigating street trees and pocket parks have found positive associations in terms of health and well-being (Nordh and Østby, 2013; Kardan et al., 2015; Taylor et al., 2015), but these smaller forms of urban nature that individuals have daily contact with are relatively understudied.

Participant Experience Elements

Most often studies exposed participants alone, especially when those studies were experimental. However, cross-sectional studies, in contrast, were more diverse and included participants being on their own and in groups, often due to approaching individuals who were already using the green space. In addition to social context, the type of activity was consistent across studies, with walking being the most common. Again, it could be hypothesized that higher levels of inclusion of participant activity information in studies was methodologically driven. Given that reporting such information is common practice in psychological studies as part of a robust methodology. An aspect of participant activity which is not reported is additional context related to describing the actual *experience* of individuals. For example, studies reported that participants walked alone, but did not provide additional context around who or what they might have encountered and interacted with, and where their attention was focused during the exposure. Duration of exposure was also an interesting aspect, with a range from 10 min to over 360 min in a single dose. The finding of an ideal 'dose' has been a topic of discussion previously (see Bratman et al., 2012). Related to duration is also frequency of contact with nature, which to date research has found mixed results as to whether or not frequency provides additive well-being benefits or not (Korpela and Yién, 2007; Lafortezza et al., 2009). Seasonality was the last common element of participant experiences, and was notably an element which was reported on a fairly consistent basis in the reviewed studies. We found a noticeable bias toward spring and summer seasons in reviewed studies. Most locations where nature-exposures took place were in temperate regions (**Figure 1**) that have a wide range of seasonal variability. With most studies reporting seasonality, it is one of the areas in which further work can be done right away posing the question whether mental health benefits of nature persist in winter when significant changes in the natural landscape occur. Most studies included the four elements of participant experiences (social context, dose, activity, seasonality), however, clarity in the social context, and the specific types of interactions that happened to or among participants during their nature-exposure were largely unreported and should be improved in future work. This can also be seen in the dimension of seasonality as perhaps certain types of interactions are more common in different seasons, and thus could alter the experience of nature.

Broader Contextual Elements of Urban Green Spaces

First, the broader context in which nature experiences take place are commonly not reported in nature-exposure studies. The issue of addressing the broader context in which such nature exposures take place starts with the lack of specificity in defining the boundaries of the green spaces themselves. Few current studies under review reported the boundaries or definitive size of the green spaces. Green space size was most often reported for spaces that had defined boundaries (e.g., a contained urban park) compared to those with more amorphous borders (e.g., rural natural area). The lack of defining boundaries and size makes it

difficult for designers and planners alike to assess the potential for proximate sources of nuisances such as noise or pollution. Descriptions and photos illustrating proximity to structures and built form, land use type and transportation infrastructure were key missing features that are essential in supporting actionable solutions for designers, especially for natural spaces located in highly dense urban landscapes. Building density proximate to green space may reduce the positive outcomes achieved in green spaces designed for positive mental health benefits due to increased nuisances. The nearby density and other sources of auditory and olfactory nuisances (e.g., trains, factories) could impede the effectiveness of urban nature to provide mental health benefits for residents (Lyytimäki et al., 2008; Tzivian et al., 2015; Hammersen et al., 2016). Another issue affecting the broader context of urban green spaces is the relative density of public green spaces that occur within a city. Specifically a question that arises related to this issue of public green space density would be if the effects of green spaces on mental health are intensified in low green space density cities vs. greater green space density. Describing and ideally inventorying the broader context in which nature exposures occur would be helpful in identifying potential sources of stressors, nuisances, and density issues that could play a role in driving the observed effects of nature on mental health benefits while offering the designer and planner key design direction when developing and planning nature space.

Understanding both specific elements and the broader contextual aspects related to public urban green spaces are not only important for those individuals who actually experience such spaces first hand, but also for those who experience such spaces through viewing them. Recent work has connected views of nature to mental health and well-being (Kaplan, 2001; Pretty, 2004; Honold et al., 2016). Therefore a deeper understanding of the specific elements and broader contextual aspects of urban green spaces can have a much greater impact beyond those individuals directly exposed to the space itself.

Recommendations

In an effort to understand specific features that elicit mental health benefits, provide practitioners with easily accessible and readable information, and increase transparency in nature-exposure research, we provide the following list of actionable recommendations that could be adopted by those involved in future study design and reporting of nature-exposure for mental health research.

Participant Experience

- Ensure exposure experience descriptions are specific including:
    - Duration of nature-exposure experience for each participant
    - Information on whether participants were alone or with others
    - Specific activities of participants (e.g., walking slowly and surveying nearby vegetation)
    - Map and provide a specific description of exposure route (if mobile) or exact location (if stationary).

Exposure Location and Geography

- Identify and report nature-exposure exposure sites by most commonly known name (e.g., Golden Gate Park), or location in relation to another landmark (e.g., campus green space west of Coffey Hall, University of Minnesota), if no formal name exists.
- Include location and map of where exposure took place and a description of the surrounding area. This may include sights, sounds, and smells.
- Include proximity, porosity/imperviousness, and relative density of adjacent structures.

Environmental Context and Natural Elements

- Photograph surroundings that participants would view or encounter during exposure.
- Describe nearby built and natural features that participants may experience.
- Include not only amenities but also stressors, such as:
    - Sources of noise (e.g., nearby railroad lines, airports, highways, etc.)
    - Sources of strong odors (e.g., factories, construction, restaurants, etc.)
    - Other unique factors or stimuli that may influence participant experience

Overarching Recommendations

- Use accessible tools including GIS software and Google Maps to summarize natural and neighborhood metrics of exposure sites
- Explore opportunities for conducting exposure studies in locations where existing evidence is lacking, particularly in the Global South
- Encourage a broader range of seasonal experiences and exposure in nature as well as time of day and duration.

Our findings and these recommendations can be taken as a call to continue improving how we understand what factors are associated with mental health benefits of nature and what causal mechanisms may be responsible. The recommendations provide a starting point for understanding the complex relationship between nature and well-being. Limitations in our own work given gaps in available, in-text descriptions that made it difficult to interpret or code specific elements present in the mental health and well-being benefits based on in-text study descriptions alone. Because of these gaps, we relied on coding a large number of locations and landscape elements ourselves using available online resources, including Google Maps or Street View.

CONCLUSION

We provided an assessment of the current state of knowledge of nature-exposure studies that resulted in reported positive mental health benefits. Overall, we found that studies of nature exposure for mental health generally described participant experiences better and more comprehensively than information on either

location or landscape context. A significant first step then is providing greater detail in studies as to the nature of the nature in order to assess features and elements that can measurably be attributed to enhancing an individual's sense of well-being. Additionally, such details will assist to enhance the design practice, encourage interdisciplinary research, and ultimately design better public spaces.

AUTHOR CONTRIBUTIONS

MB and MD wrote the manuscript. BK conceived of and supervised the project and manuscript through its creation. CS and TM gathered and analyzed data. LS provided expert advice and guidance for practitioners. All authors provided substantive feedback throughout.

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SUPPLEMENTARY MATERIAL

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Not All Green Space Is Created Equal: Biodiversity Predicts Psychological Restorative Benefits From Urban Green Space

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Contemporary epidemiological methods testing the associations between green space and psychological well-being treat all vegetation cover as equal. However, there is very good reason to expect that variations in ecological "quality" (number of species, integrity of ecological processes) may influence the link between access to green space and benefits to human health and well-being. We test the relationship between green space quality and restorative benefit in an inner city urban population in Bradford, United Kingdom. We selected 12 urban parks for study where we carried out botanical and faunal surveys to quantify biodiversity and assessed the site facilities of the green space (cleanliness, provision of amenities). We also conducted 128 surveys with park users to quantify psychological restoration based on four self-reported measure of general restoration, attention-grabbing distractions, being away from everyday life, and site preference. We present three key results. First, there is a positive association between site facilities and biodiversity. Second, restorative benefit is predicted by biodiversity, which explained 43% of the variance in restorative benefit across the parks, with minimal input from other variables. Third, the benefits accrued through access to green space were unrelated to age, gender, and ethnic background. The results add to a small but growing body of evidence that emphasize the role of nature in contributing to the well-being of urban populations and, hence, the need to consider biodiversity in the design of landscapes that enhance multiple ecosystem services.

Keywords: green space, psychological restoration, biodiversity, park, urban, city, birds, plants

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INTRODUCTION

Urban green spaces have been shown to improve health and well-being through conferring a number of ecosystem services (Scott et al., 2016) including buffering noise pollution (Margaritis and Kang, 2016), improving air quality through absorbing and shielding from particulates (Nowak et al., 2006; Hartig et al., 2014), and preventing heat stress by providing shade (Lee et al., 2016). A further ecosystem service is the proposed ability of biodiverse urban green spaces to improve

psychological well-being (Sandifer et al., 2015). Such restorative ecosystem services provide one of many arguments for biodiversity conservation (Sandifer et al., 2015). In the United Kingdom, over 80% of the population dwells in urban areas, but along with considerable benefits to health, economies, and education, urbanization has brought great challenges for both social and natural systems (Rook, 2013). Mental health problems affect at least 1 in 6 people in the United Kingdom (Faculty of Public Health, 2010), with an estimated cost to the United Kingdom economy of £105 billion a year, and rising (Mental Health Taskforce, 2016; WHO, 2016). The improvement and expansion of green space has been proposed as a tool for increasing both ecological and psychological well-being in urban environments (Dean et al., 2011), with the Faculty of Public Health claiming that: "safe, green spaces may be as effective as prescription drugs in treating some forms of mental illness" (2010; p. 2). Indeed, 34 English conservation NGO's have lobbied for 1% of all health spending to be invested in nature-based solutions by 2018 (Response for Nature Partnership, 2015).

The value of green space for psychological well-being has gained increasing academic attention (Sandifer et al., 2015). From the holistic intervention of wilderness therapy (Norton, 2010) to a view of greenery out of the window (Herzele and De Vries, 2012; Honold et al., 2016), many aspects of interaction with green space are being recognized as effective tools for improving well-being. Kaplan and Kaplan (1989) proposed that access to green spaces in urban environments allows the mental fatigue of modern life to be countered by "psychological restoration." Proximity to green space has been found to improve psychological health through: decreasing cortisol levels (Roe et al., 2013), acting as a buffer to stressful life events (Van Den Berg et al., 2010), increasing social cohesion (Hartig et al., 2014; Gonzalez and Kirkevold, 2016), decreasing maternal depression (Mceachan et al., 2016), and increasing general psychological well-being (Annerstedt et al., 2012; Triguero-Mas et al., 2015). As well as proximity to green space, the "dose" of green space exposure has been shown to impact the benefits gained (Shanahan et al., 2016), with Cox et al. (2017a) finding that 27% of depression cases could be prevented by spending 5 h or more a week in a garden. However, despite many individual studies demonstrating evidence of a mental health benefit the quality of evidence is often poor and general trends from systematic reviews are weak (Gascon et al., 2015). A major issue is the methodological quality of previous studies, which have led to inconsistent results (Lee and Maheswaran, 2011; Hartig et al., 2014).

Our understanding of the links between green space and psychological well-being may be confounded by other factors that influence the value of green spaces for psychological restoration (Nordh and Ostby, 2013; Taylor and Hochuli, 2015). Specifically, the relationship between green space and health has often been investigated through proximity of people to green areas, and neighborhood "greenness" through normalized difference vegetation index (NDVI) values (Ekkel and De Vries, 2017). Francis et al. (2012), however, contend that quality is as important for mental health as quantity, and that research focusing only on quantity is not sufficient to inform policy on public health, or indeed to aid biodiversity conservation (Dean et al., 2011; Taylor and Hochuli, 2015). Green space quality can be quantified from the perspective of the human user through measurement of furniture, management, and cultural cues that can make green spaces feel safe and accessible (Nassauer, 2004; Roberts et al., 2018), and therefore potentially more conducive to relaxation and psychological restoration (Kazmierczak, 2013; Nordh and Ostby, 2013) alongside many other benefits (WHO, 2016). This may include: lighting, adequate seating, signs, indications of management such as cut grass, and lack of graffiti and litter. Green space quality can also be assessed from the perspective of the ecosystem, by quantifying habitat diversity, species diversity, or ecological functions (Lovell et al., 2014; Sandifer et al., 2015). The discussion over what features of green spaces influence attitudes and benefits is a relatively recent addition to the field (Keniger et al., 2013), and has led to a shift from a discussion of "macro" (Dadvand et al., 2014; Mceachan et al., 2015) to "micro" features, and biodiversity in particular (Schebella et al., 2017). For example, a study of interactions with particular plant species in Berlin parks demonstrated that 26 different species of plant formed the basis for green space use for consumption, decoration, or biodiversity experience (Palliwoda et al., 2017). While experimental laboratory work has suggested that there is little difference between the restorative benefits of very different types of natural scenes (Van Den Berg et al., 2014), there is a strong cross-cultural preference for semi-natural green spaces as opposed to more formal parks (Žlender and Ward Thompson, 2017).

What is unclear is whether the presence of site facilities conflicts with high biodiversity (e.g., a trade-off in space use for amenity vs. natural features), and so for a nuanced view of the benefits of green spaces, the correlations between these two components of quality need to be understood. Indeed, a trade-off between site facilities and ecological function is not inevitable, nor are the two components of green space quality necessarily mutually exclusive. Although urban areas often contain far fewer species than rural areas, they retain the ability to hold endemic and sometimes diverse wildlife populations (Aronson et al., 2014) and urban areas can contain more species than rural areas in some cases (e.g., plant richness peaks at intermediate levels of urbanization Mckinney, 2008), thus urban green spaces are increasingly being seen as important stepping stones for wider biodiversity conservation goals (Dearborn and Kark, 2010; Goddard et al., 2010). This diversity can contribute to the positive experience of park users. Lepczyk et al. (2017) noted that small urban green spaces, such as parks, can be incredibly diverse, depending on their connectedness and their habitat quality (Matthies et al., 2017). However, some large open green spaces can have little ecological value, consisting largely of species-poor amenity grassland. Hence, variation in benefits may result from site level factors beyond simple size considerations, which raises the important (but neglected) point that green space area, habitat cover, and biodiversity are not interchangeable concepts (Lepczyk et al., 2017). Urban planning for public health requires an understanding of how site facilities and biodiversity of green spaces are associated with the restorative benefit derived from those spaces.

In addition to research over access to natural spaces in general, there is a considerable body of work on the specific aspects of nature that confer benefits. In particular, it has long been understood that the experience of biodiversity and other aspects of the natural world can act through psychological and psychophysiological mechanisms to enhance well-being (Wilson, 1984; Roszak et al., 1995). However, research that has attempted to investigate the link between biodiversity in green spaces and psychological well-being has produced mixed results (Lovell et al., 2014). Fuller et al. (2007) found a correlation between species richness and psychological benefit in parks in Sheffield, whereby the benefits gained from visiting green space were higher with both higher bird and higher plant diversity. Similarly, Cox et al. (2017b) found that both vegetation cover and afternoon bird abundance in urban areas reduced the severity of depression, anxiety, and stress. In contrast, Dallimer et al. (2012) found a lack of a consistent relationship between diversity and psychological benefit. Instead, they found that perceived species richness did correlate to well-being, but that perception did not correlate to actual species richness. However, studies focusing on flower meadows have shown that perceived and actual species richness do correlate strongly, and that plant, bird, and butterfly richness were positively associated with well-being (Southon et al., 2018). The difference in the accuracy of public judgments of biodiversity may relate to the greater number of more salient cues to diversity in plants, such as color, vegetation height, and evenness (Southon et al., 2018). Fuller et al. (2007) posited that some of the benefit from increased biodiversity might be manifested through environmental cues such as habitat heterogeneity, finding that the number of habitats also correlated to well-being measures. Similarly, tree cover has been shown to be correlated with psychological well-being, with the suggestion that tree cover is a proxy for perceived "naturalness" (Dallimer et al., 2012). The link between biodiversity of green spaces (however, measured) and psychological well-being remains unclear, and few studies have also attempted to incorporate an analysis of non-biological (site facilities) quality.

Research Aims and Objectives

The current literature suggests a strong, positive relationship between urban green spaces and psychological well-being, but the mechanisms are unclear. Our study aims to fill an important gap in the literature by answering the following research questions:

(1) What are the relationships between site facilities and biodiversity within urban parks set in a multicultural deprived urban area?
(2) How are the site facilities and biodiversity of parks related to psychological restoration?
(3) Do relationships between the features of parks (site facilities or biodiversity) and psychological restoration vary amongst population subgroups (for example, by ethnicity, age, or gender)?

Through the rest of the paper, the following terms are used: "biodiversity" – an umbrella term for biological diversity than encompasses species richness and the number and diversity of habitats; "species richness" – the number of species found in a particular area; "site facilities" – the non-natural objects found within the green spaces (e.g., benches, dustbins, and lighting) and the quality of those amenities (e.g., presence of litter and graffiti).

MATERIALS AND METHODS

The study was undertaken in the city of Bradford, the fifth largest Metropolitan district council in England with a population of 534,300 and was further located within the Better Start Bradford programme area. Better Start Bradford is a Big Lottery funded project set within three most deprived wards of the city (Little Horton, Bowling and Barkerend, and Bradford Moor; total population of 63,400; Dickerson et al., 2016). The programme aims to improve health outcomes for some of the most deprived families in the country and includes a focus on improving local green spaces within the area to promote their use[1]. We restricted our work to formal green spaces (defined as sites that are managed, with a structured path network, and an organized layout) which are managed by a single local government department and which are relatively homogeneous in structure and purpose. Google Earth was used to locate potential sites, and site visits were used to select those parks that met the requirements of: constant and full public access, fenced areas in which children could play, and benches as a minimum of park furniture. We selected these minimum requirements to constrain the variation in green space structure to a range of green space types that might be more highly used by the general public. A total of 12 green space sites (parks and recreation grounds) that met these requirements were located within the Better Start Bradford wards, or had a boundary with the area (see **Figure 1**) and so all work was done in those areas. As even very small parks have been shown to have restoration potential (Krekel et al., 2016), no area constraints were used in selecting sites, however, area was considered in the analysis.

Before describing the methods, it is worth noting that there are potential issues with the definition of "nature" as it relates to the ecological and psychological sciences. Urban ecology has traditionally considered "natural" and "urban" spaces as being spatially separated, while urban spaces can contain biodiversity that varies by degrees in its similarity to that of natural landscapes (Mckinney, 2008). On the other hand, psychological or social definitions of nature experiences tend to include all organisms irrespective of anthropogenic impact alongside socio-cultural context and the changes that occur within the individual as a result of the experience (Clayton et al., 2017). It is worth noting that biodiversity could also incorporate some aspects of ecological processes or functions to complement the biodiversity and habitat variables that we describe above. For example, the quality of an ecosystem could involve the integrity of processes such as nutrient cycling or carbon sequestration, or structural features such as the complexity or functional redundancy of ecological networks. In addition, biodiversity should also not be seen necessarily as a proxy for "naturalness," as unnatural

[1] www.betterstartbradford.org.uk

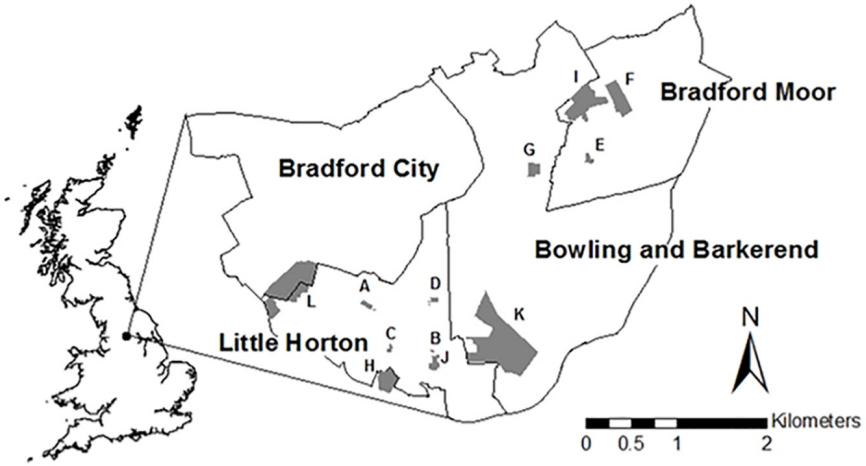

FIGURE 1 | A map of the locations of the parks selected for study across the Better Start Bradford area, denoted by letters.

but biodiverse areas (e.g., floristically diverse horticultural landscapes) could provide considerable restorative benefit. The methods described above consider all biodiversity (whether "natural" or "anthropogenic" in origin) as a single category, and so the resulting measures of biodiversity should not be seen as equivalent to "naturalness" or "wildness." Hence, the methods represent the common public perception of "nature" as the "living world," as opposed to ecologically natural communities of organisms.

Study 1: Green Space Assessments

The site facilities within green spaces were measured using a prototype version of the Natural Environment Scoring Tool (NEST, Gidlow et al., 2018), adapted from the Neighborhood Green Space Tool (Gidlow et al., 2012), that assesses: access, recreational facilities, amenities, natural features, and incivilities. "Access" refers to entrance points and paths, and "recreational facilities" to availability of features such as playgrounds and sports courts, as well as space for physical activity including walking. "Amenities" relates to the placement of sufficient seating, bins, and lighting, "natural features" refers to the maintenance and aesthetics of features such as grass and shrubs, and "incivilities" measures anti-social behavior such as littering, graffiti, and signs of alcohol and drug use. As the tool is a subjective, qualitative scoring measure, two researchers independently assessed each park, and then discussed the results to produce an agreed total score, using Gidlow et al.'s (2018) scoring and weighting system.

While site facilities incorporate a component of natural features (6 out of 47 items on the NEST), we defined a separate measure of biodiversity based specifically on species richness and habitat structure. At each green space, habitats were mapped by identifying the locations and extents of different habitat types. Habitat types included: anthropogenic surfaces (such as playgrounds, sports courts, buildings, and paths), tree cover, amenity grassland, scrub/shrubs, unmown grassland, rough grassland, and waterbodies. Habitat maps were then drawn up for each park using ArcGISv10.4.1, in order to calculate the total area, and the area covered by each habitat type. Tree cover was estimated by drawing polygons around canopy cover from satellite images and habitat diversity was then calculated from the percentage cover of different habitats using Shannon's diversity index (Dallimer et al., 2012).

Biodiversity surveys were undertaken in such a way that they were representative of the diversity that an individual might experience on a visit to the park. In order to survey the plant species richness at each site, 5 1 m × 1 m quadrats were sampled in each habitat type, or until all of a given habitat was sampled. In woodland, quadrats were 10 m × 10 m, and were adapted to fit the habitat area where this was not possible. Species richness was the total number of species found in all of the quadrats at each green space. Animal species that are likely to be noticed on an everyday visit to parks in the summer (birds, butterflies, and bees) were also surveyed. To conduct bee and butterfly surveys, transects were walked across each site that encompassed all habitat types (Fuller et al., 2007). Any individual butterflies and bees that were seen within 2.5 m on either side of the route and less than 5 m in front of the observer were recorded (Pollard et al., 1986). At the same time, any birds that were seen or heard within the green space area were also recorded (Fuller et al., 2007). The transects were walked twice, once in June and once in July at least a week apart, in suitable weather conditions, with temperatures of at least 13°C, under 50% cloud cover, and wind speeds of no more than 5 on the Beaufort Scale (Carvell et al., 2016). Species richness was the total number of species encountered on the two visits. Although avian species richness is highest in the 3 h after dawn, this is not the time during which people are most likely to utilize green space, and Cox et al. (2017b) found that psychological benefit was correlated to afternoon bird occurrence. Therefore, the surveys were all conducted between the hours of 10am and 5pm in an attempt to sample the species richness that might be experienced on a typical visit to the green space in the summer. This suite of ecological variables incorporate not only taxonomic diversity but also aspects of ecological processes and ecosystem

functions such as pollination (bee and butterfly diversity) and carbon sequestration (tree diversity and cover).

Study 2: Restorative Benefit Surveys

Measures

The potential for psychological restoration was measured through four 5-point Likert scale questions used by Nordh et al. (2009) in their photo-elicitation study about pocket parks in Scandinavian cities, and were based on the Attention Restoration Theory (ART) of Kaplan and Kaplan (1989) and the 21 point ART questions developed by Hartig et al. (1997). Kaplan and Kaplan's (1989) theory is based on four characteristics of green spaces that influence psychological well-being: 'fascination' whereby attention is grabbed by elements such as biodiversity through exploration of the site; "being away" as the ability to be psychologically removed from the strains of everyday life; "extent" refers to the order and coherence of a site; and "compatibility" explores how well a green space matches what an individual wishes to do on site. Nordh et al. (2009) focused on overall restoration, being away and fascination from Hartig et al.'s (1997) ART scale, and general preference for a space. That study validated a reduced form of the 21 item ART survey which used the four questions on being away, fascination, likelihood of restoration, and preference in order to reduce the burden on participants (Nordh et al., 2009). For each question, participants were asked to rate the park from 1 to 5, where 1 is strongly disagree, 3 is neutral, and 5 is strongly agree. Answers to the four restoration questions were averaged to give a general score for restorative benefit for each participant. As well as psychological restoration potential questions, all survey participants were asked to complete six 5-point Likert questions about "connectedness to nature" (a measure of the emotional connection or "oneness" with the natural world) that were a short form of Mayer and Frantz's (2004) scale, developed by Nisbet and Zelenski (2013), to assess if connection to nature had any bearing on restoration potential. Answers to these six questions were also averaged to give a general score of connectedness to nature for each participant. Participants were also asked about their use of the park, such as the activities that they undertake, and how often they visit (see **Supplementary Information** for the full questionnaire). Demographic data on age, gender, and ethnicity were also collected.

Participants

All adults entering or leaving the park during the time of the audit were considered to be eligible to take part. In the busier parks, every third person was approached. However, in the less visited parks, to ensure that adequate sample sizes were reached, every person entering the park was approached. All participants completed the surveys alone, with people in pairs surveyed separately by different researchers, and only one person per group of >2 approached to reduce non-independence of responses. Children were not approached to avoid concerns over vulnerability and to allow the development of a single, age-appropriate survey. Participant demographics were compared against 2011 United Kingdom census data for the three wards (Bowling and Barkerend, Bradford Moor, and Little Horton) to evaluate the representativeness of the sample.

Procedure

Face to face surveys were conducted in English by two interviewers in July and August 2017 at the entrance to each of the 12 parks. At least 12 person-hours of survey effort was undertaken in each park at similar times of day in order to obtain a comparable sample of park users for each site. After taking informed consent, the survey took approximately 10 min to complete. Ethical approval was given from the Faculty of Biological Sciences Ethics Committee (reference: LTSBIO-004).

Statistical Analysis

All statistical analysis was conducted in R (R Core Team, 2015), with the lme4 (Bates et al., 2015), car (Fox and Weisberg, 2011), MuMIn (Barton, 2016), and LMERConvenienceFunctions (Tremblay and Ransijn, 2015) packages. In Study 1, all variables approximated a normal distribution in a Shapiro–Wilk normality test, and so Pearson correlations were used to test for associations between different variables. In Study 2, we calculated a single value for restorative benefit and connectedness to nature for each participant by averaging the scores for the component questions (four questions for restorative benefit and six questions for connectedness to nature). Although Likert scale data is ordinal, averages taken across the scale are often treated as continuous and subjected to parametric analysis (e.g., Fuller et al., 2007; Dallimer et al., 2012), and discussion in the statistical literature suggests that there is a strong basis for doing so, as long as the model assumptions are met (Harpe, 2015). For all of the tested linear models, the residuals were inspected to ensure that the assumptions of homogeneity of variance and normality were not violated.

In Study 2, analysis of restorative benefit was done in a two-tiered approach, whereby park level relationships (n = 12) were first considered by using the average restorative benefit across all participants to give a value for each park in linear regression models. This park-level analysis accounted for the potential pseudoreplication that may have arisen from having participants surveyed from the same small set of parks. However, the park-level analysis also lacked statistical power due to the focus on a relatively small number of sites. As a result, a second, complementary analysis was also conducted using the individual-level data (n = 128). This individual-level analysis used linear mixed effects models with the park as the random effect. In this way, we examined patterns across individual participants while accounting for the fact that they experience different park environments. In both cases, we use a model selection approach based on Akaike's information criterion (AIC). First, we began with a full model containing all variables of interest (habitat diversity, number of trees, species richness of birds, plants, bees/butterflies, habitat number, and site facilities). Since there was a strong probability that some of these predictors would be collinear, and therefore would have inflated the estimation of standard errors associated with parameters, we checked for multicollinearity using variance inflation factors (VIFs). Where collinearity was identified in the ecological

variables (VIF $\geq$ 5, Akinwande et al., 2015) we used a principal component analysis (PCA) to summarize those variables. The PCA produced orthogonal principal components that explain different dimensions of a higher-order dataset and can be included as predictors in place of the collinear variables. Next, we constructed a set of models containing different combinations of predictors. Since there were no strong *a priori* expectations of which parameter combinations might provide the strongest fit, the full models for both studies (green space quality and restorative benefit), and both levels of analysis (park-level and individual-level) were then subjected to a comparison of all possible fixed effect combinations. The mixed models were fitted by maximum likelihood to allow model comparison. This process generated a large set of models which were then compared using AIC to find the best-fit model in each analysis. Where multiple models exhibited similar AIC scores (ΔAIC $<$ 2) we used model averaging to calculate parameter estimates that incorporated information from each of those top models, weighted by their goodness of fit (Grueber et al., 2011).

RESULTS

Study 1: Assessment of Park Quality

Across all of the sites, there was substantial variation within the park quality metrics (see **Table 1**), with both plant (16–100 species) and bird (4–21 species) richness varying by a factor of five. From the ecological surveys, the most abundant and constant herbaceous species were: perennial ryegrass (*Lolium perenne*), annual meadow-grass (*Poa annua*), and white clover (*Trifolium repens*), with silver birch (*Betula pendula*), sycamore (*Acer pseudoplatanus*), and cherry (*Prunus* spp.) the most common woody species. The most common bird species were the: feral pigeon (*Columba livia domestica*), blackbird (*Turdus merula*), and house sparrow (*Passer domesticus*). Of the bees and butterflies, the most often encountered were the: small white butterfly *(Pieris rapae*), buff-tailed bumblebee (*Bombus terrestris*), and tree bumble-bee (*Bombus hypnorum*).

Across all 12 sites, the species richness of different taxa was correlated between plants and birds (r = 0.901, p < 0.001), between bees/butterflies and birds (r = 0.637, p = 0.026), and also between plants and bees/butterflies (r = 0.658, p = 0.020). Both plant and bird species richness were correlated with habitat number (r = 0.828, p = 0.001; r = 0.799, p = 0.002, respectively), but no diversity or richness variables showed significant correlation with tree cover or habitat diversity. Site facilities (from the Natural Environment Scoring Tool) correlated only with plant (r = 0.671, p = 0.017), and bird richness (r = 0.602, p = 0.038) (**Figure 2**).

Land area varied greatly across the parks, with a range of 0.14–32.56 hectares, and all variables except butterfly and bee richness, habitat diversity, and tree cover significantly correlated to the $\log_{10}$ area of the parks (**Table 2**). For site facilities there was also a strong positive effect of area. Due to the correlations of park variables with area, in subsequent analysis, a model with area

TABLE 1 | Site level characteristics, including ecological and site facilities characteristics across the 12 studied parks.

Park quality variables	Mean	*SD*	Min, Max
Site facilities (Natural Environment Scoring Tool, 0–100)	52.60	9.17	35, 67
Plant richness (number of species)	47.42	26.77	16, 100
Bird richness (number of species)	11.50	6.43	4, 21
Bee/butterfly richness (number of species)	7.00	3.81	0, 12
Habitat diversity (Shannon's Diversity Index)	1.09	0.23	0.77, 1.51
Habitat number	4.83	1.12	3, 7
Tree cover (%)	19.09	10.30	6.47, 41.85

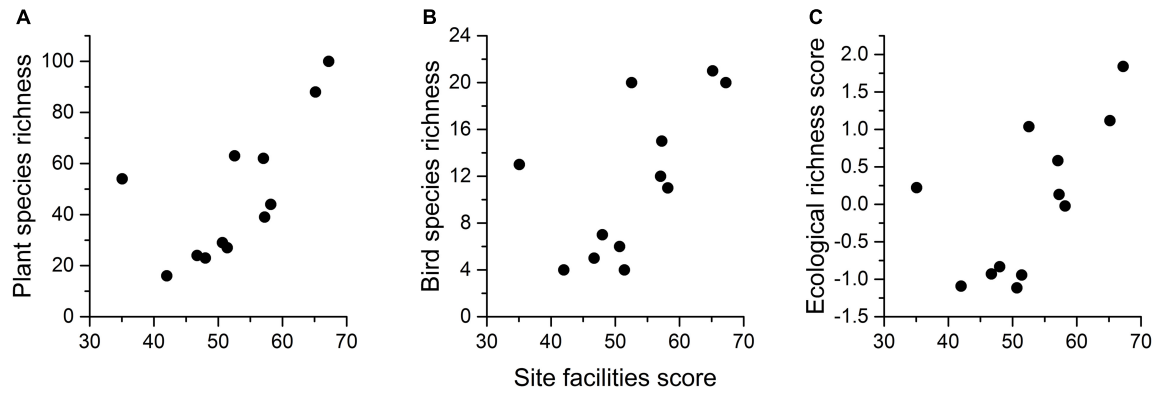

FIGURE 2 | The relationship between site facilities and **(A)** plant species richness, **(B)** bird species richness, and **(C)** the ecological richness score based on a combination of biodiversity-related factors.

TABLE 2 | Pearson correlation results between the park variables and park area.

Correlations with $\log_{10}$ area	*N*	*r*	*P*
Site facilities	**12**	**0.662**	**0.019**
Plant species richness	**12**	**0.805**	**0.002**
Bird species richness	**12**	**0.917**	**<0.001**
Bee/butterfly species richness	12	0.461	0.132
Tree cover	12	0.515	0.087
Habitat diversity	12	0.037	0.908
Habitat number	**12**	**0.647**	**0.023**

Significant correlations ($p < 0.05$) are highlighted in bold.

TABLE 3 | Demographic characteristics of survey participants.

Characteristics		% Participants (*n* = 128)
Gender	Male	54
	Female	46
	Other	0
Age	18–25	9
	26–35	19
	36–45	23
	46–55	19
	56–75	26
	76+	4
Ethnicity	Pakistani	40
	White British	36
	Indian	5
	Eastern-European	5
	British Pakistani	4
	Bangladeshi	3

as a predictor was run to explore the relationship of area with restorative benefit (Fuller et al., 2007).

Study 2: Restorative Benefit Surveys

Participant demographics were compared against 2011 census data for the three wards in which the parks were located (**Figure 1**). Country of birth was very similar between survey respondents (65.9% United Kingdom born, 26.4% South Asia born) and the local population (66.2% United Kingdom, 24.0% South Asia), as was the marital status (52.7% married in survey, 49.3% married in census). The survey included a greater percentage of female respondents than the local population (54.7%, compared to 49.8%) and tended to include older individuals (49.6% were aged 46 or older in the survey compared to 18.4% being aged 50 or older in the census). These results suggest that the survey respondents are broadly representative of the local population in terms of race, gender and ethnicity, but that older people were over-represented. Analysis of variance (ANOVA) showed no significant differences in restorative benefit between sexes ($F_{1,127} = 2.208$, $p = 0.140$), United Kingdom-born or foreign born ($F_{1,127} = 0.341$, $p = 0.560$), ethnicities ($F_{1,127} = 0.302$, $p = 0.584$) or ages ($F_{1,127} = 2.468$, $p = 0.119$).

At one site, only one survey was completed during 6 h of interviewing effort due to low use of the space and so that site is excluded from the following analysis. For the remaining 11 sites, a total of 128 participants completed the survey (mean 11.6 per site, range: 5–21) and the participant demographics are presented in **Table 3**. During survey periods, 63% of people who were approached agreed to take part in the surveys. The mean restorative benefit (averaging four 5-point Likert scale questions where higher numbers indicate greater agreement with statements about restorative benefit) across the 11 sites was 3.635 (SE = 0.094), indicating a general perception of positive restorative benefit. There was a significant difference in the restorative benefit reported by individuals among the 12 sites based on individual-level data ($F_{10,116} = 3.468$, $p = 0.001$).

In order to explore the relationships between ecological quality and site facilities and restorative benefit we first tested for collinearity in the predictor variables, which would inflate the SE of parameter estimates. VIF scores were calculated from a full model of all of the variables across the 11 green spaces used in the *in situ* study and showed that four of the biodiversity-related variables (plant, bird, and bee/butterfly species richness, and habitat number) all showed significant collinearity. To account for this collinearity, a new variable, hereafter called "ecological richness score," was derived from the first principal component of a principal components analysis using the four biodiversity variables. The ecological richness score accounted for 84% of the variance in the four component biodiversity variables and, once this factor was used, the VIF values for terms in the full model were below 3 for all variables.

Model selection using park-level data to explain variation in the restorative benefit reported by participants produced two highly supported models (where ΔAICc < 2 of the top model, **Table 4**). The top model contained only the ecological richness score and the second model contained the ecological richness score and tree cover (**Table 5**). Only the ecological richness score featured in both models and the model with only the ecological richness score had a model weight of 0.480 and explained 43% of the variance in restoration ($F_{1,9} = 8.658$, $p = 0.016$, $R^2 = 0.434$, **Figure 3**).

To evaluate the roles of different predictors of restorative benefit at the level of individual participants, mixed effects models were used to assess the individual level data with site as a random factor. The four biodiversity variables were collinear again, as in the park-level analysis, so the ecological richness score was calculated using PCA as above for this dataset. A full model was created using all variables (park-level data: site facilities, ecological richness score, tree number, habitat diversity; plus individual-level data: ethnicity, age, gender, connectedness to nature) and all possible variable combinations were compared using AIC, then model averaging was used with the model set that was within ΔAICc < 2 of the top model (**Table 4**). There were not enough individual survey results that included combinations of ethnicity, gender, and age groups to enable all three terms to be considered in the same model. Instead, each of those three variables was used in a separate model with the rest of the terms. Neither ethnicity nor age, however, appeared in the top models, and so only gender appears in the top model set

TABLE 4 | The models selected for model averaging where ΔAICc < 2 of the top models.

Model	*df*	AICc	ΔAICc	w_i
Park-level models				
Ecological richness score	3	22.72	0.00	0.63
Ecological richness score, tree cover	4	24.56	1.84	0.25
Individual-level models				
Ecological richness score, tree cover	5	370.58	0.00	0.20
Ecological richness score, connection to nature, tree cover	6	371.08	0.50	0.20
Ecological richness score	4	371.43	0.85	0.20
Ecological richness score, habitat diversity	5	371.54	0.96	0.13
Ecological richness score, connection to nature	5	371.88	1.30	0.11
Ecological richness score, connection to nature, habitat diversity	6	372.10	1.52	0.10
Ecological richness score, habitat diversity, tree cover	6	372.10	1.53	0.10
Ecological richness score, gender, tree cover	6	372.49	1.91	0.08

The null models had an AICc of 26.20 and 376.48 and a ΔAICc of 3.49 and 5.90 for the park- and individual-level models, respectively.

TABLE 5 | Average models for park-level and individual-level model selection explaining variation in restorative benefit based on models in **Table 4**.

Variable	Importance	Coefficient	SE	*Z*	*P*
Park-level models					
Ecological richness score	**2/2**	**0.497**	**0.171**	**2.552**	**0.011**
Tree cover	1/2	−0.026	0.015	1.447	0.148
Individual-level models					
Ecological richness score	**8/8**	**0.485**	**0.149**	**3.214**	**0.001**
Tree cover	4/8	−0.011	0.014	0.814	0.416
Habitat diversity	3/8	−0.221	0.452	0.488	0.625
Connection to nature	3/8	−0.043	0.094	0.454	0.650
Gender (female vs. male)	1/8	−0.008	0.059	0.139	0.900

Importance is defined as the fraction of top models (ΔAICc < 2) in which each term is found. Significant parameters are highlighted in bold.

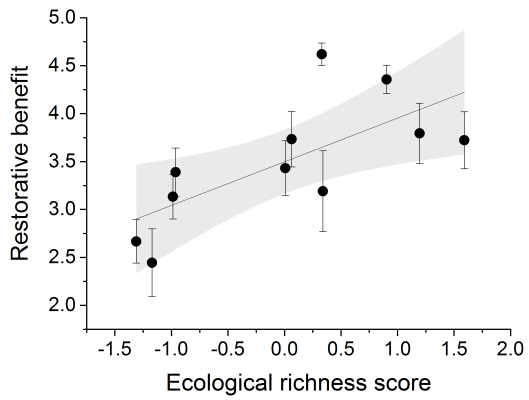

FIGURE 3 | The relationship between the ecological richness score (a composite score based on a combination of plant diversity, bird diversity, bee/butterfly diversity, and habitat number) and the mean restorative benefit of each park. Shaded area represents the 95% confidence band of the linear regression line.

(**Table 4**). The set of top models indicated that ecological richness score had by far the greatest model importance, appearing in all 16 of the top models (**Table 4**), as in the park-level analysis. To answer our second research question, restorative benefits perceived from parks were principally predicted by biodiversity, while site facilities did not feature in any of the top models (**Table 5**). Although connection to nature features in some of the top models, the effect sizes attributable to connection to nature were negligible (**Table 5**). Finally, in answer to our third research question, we find no evidence of the contribution of ethnicity or age to explaining variation in restorative benefit. While gender appears in some of the top models, the contribution of gender to the statistical model is negligible (**Tables 4**, **5**). Hence, our findings suggest that restorative benefit is independent of demographic characteristics.

DISCUSSION

We demonstrate that site facilities and ecological (i.e., biodiversity and habitats) quality of parks are positively correlated, suggesting not only that there is no trade-off but that higher quality parks have a function both for amenity and biodiversity. Furthermore, there are strong differences in the restorative benefits obtained from different parks. However, when the associations between different aspects of quality and restorative benefit are compared in models of both parks ($n = 11$) and individuals ($n = 128$), the restorative benefit of the parks appears to be predicted principally by biodiversity rather than

site facilities. When different demographic groups are compared, the benefits accrued in terms of restoration are independent of age, gender, and ethnicity. These results add to the growing evidence for an important role of biodiversity in driving the ecosystem services that can be derived from urban landscapes.

The major strength of this study in comparison with the existing literature was the consideration of both site facilities and biodiversity in exploring the benefits of green space. Previous studies have largely only considered site facilities, when biodiversity and habitat measures can make a difference to how people use and interact with green spaces (Nordh and Ostby, 2013; Roberts et al., 2018). In addition, previous studies have focussed on park level data (Fuller et al., 2007; Dallimer et al., 2012), but here the use of mixed models allowed individual level data to be analyzed to explore potential differences in restorative benefit with age, gender, ethnicity, and connection to nature. Restorative benefit and well-being have been shown to be correlated to "natural features" such as a high vegetation cover and plant/flower abundance (Nordh and Ostby, 2013), and plant richness, bird richness, and habitat diversity (Fuller et al., 2007; Southon et al., 2018). However, other studies suggest that the effect is not a direct benefit from biodiversity but is influenced by how biodiverse a person believes that environment to be (Dallimer et al., 2012). Our data support the link between biodiversity and well-being, but not between well-being and connectedness to nature that is commonly reported (Capaldi et al., 2014). One possible explanation could be the malleability of connectedness to nature as a concept. Nature connectedness can be influenced either by heightening self-awareness (Frantz et al., 2005) or by increasing exposure to natural places (Schultz and Tabanico, 2007). It is possible that urban populations have a relative low and similar degrees of connectedness to nature based on sporadic contact with natural places, as both connectedness and positive benefits can be enhanced through exposure to nature (Mayer et al., 2009). While previous studies have demonstrated links between connectedness to nature and well-being, our study was more about the evaluations of place, rather than of self. Hence, a direct relationship between perceived restorative benefit and nature connectedness may not be as intuitive as it first appears.

There were no differences discovered in the restorative benefits of green space between ethnic groups, in contrast to some existing literature (e.g., Dadvand et al., 2014). Access to green space only correlates with health outcomes in minority ethnicities with very poor health, but not with ethnic groups that enjoy better health (Roe et al., 2016) and so we might expect to see a difference between ethnicities. There are two potential explanations for this observation. The first is that our area of study is a relatively impoverished region of Bradford and so all ethnicities may have the same starting poor health. Second, our study population was not local residents for whom benefits from local green space might be influenced by access, cultural differences, economic status, mobility, or health problems, but the park users themselves. It could be that once the different ethnicities access the green space the differences in health outcomes are not significant, in contrast to the results of epidemiological studies that incorporate many barriers to access.

We expected that we would find an effect of age and connection to nature on well-being benefits, as has been described before (Luck et al., 2011), but neither exhibited a significant effect. It is possible that our self-selected sample of individuals – who had already made the choice to engage with the green space (by virtue of conducting surveys within those green spaces) – may exclude those individuals who are less connected to nature, and therefore have less to benefit from increased biodiversity (Mayer and Frantz, 2004). Children have been shown to exhibit no preference for biodiverse or wilder areas, even when they have access to those places (Hand et al., 2017), but only adults were included here and those adults tended to be older than the average for the area. A broader age range may have revealed underlying age-related patterns more clearly, and adult preferences do seem to show a positive association between perceptions of attractiveness and ecological diversity (Davis et al., 2016).

The move toward, and growing evidence base for, nature-based solutions to urban problems may facilitate secondary well-being benefits from new nature-based infrastructure (Keesstra et al., 2018). Nature-based solutions are typically defined as "*. . .actions to protect, sustainably manage and restore natural or modified ecosystems, which address societal challenges (e.g., climate change, food and water security or natural disasters) effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits*" (Cohen-Shacham et al., 2016). These definitions seem to limit health-related outcomes to ancillary or secondary benefits of solutions that focus on largely engineering-based problems. However, there is clearly a strong need for nature-based solutions that have health improvement as a key primary outcome, and this could be achieved through the enhancement (in extent and quality) of urban green and blue spaces. It is worth noting that closer inspection of green space types has shown that other ecosystem services such as air purification and climate regulation also vary between different types of green space (Vieira et al., 2018). There are obvious implications for general urban green space management and planning. In an urbanizing world where mental illness is not being reduced despite substantial increases in the investment in treatment (Jorm et al., 2017), the central tenet of urban planning must be human health and well-being (Barton et al., 2009), and this process must necessarily include a consideration of biodiversity (Sandifer et al., 2015). A survey of green space managers in America showed that they feel that there is a movement toward managing for ecosystem services (Young, 2010), such as improving human well-being. Similar patterns are seen among Swedish green space managers, who report local targets for green spaces in terms of stormwater management, education, and health alongside biodiversity (Randrup et al., 2017). Broader trends in "urban greening" suggest that increasing nature in cities is associated with a number of outcomes, including biodiversity and health, across the United States, Canada, and Western Europe (Anguelovski et al., 2018). Yet studies that have considered all green spaces as equally valuable have not been adequate to inform policy on improving human health and would likely have no impact on improving urban biodiversity (Dean et al., 2011).

The number of studies considering associations between different aspects of well-being and a broad range of green space variables is small and so it is premature to make policy recommendations. However, there are potentially substantial, cost-effective health gains to be made should policymakers incorporate green space enhancement into health care budgets. Funding associated with the maintenance of urban green spaces has been reduced for 92% of park managers in the United Kingdom from 2012 to 2015 (Heritage Lottery Fund, 2016), while costs of mental health treatment and impacts continue to increase to over £100bn (Department of Health, 2011). Results such as ours provide further provisional support for the prescribing of green space as a cost-effective investment for mental health, in addition to the current park prescriptions for physiological health. With green space being increasingly proposed as a tool to aid psychological well-being, the addition of increasing biodiversity as a management strategy (e.g., Taylor and Hochuli, 2015) also has great implications for improving urban conservation and restoration of biodiverse habitats. Urban planning that includes many connected, high quality green spaces has the potential to provide major improvements to the ability of urban areas to hold diversity and connect surrounding areas (Goddard et al., 2010; Lepczyk et al., 2017). Subsequent work should examine the impacts of budgetary limitations on the maintenance of urban green spaces and the trends in ecosystem services that are derived from them. Visitors to parks often view both naturalness and neatness as high priorities for green spaces, which complicates management (Ngiam et al., 2017). Neatness also factors into issues of safety, which are often also antagonistic to biodiversity and naturalness (Schroeder and Anderson, 1984). However, it has been suggested that rather than "de-vegetating" to make spaces safer through the elimination of hiding places, it would be better to "re-people" spaces through the creation of social events in those spaces (Gobster and Westphal, 2004).

The current study has some limitations. It was based within a multicultural deprived urban area, and the extent to which the findings translate to more affluent areas needs be demonstrated. There is a lack of evidence concerning the precise mechanisms by which ecological or biological park parameters (e.g., species richness) are perceived by and influence people, and it is possible that our suite of ecological measurements excludes some parameters that are relevant. For example, area itself may have a direct impact on restorative benefit via a sense of isolation, or might enhance opportunities for exercise which, in turn, improve well-being (Berman et al., 2012; Aspinall et al., 2015). Perceived naturalness (which is likely linked to area) has been shown to interact with perceived restorativeness to enhance positive outcomes from green space exercise (Marselle et al., 2015). Acoustic stimuli have also been shown to be important in stress reduction (Alvarsson et al., 2010; Annerstedt et al., 2013), but soundscapes were not monitored in the green spaces in this study. Due to resource limitations we were unable to include participants who did not speak English, and so the results may underestimate ethnic differences if those potential participants with larger cultural differences were unable or unwilling to take part. Participants completed surveys *in situ* and their perceptions of the psychological restoration of parks may differ from non-park users.

Our survey sample was broadly representative of the local resident population based on census data, apart from an over-representation of older individuals. Age is known to be one of a range of factors that influence self-reported measures of well-being in national surveys (Steptoe et al., 2015) but was not associated with well-being in this study. More generally, subjective measures of well-being have been shown to be associated with lower mortality and have been advocated for inclusion in national statistics for social and economic progress (Stiglitz et al., 2009). There is a considerable body of instruments that can be used to evaluate subjective well-being in a generic sense, with great variation between those instruments in the conceptual basis and what, exactly, is being measured (Linton et al., 2016). However, our approach uses a focused and well tested survey instrument that, while it is specific to restorative benefits associated with place, has been shown to be consistent and well-grounded in theory (Hartig et al., 1997; Nordh et al., 2009). Despite this, there are considerable opportunities to enhance data collection using objective measures of well-being, such as health outcome data from longitudinal studies (Dadvand et al., 2014; Mceachan et al., 2015) or *in situ* measures of stress (Roe et al., 2013).

CONCLUSION

Our paper is one of the first to explore explicitly relationships between objectively assessed biodiversity, site facilities and participant reported assessed of psychological restoration. We found that biodiversity and site facilities were positively correlated within urban parks. However, we found that only biodiversity was related to perceptions of psychological restoration amongst a multi-ethnic group of participants. These findings suggest that urban planners should aim to enhance ecological diversity in urban green spaces. Specifically, there are likely to be secondary benefits from nature based solutions in cities which introduce additional green or blue infrastructure in place on gray infrastructure. However, there are also opportunities for nature based solutions that have health outcomes as a primary aim, such as expanded or increased numbers of parks, planting of trees to minimize urban noise pollution, and enhancement of botanical or floral diversity that seems to be most strongly associated with restorative benefit across studies. Future research is warranted to test the replicability of these emerging findings in other social, geographic and ecological contexts. Beyond epidemiological studies, empirical work is particularly needed to produce a stronger and more persuasive evidence base for policymakers.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the Faculty of Biological Sciences Research Ethics Committee at the University of Leeds. The protocol was

approved by the Faculty of Biological Sciences Research Ethics Committee at the University of Leeds (ref: LTSBIO-004). All subjects gave written informed consent in accordance with the Declaration of Helsinki.

AUTHOR CONTRIBUTIONS

All authors contributed to the design of the experiment and writing of the manuscript. EW and AH collected the data in the field. EW and CH analyzed the data.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2018.02320/full#supplementary-material

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For the Love of Nature: Exploring the Importance of Species Diversity and Micro-Variables Associated with Favorite Outdoor Places

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Although the restorative benefits of nature are widely acknowledged, there is a limited understanding of the attributes of natural environments that are fundamental to restorative experiences. Faced with growing human populations and a greater awareness of the wellbeing benefits natural environments provide, park agencies and planners are increasingly challenged with balancing human and ecological outcomes in natural areas. This study examines the physical and experiential qualities of natural environments people referred to when describing their connection to their most valued natural environments in an online questionnaire. Recruited primarily via a public radio program, respondents were asked to identify their favorite places and explain what they loved about those places. Favorite places are considered exemplars of restorative environments and were classified based on an existing park typology. Reasons people liked particular sites were classified into three domains: setting, activity, or benefit. Content analysis was used to identify the attributes most commonly associated with favorite places. These attributes were then related to the four components of restorative environments according to Attention Restoration Theory. In contrast to previous research, we found that "fascination" was the most important component of favorite places. Possible reasons for this contrast, namely, respondents' median age, and the likelihood of a high degree of ecological literacy amongst the study population are discussed. South Australians' favorite environments comprise primarily hilly, wooded nature parks, and botanical gardens, in stark contrast to the vast arid areas that dominate the state. Micro-variables such as birds, plants, wildlife, native species, and biodiversity appear particularly important elements used to explain people's love of these sites. We discuss the implications of these findings and their potential value as an anchor for marketing campaigns seeking to encourage contact with nature, as well as education programs designed to improve people's understanding of important but intangible concepts such as biodiversity. The findings have clear, practical

implications for park managers given the modifiable nature of many of the attributes identified as being most important to our respondents, and we believe attention to such elements has the potential to simultaneously enhance people's nature experiences, optimize restorative outcomes, and improve environmental stewardship.

Keywords: biodiversity, ecological literacy, favorite places, nature connectedness, restorative environments

INTRODUCTION

For many people contact with nature is no longer a by-product of everyday life. For the vast majority of human history, we relied upon the natural environment for food, water, and shelter in very direct and unambiguous ways, as all species do. Today, although we are equally dependent upon the environment to sustain us, the majority of the world's population now resides in towns and cities (The United Nations, 2014), where they are largely sheltered from the natural processes and ecosystem services that make their existence possible (Miller, 2005). The consequences of this separation between "people" and "nature" are two-fold. Firstly, as each succeeding generation becomes increasingly disconnected from the natural world, the collective importance placed upon the environment by urban populations is likely to diminish (Pyle, 2002). In turn, this may lead to reduced advocacy and funding for conservation and biodiversity protection, which has long-term global implications. Secondly, a lack of contact with the environment is thought to be a contributing factor to the increasingly poor health and wellbeing of urban inhabitants (Maller et al., 2008), which some scholars suggest is the result of a failure to fulfill our inherent biological need to spend time in nature (Wilson, 1984).

In order to develop policies and practices that see contact with nature become commonplace again, we must first understand the activities, environmental settings, and benefits that encourage people to seek out nature experiences. As exemplars of restorative, health-giving environments, we believe investigating perceptions of "favorite places" and the attributes people describe when explaining their connection to these settings will provide valuable information for urban planners seeking to optimize the health benefits of nature. In this paper we explore the attributes of outdoor environments that people place great personal importance on and consider the implications of these findings to modern societies.

The Psychological Benefits of Contact with Nature

The well-being benefits of contact with nature has long been a topic of interest to researchers across diverse disciplines, and there is now a broad evidence base supporting a positive relationship between human health and nature (e.g., Velarde et al., 2007; Keniger et al., 2013). The influence of the quality of natural environments on mental health, and the relative importance of individual environmental variables on psychological outcomes, are examples of areas that remain poorly explored (Gascon et al., 2015). Despite concerns raised by researchers regarding the methodological limitations and lack of consistency in the results of some nature-health research (Lee and Maheswaran, 2011; Hartig et al., 2014; Gascon et al., 2015), studies into human interactions with nature are generally supportive of the premise that natural environments have a more favorable effect on human psychological health than do urban or built environments, whether experienced indirectly or directly through visual (Kaplan and Kaplan, 1989; Ulrich et al., 1991), auditory (Alvarsson et al., 2010; Annerstedt et al., 2013), or olfactory contact (Tsunetsugu et al., 2010). People living in urban areas with more green space are often found to have better mental health and perceived general health than people living in urban areas with less green space, even when controlling for a range of extraneous factors such as income and marital status (De Vries et al., 2003; Beyer et al., 2014). Studies suggest that visiting or viewing natural settings may improve concentration in children with ADHD (Taylor and Kuo, 2009); reduce anxiety in hospital patients (Beukeboom et al., 2012); minimize perceived pain and discomfort (Diette et al., 2003); restore cognitive function (Hartig et al., 1991); and facilitate recovery from stress (Ulrich et al., 1991; Beil and Hanes, 2013). Furthermore, contact with nature has been associated with lower frustration (Aspinall et al., 2015); increased happiness (Mackerron and Mourato, 2013); improved mood and self-esteem (Barton and Pretty, 2010); and faster recovery from surgery (Ulrich, 1984). For these reasons and more, it is not surprising that the presence of natural space in urban areas is considered by many to be a form of "upstream health promotion" that has the potential to positively influence human wellbeing on a population-wide scale (Maller et al., 2006).

In spite of a growing body of research documenting the importance of nature to human health, natural space in many urban areas is decreasing (McDonald et al., 2010; Sivam et al., 2012). The demand for infrastructure to meet the needs of growing urban populations is often met through the development and modification of natural areas. This is of great concern, as a lack of green space reduces opportunities to experience nature, and may be impacting the mental health of urban inhabitants (Bratman et al., 2015). In Australia, urban residents are more likely to suffer from high or very high psychological distress (Australian Bureau of Statistics, 2011) and face a higher risk of developing substance use disorders than rural residents (Cantwell et al., 2012). The story is similar in other western nations such as Great Britain, where people residing in cities have been found to have poorer mental health than their rural counterparts (Paykel et al., 2000). Some researchers have estimated that urban inhabitants face a 21% greater risk of developing an anxiety disorder, and a 39% greater risk of developing a mood disorder than rural inhabitants (Peen et al., 2010). The proportion of the global population residing in urban areas is expected to continue rising for decades to come (The United Nations, 2014), and with this shift, we can expect to see continued increases

in psychological disorders such as chronic stress, anxiety, and depression. Providing planners with information about the attributes of natural environments that optimize recovery from stress and fatigue may therefore contribute to improving quality of life for many people.

A Healthy Urban Environment

Increasing the amount of natural space in urban areas, or "neighborhood greening" has been proposed as one possible approach to helping create a healthier living environment for urban inhabitants (Beyer et al., 2014). However, some studies indicate that simply having more green space in urban settings may be ineffective at improving human health (Richardson et al., 2012) or promoting greater use of natural environments (Francis et al., 2012). After decades of research that followed a largely dichotomous "urban" vs. "natural" environments approach, many scholars have noted there is a dearth of information regarding the actual attributes of natural environments that are required to facilitate psychological benefits (Frumkin, 2003; Nordh et al., 2009; Keniger et al., 2013). More recently, researchers have begun focusing on the "micro" features of natural settings that might promote greater use and improve mental health outcomes in urban areas. As opposed to "macro" features, which typically include landscape-scale elements such as the quantity of green space in a given area, or its proximity to people's homes, "micro" features refer to site-specific differences between green spaces that might encourage use or enhance visitor experiences. Such "micro" features may include particular vegetation types, opportunities to view wildlife, specific landscape elements such as creeks, and physical amenities such as trails or exercise equipment. In Perth, Western Australia, Francis et al. (2012) used the Public Open Space Tool (POST) to assess park quality, considering "micro" variables such as walking trails, shade, birdlife, and the presence of water as contributors to park quality, based on the opinion of an expert panel. Their study concluded that the quality of green space in one's neighborhood was more important to one's mental health than the quantity of green space or the frequency with which one visited it. Other studies have found that different types of urban green space facilitate different types of health benefits (Brown et al., 2014); that the psychological benefits of contact with nature may be positively influenced by biodiversity (Fuller et al., 2007; Carrus et al., 2015) or perceived biodiversity (Dallimer et al., 2012); and that restorative outcomes may be associated with naturalness in pocket parks (Nordh et al., 2009). In this study, we aimed to identify the types of natural environments and "micro" attributes that are most important to South Australians. Using self-reported "favorite places" as exemplars of restorative environments, we also explored the relative importance of the key components central to Attention Restoration Theory (ART) (Kaplan and Kaplan, 1989).

Restorative Experiences and Favorite Places

The restorative benefits of natural environments are widely documented (e.g., Kaplan and Kaplan, 1989; Hartig et al., 2003), and have been a prominent feature of nature-health research for decades. Restoration refers to the psychological and/or physiological recovery one experiences during exposure to certain environments, and is most commonly explained by two dominant theories in the field: ART and Stress Reduction Theory (SRT). The two theories attempt to describe the mechanisms by which natural environments have a positive effect on human wellbeing, with ART concerning recovery from cognitive or attentional fatigue (Kaplan and Kaplan, 1989), and SRT concerning recovery from stress (Ulrich, 1983). In nature-health research, ART and SRT have commonly been regarded as "complementary perspectives that focus on different aspects of the restorative process" (Joye and Van Den Berg, 2013, p. 59).

According to ART, an environment is more likely to be restorative if it exhibits four characteristics: (1) it allows for a feeling of "being away" by being geographically and/or psychologically distant from the daily hassles of life and the sources of attentional fatigue; (2) it has sufficient "extent" and scope to allow for an immersive experience; (3) it is able to offer "compatibility" with the intentions/needs of the person experiencing the environment; and (4) it provides "soft fascination" to catch one's attention without cognitive effort. As opposed to fascination in general, which may be derived from stimuli such as car accidents or violent scenes, settings that are rich in soft fascination—such as "the play of light on foliage" (Kaplan and Kaplan, 1989, p. 193)—capture our involuntary attention in a non-threatening way, allowing the mind to wander and our attentional capacity to replenish. Generally, these features are more characteristic of natural rather than urban or built environments (Kaplan and Kaplan, 1989).

Natural environments are frequently cited as being "favorite places" of participants in restoration and place attachment research (Newell, 1997; Korpela and Ylén, 2007). Favorite places are those locations that individuals have formed an "emotional tie or affective bond" with (Korpela et al., 2009, p. 96). They are places that one might "value being in more than any other place" (Korpela et al., 2001, p. 579), or would choose to protect from "damage or destruction" above all others (Newell, 1997, p. 500). It has been suggested that this emotional bond forms because favorite places facilitate self-regulation, the act of mentally processing the psychological influences of external factors such as emotionally arousing situations (Korpela and Ylén, 2007) or sensory stimuli (Korpela, 1992). Self-regulation occurs when one applies mental, social, physical, or environmental strategies to help regulate their feelings and maintain their sense of self, or self-esteem. As restorative experiences may involve "reflection on oneself and one's place in the world" (Korpela and Hartig, 1996, p. 222), interacting with natural environments can be considered a form of environmental self-regulation (Korpela and Ylén, 2007). People are known to actively seek out natural environments when they are in need of restoration (e.g., Irvine et al.'s, 2013) and preferences for nature are found to be higher in individuals who are in greater need of restorative experiences (Hartig and Staats, 2006). According to Korpela et al.(2001, p. 573) "places that a person can rely on for restorative experiences are thus more likely to be places for which attachments develop over time and that in turn come to figure in place identity." Tellingly, individuals prescribed with visiting their favorite places have been shown

to experience significantly stronger restorative outcomes than individuals visiting other places (Korpela et al., 2009). For this reason, favorite places have been used as a "window" into restorative environments in previous research (Korpela et al., 2008, p. 637).

Favorite Places and Environmental Attributes

As "exemplars" of environments used in self-regulation and restorative experiences (Korpela and Hartig, 1996), an evaluation of the types of natural environments people consider to be their favorite places is relevant, as is identifying the elements people use to explain why an area is favored. A search for "favorite place" or "favourite place" literature published in peer reviewed journals over the past 30 years revealed only 10 articles. The majority of these articles were conducted by Korpela and associates, and have been primarily based in Europe. Two studies took place in the United States (Newell, 1997; Korpela et al., 2001), one of which also collected data in Ireland and Senegal (Newell, 1997). No explicit "favorite place" research appears to have been conducted in Australia. Each article was assessed to identify the types of environments and environmental characteristics that respondents valued most highly (**Table 1**).

In general, natural settings were the most commonly identified favorite places, with two exceptions (Korpela, 1991, 1992). Overall, there was great variation in the types of natural environments reported as favorite places, which may be a result of the classification systems used in different studies. Only two studies (Korpela, 1989; Korpela and Hartig, 1996) explored the attributes of favorite places. As shown in **Table 1**, "beautiful views" and "sunlight" were the most frequently mentioned attributes of favorite places in Korpela and Hartig (1996), and in Korpela (1989) responses such as "homelike" and "peaceful" featured frequently. Two studies also related responses back to the components of restorative environments by using the Perceived Restorativeness Scale (PRS) (Korpela and Hartig, 1996; Korpela et al., 2001). Interestingly, in both of these studies, fascination was found to be the least important component of restoration in favorite places.

The Importance of Healthy Natural Environments

Fascination is a central component of restorative experiences (Kaplan, 1995), and the likelihood of restoration is thought to be greater in natural environments that exhibit more fascinating qualities (Nordh et al., 2009). Fascination has been related to concepts such as naturalness (Nordh et al., 2009; Van Den Berg et al., 2014) and wildness (Annerstedt et al., 2012), which may also relate to ecological quality (Winter, 2012). As fascination refers in part to the ability of an environment to capture and hold one's attention, and natural scenes are considered to "contain many more fascinating features or elements than urban environments" (Joye et al., 2013, p. 3), it stands that dynamic environments containing a greater variety of plant and animal species might thus generate greater fascination. Indeed, visitors to high biodiversity environments have been found to derive a greater level of psychological benefit than visitors to low biodiversity environments (Fuller et al., 2007; Carrus et al., 2015), although this was not directly linked to fascination by the researchers.

There have been repeated calls for research that provides insight into the specific features of natural environments that are required for the attainment of psychological benefits (e.g., Frumkin, 2003; Velarde et al., 2007; Bratman et al., 2012; Keniger et al., 2013). There is a dearth of practical information on this topic available to park agencies tasked with balancing human and environmental benefits in parks and protected places. Furthermore, studies into the health benefits of natural environments have been almost exclusively anthropocentric in nature, and have paid little attention to the health of ecosystems (Jorgensen and Gobster, 2010; Lang and Rayner, 2012). As environmental health and mental health in many urban areas continues to deteriorate, research that prioritizes the health of both human beings and the natural environment will be of increasing importance (Parks Victoria, 2015). As exemplars of restorative, health-giving environments, we believe investigating perceptions of "favorite places" and the natural micro features that people use to explain their connection to these settings will provide valuable information for urban planners seeking to optimize the health benefits of nature. Using previous restoration research as a means to classify responses, we also sought to explore how Australians compared to their European and North American counterparts, in terms of the relative importance they placed on the four components of restorative environments according to ART. The three questions that guided our inquiry were:

1. Which types of natural environments do South Australians value most highly?
2. What attributes of natural "favorite places" do individuals take notice of and use to explain their connection to these places?
3. Does the relative importance of the four ART components in Australian "favorite places" reflect those of European and North American favorite places?

METHODS

Study Setting

The study was conducted in South Australia, a state that spans an area of 984,377 km² and contains a population of 1.7 million people (Australian Bureau of Statistics, 2015). The state's diverse landscapes, varying described as varying "from rugged outback wilderness and desert to scenic mountain ranges and a coastline that stretches more than 3,700 km" (South Australian Government, 2014, p. 1), made it an ideal location to examine the attributes that are associated with favorite places. The state's population resides primarily in the capital city, Adelaide (77%), but also in large regional centers, and hundreds of small country towns. The study surveyed residents across the State as a whole, to learn more about "favorite places" within South Australia.

TABLE 1 | Favorite place types and features identified in previous research.

Author/s	Favorite Place Types	Method of identifying favorite places	Consideration of ART	Consideration of attributes	Study Population
Korpela, 1989	Focus was on feelings created by the environment, rather than the physical characteristics of it. However, features frequently described by respondents included: homelike, peaceful, secure, comforting, huge, indomitable, powerful, beautiful, silent, rugged, pleasant smell of wood, and colorfulness and grayness and ugliness at the same time.	Survey and essay. Survey: the 9 and 12-year old students answered 10 verbally delivered questions, asking them to describe their favorite place and why they like to visit it. Essay: the 17-year old students were asked to write an essay about their favorite place, its features, the feelings it gives them, and the mood they are in when they visit it.	No	Yes	Students aged 9, 12, and 17 years old, in and near Tampere, Finland
Korpela, 1991	Most common types of favorite places were: private homes (39%), restaurants/downtown (16%), natural settings (14%), sport facilities (14%), clubs (7%), and "other," such as a car or motorcycle (10%).	Essay: in first study, respondents were asked to write an essay on their favorite place, explaining why it was important to them and what experiences and feelings they had there. In second study, participants were asked to write an essay on their experiences in their favorite place, focusing on the situations and feelings that motivated them to go there.	No	No	Students aged 17–18 years, near Tampere, Finland
Korpela, 1992	Most common types of favorite places were: private homes (39%), natural settings (15%), restaurants/downtown (15%), sport facilities (13%), clubs (7%), and "other," such as a car or motorcycle (7%).	Essay: students were asked to write an essay about their favorite place, describing what sort of place it was, why it was their favorite place, and what personally important thoughts, feelings or experiences they have had there.	No	No	Students aged 17–18 years, near Tampere, Finland
Korpela and Hartig, 1996	Using a list of characteristics, respondents indicated the extent to which they were present in their favorite places. The most frequently reported characteristics were: beautiful views (83.3%), sunlight (83.1%), the presence of water (73.1%); and the presence of personal belongings (56.4%).	Survey: respondents were asked to evaluate seven settings, including a "favorite" and "unpleasant" place in their life, by completing the Perceived Restorativeness Scale (PRS) and the Zuckerman Inventory of Personal Reactions (ZIPERS).	Yes	Yes	Students from the University of Tampere, Finland. Aged 19–46 years
Newell, 1997	Natural sites in general were the favorite places of respondents. Ten place type categories ranked according to frequency: (1/2) "personal bedroom/belongings" were equal with "outdoors, nature, the Earth"; (3) beaches/coastline; (4) family home and surroundings; (5) built environment, pubs, streets; (6/7) woods/forests were equal with countryside/fields; (8) mountains; (9) recreation areas/parks; (10) rivers, lakes, and ponds.	Survey: open-ended responses to a question about their one favorite place "to save from damage or destruction."	No	No	Psychology and sociology students from universities in: USA, Ireland and Senegal. Aged 18–45 years
Korpela et al., 2001	Largest proportion of favorite places (48%) were natural spaces, followed by residential sites (19%); geographic areas such as a country or city (16%); leisure settings such as amusement parks and zoos (5%); and school/university settings (4%).	Survey: open-ended responses to questions about their favorite place. Respondents asked to imagine being in their favorite place, "that one place in which you have most enjoyed spending time, or that you have valued being in more than any other place. Perhaps you view this place as being particularly significant in your life." Also completed the PRS.	Yes	No	Psychology students from Berkeley, United States. Aged 17–47 years
Korpela and Ylén, 2007	Natural sites favorite places of 51% of respondents. No figures provided for place types, but the most frequently mentioned favorite natural places were nearby parks, woods, and seashores.	Survey: open-ended responses to the question: "Think about your residential area for a moment. What is your *favorite* place within the area? This place may be located indoors or outdoors."	No	No	Residents of four residential areas in Helsinki, Finland. Average age 40 years

(Continued)

TABLE 1 | Continued

Author/s	Favorite Place Types	Method of identifying favorite places	Consideration of ART	Consideration of attributes	Study Population
Korpela et al., 2008	Natural sites favorite places of majority of respondents. Sixteen favorite place types were grouped into five main place types. Ranked according to frequency: (1) extensively managed natural areas, e.g. woods, forests, meadows; (2) built-up green spaces, e.g. parks; (3) waterside environments, e.g. beaches and harbors; (4) exercise and activity/hobby areas, e.g., playgrounds and sports ovals; (5) indoor and outdoor urban/built areas.	Survey: rating the personal significance of 16 types of settings in the local area. Selecting one type in which their favorite place is represented, and describing that place. Descriptions used to categorize place types.	No	No	Residents of Helsinki and Tampere, Finland. Aged 15–75 years
Korpela and Ylén, 2009	Natural sites favorite places of majority of respondents. Looked at consistency of re-selecting same type of favorite place over a 10-month period. Most frequently selected favorite places in both surveys were small-scale natural state areas, beaches and harbor areas, and large forest areas.	Survey: rating the personal significance of 16 types of settings in the local area. Selecting one type in which their favorite place is represented, and describing that place. Descriptions used to categorize place types.	No	No	Residents of Helsinki and Tampere, Finland. Aged 15-75 years.
Korpela et al., 2010	Natural sites favorite places of majority of respondents. Sixteen favorite place types were grouped into five main place types. Ranked according to frequency: (1) extensively managed natural areas, e.g. woods, forests, meadows; (2) built-up green spaces, e.g. parks; (3) waterside environments, e.g. beaches and harbors; (4) exercise and activity/hobby areas, e.g. playgrounds and sports ovals; (5) indoor and outdoor urban/built areas.	Survey: rating the personal significance of 16 types of settings in the local area. Selecting one type in which their favorite place is represented, and describing that place. Descriptions used to categorize place types.	No	No	Residents of Helsinki and Tampere, Finland. Aged 15–75 years

Data Collection and Procedure

Data collection took place between 1 September and 30 November 2014, using an online questionnaire. The questionnaire consisted of 19 questions exploring participants' use of public and private green spaces, their memories of interacting with nature as children, the centrality of nature in their lives today and a set of demographic questions. The questionnaire also contained two open-ended questions, which form the focus of the present paper. Respondents were asked "what are your favorite outdoor places in South Australia?" and "What is it that you love most about these places?"

Following approval by the University of South Australia Human Research Ethics Committee, the survey was launched on a specially designed webpage that included short human interest stories about outdoor experiences, as well as podcasts of a 6-week radio program titled "Operation Outdoors." The survey was kept open for 6 weeks after the end of the radio program. The webpage was hosted by ABC Adelaide, who in 2015 held a 12.5% share of South Australia's radio audience; the second most popular radio station in the State (Commercial Radio Australia, 2015). As part of the Australian Broadcasting Commission (ABC), ABC Adelaide's existing website received high traffic and we were confident the popularity of the company's website would lead some people to the Operation Outdoors page independent of promotion. In addition, the page was promoted during the 6-week program of bi-weekly "talkback radio" sessions hosted by two of the authors. The radio sessions focused on an eclectic mix of topics related to the natural environment. Broadly speaking, the radio segments were conversations encouraging people to reminisce about outdoor experiences and the value of those experiences, rather than conversations about specific places. Half of the sessions discussed historical perspectives of green spaces, and included topics such as "A Spring in My Step," "The Value of Parklands," and "Drunkenness or Civilization: the Story Behind our Gardens." This novel method of recruitment was trialed due to the increasing difficulty of engaging the public to complete surveys. Given the indirect method of participant recruitment for this convenience sample, a traditional study response rate cannot be calculated. Participation in the study was voluntary, and no incentive was provided to respondents.

To investigate potential bias, we examined the timing of questionnaire completions, and while there was a peak in responses on the day of each radio session, there was steady traffic throughout the week, and also during the 6 weeks after the program had finished. Audio recordings of each radio session were transcribed, allowing us to examine potential bias in self-reported "favorite places" that might be associated with mentioning specific natural sites during the radio segments. Notably, in the week the radio hosts discussed the history of gardens there were more mentions of the Botanic Garden (17.5% greater that week), compared to the other 11 weeks. This should be taken into consideration when viewing the results.

Overview of Respondents

In total, 447 people completed the questionnaire. The majority of respondents were female (65.7%), mature aged (range: 14–81 years; mean 52 years), and highly educated (53.66% with a bachelor degree or higher), as shown in **Table 2**. Commensurate with this, the majority of respondent households contained mature/older adults with no children (55.3%, i.e., mature singles and older couples with no children at home). According to census data (Australian Bureau of Statistics, 2015) the demographics of the study sample are not necessarily reflective of the South Australian population, which has a lower proportion of females (50.7%); a younger median age of 39 years; a greater number of households with children (57.8%); and far fewer people with university degrees (14.4%). This is likely a result of the methods used to recruit participants, as both the radio station, and the particular program which included discussions and interviews about the environment and our historic use of it, were more likely to attract an older, more highly educated audience.

TABLE 2 | Overview of respondent characteristics ($N = 447$).

Demographic variable	Option	Percentage
Gender	Female	65.7
	Male	34.3
Education	Bachelor degree	30.49
	Postgraduate degree	23.17
	Some undergraduate tertiary	14.02
	Secondary school	13.72
	Vocational/technical training	12.50
	Primary/some secondary school	6.10
Lifecycle	Older couple, no children at home	34.0
	Mature single	21.3
	Middle family (youngest child 6-15 years of age)	12.3
	Mature family (all children over 15 years of age)	10.2
	Young single	9.3
	Young family (youngest child <6 years of age)	7.7
	Young couple, no children	5.2

Analysis

Participants' favorite places and demographic data were analyzed using SPSS® software to calculate descriptive statistics such as frequencies and means. Participants' responses about why they loved particular places were coded in QSR Nvivo® using inductive content analysis. Directed content analysis was used to examine the relative importance of the four ART components in Australian "favorite places." The two procedures are explained in the following sections. Similar to Irvine et al.'s (2013) study, where multiple answers were provided by respondents, they were treated as separate, individual statements.

Popular Types of Natural Favorite Places

Favorite places were initially grouped by name so that we could ascertain which favorite places were shared amongst multiple respondents. This process resulted in 241 unique locations across South Australia. These favorite places were then classified using a modified National Recreation and Parks Association (NRPA)

park typology (Mertes and Hall, 1996) to identify the types of natural environments that are favored by the public. The NRPA classification system primarily differentiates parks according to their size, location, and use. However, given the non-spatial method of data collection in the present study, we made several modifications to the park typology that we considered to be more locally indicative of how the parks were used. These changes—such as combining neighborhood, mini, and community parks—are shown in **Table 3**, which outlines the eight classifications used in the study and provides a rationale for changes made to the original NRPA typology.

Loved Attributes of Natural Favorite Places

To identify the loved attributes of respondents' favorite places we used an inductive approach to content analysis, whereby we avoided using preconceived categories and instead allowed the categories and their names to flow from the data as we explored it (Hsieh and Shannon, 2005). Although the majority of characteristics identified by Korpela (1989) and Korpela and Hartig (1996) were also in our final word lists, we did not confine our content analysis to the items used in those studies, for several reasons: (1) Lack of background knowledge as to how Korpela and Hartig (1996) derived the initial list of 16 attributes that they provided their respondents with; (2) We believed a list of 16 attributes was unlikely to be sufficiently exhaustive to accurately reflect the experiences of hundreds of respondents in hundreds of different locations; (3) Some of the items used in the previous studies were not suitable for a South Australian context, such as "lake ice" (Korpela and Hartig, 1996); (4) Korpela's (1989) focus was on feelings created by favorite places, and as a result he paid little attention to the attributes he identified as being important, such as "greyness" and "ugliness," but rather the feelings they conjured; and lastly, (5) There was little consistency between the two previous studies in terms of the attributes they identified, which further encouraged us to err on the side of caution and follow an inductive approach. Whilst conducting the inductive content analysis we believed there was some risk of bias, in that we might misinterpret certain statements simply by restricting them to a single node. To minimize this potential bias, the researchers undertook the first step together, and when necessary, allowed responses to be coded into multiple nodes to avoid making assumptions about intended meanings.

An initial sample of 100 responses was read by the researchers, who agreed there were three broad themes running through the data, namely: descriptions of the physical environment, recreational activities that occurred in favorite places, and the benefits people derived or desired from them. Following this early analysis, we used Moore and Driver's (2005) synthesis of benefit research to strengthen category formation, and using the complete set of responses, highlighted all occurrences in which we believed the respondent was referring to an aspect of the biophysical setting, an activity, or a benefit. Discrepancies were overcome through discussion and the establishment of rules that enabled similar phrases or words to be categorized consistently. Following the extraction of all setting-, activity-, and benefit-related responses, a similar approach using multiple researchers to triangulate results was used in further analysis and coding into sub-nodes. The nodes used in the study are shown in **Table 4**, along with examples of sub-nodes and participant responses. A complete list of sub-nodes can be obtained from the authors upon request.

Relative Importance of ART Components in Natural Favorite Places

The third objective of the study was to explore how participants' personal descriptions of their favorite places related to the four components of restorative environments according to ART, i.e., being away, fascination, extent, and compatibility. To do this, we used a directed approach to content analysis, where existing research about restorative environments helped to determine the initial coding scheme (Hsieh and Shannon, 2005). To begin, we compiled lists of words that have been used in previous restorative environments studies to describe the four components of ART (e.g., Kaplan, 1995). Many words and phrases were adopted from the PRS developed by Hartig et al. (1997). After an initial read-through of the responses, we were able to add words and phrases to the lists, which we felt were reflective of particular ART components. At times we used a thesaurus to identify related words, or in the case of "chaos" from the PRS, to identify antonyms. The use of a thesaurus also helped the researchers to reach consensus about which component of ART particular words related to.

As with the inductive coding used to identify loved attributes of favorite places, when necessary, we again allowed responses to be coded into multiple nodes. In doing so, we acknowledged that some responses, such as particular environmental attributes, might be correlated with multiple items. For example, using the PRS, Scopelliti et al. (2012) found that biodiversity was correlated with being away, compatibility, extent, and fascination. It is generally agreed that an interest in observing natural elements is consistent with the construct of fascination, rather than compatibility [e.g., "many interesting things" and "looking at the surroundings" from the PRS (Hartig et al., 1997) and "living things" from Joye et al. (2013)—see **Table 5**]. Thus, it seems that a significant relation between biodiversity and all four ART components, e.g., in Scopelliti et al. (2012), could be due to a method bias associated with the PRS as discussed by Joye et al. (2013, p. 2)—i.e. correlations between items may simply be "due to employing one common method of measurement for all these items." Therefore in the present study, unless respondents explicitly referred to engaging in an activity dependent on particular natural features, such as "bird watching," references to natural elements (including biodiversity) were coded solely as fascination. The word lists are provided in **Table 5**.

RESULTS

Popular Types of Natural Favorite Places

Respondents were asked the question, "What are your favorite outdoor places in South Australia?" A total of 1,022 favorite places were provided, with respondents generally listing between one and three favorite places. After grouping the favorite places by name, this list was reduced to 241 unique locations. Each unique location was then classified using a modified NRPA park

TABLE 3 | The modified NRPA park typology used to classify "favorite places."

Classifications used in this study	Description	NRPA classifications	NRPA size and location guidelines	Modification rationale
Community park	Variable size and location. Recreational green spaces, not dedicated solely to conservation or sports	Community park	Usually between 30 and 50 acres, ½ mile to 3 mile distance	Incorporated neighborhood, mini-parks and large urban parks based on their similarities in intended use, as places of passive and active recreation.
School park	School-owned green spaces, not always publically accessible. Variable size, location determined by school	School park	Variable size, location determined by school	No change.
Sports park	Sports complexes and ovals, location and size variable	Special use, Sports complex	Special use—size variable, location variable Sports complex—usually a minimum of 25 acres with 40–80 acres optimal, strategically located	The study sites were specifically sports fields.
Nature park	Natural resource areas, for example National Parks—size variable, location depends on availability and opportunity	Natural resource areas	Size variable, location depends on availability and opportunity	The new terminology is to clarify that these areas are parks.
Linear park	Greenways and trails—location variable	Park trails, Connector trails	0.5 miles per 1,000 (1983 NRPA standard), location variable	More precise terminology has been used because the connector trails in this study were linear parks.
Botanical gardens and arboreta	Formal botanical gardens, zoos, and arboreta dedicated to the display and study of different species	N/A	N/A	This classification was added to differentiate these green spaces based on their intended use as places of recreation, learning, and the public display of species.
Beach or coastal park	Beaches—Size variable, location depends on availability and opportunity	N/A	N/A	Beaches were differentiated from other natural parks, based on their distinct natural features.
Private green space	Privately owned gardens and back yards	N/A	N/A	Although not a type of park, private green space represented a substantial number of favorite places and warranted differentiation from public parks.
		Neighborhood park	5–10 acres optimal, ¼ to ½ mile distance	Neighborhood parks were classified as community parks because they are both managed by local councils, and tend to have more similarities than differences in terms of services, facilities, and use patterns.
		Mini-park	Between 2,500 sq. ft. and one acre, <¼ mile in residential setting	Mini-parks were classified as community parks because they are both managed by local councils, and tend to have more similarities than differences in terms of services, facilities, and use patterns.
		Large urban park	Usually a minimum of 50 acres with 75 or more acres optimal, usually serves entire community	Large urban parks were classified as community parks because they are both managed by local councils, and tend to have more similarities than differences in terms of services, facilities, and use patterns.

TABLE 4 | The nodes used in inductive content analysis during the study.

Domain	Nodes	Example sub-nodes	Example responses
Setting attributes	Natural attributes	Birds Other fauna, wildlife Plants, vegetation, flora Flowers, orchids, blossoms Aesthetics, beauty, views Quiet, peace, tranquillity, silence Natural processes, seasonal changes Biodiversity and diversity Creeks, rivers, lakes Beach, ocean, sea Sounds and smells of nature Rocks, cliffs, soils, geology Mountains	"Tall trees attracting native birds, hearing and watching bird activities… Seeing the buds burst into color, smelling the flowering creepers and plants, nature's perfume, habitat for insects and butterflies…" † (Natural attributes; low intensity activities) "Birds and plants are always interesting." "It's full of native critters; creek systems, caves, waterfalls, billabongs, cliffs, beaches…" "The cliffs and hills are a myriad of colors and the views from the top are fantastic. I regularly watch many species of birds including kestrels, peregrine falcons, white-breasted sea eagles, pacific gulls, cormorants, terns, hooded plovers, etc. Brown snakes, lizards, dolphins, NZ fur seals and many other critters, both indigenous and (sadly) exotic." † (Natural attributes; low intensity activities). "I enjoy…the geology, the wildlife, the creeks and rivers. Any weather and season there is always something new." "…take in the sights, smells and sounds - it is a very sensory experience for me."
	Human-managed attributes	Accessibility and proximity Picnic and BBQ facilities Swimming pools Seating Art and sculptures Toilets Walking and cycling trails Park maintenance, cleanliness Playground or play space	"Close to home, paths allowing easy access." "Lots of hiking tracks to walk. Facilities like BBQs..." † (Human-managed attributes; moderate intensity activities) "A mixture of special plants, garden art and sculptures..." † (Human-managed attributes; natural attributes) "The athletics field is well maintained." "There are places I like to have coffee, toilets, children's playground, dog poo bags, barbecues, anything you might desire." † (Human-managed attributes; low intensity activities). "Kept tidy and clean, convenient, traffic is minimal and slow…"
Activities	Low intensity activities	Bird watching Picnics/dining Sitting Fishing Reading	"I can watch the birds eating insects and nectar, scratching in the dirt and collecting material to build nests." † (Low intensity activities; natural attributes). "A good place to read books and eat a picnic lunch…" "…Sitting in the sun, reading quietly, relaxing and feeling the grass beneath my feet." † (Low intensity activities; natural attributes, personal benefits).
	Moderate intensity activities	Walking Gardening Cycling Swimming Kayaking	"Hiking, geocaching, kayaking…" "I ride my bike from Paradise to the sea - such fun on the downhill run, though a lift home helps." "I love getting my hands in the dirt and gardening" "I love going there for a swim on a hot summer's day."
	High intensity activities	Sport Running/jogging Mountain Biking	"The ability to have a run around or a kick of the footy."

(Continued)

TABLE 4 | Continued

Domain	Nodes	Example sub-nodes	Example responses
			"Good training grounds for running."
			"Fantastic mountain bike ride up to Cleland..."
Benefits	Personal benefits	Solitude, privacy, escape crowds or city Discovery, exploration, learning Rest and relaxation Improve mood or happiness Spiritual or personal values, connection Nostalgia and memories Physical fitness and exercise Independence, freedom, autonomy Feeling Safe Awe, wonder, marvel	"A chance to escape from a busy and scheduled day-to-day life without phones and screens."
			"A sense of being outside the city, personal restoration, exercise."
			"Still so much to be explored and discovered…"
			"…The freedom to explore different footpaths and get lost but always feel safe." † (Personal benefits; human-managed attributes).
			"Flinders is a spiritual home - wild, silent, magnificent. I connect with God and the traditional owners." † (Personal benefits; social benefits; natural attributes).
			"…Strong childhood memories, so will always love."
			"…Sense of awe and wonder they engender. Supports spiritual development… De-stress… Re-energise... Development of wisdom through just being there."
	Social benefits	Family bonding Be with friends Neighborhood relations Teaching, leading, sharing skills	"…Many afternoon teas shared there with family and friends." † (Social benefits; low intensity activities).
			"I more easily chat to neighbors if I am in the garden trimming or weeding, so neighborly relations develop naturally." † (Social benefits; moderate intensity activities).
			"Teaching my kids about nature and instilling in them an appreciation and respect for nature." † (Social benefits; environmental benefits)
	Environmental benefits	Environmental stewardship	"We feel ourselves to be stewards of this land and the ones to look after it…"
			"I am a bush Carer with Trees For Life there. This means that I have a great emotional attachment to it, what I do by planting trees and removing introduced weeds from it greatly helps local native plant species return." † (Environmental benefits; personal benefits; natural attributes).
			"Being part of preserving the biodiversity of this area is a huge buzz. Saving the flora and fauna for future generations is very satisfying…" † (Environmental benefits; natural attributes).

† *Denotes an item that was coded into multiple nodes. The nodes are provided in parentheses following the quote.*

typology (**Table 3**). Certain responses could not be classified using the typology, as they were either too vague (e.g., "local park") or referred to a large region that likely contained multiple types of green space (e.g., "the Adelaide Hills"). These responses were coded as "unknown" or "general region", respectively. The most frequently listed favorite places were "nature parks" such as conservation reserves and National Parks (39.52%) as shown in **Figure 1**.

The second most frequently listed favorite places were "private green spaces" such as backyards (14.5%) and "botanical gardens and arboreta" (14.5%). The apparent popularity of botanical gardens is particularly interesting, given the number of these green spaces in the State is considerably lower than any other type of green space, i.e., 14.5% of favorite places were comprised of 11 botanical gardens and arboreta, whereas "private green spaces" (also 14.5%) were comprised of hundreds of different gardens and backyards. It should be noted that one of the radio segments promoting the study did discuss one of the State's 11 botanic gardens, however, three botanic gardens featured in the 20 most popular parks in the State (**Table 6**). The least popular types of favorite places were school parks (0.3%) and sports parks (2.3%).

Excluding private green spaces and ranked according to frequency of mention, the 20 most popular favorite places in South Australia are shown in **Table 6**. Again, the importance of

TABLE 5 | Word lists used in directed content analysis.

Component	Associated words, phrases and concepts	Source	Example responses
Being away	Being away	Kaplan and Kaplan, 1989	"Vast natural spaces that seem far away from man made structures… Far away from traffic and modern life…" † (Being away; extent).
	Getting away	Kaplan, 1995	"…Once you are there it feels like "getting away" from city life just for a few hours."
	Distance from: daily hassles, work, routines, ordinary aspects of life	Hartig et al., 1997	"Being able to switch off from the regular stresses of life."
	Escape unwanted distractions; an escape experience	Hartig et al., 1997	"Being outside away from computers, lights, advertising… Peace and quiet."
	Movement to another setting or another situation	Hartig et al., 1997	
	Geographical or psychological distance	Hartig et al., 1997	
	Having a break; taking a break	Hartig et al., 1997	
	Rest and relaxation	Authors	
	Private; privacy	Authors	
	Getting away from: the city, traffic, noise	Authors	
	Getting outside, getting some fresh air	Authors	
	Enjoy the peace and quiet	Authors	
		Authors	
Fascination	Fascination	Kaplan and Kaplan, 1989	"I enjoy watching the plants and flowers grow. I also enjoy watching the wildlife about the place (lizards, butterflies, spiders etc.). Just going bird watching, the birds are glorious." † (Fascination; compatibility).
	Beauty	Korpela et al., 2001	"…I have a feeling of calm and 'slowing down' when I'm observing small things close up - like insects or flower parts or the behaviour of birds - it's these times when I can focus on the now without other thoughts crowding in." † (Fascination; being away).
	Exploration	Hartig et al., 1997	"All are home to a myriad of birds, animals and little creatures…"
	Fascinating qualities	Hartig et al., 1997	"…I also enjoy the life that crops up boldly by itself - like the lichens on the footpaths and roofs, the single little grass that lives in a tiny hole in the footpath, the small bluetongue poking its head out of an unruly garden, the native cockroaches quietly going about their business in the creeper in a tucked-away local park…"
	Many interesting things	Hartig et al., 1997	"…The difference in the water whenever one looks at it, depending on the weather."
	Getting to know the place better	Hartig et al., 1997	"…The constant change of colour of the paddocks, the blossom and flowers on the trees, the lambing season, the change in the appearance of sheep after shearing, the noise of the guinea fowl, geese, chooks, pheasants."
	Explore and discover	Hartig et al., 1997	"Mostly the sensory pleasure they bring."
	Looking at the surroundings	Hartig et al., 1997	
	Living things	Hartig et al., 1997	
	Changing colors, seasonal changes	Joye et al., 2013	
	Constant change, e.g. clouds, flowing rivers	Joye et al., 2013	
	Variety of plants and animals	Joye et al., 2013	
	Sounds and smells	Authors	
	Plants, animals, natural features	Authors	
		Authors	
Extent	Being in a whole other world	Kaplan, 1995	"The wide open spaces…"
	Provides enough to see, experience, and think about	Kaplan, 1995	"…Wander in another world…just escape..." † (Extent; being away).
	Ability to make sense of the environment	Hartig et al., 1997	"In every place and every time you see something unique and memorable." † (Extent; fascination).
	Distraction	Hartig et al., 1997	"I love these spaces because there is lots of space to do whatever you want…" † (Extent; compatibility).
	Order, harmony (opposite of 'chaos' from PRS)	Hartig et al., 1997	
	There is a lot going on	Hartig et al., 1997	
	Large enough to explore	Bodin and Hartig, 2003	
	Space; wide open spaces; lots of space	Authors	
	Big enough to get lost	Authors	

(Continued)

TABLE 5 | Continued

Component	Associated words, phrases and concepts	Source	Example responses
Compatibility	Feelings of belonging	Korpela et al., 2001	"The peace that being in this place brings my soul."
	Match between inclinations/activities and environment	Hartig et al., 1997	"Halbury Parklands: The love of my childhood life. My playground and education. The scrub and me were/are one!
	I can do things I like here	Hartig et al., 1997	At 71 years of age I return to it annually to 'ground' myself, to reconnect with what is most important to me…"
	The sense that I belong here	Hartig et al., 1997	"I like the wide open spaces and how you can play soccer and ride a bike in the same place." † (Compatibility; extent)
	Sense of oneness with the setting/the environment	Hartig et al., 1997	"…Port Elliot is a 'homing' place for me as I spent many, many weeks as a child there in the caravan park. Even though
	Being here suits my personality	Hartig et al., 1997	I go only rarely now, when I do, I have a calm feel, Rooted is the best description."
	Enjoy this place	Hartig et al., 1997	"Provides a sense of place and connectedness…"
	Reference to activities: walking, picnicking, etc.	Authors	
	Time with family and friends	Authors	
	Near where I live; proximity to my home	Authors	
	Safety; feel safe here	Authors	

† *Denotes an item that was coded into multiple nodes. The nodes are provided in parentheses following the quote.*

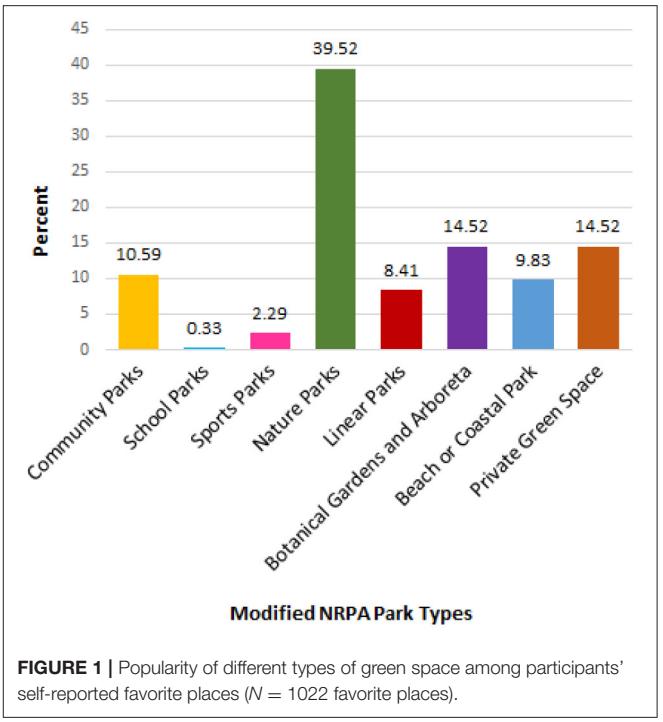

FIGURE 1 | Popularity of different types of green space among participants' self-reported favorite places ($N = 1022$ favorite places).

nature parks is clear, with 13 of the top 20 parks (65%) being comprised of natural areas such as conservation reserves and national parks. Although the frequency with which individual parks were mentioned might seem quite low, we must keep in mind that respondents were surveyed across a State that is almost one million square kilometers in size, contains 352 protected areas, and thousands of community parks. A total of 187 of the 241 places listed were only mentioned by one or two people. Results in **Table 6** also suggest the importance of access to greenspace, with half of the parks listed being within close proximity to the majority of respondents (within 15 km of the Adelaide Central Business District). The noteworthy characteristic of the other half of parks, is they are very large and comprise diverse environments and multiple recreation opportunity classes.

Interestingly, despite 87% of South Australia being classed as arid (Department for Environment and Heritage, 2007), only two of the top 20 parks (Flinders Ranges National Park and Mount Remarkable National Park) are located in this arid region. Unlike most of the arid-land parks, both of these parks are situated in mountainous/hilly areas, as are many of the top 20 parks. Half of the top 20 parks (parks 4, 5, 7, 8, 10, 11, 12, 14, 17, and 18) are located in the Mount Lofty Ranges, which surround the capital city of Adelaide. Also of interest, despite a coastline of more than 3,700 km, only three parks listed in the top 20 were coastal parks (parks 8, 9, and 13), although an additional five (parks 3, 11, 14, 15, and 16) included some form of blue space (river, lake, or waterfall).

Loved Attributes of Natural Favorite Places

Respondents were asked the open-ended question, "What do you love about your favorite outdoor places?" Respondents were

TABLE 6 | The 20 most popular "favorite outdoor places" in the study, ranked by frequency of mention.

Rank	Park name	Park type	Frequency of mention	Distance from CBD† (km)	Approximate park size (ha)
1	Adelaide Botanic Gardens	Botanical garden or arboretum	97	2.3	51
2	Flinders Ranges National Park	Nature park	57	466	93,400
3	Torrens River Linear Park	Linear park or trail	53	1.5	60*
4	Belair National Park	Nature park	45	12	835
5	Morialta Conservation Park	Nature park	33	12	533
6	The Adelaide Parklands	Community park	22	2	930
7	Mt Lofty Botanic Gardens	Botanical garden or arboretum	22	19	97
8	Deep Creek Conservation Park	Nature park	15	101	4,496
9	Innes National Park	Nature park	14	288	9,400
10	Cleland Conservation Park	Nature park	11	11	992
11	Onkaparinga River National Park	Nature park	10	33	1,500
12	Mt Lofty Summit	Nature park	10	18	Within Cleland C.P.
13	Coorong National Park	Nature park	9	87	48,990
14	Waterfall Gully	Nature park	9	9.7	608
15	Thorndon Park	Community park	9	11	22
16	Murray River National Park	Nature park	9	75	13,000
17	Wittunga Botanic Gardens	Botanical garden or arboretum	7	15	13
18	Kuitpo Forest	Nature park	6	42	3,600
19	Mt Remarkable National Park	Nature park	6	261	18,270
20	Hazelwood Park	Community park	5	6.4	15

† *Travel distance from center of CBD.*

* *Estimate: Linear park 30 km in length; size calculation based on width of 20 m.*

not prompted to refer to the physical attributes of the setting, nor their own experiences, benefits, or memories, and were free to write whatever came to mind when thinking about their favorite places. Our first step was to identify the proportion of responses that referred to a specific attribute of the biophysical setting, a particular personal benefit, or an activity. Where multiple responses were provided, these were treated as separate statements. Statements that did not fit within a single node were coded into multiple nodes. This initial coding process resulted in 2,460 coded responses. The top 20 "loved" elements of respondents' favorite places are shown in **Table 7**. Fifteen of the top 20 elements were classified as "setting attributes." Overall, the most loved attributes of favorite places were birds and plants, which were mentioned with near equal frequency. For example: "The thing that makes it most special is the animal life in the area like native wild birds…" and, "I love watching the Australian native plants grow and attract bees and butterflies and birds…"

Aesthetics was also mentioned with a high degree of frequency, consistent with findings by Korpela and Hartig (1996), e.g., in explaining why they love their favorite place, one respondent wrote: "It is an amazing place of great beauty on the edge of the desert… I greatly appreciate the natural beauty of this place…"

Overall, 64.75% of statements referred to a setting attribute of the favorite place (e.g., "The remnant vegetation and the bird-life to be seen"); 20.7% referred to a personal benefit derived from the place (e.g., "It's a fantastic place for renewing your spirit—escaping the city—and just relaxing"); and 14.5% of statements referred to an activity conducted in the favorite place, e.g., "…a wonderful gift to be able to visit for picnics or tennis or parties."

Given our interest in providing usable information for park management and nature conservation in Australia, we then identified that 84.6% of loved "setting attributes" referred to natural features of the environment, and 15.4% referred to human-made features such as toilets and walking trails. We further categorized the natural features into elements we believed park managers could modify [such as particular types of plants, e.g., "…I love seeing native plants (groundcovers, heaths, flowering creepers…)" and "…under the shade of beautiful trees, lots of simple things like old logs, mounds to climb on, and play imaginative games. Hard to beat"] and those we considered were beyond reasonable human control (such as the presence of mountains, e.g., "…waterfalls, huge rock-faces and cliffs" and "…breathtaking sandhills and inlets and headlands that seem to never end"). Under this classification system, 70% of statements referring to a "setting attribute" concerned a modifiable natural feature, 15.4% concerned a human-made feature, and 14.6% concerned an unmodifiable natural feature.

In regards to responses lending support to conservation objectives, references to terms such as "biodiversity" and "native species" were surprisingly frequent (e.g., "…great remnant biodiversity," "It is a desert biodiversity hotspot," "Tall trees attracting native birds…," and "I love watching the Australian native plants grow"). Although explicit references to biodiversity

TABLE 7 | The top 20 "loved" elements of respondents' favorite outdoor places, ranked by frequency of mention.

Rank	"Loved" elements	Type	Frequency of mention
1	Birds	Setting attribute	139
2	Plants, vegetation	Setting attribute	137
3	Aesthetics, beauty	Setting attribute	119
4	Wildlife, animals, fauna	Setting attribute	96
5	Walking	Activity	93
6	Nativeness (of species present)	Setting attribute	85
7	Solitude, privacy, escape crowds/city	Benefit	85
8	Quiet, peace, tranquillity, silence	Setting attribute	81
9	Open space, space, vastness	Setting attribute	76
10	Accessibility and proximity	Setting attribute	71
11	Natural processes, seasonal changes	Setting attribute	63
12	Biodiversity and diversity	Setting attribute	54
13	Discovery, exploration, learning	Benefit	49
14	Fresh air, breeze	Setting attribute	45
15	Creeks, rivers, lakes, waterfalls	Setting attribute	45
16	Naturalness, wildness	Setting attribute	45
17	Rest and relaxation	Benefit	43
18	Beach, ocean, sea	Setting attribute	41
19	Family relations	Benefit	38
20	Sounds and smells of nature	Setting attribute	38

were fairly common, there were also many comments about the diversity of plant and animal species written in participants' own words, such as "…many trees of various varieties with different heights, colors and textures" and, "…to see a koala now and then, the kangaroos we've seen on many days, but especially the birds! So many different kinds!" As a result, nativeness, and biodiversity featured in the top 20 "loved" aspects of favorite places.

Relative Importance of ART Components in Natural Favorite Places

To explore the relative importance of the four components of restorative environments in personal descriptions of favorite places, we re-coded responses to the question "What do you love about your favorite outdoor places?" We used a directed approach to content analysis, using words and phrases from previous restorative environments research, including the PRS (Hartig et al., 1997). In contrast to the inclusive and inductive method of content analysis we used when looking at the attributes of favorite places, this time we found that we were more likely to disagree on the category in which certain statements should be placed, particularly in the case of "fascination." We disagreed on ∼5% of cases but after discussion we developed a shared understanding of how we would classify each component. Although we were able to reach a consensus (**Table 5**) we found that our results differed to those of previous research in this field (Korpela and Hartig, 1996; Korpela et al., 2001), in that fascination was found to be the most important component of favorite places, rather than the least important. This could however, simply be a function of focusing on favorite outdoor spaces, rather than favorite places in general. As shown in **Figure 2**, more than 50% of statements about what respondents' "loved" about their favorite places were categorized as being indicative of fascination. Extent was found to be the least important component, representing only 3% of responses. We considered 15.5% of responses to not fit within any of the ART categories, e.g., references to food or drink. When specific activities were given as the reason for loving a location, they were coded as "compatibility." We felt that references to an activity as being something respondents "loved" about their favorite places, were indicative of a match between their inclinations (to conduct that activity) and the suitability of the environment for conducting it in. We coded any reference to a specific natural feature such as orchids, interesting rock formations, or animals as being a sign of fascination, i.e., these features have clearly captured the attention of the respondent, so much so that they have specifically remembered those features when calling their favorite places to mind. We believe such an action was justified, given the Kaplan and Kaplan (1989, pp. 184–185) belief that when discussing "fascinating" stimuli "it would also seem appropriate to include many of the objects found in nature" such as "sunsets and waterfalls, caves, and fires." Similarly, Kaplan (1995, p. 172) suggests that "fascination can also come from content" such as "wild animals," and Berto et al. (2010, p. 494) also list "animals, people, water, nature" as fascinating objects. Such features may be sources of fascination because animate or moving objects (like animals and water) capture attention more effectively than static objects (Pratt et al., 2010). Although natural features have consistently been associated with the construct of fascination in previous research (e.g., Kaplan, 1995; Hartig et al., 1997; Joye et al., 2013), responses coded as "fascination" in the present study did not necessarily refer to any attentional outcomes.

DISCUSSION

Popular Types of Natural Favorite Places

The outdoor "favorite places" of 447 South Australian respondents were classified into eight different green space types using a modified NRPA park typology, similar to that used by Brown et al. (2014). When ranked according to frequency of mention, the types of natural places favored by respondents in our study follows much the same trend to that of Korpela et al.'s (2008) study in Finland. In both studies, the most popular types of favorite places are "nature parks" (or "extensively managed natural areas" such as woods and forests in the Finnish study). Nature parks accounted for nearly 40% of favorite places in the present study. The second most popular place type in the 2008 study was "built-up green spaces" such as parks, which would be equivalent to "community parks," "botanical gardens," and "linear parks," in the present study. Waterside environments such as beaches, followed by exercise areas and sports ovals, are ranked in the same order in both studies. "Private green spaces" and "school grounds" were not included in the Finnish study.

It is reasonable to speculate that people might derive greater restorative benefits from "nature parks," due to the frequency with which they were identified as being favorite places in the

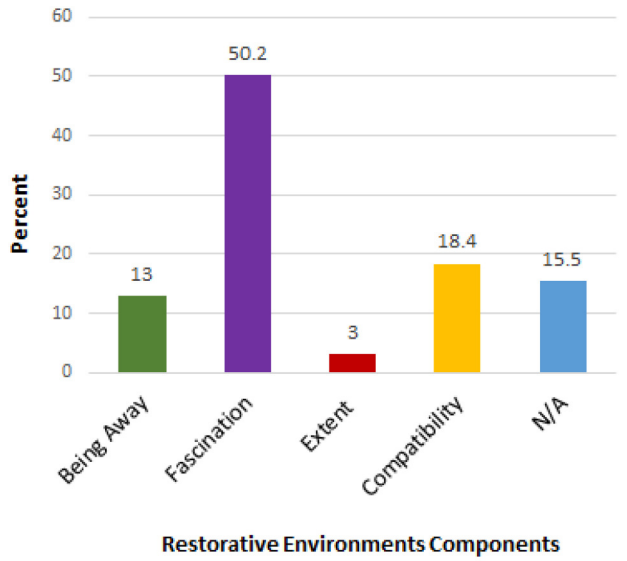

FIGURE 2 | Relative importance of ART components after initial coding, when statements regarding natural features were coded as "fascination."

present study, and in Korpela et al. (2008). In this same vein, we might expect to see the most popular "favorite place type" align with the type of green space found to best facilitate psychological outcomes in studies explicitly examining the human benefits of different natural environments. To some degree there is such support, e.g., White et al. (2013) identified forests, coastal areas, and upland areas such as hills and mountains as being the most restorative environments of 16 different place types in England. South Australia is a relatively flat state, however, over 50% of the "top 20 favorite parks" were located in its hilly areas and by far the most frequently mentioned category was "nature parks." Furthermore, although South Australia is largely arid (Department for Environment and Heritage, 2007), most favorite places were located in the 13% of the state that is not arid, where rainfall is higher, and the presence of forested areas, creeks, and rivers is much greater than in the rest of the state. Barton and Pretty (2010) found that exercising near a beach or river was associated with the greatest improvements in mood and self-esteem, but in Marselle et al. (2013) reductions in post-walk negative affect and perceived stress were associated with farmland and green corridors, but not coastal environments. In contrast to these studies, Marselle et al. (2015) found no significant difference between post-walk affect in different types of green spaces such as nature reserves, urban parks, and farmland. Determining whether these varying—and at times conflicting—results are due to methodological differences between studies, or simply reflect the many nuances of nature-health relationships, requires further research. It is possible that particular types of environments are more effective at facilitating specific psychological benefits, e.g., coastal environments might have a greater effect on restoration, mood, and self-esteem than other environments (Barton and Pretty, 2010; White et al., 2013), but not on negative affect or perceived stress (Marselle et al., 2013).

Marselle et al. (2015) found perceived restorativeness was significantly related to perceived naturalness and perceived biodiversity. Psychological benefits have been found to increase with perceived biodiversity in other studies (e.g., Fuller et al., 2007; Dallimer et al., 2012), however, species diversity is not always accurately detected by respondents. The extent to which participants are able to accurately perceive biodiversity is likely to differ, however, it is assumed that most people are able to distinguish between different types of natural settings, based on the method of self-reporting used to determine "environment type" in many studies (Korpela et al., 2008, 2010; Marselle et al., 2013, 2015; White et al., 2013). Therefore, we can assume that people have some capacity to discern variations in natural attributes, and this has been the case in Fuller et al. (2007) and Johansson et al. (2014) with regard to plant diversity, and in Lamb and Purcell (1990) with regard to naturalness. Greater species diversity and naturalness may be more representative of certain park types in the present study. For example, "nature parks" consisted largely of protected areas, which are known to harbor greater species richness and species abundance than unprotected natural areas (Gray et al., 2016). Furthermore, nature parks are more likely to exhibit the sensory cues (for example Dallimer et al., 2012 suggest that vegetation cover might be an important visual cue) that might influence people's perceptions of biodiversity, naturalness and in turn, restorativeness.

Identifying these sensory cues is of great importance to improving our collective understanding about how people perceive natural environments. At a time when many researchers are arguing that people are becoming increasingly disconnected from the natural world (e.g., Maller et al., 2008), it is valuable to know which aspects of nature people take notice of. It is of particular interest to explore whether people positively perceive features that contribute to the health of natural environments, as opposed to those that contribute only to human activities and experiences. Miller (2005, p. 431) asked, "if people no longer value nature or see it as relevant to their lives, will they be willing to invest in its protection?" Similarly, we might ask, if people no longer take notice of nature in their lives, will they ever come to value it? These questions are beyond the scope of the present study, however, working backwards, we were able to explore the aspects of nature that people use to explain their love for their favorite, and therefore most valued, natural environments.

Loved Attributes of Natural Favorite Places

Writing about one's experiences in nature has been espoused as a form of self-reflection that can improve one's connection with the natural world (Richardson et al., 2015). In the present study, participants were asked to list their favorite outdoor places, and to write about what they love about those places. Participants were not prompted to refer to the features of the environment, nor the benefits or experiences they derive from them. Thus, we believe the results go beyond determining aesthetic and recreation experience preferences, to exploring the transactional relationship between loved environments and the people who value them above all others. We consider that the relationship between person and environment can be mutualistic only if the

environment also derives some benefit from being "loved." We can assume that a person is more likely to protect or advocate for a place that they value, however, it is still of interest to know what it is about valued environments that are important to the people who value them. Developing such an understanding is of particular importance to those designing campaigns aimed at improving nature attachment in disconnected individuals.

When exploring this issue, we first categorized the "loved aspects" of favorite places as referring to a setting attribute, a benefit, or an activity. This process revealed that more than 60% of responses concerned a setting attribute, such as the presence of particular facilities or features of the environment. Of those setting attributes, ∼85% referred to natural attributes, rather than artificial or human-created aspects of the environment. Some frequently mentioned attributes were to be expected, such as references to "beauty," and the proximity of the favorite place to respondents' homes. The beauty of nature has long been considered an important component of human-nature relationships (e.g., Ulrich, 1983), and the proximity, or perceived proximity of parks to people's homes is often a predictor of park use (Giles-Corti et al., 2005; Wang et al., 2015). Interestingly, many responses referred to the micro-variables of natural settings, such as birds, plants, and wildlife. Birds and plants were mentioned with almost equal frequency and overall were the top two "loved" attributes listed by respondents. The importance of plants was not surprising, as plants are almost synonymous with the idea of "nature." We believe the prominence of birds and wildlife in respondents' writing speaks to the value placed on ecological quality in loved environments. Although some animal species can thrive in low-quality environments, there were often specific references to "native" and "remnant" species, as well as the provision of "habitat." As suggested by Gobster et al. (2007), the ecological value of an environment might give pleasure to those individuals who are able to recognize it, and this appears to be the case for many of our respondents.

We did not expect many participants to explicitly cite "biodiversity" as a loved feature of their favorite places, given previous research found 60% of respondents had never heard of the term "biodiversity" (Lindemann-Matthies and Bose, 2008). However, a recent study suggests that ecological literacy in South Australia is quite high (Pitman and Daniels, 2016). Perhaps as a reflection of this relatively high level of environmental knowledge in the South Australian population, we discovered that biodiversity was actually frequently mentioned in responses. As a result, species diversity was one of the 20 most frequently mentioned attributes of favorite places. This might be due to the fact that more than 50% of respondents in the study held a bachelor's degree or higher, however, according to Pitman and Daniels (2016, p. 12) education and occupation are not the only factors related to knowledge of the environment, and "ecological literacy need not be the exclusive domain of the highly educated or professionally employed."

Richardson et al. (2015) sought to identify the positive aspects of "mundane" or "everyday" nature that people took notice of during a 5-day intervention designed to improve nature connectedness. Although respondents in the present study had an existing strong connection with nature, comparing the two studies reveals many similarities in the attributes found to be most important to respondents. The importance of micro-variables is reflected in both studies, with "specific aspects of nature" found to be one of the strongest themes arising from responses in Richardson et al. (2015, p. 613). Participants in both studies similarly identified "beauty," "wildlife," "change," and "sensations" as being important. "Natural processes and seasonal changes" (in the present study) or "growth and temporal changes" in Richardson et al. (2015), were found to be of great importance. Clearly, the ways in which loved environments change throughout the year is noticed by the people who value them, however, the fact that participants in Richardson et al. (2015) noticed change during only a 5 day period, we believe highlights an essential aspect of nature experiences in both "mundane" and "favorite" environments, which is that the living world is never static. Kaplan and Kaplan (1989) suggest that this "ephemera" adds to the perception of fascination and may enhance feelings of "being away." Beyond this, it would appear that exposure to—and recognition of—dynamic, ever-changing environments can contribute to both the enhancement and maintenance of one's connection with nature. Although the lives of modern people are generally less dependent on the weather and the seasons than those of their ancestors', such variation is still an important and noticeable aspect of their nature experiences. Unlike the increasingly artificial and largely unchanging urban environments that many people now inhabit, the natural world undergoes constant transformation, which is clearly appreciated by many people. It is possible that management actions seeking to improve ecological quality in natural environments should be preceded by interventions that encourage park users to take notice of particular micro-variables and subtle natural processes. By initiating this early engagement, park agencies may find that their actions are received more favorably by a visitor base that has the ability and awareness to perceive the ways such actions simultaneously improve the environment and their enjoyment of it.

Relative Importance of ART Components in Natural Favorite Places

According to ART, all four components of restorative environments ("being away," "fascination," "extent," and "compatibility") are essential to restorative experiences (Kaplan, 1995). Research in Finland and the United States found a significant difference in the apparent importance placed on compatibility and fascination in favorite places, with the latter component found to be of significantly less importance than the former (Korpela and Hartig, 1996; Korpela et al., 2001). As discussed previously, fascination is linked to concepts that may be indicative of ecosystem health, such as species diversity, naturalness, and wildness (Annerstedt et al., 2012; Winter, 2012; Van Den Berg et al., 2014). It has been suggested that "experiencing a favorite place with reference to oneself and one's inclinations appears to be more important than inherently engaging or interesting properties of the environment per se" (Korpela et al., 2001, p. 585). Previous research suggests that actively noticing different aspects of natural environments,

such as wildlife and changing foliage colors can improve one's connection with nature (Richardson et al., 2015), and in turn, nature connectedness is related to pro-environmental behaviors (Kals et al., 1999). Given the potential implications of this for conservation outcomes, we sought to explore whether personal descriptions of what people "love" about their favorite places are indicative of a focus on "self" (e.g., "compatibility" between the environment and the activities and benefits desired), or indicative of a focus on the environment (e.g., "fascination" with its interesting or beautiful features).

In the present study, statements associated with the idea of fascination featured prominently in the "loved aspects" of favorite places, particularly those referring to micro-variables such as birds and plants. References to "setting attributes" accounted for 65% of responses, which we believe could be suggestive of a difference between the relative importance of ART components in South Australian favorite places and those in Finland and the United States. The great value placed on fascination in our study may reflect the high level of ecological literacy in South Australia (Pitman and Daniels, 2016), as our survey respondents may be more likely to take notice of and appreciate ecologically valuable, structurally-diverse, species-rich environments. This appreciation may indicate the existence of an "ecological aesthetic" within the sample population (Gobster et al., 2007).

Care should be taken when comparing our results to those of previous research. One of the criticisms of restorative environments research is that most studies have been performed on undergraduate university students in Western Countries (Joye and Van Den Berg, 2013). Studies examining the restorative components of favorite places have similarly focused on students, e.g., the mean participant age across two of Korpela's studies was 23 years (Korpela and Hartig, 1996; Korpela et al., 2001), compared to a mean age in the present study of 52 years. It is possible that people's interest in taking notice of the world around them increases as they age, or conversely, that younger people are more interested in the "self" than older people. It has been suggested that younger people, regardless of their generation, are more narcissistic than their elders (Twenge et al., 2008; Roberts et al., 2010). As "narcissism involves a wide range of self-regulation efforts aimed at enhancing the self" (Twenge et al., 2008, p. 877) and spending time in nature can be thought of as a form of "environmental self-regulation" (Korpela and Ylén, 2007, p. 139), it is possible that the contrasting results between our study and previous studies are age-related. Self-interest aside, it is also possible that the greater importance placed on "compatibility" in previous research is more indicative of "place dependence" rather than "place identity," based on the traditional, two-dimensional model of place attachment (Williams et al., 1992). Although the two concepts are highly correlated, and both are concerned with a setting that is valued, "place dependence" reflects a functional attachment based on the ability of the valued place to facilitate one's desired experiences, and "place identity," reflects an emotional or affective bond. It has been suggested that functional attachment may initially draw people to an environment, and that repeated visits, over time, lead to an emotional attachment being formed, i.e., place dependence may precede place identity (Vaske and Kobrin, 2010). Given their mature age, perhaps more respondents in our study have had time to develop stronger emotional connections with their favorite place, and have come to place greater importance on the inherently interesting attributes of the place than on its ability to satisfy their needs.

In the present study, "extent" was found to be the least important component of favorite place experiences. The reason for the apparent difference between our results and those of previous researchers (Korpela and Hartig, 1996; Korpela et al., 2001) may simply be due to the context. South Australians are accustomed to expansive lands and the opportunity to explore them in relatively uncrowded settings. For example, the State's capital city, Adelaide, is located <20 km away from thousands of hectares of conservation land including Belair National Park; and the Central Business District itself is bordered by more than 900 hectares of interconnected parkland. It is possible that "extent" is simply something people take for granted. Likewise, perhaps fascination is part of the national psyche. The Australian national anthem encourages people to take note of the fascinating aspects of the landscape, boasting, "Our land abounds in nature's gifts, of beauty rich and rare."

Limitations

Unlike previous research, the present study assumed that experiences of natural favorite places would be restorative, and did not directly measure restorative outcomes or perceived restorativeness. This is a limitation of the study, but we felt it was reasonable to assume most favorite places were indeed restorative environments based on previous research (Korpela et al., 2001). ART itself could also be considered a limitation. While we were interested in examining these relationships, we do concede that the limited sample of previous research may not justify the evolutionary and universalist assumptions underlying the theory (Joye and Van Den Berg, 2013). Lastly, this study is limited by the characteristics of its respondents, who were well-educated older people who clearly value nature. This is an interesting point of difference between our study and previous favorite places research, however, the results should be interpreted with caution. We acknowledge that our respondents' characteristics may be associated with the recruitment method used, as the radio station through which the study was promoted is more likely to attract older listeners. Place attachment researchers examining the effects of age, gender, and education on connections to place have not had consistent results (e.g., discussed in Rollero and De Piccoli, 2010), however, it is highly possible that the types of environments and natural attributes identified as being most important will differ between socio-demographic groups. This study was largely explorative, and we believe further research is needed to improve our collective understanding of how different environmental attributes contribute to restorative outcomes.

CONCLUSION

Consistent with European research, the most frequently reported types of favorite places in the present study were "nature parks" such as conservation areas and National Parks. Natural

micro-variables such as birds and plants were the most frequently reported "loved" attributes of favorite places, and in general respondents paid much more attention to the physical attributes of their favorite places, rather than their ability to facilitate personal benefits and activities. Accordingly, we found much greater importance was placed on "fascination" in Australian favorite places than in previous research that identified fascination as the least important component of restorative experiences in favorite places. The possible reasons for this contrasting result include the focus on outdoor spaces, the comparably much higher mean age of our respondents, as well as their high level of education. Further, they were sampled from a population likely to have a reasonable knowledge of the natural environment and ecological processes. This is reflected in the personal importance respondents placed on the ecologically valuable attributes of their favorite places, such as the habitat they provide, as well as their species diversity and nativeness. We believe these findings can provide an anchor for marketing strategies aimed at increasing the public's use of parks, and assist in the development of education programs aimed at improving people's understanding of important but intangible concepts such as biodiversity. The findings of this study offer support for interventions that encourage people to take notice of and appreciate nature without overtly seeking to educate them. Beyond exploring *how* we can attract people to nature, we might also ask *why*, i.e., are the attributes of nature that are "lovable" also those that provide health benefits? Further research exploring the ability of different types of environments and environmental features to facilitate psychological benefits, as well as the influence of environmental knowledge on individual perceptions of these environments is warranted. Understanding why people love landscapes is crucial to global efforts to connect people with nature and ultimately improve population health, environmental stewardship and conservation outcomes.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the Australian Code for the Responsible Conduct of Research, the National Statement on Ethical Conduct in Human Research and the UniSA Framework for the Responsible Conduct of Research. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the University of South Australia Human Research Ethics Committee.

AUTHOR CONTRIBUTIONS

All four authors designed the study and were involved in the collection of data and the coding of responses. Data analyses and interpretation were carried out by MS. The initial and subsequent drafts of the article were written by MS, and critical edits were made by DW, KL, and CD. All authors have approved the paper for publication.

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Coping with Stress in Deprived Urban Neighborhoods: What Is the Role of Green Space According to Life Stage?

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This study follows previous research showing how green space quantity and contact with nature (via access to gardens/allotments) helps mitigate stress in people living in deprived urban environments (Ward Thompson et al., 2016). However, little is known about *how* these environments aid stress mitigation nor how stress levels vary in a population experiencing higher than average stress. This study used Latent Class Analysis (LCA) to, first, identify latent health clusters in the same population ($n = 406$) and, second, to relate health cluster membership to variables of interest, including four hypothetical stress coping scenarios. Results showed a three-cluster model best fit the data, with membership to health clusters differentiated by age, perceived stress, general health, and subjective well-being. The clusters were labeled by the primary health outcome (i.e., perceived stress) and age group (1) *Low-stress Youth* characterized by ages 16–24; (2) *Low-stress Seniors* characterized by ages 65+ and (3) *High-stress Mid-Age* characterized by ages 25–44. Next, LCA identified that health membership was significantly related to four hypothetical stress coping scenarios set in people's current residential context: *"staying at home"* and three scenarios set outwith the home, *"seeking peace and quiet," "going for a walk"* or *"seeking company."* Stress coping in *Low stress Youth* is characterized by "*seeking company*" and "*going for a walk"*; stress coping in *Low-stress Seniors* and *High stress Mid-Age* is characterized by "*staying at home."* Finally, LCA identified significant relationships between health cluster membership and a range of demographic, other individual and environmental variables including access to, use of and perceptions of local green space. Our study found that the opportunities in the immediate neighborhood for stress reduction vary by age. Stress coping in youth is likely supported by being social and keeping physically active outdoors, including local green space visits. By contrast, local green space appears not to support stress regulation in young-middle aged and older adults, who choose to stay at home. We conclude that it is important to understand the complexities of stress management and the opportunities offered by local green space for stress mitigation by age and other demographic variables, such as gender.

Keywords: latent class analysis, latent health cluster, health cluster membership, perceived stress, stress coping scenario, deprived urban neighborhood, green space quality

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INTRODUCTION

This study explores stress patterns amongst people living in poverty and how these patterns relate to potential stress coping behaviors. It builds on our earlier research which shows that higher levels of green space in the neighborhood environment are associated with lower stress as measured by perceived stress (Ward Thompson et al., 2016) and diurnal patterns of cortisol (Ward Thompson et al., 2012; Roe et al., 2013). We were particularly interested in the current study on the opportunities that green space can offer for initiating and supporting stress regulating activities. First we set out the rationale—and evidence—for exploring green space and neighborhood attributes in relation to stress regulation and then present our methods and results.

Stress Regulation, Green Space, and Neighborhood Attributes

Most studies exploring relationships between stress and the environment focus on negative relationships: many studies have identified the features of the neighborhood environment that are associated with poor mental health (e.g., depression, anxiety, mood disorders, poor cortisol regulation, reduced cognitive functioning) such as air and noise pollution, traffic levels, high density living, and crime and violence (Aneshensel and Sucoff, 1996; Hadley-Ives et al., 2000; Robinson and Keithley, 2000; Ross and Mirowsky, 2001; Latkin and Curry, 2003; Chu et al., 2004; Gee and Takeuchi, 2004; Powdthavee, 2005; Gary et al., 2007; Chaix et al., 2008; Echeverria et al., 2008).

Fewer studies, however, have focused on the environmental attributes that support or encourage opportunities for stress mitigation. Our previous study found beneficial relationships between perceived stress and the quantity of, and access to, green space (via gardens and allotments) in deprived urban communities (Ward Thompson et al., 2016). A Danish study found increases in perceived stress in individuals living more than 1 km away from a green space (Stigsdotter et al., 2010). In the USA, higher levels of neighborhood green space have been associated with significantly lower levels of perceived stress (Beyer et al., 2014).

There is also evidence that green space has a positive effect on stress physiology. A series of Japanese studies have shown the beneficial effects of walking in forests and natural environments on physiological stress, including cortisol levels, pulse rate, blood pressure and heart rate variability (Park et al., 2010; Toda et al., 2013). The quantity of green space has also been found to have a positive effect on physiological stress regulation—as measured by diurnal daily patterns of cortisol—in deprived urban Scottish communities (Ward Thompson et al., 2012; Roe et al., 2013). A further UK study found chronic stress, as measured by hair cortisol concentration, was higher in neighborhoods with less green space, but effects were attenuated beyond significance when controlling for income deprivation (Gidlow et al., 2016).

In addition, there is evidence to suggest green space can act as a buffer to everyday life stressors in urban and rural neighborhoods, as well as having a direct effect on stress physiology. The presence of green space within a 3 km radius of a resident's home has been shown to attenuate the negative health impacts of stressful life events in Dutch adults (van den Berg et al., 2010). Research in rural USA communities has shown that nature in the immediate vicinity of the residential environment may serve as a buffer for the impact of stressful life events on children's psychological well-being (Wells and Evans, 2003). In deprived urban neighborhoods in the USA, Kuo (2001) found residents living with more neighborhood green space were significantly better able to manage major life issues (as measured by manageability of personal goals) than those residents living in areas with less green space.

The Role of Green Space in Stress Regulation

Research has suggested that visiting favorite places helps emotional self-regulation, including stress relief (Korpela, 2003). Emotional self-regulation is defined as actively coping with moods and emotional situations; a person may employ psychological, physical, social or environmental strategies in order to regulate negative mood (Korpela, 2003). Typically, the environments people seek after the experience of a negative antecedent (e.g., stress, bad mood, a quarrel with someone) are favorite places which offer relief and opportunities for emotional self-regulation (Korpela and Ylén, 2007). Research has shown that natural environments rank highly as favorite places and also offer a context for emotional self-regulation (Korpela, 2003; Johnsen and Rydstedt, 2013). A central idea within this body of research is that natural places have restorative attributes—that, for example, they are inherently fascinating and offer a context for "being away" from everyday stressors (Kaplan and Kaplan, 1989)—which support emotional regulation and recovery from low mood, fatigue and stress (Korpela, 2003). This research suggests that the active and repeated use of natural spaces for ongoing emotional self-regulation can help support resilience over time (Korpela, 2012). Environmental emotional regulation strategies therefore hold much promise for supporting well-being, both in the short-term and long-term, but there is little empirical evidence showing how the natural environment affords, or contributes to, stress-regulation in deprived urban communities experiencing major life stressors. The affordances of the environment refers to the functional properties an environment affords an individual for action, described in terms of what is *do-able* (Heft, 1988).

Opportunities for contact with nature vary enormously across socio-economic and cultural contexts. In the UK, for instance, it is known that poorer urban communities live with less green space and poorer quality green space (CABE, 2010). Nature affordances are therefore affected by the inequalities in green space provision. The type of contact with nature also varies among people, e.g., viewing nature passively from a window, or being physically active in nature (e.g., walking or gardening), as does the frequency and duration of such contact with nature (Hartig et al., 2014). Climate, seasonality, the varying needs of population sub-groups (e.g., gender, age, and ethnicity), as well as culture and individual circumstance, will all impact on the experience of nature affordances by an individual. One of the

aims of our study was to better understand the use of nature to afford stress reduction in different segments of deprived urban communities.

Our primary interest is in deprived urban neighborhoods since research suggests the association between green space and health—both for all cause mortality and for mental well-being–tends to be stronger in poorer communities (Mitchell and Popham, 2008; Mitchell et al., 2015). If access to, and use of, green space can be improved in deprived urban communities, current evidence suggests this may help address health inequalities (Allen and Balfour, 2014).

Our study used Latent Class Analysis (LCA) to, first, model clusters distinguished by general health and mental health outcomes in a sample of people aged 16 to 85 living with deprivation and, second, to explore the causes of health cluster membership and its relationship to a range of variables, including hypothetical environmental stress coping scenarios, individual circumstances and neighborhood environmental characteristics, including green space.

Four research questions guided our analysis. Amongst a sample of urban residents living in poverty:

RQ1: What different health clusters, as identified by latent class, can be found within these deprived communities?
RQ2: How are stress coping behaviors associated with the latent health clusters?
RQ3: How do demographic and other individual characteristics relate to the latent health clusters?
RQ4: How do environmental variables (particularly green space) relate to the latent health clusters?

METHODS

Study Design

This was a cross sectional study designed to understand the coping strategies of deprived urban communities in relation to stress regulation. It is one of a series of studies carried out as part of the GreenHealth project for the Scottish Government, exploring relationships between stress and green space using the study setting described below. The Final Report summarizing the project as a whole (James Hutton Institute, 2014) can be found at http://www.hutton.ac.uk/research/projects/green-health.

Study Setting

Two areas in Central Scotland were selected on the basis of, firstly, high indices of poverty using the Carstairs Index for population data in 2001 (Carstairs and Morris, 1991). Carstairs scores are an index of deprivation at ward level (i.e., a spatial unit defining electoral boundaries in the UK) based on an unweighted combination of four census variables: unemployment, overcrowding, car ownership and low social class. A higher score equates with higher deprivation, with a score of greater than 6 indicating "very deprived areas." Four areas in two cities were chosen based on the Carstairs Index from the most recent census data available at the time of data collection (2001) together with an objective measure of green space quantity, derived from ward level Census Area Statistics (CAS), created by the Centre for Research on Environment Society and Health (CRESH)[1] and available at the CRESH website (www.cresh.org.uk). The green space measure includes parks, woodlands, scrub and other natural environments. Our selection was based on achieving as wide as possible a variation in publicly accessible green space levels (i.e., excluding private gardens) whilst maintaining the high deprivation criteria and matching other environmental criteria. This reflects the fact that the areas selected for this study are characterized by social rented housing. The higher green space wards in our sample offered access to parks and informal urban green spaces, including shared community gardens. Those wards with lower levels of green space lacked access to green space, either in the wider community or immediate home environment. Further information on ward characteristics can be found in Ward Thompson et al. (2016). Note, the CAS ward level measure of green space quantity was used for case study selection only.

Stress Coping Scenarios

The stress coping scenarios for the questionnaire were identified by prior qualitative data collection via four focus groups with residents ($n = 29$) in our sampling locations. Groups were of mixed gender (31% male, 69% women) and mixed age (ranging between 18 and 65 plus). This identified four coping behaviors for self-initiated stress regulation in one's current residential environment: "*staying at home*" or going to "*some other place*" outwith the home. The latter behavior was further categorized into three outdoor behaviors: "*take a walk and get some fresh air*" (*subsequently referred to as "going for a walk," "seeking peace and quiet*" and "*seeking company*.") These behaviors—together with insights on the social and environmental contexts for each behavior choice—were used to design the questionnaire described in section Survey Variables and Outcome Measures below. Further information on the qualitative analysis is provided in the Final Report for the Scottish Government (James Hutton Institute, 2014), see section 3.2.2 http://www.hutton.ac.uk/research/projects/green-health.

Recruitment and Sample Size

Participants were recruited from each of the four areas using post-codes that met the criteria set out in section Study Setting, above. Each case study area had a total population of ∼5,000. Given the exploratory nature of this research, there was no basis for determining research power and the sample size was therefore largely determined by the limit on resources available to the study. A stratified sampling methodology was used that matched proportions of the sample to census data proportions (based on the 2001 national census and deprivation indices derived from this) for each case study area, based on age, gender and the deprivation criteria described above. This ensured a consistent sample of individuals experiencing similar levels of economic hardship. The survey was undertaken in June 2010. As a check on possible gentrification that might have occurred between the 2001 census and our survey, a check on subsequently published

[1]CRESH (The Centre for Research on Environment Society and Health). Available online: www.cresh.org.uk

2011 deprivation indices indicates that deprivation had worsened over time in 3 out of 4 case study areas, with the deprivation levels remaining constant in the fourth.

Data Collection

A cross-sectional household questionnaire was developed and administered by a survey company, using a face-to-face, computer-assisted interview (CAPI). Prior to the survey, introductory letters were posted to residents in the sample area informing them about the survey. Recruitment was door-to-door by fieldworkers in four defined locations (as described in section Study Setting above), until the sample numbers were reached. The sample size was constrained by available resources to c.100 per community. A random, quota sampling framework was used to match the survey sample to the national 2001 census profile for age, gender, and socio-economic group (SEG) for each of the areas sampled. Response rates were between 60 and 70%.

Ethics

This research was carried out in accordance with the Edinburgh College of Art, University of Edinburgh Ethics Board with written informed consent required from all subjects prior to taking part in the study.

Survey Variables and Outcome Measures

Demographics

Participants' ethnicity, age, and sex were recorded, together with type of housing tenure, education, relationship status (married, cohabiting with partner, single, etc.) number of children and private car access.

Area-level Deprivation and Individual Socio-economic Status

Area-level socio-economic deprivation was based on an independent measure—the Carstairs Index for population data in 2001 (Carstairs and Morris, 1991)—obtained via each participant's post-code. Individual socio-economic status was measured via responses to questions on education level and income coping difficulties.

Stress Coping Scenarios

Participants were asked if they felt the need to escape stress and "clear the head" on a 5-item Likert scale from *all the time* to *never*. Each participant in the survey was then asked to select one of two behavioral options they would use to escape stress or "clear the head" in the current residential environment. The behavior options were generated via qualitative methods (see section Stress Coping Scenarios above) and were presented in a two-stage process. Firstly, two environmental coping strategies were offered: an escape place within "*your own home*" or "*some other place*" *outwith the home*. If respondents answered "*some other place*" they were directed to three further choices: "*seeking peace and quiet,*" "*going for a walk*", or "*seeking company,*" resulting in four coping behaviors overall.

Individual Health and Well-being Variables

Our primary outcome measure of health was:

- *Perceived Stress*: measured using the Perceived Stress Scale (PSS, Cohen et al., 1983). The PSS comprises 10 items measured on a 5-point Likert scale from *never* to *very often*. The final score assesses perceived stress over the preceding month and can range from 0 (minimum level of stress) to 40 (maximum level of stress).

Secondary outcome measures of individual health were:

- *Perceived mental well-being*: measured using the Shorter Warwick-Edinburgh Mental Well-being Scale (SWEMWBS) (Stewart-Brown et al., 2009). SWEMWBS asks participants how they have felt over the previous 4 weeks in relation to 7 items used to measure aspects of mental well-being (e.g., feeling relaxed, feeling useful), with responses rated on a 5-point Likert scale from *none of the time* to *all of the time*. Final scores can range from 7 (low well-being) to 35 (high well-being).
- *Perceived general health*: measured via a single item asking participants to rate their general health, ranked on a 5-point Likert scale from 1 (*very poor health*) to 5 (*very good health*).
- *Self-reported physical activity levels:* measured using one item asking for the number of days on which physical activity (of sufficient exertion to raise breathing rate) reached or exceeded 30 min, recalled over the past 4 weeks. This item is recommended by the British Heart Foundation National Centre (Milton et al., 2011).
- *Social well-being:* measured using three items: place belonging, ("how strongly do you feel you belong to your neighborhood or local area?") ranked on a 5-item scale from *strongly disagree* to *strongly agree*; social isolation ("how often do you feel that you lack companionship?"), ranked on a 3-item scale of *often*, *some of the time* or *hardly ever*; and neighborhood trust (how comfortable are you giving your home key to a neighbor to keep an eye on while you are on holiday), ranked on a 4-item scale from *very uncomfortable* to *very comfortable* (Ward Thompson et al., 2016).

Place Characteristics

(a) Perceptions of green space access, quantity and quality:
Perceived quality of local green space was measured using three items (i.e., safety, attractiveness, satisfaction with quality), ranked on a 5-item Likert scale from *low* (1) to *high* (5). Distance to local green space was measured on 5-item scale, with codes 1 to 4 indicating walking distance [from *less than 5 mins* (coded 1) to *more than 30 min walk away* (coded 4)] and 5 indicating *don't know*. In addition, we included a question to capture contact with nature from the home, *access to a garden* (labeled yes/no) and *a view to green space* (labeled yes/no).

(b) Quantity of green space:
Objective measure: The quantity measure used in the analysis is a datazone green space measure based on reclassifications of the Ordnance Survey MasterMap and a city-wide audit of greenspace for Edinburgh, using classifications under Scottish Government's 2008 Planning Advice Note on Planning and Open Space (The Scottish Government, 2008) and cross-referencing to Scotland's

Greenspace Map (Greenspace Scotland, 2011). The analysis carried out on green space quantity is based on more recent mapping and verification of land use data (post-2008) than the census ward level data used for case study selection (see section Study Setting), and is at a finer spatial resolution. The *percentage green space area* derived by this means included public green space, private gardens, and other green space, such as roadside trees and grass, but did not include woodland or forestry areas that were publicly inaccessible. Further information on green space characteristics can be found in Ward Thompson et al. (2016).

Subjective measure: In addition, we asked two questions on the perceived quantity of green space in the neighborhood, the first measuring levels of green space on a 4-item Likert scale from *low* to *high*, the second measuring whether there was "sufficient green space in the neighborhood," ranked on a 5-item Likert scale from *no definitely not* to *yes, definitely*.

(c) Motivation for visiting green space: We asked one question about motivational drivers for visiting local green space, with 7 options linked to known pathways linking green space with health: visiting for relaxation/peace and quiet; to get fresh air; to see wildlife/birds; for social interactions and activities (e.g., to play with grandchildren); for exercise (e.g., walking, cycling, jogging) or for "some other reason" with an open-ended response option.

Approach to Statistical Analyses

In order to identify health sub-groups in our sample we used LCA, version 5.1, a method that we have applied previously to establish distinct sub group behaviors, for example in relation to the use of open space and childhood experiences of nature (Ward Thompson et al., 2004, 2005). The advantage of LCA is that it identifies hidden subgroup structures i.e. it will detect patterns in a sample that are otherwise unobservable, and is not limited by prior structuring or preconceptions of groupings (see Aspinall, 2007 for a description of LCA and its application in environmental research). It is widely used in social science and medical research to identify important subgroups that would not otherwise be revealed and to better target interventions.

Two approaches are available within LCA, in which either one or three steps can be used. We opted for the three step approach where:

a. First a latent class model is built for a set of indicator variables. Step 1 involves selecting the right indicators and number of clusters that establish the best-fit model. At Step 1 the Bayesian information criterion (BIC) for model selection is used to determine the best fit model. A lower BIC figure indicates a better model fit.
b. Cases are assigned to latent classes, and this classification information is saved to a file; next LCA obtains predictions for class membership based on responses for each indicator (step 2).
c. In the third step the latent classification scores saved in step 2 are related to further variables of interest e.g., environmental variables.

The three step approach is preferred according to Bakk et al. (2014) since it involves first building a latent class model and then relating it to covariates or distal outcomes. However, until recently the 3 step approach has been biased in underestimating parameter estimates in the 3rd step. The method we have used follows work by Bakk et al. (2014) in correcting for bias in this third step.

Latent class has a number of advantages, including being able to better manage variables of mixed measurement type. In all cases, latent class takes any variable (e.g., categorical or continuous) and divides it into the most evenly based categories it can find, although the frequency numbers in each category are unlikely to be exactly the same. This can generate fewer categories for some variables than allowed for in the ordinal Likert scale metrics described above e.g., LCA collapsed general health into three categories to equalize numbers in each of the ordinal scale categories; these categories are shown in parenthesis in **Table 4**.

RESULTS

Descriptive statistics for individual characteristics of the sample can be found in **Table 1**, and for the environmental variables in **Table 2**. **Table 1** confirms that our sample is very economically deprived, with 31% finding it difficult to cope on current income and with a Carstairs Index range from 3.7 to 8.7 (mean = 6.15, SD = 2.36), meaning that *all* of the sample is within the top 11% most deprived post-code areas in Scotland, according to this index.

Descriptive Statistics for LCA Covariates

Step 1: Identifying the Different Health Clusters across Age Groups (RQ1)

The main indicator entered into the health cluster model was perceived stress (PSS), alongside two further self-report indicators of health: general health and well-being (SWEMWBS). At an early exploratory stage there was found to be a significant interaction between general health and age, resulting in the latter being added as an indicator in the basic health model.

Applying the Bayesian Information Criterion (BIC) criteria for model selection (i.e., a lower value indicates better model fit), a 3 cluster model was selected (BIC value 3555.42, Table of Results provided in Supplementary Information). In addition, while for 3 clusters the p-value is significant, as a follow-up check, the bootstrap Chi Square p-value (as a more reliable estimate) showed a p-value of 0.174; therefore the model is a good fit. All bivariate residuals were <1.0 having adjusted the age-health interaction. The 3-class model was therefore selected as optimal.

Predictors of class membership: Three health indicators (i.e., perceived stress, general health, subjective well-being) and age are all highly significant in discriminating between the 3 clusters, as shown by the p-values in **Table 3** below. The table shows the significance of the parameter estimates. The R squared value indicates how much variance of each indicator is explained by the cluster model (i.e., the extremes being 62% of well-being and 18% of general health).

TABLE 1 | Descriptive statistics for individual variables, $n = 406$.

		Percentage sample	Mean (SD)
Demographics	Mean age		44 (17.1)
	16–34	34.6%	
	35–54	36.3%	
	55–64	11.6%	
	64+	17.5%	
	Gender (M = male, F = female)	M = 45%	
		F = 55%	
	Education level (% tertiary+)	14.5%	
	No of children (yes)	40%	
Socio-economic	Level of deprivation (Carstairs Index)		6.15 (2.36)
	Income coping: finding it "difficult/very difficult" on present income	31%	
	Car access, % "yes"	39.5%	
Health and wellbeing	Need to escape stress: yes "*quite often/all of the time*"	40.4%	
	Perceived stress (PSS)		15.37 (6.02)
	Perceived wellbeing (SWEMWBS)		25.35 (5.02)
	Reported physical activity (days/month)		10.32 (10.11)
	Perceived general health		3.9 (1)
Social wellbeing	Place belonging (score)		3.91 (0.85)
	Neighborhood trust (score)		2.90 (0.97)
	Social isolation (score)		2.51 (0.63)

Stress (PSS) scores: higher value, greater stress; for all other health variables (e.g., general health; social isolation): a higher value, a better outcome; for level of deprivation a higher score, higher poverty.

TABLE 2 | Descriptive statistics for environmental variables.

	Percentage sample	Total mean (SD)
Average percentage GS (objective measure) in the n/hood	56.83% (SD = 12.34)	
GS satisfaction with quality		3.63 (0.78)
GS attractiveness		3.62 (0.74)
GS distance		4.33 (0.51)
Access to a garden: percentage reporting "yes"	49%	
View to GS from Home; percentage reporting "yes"	69%	

On all green space measures, a higher score = higher satisfaction/attractiveness/closer distance to green space.

TABLE 3 | Parameter estimates for 3 class LC model.

Models for indicators

	Cluster 1	Cluster 2	Cluster 3	Wald	*P*-value	R2
Age	−0.04	0.06	−0.02	11.53	0.00	0.34
General health (GH)	0.70	−0.12	−0.58	15.85	0.00	0.18
PSS	−0.06	−0.14	0.20	32.63	0.00	0.31
SWEMWBS	0.38	0.14	−0.53	15.58	0.00	0.62

Interaction effect*

GH	Age	Wald	*P*-value
	−0.02	12.56	0.00

**There is a significant interaction effect between general health (GH) and health cluster membership.*

Step 2: Predictions for Cluster Membership

Table 4 below shows the probability of an indicator variable score or range given cluster membership. The Table shows (in the first row) that 39% of the sample are in Cluster 1, 33% are in Cluster 2 and 29% are in Cluster 3.

The values under the cluster columns are the probabilities of being in a health or age category given a person is in Cluster 1, 2, or 3. For example, given a person is in Cluster 1, the probability of being in the "*very high/high stress*" *category is 0.29 or 29);* by contrast, given a person is in Cluster 3, the probability of being in this high stress category is 0.79 or 79%.

Based on these data, we have labeled the clusters as follows:

Cluster 1: "*Low-stress Youth*" characterized by young adults (63% aged 16 to 36) experiencing relatively low stress, high well-being, in good general health.

Cluster 2: "*Low-stress Seniors*" characterized by older people (47% aged 64 to 87), experiencing low stress but in poorer general health and with lower well-being.

TABLE 4 | Probability of indicator variable given cluster membership.

	Cluster 1	Cluster 2	Cluster 3
	Low stress Youth	***Low stress Seniors***	***High stress Mid-age***
Cluster size	0.39	0.33	0.29
Indicator (LCA coding in parenthesis)			
Perceived Stress (PSS)			
Very low PSS (1–9)	0.22	0.36	0.01
Low PSS (10–13)	0.25	0.27	0.06
Average PSS (14–15)	0.24	0.20	0.15
High PSS (17–19)	0.18	0.12	0.23
Very high PSS (20–31)	0.11	0.05	0.55
Mean PSS *(higher score indicates higher stress)*	12.9	10.7	19.0
General health (GH)			
Very poor to average GH (1–3)	0.02	0.26	0.31
Good general health (4)	0.39	0.52	0.49
Very good GH (5)	0.59	0.22	0.20
Mean GH *(higher score indicates higher GH)*	12.9	10.7	18.9
Subjective Wellbeing (SWEMWBS)			
Very low SWEMWBS (1–10)	0.00	0.01	0.66
Low SWEMWBS (11–14)	0.08	0.23	0.26
Average SWEMWBS (15–16)	0.28	0.38	0.06
High SWEMWBS (17–18)	0.25	0.23	0.02
Very high SWEMWBS (19–23)	0.39	0.15	0.00
Mean SWEMWBS *(higher score indicates higher wellbeing)*	29.8	28	21
Age			
16–25 (1–10)	0.36	0.02	0.19
26–36 (11–21)	0.28	0.06	0.22
37–47(22–32)	0.22	0.15	0.26
48–63 (33–46)	0.11	0.29	0.21
64–87 (47–63)	0.03	0.48	0.12
Mean age	34	57	41

The columns under each indicator add up to 1. This is interpreted as the probability of an individual being in a particular indicator range given they are in a particular cluster.

Cluster 3: "*High-stress Mid-Age*" characterized by young to middle aged adults (47% aged 26 to 47), experiencing high stress, poor well-being, and poor general health.

Figure 1 illustrates each cluster diagrammatically; it pictures the profile table above. Cluster 1 and Cluster 3 have an orthogonal, diametrically opposed pattern, but are closest in age.

Step 3: Associations between Class Membership and Covariates

Using the three-step LCA approach next, we used linear regression to regress a series of covariates on class membership. The covariates entered into the model included, first, stress coping scenario, second, demographic/socio-economic variables, and other individual indicators (i.e., self-reported physical activity levels and social well-being) and, third, place characteristics—including urban green space—as described in section Methods above.

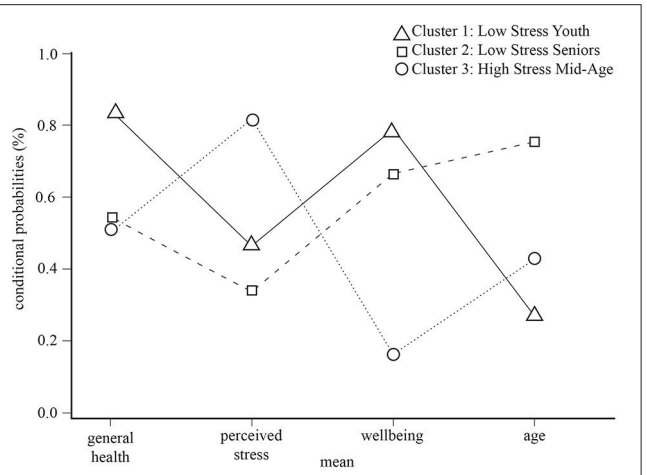


FIGURE 1 | Stress cluster membership plot.

Tables 5, **7** show the significance of the parameter estimates for each covariate, and **Tables 6**, **8** show the probability of an indicator variable given a person is in Cluster 1, 2, or 3 (further explanatory notes on reading these tables is provided in the appropriate sections below). LCA also provides diagrammatic data in the form of tri-plots which plot the probability of cluster membership given an indicator variable (the inverse of the above). Each vertex of a triangle represents one of the 3 clusters in the LCA model. The data for these plots are provided in Supplementary Information. See **Figure 2** for a full explanation on how to interpret the LCA tri-plot.

Associations between Latent Health Clusters and Stress Coping Scenarios (RQ2)

Our second research question concerned the potential behavioral choices taken to escape stress and their possible association with different health clusters. **Table 5** shows the LCA regression output and shows that cluster membership is statistically distinguished by the four stress coping scenarios to a highly significant level ($p < 0.004$). **Table 6** shows the probability of cluster membership according to these four stress coping scenarios.

We can see from **Table 6** that:

Low-stress Youth are more likely to escape stress by "*seeking company*" (42%) or "*going for a walk*" (23%).
Low-stress Seniors are most likely to escape stress by "staying at home" (65%).
High-stress Mid-age people are most likely to escape stress by "*staying at home*" (50%) but—in our sample—also have the highest probability of "*seeking peace and quiet*" (16%) away from home.

TABLE 5 | Significance of parameter estimates for individual covariates.

Indicator	Cluster 1 *Low stress Youth*	Cluster 2 *Low stress Seniors*	Cluster 3 *High stress Mid-age*	Wald	*p*-value
Stress coping scenario					
Staying at home	−1.78	2.75	−0.98	19.02	0.004
Seeking company	1.36	−1.31	−0.05		
Seeking peace and quiet	−0.19	−0.37	0.56		
Going for a walk	0.61	−1.08	0.47		
Gender					
Male	−0.47	0.82	−0.35	6.42	0.04
Female	0.47	−0.82	0.35		
Income coping					
Very difficult	−1.10	−2.73	3.82	15.52	0.017
Difficult	−0.24	−0.74	0.98		
Coping	1.94	0.67	−2.61		
Comfortable	−0.60	2.80	−2.20		
Housing Tenure					
Private landlord	3.53	−3.72	0.20	18.20	0.02
Social landlord	3.39	−1.42	−1.96		
Mortgage/shared T	2.35	−0.25	−2.10		
Owner outright	−21.98	14.68	7.30		
Neither/don't pay	12.72	−9.30	−3.42		
Disability					
Yes	−2.00	0.92	1.09	8.76	0.02
No	2.00	−0.92	−1.09		
Number of children					
Yes	2.79	−3.82	1.04	5.11	0.07
No	−2.79	3.82	−1.04		
Car access					
Yes	0.53	0.65	−1.18	13.52	0.001
No	−0.53	−0.65	1.18		
Carstairs deprivation index	−0.31	0.84	−0.53	13.61	0.001
Neighborhood trust	0.23	−0.62	0.34	5.41	0.06
Place belonging	−0.20	1.34	−1.15	8.50	0.01
Social isolation	0.07	1.63	−1.70	12.21	0.002
Physical activity	0.18	−0.16	−0.03	19.02	0.002

Figure 2 plots the probability of being in a health cluster given one of four stress coping scenarios and shows, for instance, the option "*staying at home*" is closest to Cluster 2, *Low-stress Seniors*.

Associations between Latent Health Clusters and Individual Characteristics (RQ3)

Our third research question addressed how area-level deprivation and individual characteristics, including social well-being and physical activity levels, are associated with different health clusters. **Table 5** also shows the LCA regression output for these variables across the three latent health clusters.

Table 5 shows that a number of demographic/social-economic variables (i.e., gender, disability, children, deprivation, tenure, subjective income coping and car access) distinguish between the three latent health clusters; of these, car access and deprivation score were the most significant discriminators ($p < 0.001$). **Table 6** shows the probability of cluster membership according to these individual discriminators, described below:

Low-stress Youth are more likely to be female (59% probability), living in the most deprived neighborhoods (70% in upper deprivation categories), renting from a social landlord (66%), with an average chance of coping well on a low income (52%), quite likely to have children under 16 (56%); with a low chance of experiencing a disability (3%) and of having a car (41%).

Low-stress Seniors are marginally more likely to be male (52% probability), experiencing high level deprivation (55% in upper deprivation categories), renting from a social landlord (56%), but also more likely than in other groups

TABLE 6 | Probability of individual indicator variable given cluster membership.

		Cluster 1	Cluster 2	Cluster 3
		Low stress Youth	***Low stress Seniors***	***High stress Mid-age***
Cluster size		0.37	0.35	0.28
Stress coping scenario	Staying at home	0.32	0.65	0.50
	Seeking company	0.42	0.18	0.18
	Seeking peace and quiet	0.03	0.08	0.17
	Going for a walk	0.23	0.09	0.15
Gender	Male	0.41	0.52	0.40
	Female	0.59	0.48	0.60
Income coping	V Difficult	0.02	0.01	0.19
	Difficult	0.35	0.15	0.33
	Coping	0.52	0.62	0.29
	Comfortable	0.10	0.20	0.12
Carstairs deprivation index	1–4	0.07	0.02	0.06
	5–5	0.22	0.42	0.47
	6–7	0.32	0.33	0.17
	8–8	0.38	0.22	0.30
Housing tenure	Rental: private	0.16	0.04	0.17
	Rental: social	0.66	0.56	0.63
	Mortgage/shared tenure	0.14	0.16	0.09
	Home owner	0.00	0.21	0.04
	Rent-free	0.03	0.00	0.01
Disability	Yes	0.03	0.14	0.10
	No	0.95	0.80	0.82
Children	Yes	0.56	0.05	0.44
	No	0.37	0.90	0.49
Car access	Yes	0.41	0.56	0.29
	No	0.57	0.43	0.68
Physical activity (days/month)	1–1	0.07	0.33	0.21
	2–10	0.10	0.16	0.34
	11–14	0.25	0.22	0.15
	15–21	0.27	0.15	0.12
	22–25	0.30	0.13	0.19
Neighborhood trust	v. uncomfortable	0.18	0.11	0.18
	fairly uncomfortable	0.15	0.10	0.14
	fairly comfortable	0.41	0.37	0.36
	comfortable	0.25	0.39	0.30
Place belonging	strongly disagree	0.00	0.00	0.04
	disagree	0.05	0.01	0.10
	neither disagree/agree	0.09	0.04	0.14
	agree	0.63	0.50	0.53
	strongly agree	0.21	0.44	0.18
Social isolation	often	0.01	0.07	0.16
	some of the time	0.16	0.24	0.42
	never	0.82	0.68	0.41

The figure is interpreted as the probability of an individual being in a particular indicator range given they are in a particular cluster.

to be a home owner/have a mortgage (37%); likely to be coping better on a low income (62%), with a very high likelihood of having children (90%), a low likelihood of disability (14%), and higher likelihood of having a car (56%).

High-stress Mid-age people are more likely to be female (60%), with an average chance of finding it *very difficult/difficult* to cope on a low income (52%), renting from either a social landlord (63%) or private landlord (19%); likely not to have a car (68%), unlikely to have a disability (10%), with a

lower probability of having children than in other groups (44%).

Our third research question also asked how other individual characteristics—including social well-being—are associated with different health clusters. **Table 5** shows that both physical activity levels and social well-being (i.e., place belonging and loneliness) significantly discriminate between the latent health clusters. **Table 6** shows the probability of cluster membership according to social well-being and physical activity:

Low-stress Youth are more likely to be physically active on regular basis (57% in the upper activity categories) and very likely to have good social well-being.
Low-stress Seniors are less likely to be physically active (49% in the lower activity categories) but likely to have good social well-being.
High-stress Mid-age people are likely to be physically *inactive* (55% in the lower activity categories) and experience poor social well-being.

Associations between Latent Health Classes and Environmental Characteristics (RQ4)

Table 7 shows the LCA regression output and statistically significant environmental predictors of the three latent health clusters. **Table 8** shows the probability of cluster membership based on the above predictors. Cluster membership by environmental characteristics can be described as follows:

Low-stress Youth characterized by good access to and good use of local green space, and reasonable satisfaction ratings. The probability of good access to local green space is high: the probability of living "*within a 5–15 min walk*" *is 74%*, the probability of visiting green space "*at least once a week/every day in summer*" is 64% and the chance of being *very satisfied/satisfied* with the quality of local green space is 56%. The probability of having a view from home and/or a garden is low.
Low-stress Seniors characterized by good access to a garden and local green space, but infrequent use. The probability of having a garden is 61%; the probability of living close to green space is also high (a 75% chance of living "*within a 5–15 min walk*") but the probability of visiting that green space frequently is relatively low (43% probability of visiting "*at least once a week/every day in summer*") despite a high probability of being "*very satisfied/satisfied*" with local green space (78%).
High-stress Mid-age characterized by good access to local green space, reasonable use but poor satisfaction ratings. The probability of having good access to green space is very high (90% chance of being "*within a 5–15 min walk/less than 5 min walk*"); likely to visit green space fairly regularly in summer (65% probability of visiting "*at least once a week/every day in summer*"), but less likely to be satisfied with it (48% in lowest satisfaction categories). The probability of having a view from home and/or a garden is low.

Three LCA tri-plots (**Figures 3–5**) illustrate the strongest patterns between the environmental variables and health clusters (i.e., the most significant environmental discriminators); these diagrammatically plot the probability means from the LCA output (data in Supplementary Information).

The tri-plot in **Figure 3** shows increasing dissatisfaction with green space goes with increasing stress.

On use of green space (in summer) (a significant discriminator of health clusters at $p = 0.02$), we see a strong association with age (see **Figure 4**), with more frequent visits closest to the health clusters characterized by youth and mid age (Clusters 1 and 3, respectively) and tailing off to no visits in *Low-stress Seniors* (Cluster 2). The LCA probability means (which the triangle illustrates) show an interesting difference in the young-mid-age clusters, with the probability of visiting *every day/at least once a week* high in *Low-stress Youth* (Cluster 1) (85%), falling off in *High-stress/Mid-age* (Cluster 3) to 64% (data in Supplementary Information).

Another highly significant predictor variable, contact with nature via garden access ($p < 0.001$) is highest in *Low-stress Seniors* Cluster (2), with access clustering in this older age category (a 52% probability of having a garden). This pattern is illustrated in **Figure 5**.

Motivations for Visiting Green Space by Health Cluster

The motivations for visiting urban green space significantly vary by health cluster. **Figure 6** shows that *Low-stress Youth* (Cluster 1) are more likely to visit for exercise and for social reasons (possibly reflecting their chosen stress relief behaviors to walk and seek company). Both *Low-stress Youth* (Cluster 1) and *Low-stress Seniors* (Cluster 2) are equally likely to visit for relaxation. *High-stress Mid-age* (Cluster 3) show distinctly different motivational patterns and are much less likely to visit urban green space for relaxation, exercise or social purposes.

We found no significant patterns of difference across the three health clusters in social visitation patterns (i.e., going alone or with a friend).

Summary of Findings

LCA identified three latent health clusters:

(1) ***Low-stress Youth*** characterized by young people, most likely to be aged 16 to 24, who seek company and walk as their preferred stress coping scenarios, are physically active, with good social well-being, have good access to green space, regularly visiting these spaces in summer, and are satisfied with green space quality.
(2) ***Low-stress Seniors*** characterized by older people aged 65+, who stay at home as their preferred stress coping scenario, are in poor general health, with good social well-being, but relatively physically *inactive,* infrequently visiting local green space (despite good access) but likely to have contact with nature via good access to a garden, which may be offering some buffer to life stressors. Despite good

TABLE 7 | Significance of parameter estimates for environmental covariates.

Indicator	Cluster 1: *Low stress Youth*	Cluster 2: *Low stress Seniors*	Cluster 3: *High stress Mid-age*	Wald	*p*-value
GS visits summer	0.93	−1.40	0.47	7.97	0.02
GS distance	−1.08	−2.92	4.01	5.19	0.07
GS quantity: objective measure	−0.08	0.08	0.00	5.32	0.07
Access to garden					
Yes	−1.60	1.84	−0.24	7.00	0.001
No	1.60	−1.84	0.24		
View from home					
No	2.02	−1.82	−0.21	14.91	0.001
Yes	−2.02	1.82	0.21		
Satisfaction with quality of GS	−1.34	1.25	0.09	12.84	0.002

TABLE 8 | Probability of green space indicator variable given cluster membership.

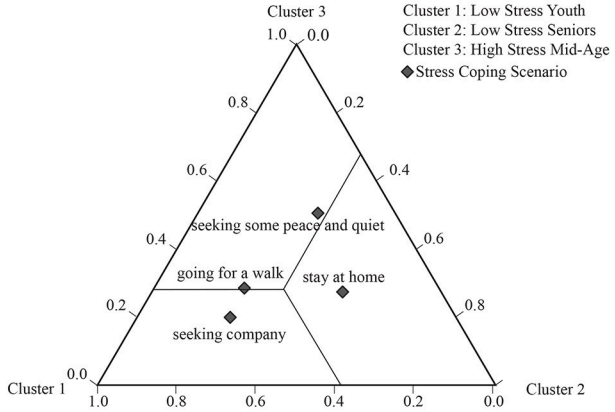
Indicator		Cluster 1: *Low stress Youth*	Cluster 2: *Low stress Seniors*	Cluster 3: *High stress Mid-age*
GS visits in summer months	Never	0.17	0.26	0.13
	Once a year	0.02	0.17	0.02
	Once a month	0.13	0.14	0.10
	Once/week	0.34	0.26	0.36
	Everyday	0.31	0.17	0.29
GS distance from home [minutes (m) walking]	>30 m walk	0.00	0.01	0.00
	15–30 m walk	0.02	0.03	0.01
	5–15 m walk	0.75	0.75	0.43
	<5 m	0.20	0.21	0.48
GS quantity: percentage	1–7 (<33%)	0.23	9	8
	8–12 (34–49%)	0.19	0.14	0.14
	13–17 (50–58%)	0.19	0.12	0.22
	18–22 (59–62%)	0.07	0.21	0.13
	23–29 (>63%)	0.09	0.23	0.14
GS access to garden	Yes	0.24	0.61	0.38
	No	0.75	0.39	0.61
GS view from home	Yes	0.09	0.32	0.37
	No	0.91	0.68	0.62
Satisfaction with quality of GS	1–3 (low quality)	0.29	0.18	0.48
	4–4 (high quality)	0.49	0.65	0.40
	5–5 (very high quality)	0.07	0.13	0.05

access to other green space, perceived as high quality, this stress cluster is not using public open space for stress regulation.

(3) ***High-stress Mid-age*** characterized by young-middle adulthood, most likely to be aged 25 to 47, who stay at home as their preferred stress management scenario, in poor general health, with poor social well-being, physically *inactive*, frequently visiting local green space (in summer) but most likely to be dissatisfied with its quality. Despite good access to green space, this stress cluster is not using public open space for physical activity or stress relief; we suggest this is likely owing to perceptions of its poorer quality.

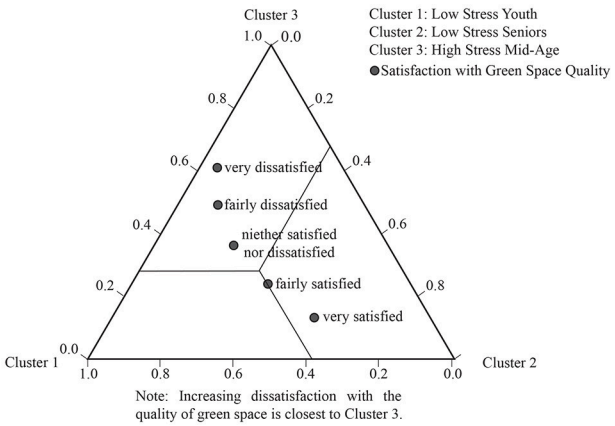
DISCUSSION

Following our earlier study on stress mitigation in the same deprived urban population (Ward Thompson et al., 2016), our interest in the current study was in *how* the local environment (including one's home) might assist with stress regulation in a population experiencing higher than average stress. Whilst our earlier study established a relationship between perceived stress and access to green space (including quantity of green space in the neighborhood and access to a garden/allotment), it did not establish *why* green space has this effect. For instance, is the relationship owing to people being more physically active or more social in their local green space, or both? Whilst physical



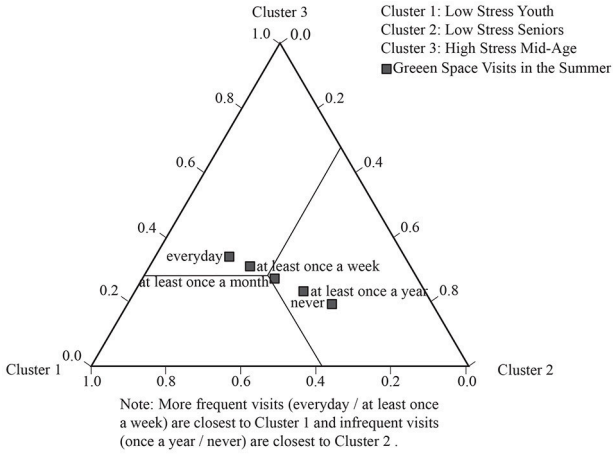
The 3 clusters are represented by the 3 vertices of the triangle. The lateral and base edges of the triangle represent the cluster probabilities. The centroid of the triangle represents the mean observation, and is plotted at the point corresponding to the overall cluster probabilities obtained from the first row of numbers in the Probability Means table (see Supplementary Information). Lines that are parallel to each of the 3 sides of the triangle emanate from this point and intersect each side at the corresponding cluster probability. For example, the probability of being in Cluster 1 is 0.37, which is obtained at the point of intersection with the base of the triangle. The diamond symbol indicates that the two stress coping scenarios, 'seeking company' and 'going for a walk' are closest to cluster 1, 'stay at home' is closest to Cluster 2, and 'seeking some peace and quiet' is closest to Cluster 3.

FIGURE 2 | LCA tri-plot showing relationships between health cluster and stress coping scenario.



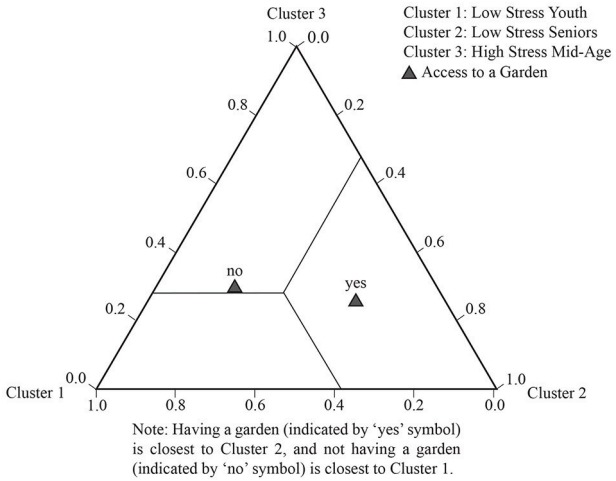
Note: Increasing dissatisfaction with the quality of green space is closest to Cluster 3.

FIGURE 3 | LCA tri-plot showing relationships between green space satisfaction and the heath clusters.



Note: More frequent visits (everyday / at least once a week) are closest to Cluster 1 and infrequent visits (once a year / never) are closest to Cluster 2 .

FIGURE 4 | LCA tri-plot showing relationships between green space visits (summer) and the heath clusters.



Note: Having a garden (indicated by 'yes' symbol) is closest to Cluster 2, and not having a garden (indicated by 'no' symbol) is closest to Cluster 1.

FIGURE 5 | LCA tri-plot showing relationships between garden access and the heath clusters.

activity, mental relaxation, and social interactions are believed to be potential pathways to the health benefits of green space (Lachowycz and Jones, 2013; Hartig et al., 2014), current research evidence in deprived urban populations is very limited. The aim, therefore, in the current study was to tease out *how* people use their immediate and local environment for stress regulation, and how these behaviors relate to perceived stress.

Firstly, we used LCA to identify health sub groups in a population experiencing economic stress. The best fit model was a three cluster model with perceived stress and age the most significant discriminators (RQ1). Our youngest participants (likely to be aged 16–24) were the healthiest; our mid-age participants (likely to be aged 26 to 47) were the least healthy; our older participants (likely to be aged 64 to 87 group) were unhealthy, but the least stressed of our sample.

Secondly, LCA established relationships between health cluster membership and a series of indicator variables (or co-variates). First, it established a relationship between health membership and people's hypothetical stress coping strategies. Our healthiest cluster (*Low-stress Youth*) are most likely to seek company (outside of the home) and walk to escape stress; they are more physically active, in better general health, and have better subjective and social well-being. By contrast, our poorest health cluster (*High-stress Mid-age*) is more likely to stay at home for stress relief, as is Cluster 2 (*Low-stress Seniors*). These two health clusters have lower physical activity levels and poorer general health. *Low-stress Seniors*, however, are the most robust to stress in our sample: it is possible that this health cluster is experiencing sensory contact with nature via greater access to a garden and/or a view from home, and that this is helping buffer stress levels.

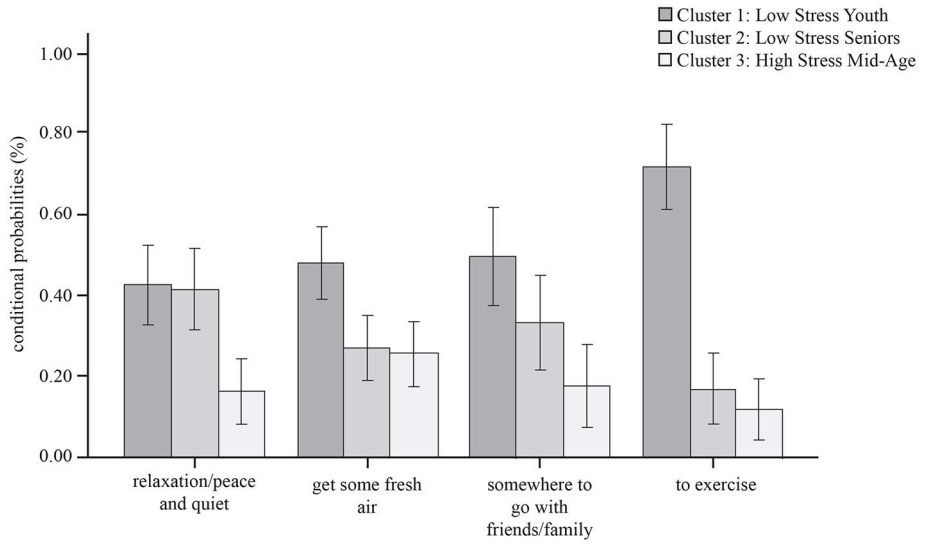


FIGURE 6 | Primary motivations for visiting local green space by health cluster.

Next, LCA established relationships between health cluster membership and individual characteristics including gender, subjective income coping, housing tenure, and deprivation indices (RQ3). For instance, health clusters are characterized by gender differences: younger to mid-aged women (aged 48–62) were the most stressed in our sample (Cluster 3, *High stress Mid-age*) (**Table 6**). We also found strong relationships between health clusters and income coping: the probability of coping on a low income is significantly lower in *High stress Mid-age* (29%), as compared to the other (better) health groups (**Table 6**). Raising children had marginal significance on health membership ($p = 0.07$). Whilst raising children is an identified stressor in families living with poverty in the US (Kuo, 2001), we found the inverse pattern in our sample. Our younger, healthier group are more likely to be raising children under the age of 16 (**Table 6**) than less healthy sub-groups. We suggest having children might therefore be acting as a moderator in the relationship between getting outdoors more frequently and being more social. For instance, parents/carers with children are more likely to be walking outdoors to and from routes to school and interacting with eachother on a daily basis.

Finally: we found that health cluster membership is strongly related to a range of green space attributes (RQ4). *Low-stress Youth* are most likely to be satisfied with their local green space, have good access, and have a higher likelihood of visiting their local green space in summer (this pattern also continues into winter visits). They are motivated to visit local green space for a range of relaxation, exercise and social purposes. By contrast, *High-stress Mid-age* people, whilst having a similar likelihood of good access to green space, have much lower perceptions of its quality, and are less motivated to visit for relaxation, exercise or social purposes. Whilst use of green space is very low in *Low-stress Seniors,* this group has the highest likelihood of immediate contact with nature via access to a garden or a view from home, and we suggest that this visual contact to nature may offer a buffer against life stressors, although not contributing to general health or physical activity levels in our sample.

Despite good access (all three latent health clusters live reasonably close to their local green space) it appears that relationships between *use of* and *satisfaction* with urban green space is moderated by age. Whilst *Low-stress Youth* are using nearby green space regularly and are satisfied with its quality, the same (or similar) outdoor space is not supporting the needs of young-middle aged adults, most of whom simply stay at home for stress relief. As one approaches mid-life, perceptions of *quality* of the local environment may become more discerning, or this age group may demand different attributes from green space. By contrast, *Low-stress Seniors* are satisfied with the quality of their local green space but don't appear to use it. The motivations for use of local green space also vary across our three clusters, *Low-stress Youth* are most likely to visit for exercise; *Low-stress Seniors* are most likely to visit for relaxation; whilst the *High-stress Mid-age* people appear to have no strong motivations for visiting green space. In this deprived urban population, it appears quality judgements about green space are more important for utilizing green space than either the amount of green space available or proximity, but judgements clearly vary across the lifespan.

Our study's finding that quality of green space is significantly related to health group membership is an important finding since research on the health benefits of green space is largely focused on issues of quantity or proximity, using objective measures of distance to green space or percentage calculations. Addressing issues of quality of green space—and its relationship to health and well-being—is a theme identified in our prior research in deprived urban communities (CABE, 2010; Ward Thompson et al., 2013; Roe et al., 2016). Poorer communities live with both poorer access to green space and poorer quality green space (CABE, 2010). Lennon et al. (2017) argue that more attention

be paid to quality, alongside issues of proximity, and for a more nuanced and dynamic understanding of green space use and perceptions. The authors suggest a framework of affordances to capture multidimensional perspectives of quality amongst diverse sub-groups (e.g., by age, gender, ethnicity). Quality is conceptualized in terms of the opportunities (or constraints) a park offers in relation to six attributes: space (e.g., landforms); scale; time; objects (e.g., presence of absence of trees, benches, cycleways); actions (e.g., climbing, jogging, bird watching); and the physical and psychological state of the person positioned in relation to these other dimensions. Understanding how these attributes interact to generate quality green space experiences is one promising area for future research.

As far as we know, this is the first study to explore health sub-groups and relationships to environment in terms of stress regulation in a deprived urban population. The current literature on environmental emotional regulation and the benefits of nature in supporting mood regulation is largely focused on younger populations such as students (e.g., Korpela et al., 2001) or less deprived populations (e.g., Korpela, 2003; Korpela and Ylén, 2007). Understanding how the neighborhood environment, including the home, supports stress regulation in people living in poverty is therefore an important contribution to this body of research. Furthermore, since there is evidence that going for a walk in local green space offers opportunities for reflection and to "think things through," reducing negative thinking and rumination (Bratman et al., 2015), then if nature access can be increased in these communities, one important potential benefit may be a reduction in mental health inequities. Evidence shows that access to green space is associated with a reduction of up to 40% in mental well-being inequalities (Mitchell et al., 2015). We conclude that, as well as focusing on proximity and quality measures, a focus on understanding the interactions between *quality* and *use* of green space for mental well-being in people living with poverty is likely to be a fruitful approach in tackling mental health inequities.

IMPLICATIONS

Although access to green space is associated with health benefits, particularly for economically deprived urban populations, the challenge in addressing health inequity is not simply about availability of green space but also how to support people living in poverty to derive health and well-being benefits from their local green space. We have shown that patterns of perception and use are likely to vary according to life stage. The advantage of LCA is that is reveals otherwise unobservable sub-groups in the population under study, and allows for interventions to be targeted at these sub-groups. To date, studies of green space proximity have rarely addressed the importance of programming and differences in lifestyle to afford greater access and benefit levels from urban green space. In applying the research findings to social and recreational policy, we suggest that *Low stress (but low health) Seniors* need encouragement to use their local green space and/or garden to improve their physical activity levels and general health. Raising awareness of the benefits of contact with nature and encouraging Seniors to be more aware, e.g., of the sensory affordances of local green space, may also have positive effects on their subjective well-being (which is low in this group). Furthermore, LCA identified mid-aged people living in poverty are at risk from high stress and poor overall health and well-being. Local initiatives to tease out why such sub-groups perceive their local urban green space as of poor quality (via focus groups and surveys) can help target physical interventions to improve the quality of local green space for health and well-being in this segment of the population. In addition, as mentioned above, better understanding of the specific park attributes that encourage use for, say exercise, or social activity, will also enhance the potential of green space for health and well-being amongst poorer health sub-groups. Finally, estimating the economic value of improving green space access for health and well-being outcomes in this demographic warrants further attention; several useful protocols have been established (Silveirinha de Oliveira et al., 2013; Wolf et al., 2015).

LIMITATIONS

Our study was based on four hypothetical behavior choices (set within the context of the current neighborhood environment) rather than actual activities reported as undertaken for stress relief. Whilst it is reasonable to assume one's intended motives for stress reduction bear some resemblance to actual behavior, our study does not support this. For instance, the low levels of monthly reported physical activity across all health clusters indicate that most of our sample are not engaged in any regular physical activity. In future it would be important to identify *actual* stress regulation behaviors and the exact environmental context in which such behaviors take place (e.g., via mobile phone applications integrated with GPS).

Our four, proffered stress relieving activities are not mutually exclusive categories, i.e., it is possible someone "*seeking company*" away from home will also partake in the activity "*going for a walk.*" However, in asking participants to make a distinct choice between one coping activity over another, this suggests—say in the case of "*going for a walk*"—the main motivator is exercise, and that any social motivator is secondary to that intent (otherwise the participant would select "*seeking company*" as the primary activity).

A limitation of the current study is that we explored *use* and *quality* (i.e., satisfaction with the quality of green space) as single entity variables. But these concepts are multi-dimensional (i.e., *use* constitutes more than walking to and within a local green space). Two recent studies have explored interactions between use and quality perceptions of green space. The first reports that quality perceptions of open space and frequency of use of green/social spaces have a significant mediating role in the relationships between the neighborhood environment and mental well-being (Hadavi, 2017). The second study identified significant interactions between quality perceptions of specific park ingredients (i.e., satisfaction scores with the quality of different park components such as trees, lawns, flower beds etc.) and different types of use (i.e., walking, running, biking

etc.) (Hadavi and Kaplan, 2016). Future research needs to better understand these active park "ingredients," quality perceptions and their role in stress reduction.

Whilst we explored motivations for use of parks, our research on motivational affordances of local green space for stress relief was limited to one generic question presenting seven options (see section Place Characteristics, item "c"). Whilst these options were established from previous analyses of motivational patterns in similar populations, further research is needed to explore a wider range of motivations and how environmental interventions—social and physical—might shift these motivations to facilitate actions that help maintain good health.

The data for this study were collected primarily to explore differences in green space quantity and perceived stress (the subject of Ward Thompson et al., 2016). Our objective quantity measure of green space was not a significant discriminator of health clusters in this study (although marginally so at $p > 0.07$); our reporting in this study therefore does not dwell on the significance of green space differences in quantity between neighborhoods.

Finally, there is a possibility of response bias despite the quota sampling approach (see section Data Collection), in relation to characteristics not included in the quota, (e.g., people excluded because they were not at home). This was minimized by repeat household call backs by the survey company. Also, recruitment was in a deprived urban population, many of whom would be at home for various reasons (e.g., unemployment, caring for a family member).

CONCLUSION

Amongst people living with high economic deprivation, our study identified three distinct health clusters and identified relationships between these health clusters and stress coping scenarios in relation to participants' local environment. Relationships were also found between health cluster membership and environmental variables, including access to urban green space and gardens. Our study has highlighted that environmental opportunities for stress regulation vary by age: younger people go outdoors more often for stress relief, appear to use green space more regularly and are less discriminating about its quality. By contrast, people in middle age experience higher levels of stress, tend to stay at home for stress relief, are more physically inactive, and more negative about the quality of their local environment. Older people are more likely to be in poor general health, and not to use their local green space, are less physically active, but happier with the quality of their local green space. We suggest policy efforts therefore focus on targeted health promotion initiatives that raise awareness of the benefits of local green space for health and well-being—but also facilitate increased access, including exploring with the local community ways in which quality can be improved.

Our study is the first to employ LCA to understand better how the local neighborhood environment—including access to local green space—affords some people opportunities for stress relief but not others. Since a significant body of experimental and epidemiological evidence now points to green space as a salutogenic and stress-mitigating environment, urban planners and designers need to engage with deprived urban communities—across the lifespan—to better understand how their local green space might better serve their health and recreational needs.

AUTHOR CONTRIBUTIONS

All three authors conceived and designed the research. JR, as the first and corresponding author, carried out descriptive statistics and wrote up the manuscript in collaboration with the other authors. PA carried out the LCA data analyses and provided the figures and table output for the research report. CW was the Principal Investigator for the research study. All authors contributed to development of the research questions and interpretation of the findings and their implications.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2017.01760/full#supplementary-material

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Nature as a Commodity: What's Good for Human Health Might Not Be Good for Ecosystem Health

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Are you getting enough Vitamin N? Richard Louv (2008) coined this term in his book "Last Child in the Woods," in response to growing evidence that suggests humans are increasingly disinterested with, and disconnected from the natural world. Concurrent with the literature on the extent of disconnection (Miller, 2005; Soga et al., 2016; van Heezik and Hight, 2017) is an ever-expanding body of literature documenting the many psychological, physical, and spiritual health benefits derived from nature contact (Keniger et al., 2013; Bratman et al., 2015; Martyn and Brymer, 2016; Frumkin et al., 2017). In fact human survival is inextricably linked with nature: the species and their inter-relationships that make up the fabric of ecosystems function to sustain all life on Earth. Biodiversity in all landscapes, including urban ones, provides humans with essential ecosystem services, such as food provisioning, climate and flood regulation, nutrient cycling, carbon sequestration, and pollution reduction (Elmqvist et al., 2015). Frameworks have been proposed for evaluating the economic value of biodiversity (Edwards and Abivardi, 1998), with more recent approaches acknowledging the inter-play between social well-being, economic sustainability, and biodiversity and ecosystem function (Tzoulas et al., 2007; Laurila-Pant et al., 2015). These socio-cultural valuation techniques recognize that biodiversity provides society with benefits, such as mental well-being, ethical, spiritual and cultural values, as well as economic values. Psychological well-being benefits have been positively associated with the number of species perceived by people in the environments around them (Fuller et al., 2007; Dallimer et al., 2012). Loss of biodiversity reduces the efficiency by which ecological communities perform ecosystem services, as well as the stability of ecosystem function over time (Cardinale et al., 2012).

The role that urban nature can play in enhancing psychological and physical well-being and reducing health-related costs could be seen by those advocating for the protection and restoration of urban biodiversity and ecosystem function as a positive outcome, suggesting a need to place greater value on biodiverse urban spaces. Another, less positive, scenario is that the connection between human health and nature might threaten the ecological integrity of urban green spaces by commodifying nature, especially if green spaces are designed and managed for human health benefits alone, with little concern for supporting biodiversity or ecosystem services. In this latter scenario nature could become a "pill" with only those aspects of nature that most strongly influence human health and wellbeing considered to be important in the design process. Here we demonstrate how this undesirable outcome might be realized, and argue that a focus on treating urban nature purely as an efficient means of delivering minimal levels of psychological well-being is short-sighted. The development of knowledge and implementation of best practice that ensures outcomes that provide for psychological well-being requires an interdisciplinary approach that encourages diverse ecological communities with greater input by ecologists.

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NATURE AS A THERAPEUTIC DEVICE

Mounting support for the link between contact with nature and improved human health and well-being has led to nature being applied for therapeutic purposes; for example, Shinrin-yoku or "forest bathing" in Japan (Song et al., 2016; Hansen et al., 2017), horticultural therapy or gardening (e.g., Clatworthy et al., 2013; Kamioka et al., 2014), participation in woodland management (Townsend, 2006), and green prescriptions (Van den Berg, 2017). A systematic review of studies of nature-assisted therapy revealed robust support for its effectiveness (Annerstedt and Währborg, 2011). Evidence suggests that time in nature is particularly beneficial for psychological health (Brymer et al., 2014; Bragg and Atkins, 2016). Consequently, some researchers have been focusing on identifying the minimum "doses" of nature needed to benefit well-being (Shanahan et al., 2015; Cox et al., 2017).

MINIMUM DOSES FOR WELL-BEING BENEFITS; WHAT MIGHT THEY MEAN FOR BIODIVERSITY?

How much nature exposure is required to derive a psychological health benefit? Shanahan et al. (2016) focused on time spent by people in nature and applied a dose-response analysis, used in health contexts to evidence effectiveness: they found that visits of 30+ min to green spaces could reduce the population prevalence of depression and high blood pressure by 7 and 9%, respectively, translating to savings for public health budgets. Such evidence has influenced health-related decision-making globally. In general, dose-response calculations have influenced physical activity research and manifest as green prescriptions by doctors, whereby people are encouraged to be more active, and green spaces are promoted as beneficial. From this perspective, psychological health benefits come about directly from the fact that green spaces encourage physical activity. However research also indicates green spaces have direct positive effects on psychological health and well-being (Pretty et al., 2006; Barton et al., 2016). Green prescriptions can therefore be an important contribution to public health, and strategies to encourage adoption of green prescriptions have been proposed (Van den Berg, 2017).

While green prescriptions and recommendations on the frequency and duration of exposure to nature might seem helpful, or at least benign, Stanley et al. (2015) argue that considering nature in this way has detrimental consequences for biodiversity. Specifically, the growing numbers of people accessing green spaces only for health benefits, together with the promotion of health-related (including exercise) requirements within green space design, threatens biodiversity and the integrity of urban ecosystems. This is because green spaces are inevitably modified to accommodate human use. Examples include, pathways extended and widened, large flat areas (e.g., lawns) created for exercise groups, vegetation modified to enhance users' perceptions of safety, and artificial lighting installed for use outside daylight hours (Stanley et al., 2015). Habitat design, if undertaken purely from a health and well-being perspective, might exclude species perceived as undesirable, such as snakes or spiders. Often these green spaces are rated on aesthetic characteristics and because aesthetic preferences do not always align with habitat supporting biodiversity, recreational spaces might provide resources for only the most tolerant urban exploiters, which are often non-native (McKinney, 2002). Less tolerant species are likely to abandon popular, well-lit areas when frequent noise interferes with auditory cues, when sounds are perceived as threats, and when pedestrians and dogs interrupt foraging, resulting in more time being vigilant, energy wasted, and foraging opportunities lost. While urban green spaces might provide habitat for some hardy non-human residents, paradoxically "people-friendly" spaces are not necessarily "wildlife-friendly." Thus design of green spaces might need to consider a broader perspective than aesthetic characteristics or the maximization of recreation activities.

Others have applied dose-response curves to estimate the minimum levels of vegetation required for improved well-being. Cox et al. (2017) evaluated five neighborhood nature characteristics and calculated dose-responses for mental disorders, concluding that quantifiable reductions in the prevalence of poor mental health could be achieved with even low levels of components of neighborhood nature. Another study investigated the dose of nature required to reduce stress in people subjected to a Trier Social Stress Test. Study participants watched assigned street scenes with different tree densities; the male dose-response curve indicated that stress reduction was greatest at tree densities of 24–34% (Jiang et al., 2014).

While these studies provide valuable insights into the amount and type of nature exposure necessary to effect improved human well-being, this approach becomes problematic when the minimal levels and type of vegetation identified as safe and adequate to enhance human well-being are insufficient to support biodiverse communities and stable ecosystem function. Tall trees and shrub understoreys provide habitat for small mammals (Dickman and Doncaster, 1987), birds (Jokimäki and Suhonen, 1993; van Heezik et al., 2008), and invertebrates (Smith et al., 2006), and are an important generator of ecosystem services (Gaston et al., 2013). Despite the important role that vegetation volume plays in supporting biodiversity and ecosystem services, trade-offs, and conflicts exist between planning for biodiversity and planning for local residents. For example, these same rich biodiverse habitats might also present health and safety issues (e.g., dark parks, health problems from pollen, places for drug taking activities). It is therefore feasible that those responsible for greening urban environments might introduce vegetation based on an easy-to-manage approach, rather than an approach that considers local biodiversity and ecosystem services.

WHAT KIND OF NATURE?

Keniger et al. (2013) emphasized the importance of understanding the characteristics of natural settings that trigger well-being benefits and how these vary among cultural and socioeconomic groups. However the kind of nature

researchers have focused on to demonstrate links to positive well-being responses is frequently not reflective of the type of natural environments conservationists seek to encourage. In many studies on psychological well-being benefits the natural environment is described as parkland with scattered shrubs and trees (Bowler et al., 2010; Bratman et al., 2015). Descriptions of "nature treatments" can be very broad. From a health perspective the notions of greenness and nature often stem from what the environment looks like, and biodiversity is either assumed because the environment looks green or not considered at all (Keniger et al., 2013; Shwartz et al., 2014; Sandifer et al., 2015). This is because few studies specifically focusing on health have involved ecologists. "Greenness" is measured remotely if the focus of the study is on entire neighborhoods (e.g., Beyer et al., 2014; Dadvand et al., 2016) or using generalized land-use databases (e.g., Alcock et al., 2014; Gidlow et al., 2016). These are convenient to use in population-level studies, but do not represent many of the relevant features of the greenness, such as species diversity and composition, vertical structure, and wildness. In a review of 125 journal articles about green space, fewer than half defined what the green spaces consisted of with only simple generic descriptions provided; e.g., park, golf course (Taylor and Hochuli, 2017). Moreover, when greenspace quality was referred to, "quality" was subjectively determined without reference to ecological integrity.

DOES USING NATURE TO ENHANCE HUMAN WELL-BEING COMPROMISE BIODIVERSITY?

Urban nature is increasingly seen as a manageable resource to enhance human well-being. By viewing nature as a commodity that supplies health benefits, and by identifying minimum amounts needed to gain benefits, we risk trivializing a deep affective response to nature. We might end up with a watered-down, biodiversity-poor version of nature with compromised ecosystem services. By creating a new baseline of what is considered normal we could exacerbate ongoing shifts toward more depleted environments. The concept of shifting baselines (Pauly, 1995) is pertinent to each generation of urban residents that perceive the state of the environments they encounter in their childhood as normal, unaware of the past losses and the depleted and altered nature of the biodiversity that remains. Paradoxically, this could also reduce the psychological benefits from human-nature interactions.

Research linking psychological wellbeing and nature has traditionally focused on the individual psychological workings of the individual or the form and structure of nature (e.g., color, objects and spaces between objects), often arguing for "greenness" as the mediator for wellbeing (Brymer et al., 2014). If well-being benefits, albeit minimal, can be gained from highly modified, simplistic greenspaces, and these types of green spaces become the new norm for the next generation, then there will be little incentive to restore greenspaces to a more natural biodiverse state, or even to protect what we currently have from degradation.

While it is still early days, in recent years research into human health is acknowledging that the focus on "greenness" is too simplistic and, when considering psychological well-being, the "richness" of the environment and the human-nature relationship is turning out to be of paramount importance (Brymer et al., 2014; Fabjanski and Brymer, 2017; Lawton et al., 2017). Therefore, an interdisciplinary approach, including input from ecologists and health professionals, is essential to optimize green space design for psychological well-being, which will also ensure ecosystem well-being. A consensus on greenspace definitions is necessary to provide a context for such research (Taylor and Hochuli, 2017). Tools such as the "Bioscore" developed by Hand et al. (2016), which incorporates perceived diversity and human perceptions of naturalness, might be applied to a variety of greenspaces (e.g., Müller et al., 2018). Viewing nature as a "pill," separate from humanity but applied as required, is short-sighted. More meaningful gains for human well-being can be achieved through recognition that the artificial divide between people and nature is false. Developing a culture of stewardship rather than one of exploitation, and lifting biodiversity baselines through ecological restoration is necessary. From a psychological health perspective, what is urgently needed is a principled theoretical framework, combining ecological, and psychological related knowledge that can guide a more enlightened program of research and practice. Only through this interdisciplinary approach, and the development of frameworks that support this approach, will we promote and protect the health and well-being of people and of nature.

AUTHOR CONTRIBUTIONS

YvH conceptualized the opinion piece and wrote a first draft. EB contributed to concept and refined the manuscript.

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Ecotherapy – A Forgotten Ecosystem Service: A Review

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Natural ecosystems provide important services upon which humans depend. Unfortunately, some people tend to believe that these services are provided by nature for free; therefore, the services have little or no value. One nearly forgotten ecosystem service is ecotherapy – the ability of interaction with nature to enhance healing and growth. While we do not pay for this service, its loss can result in a cost to humans resulting in slower recovery times, greater distress and reduced well-being. Losses in these images of nature can diminish our basic happiness. Little is understood or, at least, appreciated concerning the potential ecotherapy benefits of the natural environment and its ecosystem services. The complex and interactive relationship of ecosystems, their services and human well-being is poorly acknowledged in the broad social, philosophical, psychological and economic well-being literature. In this article, we examine the role of nature and its ecosystem services in ecotherapy and its associated enhancement of recovery from physical and mental illness through a review of studies evaluating this ecosystem service-recovery connection.

Keywords: ecotherapy, ecosystem services, recovery times, nature, broaden-and-build theory

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INTRODUCTION

Ecosystems provide basic services upon which humans depend. Unfortunately, people tend to believe that these ecosystem services are provided for free; therefore, the services are of little or no economic value. These services may not have a specific cost in dollars, but ordinary decisions by communities usually have an effect on the quality and magnitude of nature's provided ecosystem services. While humans do not pay directly for them, we bear the significant cost for their loss regarding increased illness, reduced soil fertility, moratoriums on greenhouse gasses, wastewater treatments facilities, and losses in those images of natural ecosystems that enrich our basic happiness.

The entire human economy depends on the goods and services provided by natural ecosystems (Daily, 1997). The natural processes of restoration (cleaning, recharging, and recycling), along with goods such as forage, timber and seafood, are worth trillions of dollars annually. Nothing could survive without these ecosystem services. Growing human interventions on the environment can significantly alter the functioning of natural ecosystems reducing the delivery of their services. Ecosystems have been changed by humans more extensively and rapidly in the last 75 years than in any previous period of human existence (Daily, 1997). We have used these resources to meet the world's growing demands for fiber, food, fuel, freshwater and timber. These alterations to ecosystems likely appear to raise the well-being of billions of people. However, these changes may have, unintentionally:

- Caused a major and sometimes largely permanent loss of biodiversity,
- Stressed the ability of natural systems to continue contributing necessary and important services,
- Aaltered our comfort level with nature and our sense of place and,
- Reduced human well-being significantly.

Ecotherapy is one of ecosystem services that nature provides and is based on the theories of ecopsychology. Broadly speaking it is an area of psychology that embraces ecology and aims to be holistic in theory and practice (Buzzell and Chalquist, 2009). This means that from an ecotherapy perspective, the health (physical and mental) of a human being is viewed in the context of the health of the Earth and its natural ecosystems (Swimme and Berry, 1994; Clinebell, 1996). Ecotherapy helps people connect with nature to aid in dealing with physical and mental illnesses (Buzzell and Chalquist, 2009). This idea of reconnection seeks to remind humans that we are part of ecosystems rather than separate from them (Jones, 2010; Totton, 2011). The philosophical approach is similar to philosophies of deep ecology known as ecosophy T (Naess, 1973, 1990, 2001). Ecotherapy is evidenced by numerous approaches – green exercise (Pretty et al., 2005, 2007), green views (Ulrich, 1984; de Vries et al., 2003), horticultural therapy (Linden and Grut, 2002), wilderness therapy (Russell, 2001), body therapy through movement (Clinebell, 1996), art therapy (Degges-White and Davis, 2010) and animal-assisted therapy (DeMayo, 2009). Sometimes, ecotherapy can be just taking more traditional talk therapy outside into a garden, public space, forest or beach. Ecotherapy often incorporates elements of mindfulness practices (Ambrose-Oji, 2013; Jordan and Hinds, 2016). During outdoor therapy, both nature and human beings serve as therapists, assisting the client toward healing.

Since the advent of major technological advancements, Western society has retreated from the "Great Outdoors" and placed more emphasis on technology; such as, television, computers, and gaming (Hartig et al., 2014; Chawla, 2015). Mounting evidence suggests that people, by pushing away from nature, have distanced themselves from major environmental issues (e.g., acute weather events, water quality, air quality) and, in the end, have begun to lose contact with a necessary tool for their mental health that is available to all at little or no cost. By denying interactions with natural ecosystems, people jeopardize the rejection of a basic part of our being – a principle that is ironically more evident due to advances in medical technology (van den Berg et al., 2010; Thompson et al., 2012).

Healers in many medical systems, from Ayurvedic medicine (Chopra and Doiphode, 2002) to traditional Chinese medicine (Kayne and Booker, 2010) to many Western pediatric perspectives (Little and Wyver, 2008; Prince et al., 2013), have long advocated the importance of nature to well-being. However, the concept that flowers and trees can influence well-being, psychologically, was largely untested until the late 1970s, when R.S. Ulrich examined the psychological influence of scenes of nature on stress experienced by students (Ulrich, 1979, 1981, 1983, 1986) and medical recovery rates (Ulrich, 1984). His testing showed changes in mental states and conditions after students observed "natural" scenes associated with the environment. These scenes increased positive feelings of friendliness, affection, joy and playfulness. Views of non-nature based phenomena like urban settings, on the other hand, resulted significantly in one primary feeling: sadness. Viewing urban scenes also had a tendency to increase feelings of aggression and anger while viewing nature tended to reduce those feelings. Scenes of nature and natural ecosystems fostered positive thoughts and lowered anger and aggression. Based on these findings, Ulrich measured brain activity in healthy, unstressed adults and demonstrated that seeing landscapes associated with nature resulted in the increased production of serotonin (Ulrich et al., 1991). Many antidepressant medications used in Western medicine are thought to work by elevating the availability of serotonin to enhance communication among nerve cells. Many subsequent researchers have conducted objective testing to confirm this phenomenon. Ulrich's pioneering research showing changes in surgery recovery times based on patients' window views of nature (trees) and urban scenes (walls, concrete) demonstrated this "natural" capacity extended beyond feelings to detectable medical phenomena.

Nature, whether you're in the woods far away from it all, in a city park, or simply walking down a tree-lined street, has the power to make people feel new again. Studies have shown that a simple walk in nature can reduce anxiety, keep your spirits high, and even improve memory. Even just looking at photographs of greenery for less than a minute can give you a mood boost. Spending time in nature reduces stress and helps people feel energetic and more alive, according to scientists at the University of Rochester (Brown and Ryan, 2003). A recent study used mobile EEG devices to monitor participants' emotions during a walk in nature. Researchers also found that people were more likely to experience meditative-like brain waves and exhibit less frustration if they were walking in a green space, compared to a bustling shopping street or a busy business area (Aspinall et al., 2013).

Greencare is recognized as an increasingly important phenomenon. It encompasses or involves activities such as care farming, animal-assisted interventions (AAI), social and therapeutic horticulture (STH), healing gardens and facilitated green exercise. Despite the importance of Greencare therapies, there is a lack of appreciation that all of these care intervention types and related research are the result of a simple ecosystem service. Humans' need for nature is more than a simple requirement for material exploitation. Humans also need interaction with nature and its ecosystems to enhance our cognitive, emotional, spiritual and aesthetic development. This review will examine the role of this important ecosystem service (Nature being there) in therapies for several disorders and for several developmental aspects. These include the following physical and mental health disorders:

- General medical recovery (e.g., heart rate, blood pressure, surgery recovery, cardiopulmonary rehabilitation)
- Pain reduction

- Mood and Stress (e.g., post-traumatic stress, anxiety, self-esteem, addiction, mental well-being)
- Attention Deficit/Hyperactivity Disorder
- Dementia
- Obesity
- Other Disorders (e.g., vitamin D deficiencies, general mental health issues)

Finally, Nature therapy is important for several normal developmental aspects of children and the maintenance of those aspects for adults. Therefore, the following developmental aspects are considered in this review:

- Creativity
- Cognition
- Restoration
- Well-being and Life Satisfaction.

PHYSICAL AND MENTAL HEALTH DISORDERS

Medical Recovery

One of the first observations of the restorative effects of nature in a medical setting showed more rapid recovery rates from gall bladder surgery if patients had a view of nature through their windows versus either no window or no natural view (Ulrich, 1984). Anxiety was reduced in these patients and the recovery times of patients with a "view" of nature was half that of those with a view of a wall. Ulrich also measured brain activity in healthy, unstressed adults and demonstrated that viewing scenes of nature was associated with the elevated production of serotonin (Ulrich et al., 1991). Viewing nature scenes stimulated positive thinking and reduced aggression and post-stress anger. Ulrich's pioneering research showing changes in recovery times following operations based on patients' window views of nature (trees) and urban scenes (walls, concrete) demonstrated this "natural" capacity extended beyond feelings to tangible medical phenomena. Many other researchers have used objective testing to confirm this phenomenon.

Flowering plants and foliage in hospital rooms have attributed to enhanced recovery rates of patients undergoing appendectomies (Park and Mattson, 2008, 2009a). Patients in rooms with flowers and plants required less post-operative medications, demonstrated more positive physiological responses (heart rate, anxiety and fatigue, lower systolic blood pressure, pain ratings) and had more positive emotions and greater satisfaction with their hospital rooms than those in the control group. Indoor ornamental plants were also linked to generalized enhanced health outcomes in patients recovering from surgery (Park and Mattson, 2009b). Indoor plant exposure in Norway enhanced mental health recovery rates of coronary and pulmonary patients but did not enhance their physical recovery (Raanaas et al., 2010). A recent review (Bringslimark et al., 2009) cataloged the numerous psychological benefits of passive indoor plant exposures. Passive exposure results are mixed but plant exposure has been shown to result in a variety of outcomes, including reduced pain perception, enhanced emotional states, reduced autonomic arousal, and enhanced creativity and task-performance.

Pain Reduction

There has recently been a heightened recognition that environmental factors, including exposure to nature scenes, can influence pain (Malenbaum et al., 2008). Wilson (1984) suggested that human beings have an inherent bond with nature and the contact with the natural world could be beneficial to human health. Given this connection, it is reasonable that nature, natural settings and plants could be useful in healthcare facility design targeted to reduce pain. Natural views of landscapes are not always accessible for hospitalized patients but, even, using simple images of nature enhance recovery rates and pain reduction of coronary surgical patients (Ulrich et al., 1993). Patients exposed to images of nature were much more likely to change from stronger to weaker pain medication during recovery. Patients exposed to nature images reported significantly less anxiety as well.

Combining nature sounds and images was shown to reduce pain in a randomized clinical trial of patients undergoing flexible bronchoscopies (Diette et al., 2003). Patients who were exposed to sounds and scenes of nature reported significantly enhanced levels of perceived pain control. In an experiment where healthy participants had pain induced, exposure to a video of natural scenery increased pain tolerance and threshold (Tse et al., 2002). Exposure of increased levels of sunlight for patients having undergone spinal surgery resulted in reduced pain, stress, use of painkilling medication and the overall costs of pain medication (Walch et al., 2005).

Biomonitoring experimental sessions showed increases in pain tolerance as a result of exposure to ornamental plants in a simulated hospital room (Park et al., 2002). Similarly, pain perception appears to be altered by exposure to nature (Lohr and Pearson-Mims, 2000). Subjects were more willing to keep a hand submerged in ice water for 5 min if they were in a room with flowers than in a room without plants. However, this "plant" effect was also observed when subjects in non-plant rooms were provided other "non-nature" stimuli to distract them (e.g., bright colors).

PTSD, Mood Modification and Stress Reduction

Post-Traumatic Stress Disorder (PTSD) is one of the most compelling costs of war. PTSD can be defined as an anxiety that can develop after exposure to a terrifying event in which grave physical harm occurred or was threatened (NIMH, 2011). The prevalence of PTSD among veterans has been pronounced over the years, ranging from about 30% for men and women during the Vietnam era (Kulka et al., 1990) to 12% in the Gulf War (Kang et al., 2003) to about 23% overall in Afghanistan/Iraq conflicts (Tanielian and Jaycox, 2008; Ramchand et al., 2010; Fulton et al., 2015). Typical mental health treatments for these veterans include trauma-focused cognitive behavioral therapies (e.g., cognitive-processing therapy, cognitive restructuring, exposure

therapy, stress inoculation therapy) (Taylor et al., 2003; Hassija and Gray, 2010; Hoge, 2011), eye movement desensitization and reprocessing (Macklin et al., 2000; Shapiro, 2014) and pharmaceuticals such as selective serotonin uptake inhibitors (Marshall et al., 2001; Stein et al., 2002; Hoge, 2011).

An alternative strengths-based strategy for PTSD treatment has been various forms of recreation-based ecotherapy (Hawkins et al., 2016). Strength-based approaches focus on internal strengths (e.g., interests, beliefs, talent abilities, skills, knowledge, aspirations, character strengths, virtues), external strengths (e.g., family support and involvement, social support, positive attitudes, community and home resources, ecological factors) and existing skill sets (e.g., character strengths, military skill sets). The individual's hopes, aspirations and values take priority in treatment instead of medically directed care that focuses on reducing symptoms and functional deficits (Anderson and Heyne, 2012; Heyne and Anderson, 2012). Based on Attention-Restoration Theory (ART, Kaplan and Kaplan, 1989), this type of strengths-based therapy proposes that people are restored in natural environments because they escape from usual settings and become fascinated by stimulation in natural ecosystems that take their mind off their day-to-day problems. Outdoor adventure, wilderness therapy, outdoor experience and green space-based ecotherapy (e.g., whitewater river rafting, fly-fishing, educational decision-making in nature, interactions and participation in nature) have been shown to be effective therapeutic media for veterans coping with PTSD (Berman and Davis-Berman, 1995; Hattie et al., 1997; Fredrickson and Anderson, 1999; Ewert et al., 2001; Burls, 2007; Dustin et al., 2011; Mowatt and Bennett, 2011; Sibthorp and Jostad, 2014). For many veterans, being in nature is emotionally calming and helps them manage negative mental health symptoms through immersion in novel, natural environments. As a result of ecotherapy, many veterans can see beyond their past military experiences and injuries and establish a greater sense of purpose beyond themselves.

Green space and wilderness therapy are two ecotherapy approaches being used to address mood modification and stress reduction. Green space is important for physical and mental well-being. Interaction and engagement with green space have been linked with increased length of life and deceased risk of mental illness across a number of countries (Takano et al., 2002). Wilderness therapy is a treatment which uses a structured approach to work with adolescents with behavioral problems (Russell et al., 1999; Hill, 2007). This type of therapy is most frequently used with adolescents at risk to help them deal with a variety of psychological problems such as adjustment, emotional or addiction (Annerstedt and Wahrborg, 2011). The mental health conditions that can be addressed by these types of ecotherapy include anxiety, depression, self-esteem, addiction and stress reduction.

Coronary heart disease patients are often offered some form of rehabilitation that generally involves a combination of health education and exercise. Psychosocial mediations aimed at reducing such risks factors as anxiety and stress are less regularly included although a large body of work indicates they can be successful in modifying the progression of coronary heart disease (Ornish et al., 1990; Krantz and McCeney, 2002). Following a myocardial event, cardiac patients report high levels of anxiety and stress during hospitalization and post-discharge. A patient's overall mood can modify rehabilitative efforts. An affirmative emotional state can offer people the freedom to examine plans for the future. Gardening is a popular and often available method of recreational ecotherapy that lends itself to a healthy lifestyle. Horticultural therapy (HT) is a process through which gardening activities, interaction with plants and closeness to nature are used as a rehabilitative strategy (Simson and Straus, 1998). Horticultural therapy has been shown to improve mood state reducing stress and its contribution to coronary heart disease (based on POMS score) (Wichrowski et al., 2005), improve self-esteem and reduce depression (Son et al., 2004; Lee et al., 2008), improve sleep and cognitive issues in dementia patients (Lee and Kim, 2008), improve engagement and mood-related to dementia (Gigliotti et al., 2004; Gigliotti and Jarrott, 2005) and as a general treatment for mental health issues (Szofran and Myer, 2004). Further, horticultural activities (Richards and Kafami, 1999) and integrated adventure therapy programs (Bennett et al., 1998), have been shown to be useful in substance abuse treatment.

Adventure-based treatment programs have shown success in treating self-esteem issues, schizophrenia, mood modification, adolescent behavior, school success, anger management, sociality and family functionality (Wilson and Lipsey, 2000). Adventure- and recreation-based group interventions have been useful in promoting well-being and weight loss in schizophrenia (Voruganti et al., 2006). A 2-week wilderness camp enhanced 10 community-level coping skills related to community survival of chronic mentally ill patients (Banaka and Young, 1985). Participation in a 10-day winter outdoor adventure enhanced the self-concept and locus of control for hearing-impaired individuals (Luckner, 1989a,b). Similarly, outdoor experiential approaches have proven useful in promoting adjustment to brain injury (Thomas, 2004). One of the most useful applications of wilderness and outdoor experiences has been with the improvement of family functionality and well-being (Davis-Berman and Berman, 1989; Harper and Cooley, 2007; Harper et al., 2007; Harper and Russell, 2008), adolescent attachment (Bettman, 2007) and chemical dependency (Kennedy and Minami, 1993).

Healing gardens and natural ecosystem encounters have been shown to reduce depression (McCaffrey, 2007), restore attention in cancer patients (Cimprich and Ronis, 2003), treat dementia (Detweiler et al., 2008) and reduce stress (Kohlleppel and Bradley, 2002). Wells and Evans (2003) reported that 8–10 year-old children from rural areas who were exposed to high levels of nearby nature experienced less stress and tended to recover from stress events more rapidly than children living in homes that lacked direct contact with nature. Cause and effect are difficult to disentangle in these interactions – does nature provide an opportunity for stress recovery; or does contact with nature assist in the development of coping mechanisms; or does it enhance possibilities for interaction with other children; or is the improved stress tolerance simply due to a combination of social and environmental factors? Almost twice as many children chose

to play in spaces with trees than in spaces lacking natural elements (Taylor et al., 1998).

ADHD

The lack of contact with nature (Louv, 2008) has been suggested to be one of the primary reasons underlying the recent surge in childhood maladies like Attention Deficit Hyperactivity Disorder (ADHD) (van der Berg and van der Berg, 2010). Over 6 million children in the United States are struggling to cope with chronic attentional deficit or attention-deficit/hyperactivity disorder (ADHD) (CDC, 2017a). ADHD reduces children's attentional capacity and can have detrimental effects on many aspects of their lives (e.g., interpersonal relationships, school, personal growth). Many current treatments for ADHD have limited success and have numerous weaknesses, including appetite suppression, sleep disruption, depression and flattened affect (Douglas, 1972; Fiore et al., 1993; Hinshaw, 1994; Smucker and Hedayat, 2001; Purdie et al., 2002; Collingwood, 2010). Similarly, behavioral therapies, the second form of ADHD treatment (e.g., direct contingency management, self-monitoring), are typically insufficient to bring children into normal ranges of functioning (Hinshaw, 1994). Unfortunately, some available treatments have costly side effects and many have limited effectiveness. Attention Restoration Theory proposes that contact with nature and natural ecosystems support attention enhancement and many studies have demonstrated that contact with nature can result in increased attention in adults (Kaplan, 1995) and children (Taylor et al., 2001).

Factors like children's motor ability, concentration and social play are all positively influenced following interaction or play in nature (Fjortoft and Sageie, 2000; Fjortoft, 2001, 2004). This improvement is particularly apparent involving children with ADHD (Taylor et al., 2001; Kuo and Taylor, 2004; Taylor and Kuo, 2009). Exposure to an ordinary natural setting (i.e., Nature) may be widely effective in reducing attention deficit symptoms in children. Increased green outdoors activities result in reduced children's ADHD symptoms and have more positive affect effects on symptoms than activities in other settings (Kuo and Taylor, 2004). This green advantage was found among children who lived in a variety of community types regardless of community size, geographic region or household income. This positive effect of natural exposure on ADHD symptoms cannot be the result of the novelty of exposure to green spaces for urban children as rural children show similar positive results (Kuo and Taylor, 2004).

Attention Restoration Theory (ART) (James, 1962; Kaplan, 1995) was originally developed in environmental psychology to explain why people consistently reported a sense of renewal after wilderness and other natural environment encounters. Adults and children tend to perform systematically better on objective attention measures after viewing or spending time in natural surroundings (Tennessen and Cimprich, 1995; Kuo, 2001; Taylor et al., 2002; Taylor and Kuo, 2009).

Dementia

Nature-related activities are a normal part of life – pottering in a garden, looking out a window or walking in the countryside. Such basic pleasures are often unattainable for a person with dementia living in a care facility. Holistic, interdisciplinary approaches to integrating nature into dementia care facilities provide care that supports both natural sensory stimulation and nature-based activities (Chalfont, 2007). Horticultural therapy for dementia patients seeks to increase human contact while engaging clients with nature (Abbott et al., 1997; van Loon, 2004). The modification of dementia residential design plans in order to incorporate plants, nature and gardens have shown positive effects (Day et al., 2000; Cobley, 2002; Chalfont, 2005).

Agitated aggressive behavior often occurs in late stage dementia. This behavior usually results in the use of chemical and physical restraints which can have significant side effects. Environmental psychologists have shown that exposure to nature and natural settings decreases agitation (Whall et al., 1997). Walled gardens appear to have a positive effect on the morale of special care dementia patients but do not always result in reductions in disruptive behaviors (Lovering, 1990; Mather et al., 1997).

Obesity

More than 36% of United States adults and 17% of United States children are classified as obese (CDC, 2017b) and the number is increasing annually. The medical cost of obesity in the United States alone is estimated to be over $150 billion (CDC, 2017b). Globally the obesity rate increases to about 50% for adults and is about the same for children (OECD, 2017). Common health consequences of obesity include cardiovascular diseases (mainly heart disease and stroke), musculoskeletal disorders (especially osteoarthritis), diabetes and some cancers (e.g., endometrial, breast, ovarian, prostate, liver, gall bladder, kidney and colon). Childhood obesity is associated with higher chance of adult obesity, premature death and disability in adulthood. In addition to the higher likelihood of these maladies in adulthood, obese children often experience difficulties in breathing, higher risk of fractures, insulin resistance, hypertension, early markers of cardiovascular disease and mental health issues.

The interaction between the children's physical activity and the environment is very complex. Physical activity is important for children's health at all ages. It is clear that physical activity is strongly related to both the obesity and fitness of children. Both obesity and fitness track into adulthood where they can enhance risk factors for cardiovascular disease, metabolic disorders and early mortality. People with ready access to nature are less likely to be obese, inactive or dependent on anti-depressants (Neslen, 2017). Greenspace is an important resource for physical activity. It has the potential to contribute to the reduction of obesity and to improve health. In a review of quantitative research examining the association of greenspace and physical activity, weight status and health condition related to elevated weight, the majority of studies found a positive, but weak, association between greenspace and obesity-related health indicators (Lachowycz and Jones, 2011). Increased vegetation and greenspace were reported to be associated with reduced weight (Liu et al., 2007; Tilt et al., 2007; Bell et al., 2008). In eight major European cities, people were 40% less likely to be obese in the greenest areas of those cities (Ellaway et al., 2005).

Other Disorders (Vitamin D)

Exposure to the sun is a requirement for the synthesis of adequate amounts of vitamin D by humans. Ultraviolet B from sunlight is absorbed by dehydrocholesterol in the skin which is subsequently transformed and converted to vitamin D3. Then, the liver metabolizes the vitamin into its biologically active form. Lack of vitamin D is recognized as a potential cause of rickets in children and elevating the potential for osteoporosis and even osteomalacia in adults. Similarly, as a result of more recent findings, it has been recognized that deficiency of vitamin D is correlated with increased multiple sclerosis, cardiovascular disease, some cancers, type I diabetes and rheumatoid arthritis, with possible links to schizophrenia and type II diabetes (Holick, 2004).

Possibly due to overall reduction of sunlight exposure, people living at higher latitudes have reduced incidence of multiple sclerosis (MS) although Norway appears to be an exception. This Norwegian anomaly may be the result of the enhanced outdoor activities by children (Kampman et al., 2007). It is possible that concerns over skin cancers being related to extensive exposure to the sun in combination with people spending less time outdoors is reducing the general population's exposure to sunlight resulting in a reduction the incidence of these chronic diseases.

DEVELOPMENT, INTERACTION WITH NATURE AND RESTORATION

Children, today, grow up with a variety of indoor play facilities to choose from, including videogames, indoor play gardens, television and even indoor playground equipment; (Karsten, 2005). Increasing urbanization has significantly reduced the opportunity for safe outdoor play in cities and, even, in the suburbs. In order to protect them from harm, many parents actively discourage children from going outdoors (Veitch et al., 2010). As a result, more children are growing up disconnected from nature and the outdoors. This severing from interactions with nature could have important ramifications for children's well-being and healthy development (Little and Wyver, 2008).

Self-Esteem, Creativity and Development

Researchers have established significant and strong connections between direct contacts with nature and strengthened development in children (Bandoroff and Schrer, 1994; Kellert and Derr, 1998; Kuo and Taylor, 2004; Noddings, 2006; Louv, 2008). Kellert (2002) concluded that direct contact with nature significantly and positively impacts children's affective, cognitive, and moral development. Wells and Evans (2003) showed that scores for anxiety, behavioral conduct disorders and depression were lower for rural children living near nature. Children living near natural ecosystems rated themselves higher on measures of self-worth than their peers in less natural settings (Wells and Evans, 2003). The greener a child's view from their apartment, the higher he or she scored on several measures of delay of gratification and impulse control (Taylor et al., 2002).

Children's general access to nature seems to be diminishing (Kahn, 2002; Kellert, 2002). Not only is there less nature for children to access but many parents may be limiting children's freedom to access nature for fear of violence and accident (Spencer and Wooley, 2000; Louv, 2008). Children's lives are increasingly filled with programmed activities, leaving them with minimal time for exploring nature. A diverse literature has explored the potential impacts of green spaces on healthy child development. Some of the most exciting findings of a link between contact with nature and developmental outcomes in children come from the effects of outdoor challenge programs on children's self-esteem and sense of self. These findings suggest that contact with nature is likely to have significant benefits for children's development (Kaplan, 1977; Kaplan and Talbot, 1983; Kellert and Derr, 1998). Similarly, many studies suggested a systematic relationship between outdoor curricula in green space and enhanced learning (Basile, 2000; Ratanapojnard, 2001). Studies comparing creative play in natural versus built spaces are consistent with nature supporting cognitive, social and emotional development (Kirkby, 1989; Taylor et al., 1998).

While methodological arguments could be raised with several of the above studies, the patterns of findings point in the same direction and the persistence of findings across cultural groups and numerous childhood settings. The general belief that contact with nature is supportive in several domains of children's development – cognitive, social and emotional. Just as children require good nutrition and sleep patterns for positive development, they also need contact with nature.

Cognition

Research into childhood outdoor experiences has identified increased cognitive functioning to be a key benefit of interaction with ecosystems (Chipeniuk, 1995; Falk and Dierking, 1997; Wells, 2000; Kisiel, 2005; Tzoulas et al., 2007). In a longitudinal study of children in low-income families where the families were relocated to houses with more nearby nature, the children had higher levels of cognitive functioning and an enhanced ability to direct attention which continued several months after returning to their original homes (Wells, 2000).

Restoration

Evidence pointing to the psychological and restorative benefits of nature has accumulated significantly over the past several decades. Olmsted (1865) was particularly sensitive to the role of nature (i.e., natural scenery) in restoration. The early writings of Thoreau and his perceptiveness and foresight are likely more appreciated today (Anderson, 1968; Stern, 1970). While these writings have great power and provide deep inspiration for some, the more empirical evidence is convincing for others. Several studies (Kaplan and Kaplan, 1989; Relf, 1992; Hartig et al., 2003; Berman et al., 2008; Bowler et al., 2010) have addressed the potential restorative qualities of the interaction with nature.

Studies in the 1990s demonstrated the restorative influence of interactions with nature with regard to directed attention (Hartig et al., 1991), information processing effectiveness (Hartig et al., 1991), cancer patient enhanced effectiveness recovery (Cimprich, 1992, 1993) and the restorative benefits of a natural view on attentiveness (Tennessen and Cimprich, 1995). These studies

demonstrated there is a link between restorative experience and directed attention.

Well-Being/Life Satisfaction

In recent years, interest has grown in the positive benefits that might be gained from natural ecosystems and time spent outdoors with regard to an individual's well-being (Pretty et al., 2003, 2005, 2007; Bird, 2007; Burls, 2007; MIND, 2007; Peacock et al., 2007). Because many people live in towns and cities, there are a number of efforts, even including exercise, to reconnect people with nature. Participating in physical activity and experiencing nature both play an important role in positively influencing our health and well-being. Short-term walking interventions, particularly in greenspaces, energize and enhance personal well-being and vitality (Peacock et al., 2007; Plante et al., 2007; Teas et al., 2007; Barton et al., 2009; Focht, 2009; Ryan et al., 2010) although walking combined with virtual reality settings depicting natural ecosystems also relaxes and enhances well-being (Plante et al., 2003, 2006). Similarly, running in nature enhances the exercise experience, modifies physiology and mood and increases overall well-being (McMurray et al., 1988; Harte and Eifert, 1995; Kerr et al., 2006; Hug et al., 2008). Research has established a strong link between contact with nature and enhanced human well-being (Greenleaf et al., 2014).

DISCUSSION

The primary interest of this review is to bring attention to an ecosystem service that is often overlooked, particularly by ecosystem services researchers. These researchers primarily address issues associated with the cleansing of air and water, the recycling of nutrients, the decomposition of waste and the support of living natural resources used for food and fiber. Nature's impact of human physical and mental health can be just as important a service to humans as the services listed above. However, in conducting this review, there are natural issues which arise outside of the ecosystem service's identification. For example, how good is the information relating the impact of nature interactions on these human health conditions? Does it indicate a strong causal linkage or a more causal association? Similarly, what are the underlying psychological processes underlying these relationships? While not, the main intent of the review, a discussion following which addresses these two points – (1) potential underlying mechanisms for these phenomena and (2) associational versus causal evidence for these impacts.

The stress of an unpleasant environment can result in feeling anxious, sad, helpless or depressed. These negative emotions, in turn, elevate heart rate, blood pressure and muscle tension which can suppress the immune system (Numeroff, 1983). Pleasing environments (e.g., nature) seem to have a reverse effect (e.g., most of the literature cited in this review). Researchers don't yet understand all the details of why changes like these occur, but one possible explanation is that the types of interaction with nature described in this review reduce stress (e.g., Kohlleppel and Bradley, 2002; Hartig et al., 2003; Wells and Evans, 2003) and help people develop a more positive outlook (Folkman, 2008) both of which have been shown to strengthen the body's immune system (Dillon et al., 1986; Reiche et al., 2004; Segerstrom and Miller, 2004).

At the most basic level, the purpose of nature-based therapeutic programs is behavior change (Maller et al., 2006). This therapeutic approach focuses on the utility of positive emotions to combat the symptoms and basis of illness. The examination of positive emotions is this manner is relatively recent (Fredrickson, 1998, 2001). Positive emotions are any feeling where there is a lack of negativity. Fredrickson (2009) identifies the 10 most common positive emotions as joy, gratitude, serenity, interest, hope, pride, amusement, inspiration, awe and love. Fredrickson (2001) formulated a new theoretical psychological model to better capture the utility of positive emotion called Broaden-and-Build Theory. This theory is in contract to traditional psychological models which described the function of negative emotions and their relationships to psychological outcomes. Life threatening circumstances often result in quick and decisive actions that are linked to negative emotions.

Although positive emotions can occur in these types of negative situations, they generally occur in non-life-threatening circumstances. Interactions with nature support several of the key propositions of the broaden-and build theory and can enhance cognition as well as intrinsic motivation to attachment styles and behavior (Fredrickson, 1998). The creation of these distinct kinds of positive emotions broaden and individual's short-term thought action processes – enhancing their abilities to cope or adjust to mental health and developmental situations. Interaction with nature develops these positive emotions and the use the connection forms the basis for eco-therapy (Buzzell and Chalquist, 2009).

Evidence (most of the studies cited in this review) suggests that enhancement of these positive emotions results in broadened scopes of cognition, attention and action; thus, addressing disorders like stress, PSTD, ADHD, and dementia. Similarly, increases in positive emotions promote well-being, sense of security, and connection to nature building intellectual, social and physical resources (Fredrickson and Branigan, 2005).

It is very difficult to "prove" or even effectively demonstrate causality in nature interaction studies involving humans. The human-nature interaction is often a holistic phenomenon not easily reduced to a reductionist hypothesis-testing approach holding only one factor in change versus a control where the factor is not changed and all other factors are held constant. Human interactions are holistic and not reductionist; therefore, several potential "causes" are always possible in many of the studies reviewed here. This likelihood of numerous "causes" often leads social scientists to evaluate using a weight of evidence approach (preponderance of associational relationships) rather than the typical hypothesis-testing approach of the natural scientist. Even many, natural scientists use observational finding (associations) to develop theoretical constructs addressing large holistic phenomena and then support these theories using reductionist experiments. Many, if not most, large-scale theoretical advances have been the result of holistic associational inferences based on associational data and then supplemented by

hypothesis-testing experimentation where feasible. Such is often the case in studies of the impacts of interaction with nature on the human condition.

With this phenomenological tenet in mind, the previous discussed studies are assessed based on the nature of the relationships – associational, weight of evidence, holistic or causal. The intent of these comparisons is not to lessen the impact of associational studies but to assuage critics of non-hypothesis-testing results as being less persuasive that direct hypothesis-testing experimentation. **Supplementary Table S1** provides an overview of the studies reviewed herein and categorizes their findings as associational, associational weight of evidence, implied causal based on holistic evidence, or causal based on quasi-rigorous or rigorous experimentation. Much of the studies relating the interaction with nature and positive physical and mental health. Of the 123 studies reviewed here, the large majority (85%) includes associational information based on observations and surveys as opposed to rigorous causal hypothesis testing. This use of associational relationships does not negate the potential of a relationship but simply suggests that other co-linear information may be confuse the specific likelihood of a specific mechanism being identified. In many instances, many of these associational relationships (30%) are the result of quasi-experimental designs that differentiate between dual or multiple groups for a specific factor but let all other factors vary as they simply occur (addressing that all other factors vary similarly). While associational information dominates the type of analyses in all types of studies linking interactions with nature and health impacts, this is the common approach used by social scientists, non-research health practitioners, and public health departments. The utility of these associations is make multiple observations to create a weight-of-evidence for a set of hypotheses relating nature and health outcomes.

While the social sciences tend to prefer the weight-of-evidence and associational approaches, 51% of the reviewed studies represented quasi-rigorously or rigorously designed hypothesis testing experiments to support the linkages between interactions with nature and changes in physical and mental health. This is a common approach for the medical research community (representing about a quarter on the hypothesis testing experiments). The fact that roughly half of the studies reviewed used some type of hypothesis-testing experimental design suggest that the linkages for some relationships – for example, nature views (including plant life) on medical recovery, pain reduction and pain tolerance; some wilderness challenges impacts on behavioral modifications and locus of control issues; some gardening and nature interactions effects on disease treatment and blood chemistry; and, nature exposure and outdoor exercise on stress reduction.

Most hypothesis-testing designs are also associational (by statistical design) so nearly 45% of the results of the reviewed studies were both hypothesis-testing and associational. The remaining 40% of associational results were largely linking recreation-based ecotherapy to changes in condition for PTSD patients; mood, self-worth and well-being modifications resulting from interactions with nature or greenspace; many behavioral modification in adolescents (including substance abuse) resulting from wilderness encounters; attention deficit improvements from nature encounters; impacts of nature encounters on dementia improvement; and nature interactions improvements to childhood development, coping skills, and cognition. Similarly, the connections between outdoor exercise and greenspaces with reduction in obesity were largely associational.

CONCLUSION

Clear and abundant evidence demonstrates that interaction with nature affects not only well-being but health throughout life. The evidence suggests that people, who as children strongly interact with ecosystems and environment, live longer with a better quality of life. This "therapy" tends to make them more active, connected to people and society, engaged with natural places and eat healthier foods. These interactions, even as an adult, often result in lower blood C-reactive proteins and cortisol levels. As a result, children and adults who interact with nature and natural settings tend to be members of groups and volunteer more, have higher self-esteem and better mood, keep learning, and continue regularly to engage with nature and be more resilient to stress. Conversely, people, who, particularly as children, tended to stay indoors (and thus not receive this "therapy"), appear to be more inactive or sedentary, disconnected from society, eat energy-dense and unhealthy foods, and have higher levels of blood c-reactive proteins and cortisol.

This review has highlighted the role of ecosystems and human-ecosystem interaction as a therapeutic device for a variety of physical, mental and developmental health issues to develop:

- Mobility, dexterity, stamina and resilience;
- Relief of depression and anxiety and improved concentration and memory; and
- Self-management, improved social and familial relations and skills, and self-esteem.

The research and literature seem to support the theoretical benefits derived from ecotherapy and human-ecological interactions. Thus, it seems rather obvious that:

- Being in nature affects health (physical and mental) positively. Being able to regularly get away from your built environment (house or office) and perform activities in a natural setting (or just being able to rest in a natural setting) can restore mental state and physical capacities (Hartig, 2007; Bjork et al., 2008; Grahn et al., 2010);
- Nature affects health positively for most people (Ulrich, 1999, 2001) or some people based on the interaction (Grahn and Stigsdotter, 2010);
- Many nature-based activities affect health positively but may depend on the context of the surrounding environment (Burls, 2007, 2008; Ottoson and Grahn, 2008; Grahn et al., 2010); and
- Some people will be more affected than others by treatment in nature-based therapeutic settings (Grahn et al., 2010).

It seems clear that this service that Nature provides (e.g., Nature being there to provide therapeutic or developmental

services), without direct cost, is an underappreciated, if not near-forgotten, ecosystem service in the ecological literature regarding intermediate and final ecosystem goods and services. While often overlooked, the Ecotherapy service provided by nature is a very meaningful and important ecosystem service, worthy of conservation and regulatory costs. In reality, these economic costs which would be more than offset by the costs of medication and treatment through more traditional medical therapies. This discussion of the need and costs of preservation of natural ecosystems, if only for their therapeutic advantages, provides a substantive example of the enhancement of well-being through holistic discourse compared to the less than holistic small talk conversations concerning the continuing development of natural ecosystems strictly for economic growth (Mehl et al., 2010).

AUTHOR CONTRIBUTIONS

JS was responsible for the bulk of this review manuscript including writing, assessment, and evaluation of materials. DV was responsible for the collection of manuscripts to review and in offering comments and edits for the draft manuscript.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2018.01389/full#supplementary-material

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"Connectedness to Nature Scale": Validity and Reliability in the French Context

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Connectedness to nature represents the relationship of the self with the natural environment and has been operationalized using different scales. One of the most systematically studied in the Anglo-Saxon context is the Connectedness to Nature Scale (CNS). In an attempt to study the psychometric properties of this instrument in a French-speaking context, three studies (Study 1 $n = 204$, Study 2 $n = 153$, and Study 3 $n = 322$) were carried out in France to provide evidence of the internal consistency of the CNS, as well as its convergent, discriminant, and predictive validity. Moreover, as anticipated, positive correlations between the CNS and the environmental identity and environmental concerns scales were observed. Based on factorial analyses of maximum likelihood and reliability, an improvement in the psychometric properties was identified by eliminating three items. Through confirmatory factor analysis, the factorial structure and the psychometric properties of the CNS French version were confirmed, as well as their significate regression prediction on eudaimonic wellbeing.

Keywords: connectedness to nature, environmental identity, French context, scale validation, well-being

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INTRODUCTION

Connectedness to nature has been defined as a self-perceived relationship between the self and the natural environment (Schultz et al., 2004); it reflects a feeling of kinship and an affective individual experience of connection with nature (Mayer and Frantz, 2004). This concept is derived from studies on environmental concerns and has been proposed as being universal regarding the relationship between one's self-image and nature, based on a biophilic disposition (Schultz et al., 2004; Mayer et al., 2009). In the same way, Kals and Ittner (2003; Kals et al., 1999) describe an emotional affinity with nature as an environmental identity (EID) indicator. They suggest that it is based on biophilia, a concept proposed by Wilson (1984) to express the feeling of an emotional link with the natural world, which means an inborn tendency to focus on life processes. This tendency is part of our genetic inheritance.

Schultz considers the valuation of the natural world as an extension of a person's cognitive representation of him/herself, thus favoring the study of environmental concerns over environmental values as determinants of significant ecological change (Schultz et al., 2004). Schultz et al. (2004) have tackled research on the self-nature relationship by using different measures (the Nature in Self Scale – INS – and the Implicit Association Test – IAT). Another concept considers that in the building of a self-concept, nature and the self are not independent but linked, as the self-concept comes from a cognitive connection between nature and the self, facilitated by memories of oneself in nature (Thomashow, 1995; Schroeder, 2007; Olivos et al., 2013; Olivos and Clayton, 2017).

This is the concept of EID proposed by Clayton and Opotow (2003). In the studies carried out by these authors (Opotow, 1993, 1994; Opotow and Clayton, 1994), the implicit connection between human beings and nature corresponds to an axis ranging from people's self-perception of superiority to plants and animals to a perception of identity that attributes the same rights to them as those of human beings.

Mayer and Frantz (2004) defined the connectedness to nature as an affective individual experience of connection with nature. To measure it, the authors presented the "Connectedness to Nature Scale" (CNS), probably the most studied scale (e.g., Frantz et al., 2005; Dutcher et al., 2007; Mayer et al., 2009; Nisbet et al., 2009; Perrin and Benassi, 2009; Brugger et al., 2011; Pasca et al., 2017). The authors' analysis of the scale achieved an alpha score of 0.84 (Mayer and Frantz, 2004). Their results also showed, among other aspects, that the CNS correlates positively with biospheric concerns, the IAT-Nature and the INS, as well as with ecological behavior. In fact, it has been determined that connectedness to nature has a positive relationship with altruism, biospheric (Stern, 2000), and egobiocentric concerns (Olivos et al., 2011), environmental behaviors and, in a lesser way, life satisfaction. This dimension negatively correlates with conservatism (Mayer and Frantz, 2004) and non-environmental behaviors (Frantz et al., 2005), particularly when people have a more focused concern on themselves or a narcissistic personality.

These results allow the CNS study to be extended in relation to EID (Clayton, 2003) and environmental beliefs, such as anthropocentrism (ANT), "the dimension based on the instrumental value of the environment for human beings," biospherism (BIO), "the dimension that values the environment for its own sake" and egobiocentrism (EGO), "the dimension that values the human being within nature as a whole" (Amérigo et al., 2007, pp. 98, 99). The theory of environmental beliefs gives a self-integration level in nature within two axes (Amérigo et al., 2012): the first one focuses on humans (EGO and ANT) and the second one focuses on nature (BIO). The relationship between the self and nature, characteristic of connectedness, should be closely linked to the kind of self-image and motivational beliefs that drive environmental behaviors. Thus, when we talk about the self as an EGO identity (e.g., Mayer and Frantz, 2004) or a metapersonal self (e.g., Olivos and Aragonés, 2014), it is similar to connectedness to nature, as this has been measured in recent years. Contact with natural environments have also been shown to have positive effects on well-being (Staats et al., 1997; Kaplan, 2001). It has indeed been observed that. It has been observed that connection to nature has a mediating effect in the increase of the positive emotional states (Mayer et al., 2009). Despite of these results, related to the called psychological well-being, their relation with subjective well-being remains scarcely studied (Olivos and Ernst, 2018).

Most of the instruments used for the study of environmental concerns originated in the Anglo-Saxon context and have gradually been adapted to other cultures and contexts, Spain and Portugal, especially. However, this has not yet been the case within the French speaking world for connectedness to nature, even though this kind of approach to studying human connection with nature represents one-third of the most recent research in this field (Ives et al., 2017). The growing interest of this dimension in the French-speaking countries requires the development of the validated and trustable tools to be able to study the links between connectedness to nature and the well-being and/or pro-ecological behaviors. We wonder whether the CNS (Mayer and Frantz, 2004) once adapted to the French language, keeps the same psychometric properties than the English version, which would help to measure the theoretical construct. Besides, France has an important tradition of studies in environmental psychology, who could benefit from the adaptation to its context of this scale. Our objective was thus to adapt and validate the Mayer and Frantz (2004) CNS within the French context as a contribution to studies about environmental concerns, which have become common in this cultural framework. This validation opens cultural perspectives as it contributes to the validation of connectedness to nature universal character, which is on the basis of this theory.

For this purpose, three studies were conducted to provide evidence of the internal consistency of the CNS, as well as its construct, convergent, discriminant, and predictive validity. The factorial structure of the scale was tested, in order to confirm these psychometric properties and the factorial structure of the CNS French version.

STUDY 1

In this study, a descriptive analysis of the items and an exploratory factor analysis (EFA) were performed on a general population sample to identify the single factor structure of the CNS, following the proposal of Mayer and Frantz (2004).

Method

Participants

The 204 participants were all living in a western French city (Nantes); women made up 72% of the sample. Average age $M = 29$ years ($SD = 10.37$). Regarding professional status, 60% were active, 6% unemployed, 1% retired, and 33% were students. This is about a convenience sample or group of volunteers. The margin of error with regard to the reference population is 6.8%. The rate of people in service is representative of the global population (60%), however, there is an over-representation of women (53% of the global population) and the average age is under the reference population (37 years old).

Material and Procedure

A self-administered questionnaire was used on paper-shaped, composed of the 14 items of the CNS and a five-point scale, ranging from "completely disagree" to "completely agree" to measure an affective individual experience of connection with nature (Mayer and Frantz, 2004). The scale was adapted to French using a two-way translation procedure (or back translation). This procedure consists in a native French-speaking translator with excellent English language skills translating the scale into French and a back translation of the previously obtained French version into English by an independent English speaking translator with excellent French language skills (Vallerand, 1989). The subjects

were debriefed by telling them the aims of the study and their informed consent to participate was obtained. The mean time to complete the questionnaire was 10 min.

Reliability and factor analysis with SPSS 24 was carried out for a descriptive and psychometric study of the scale, which is the most usual procedure for establishing dimensionality of scales (Fabrigar et al., 1999; Embretson and Reise, 2000). Descriptive analyses (means, standard deviation, kurtosis, and asymmetry index) and reliability analyses (Cronbach's alpha) were also performed.

Results

Reliability and Descriptive Statistics

An EFA of the maximum likelihood following the procedure carried out by Mayer and Frantz (2004) and other studies of reference which analyses the psychometric properties of this scale (e.g., Perrin and Benassi, 2009; Tam, 2013; Olivos et al., 2014), forcing the extraction of a single factor explained 37% of the variances (KMO = 0.870; $p < 0.001$). The CNS showed a good level of internal reliability ($\alpha = 0.80$). All the items had a positive load with values greater than 0.40 (see **Table 1**), except items 4 (fl = −0.13), 12 (fl = −0.17), and 14 (fl = −0.03), which were deleted according to the recommended load for samples between 200 and 250 participants (Hair et al., 1999).

STUDY 2

The objective of this second study was to confirm, on a second sample of the general population, the single factor structure of the CNS. In addition, we wanted to assess the internal consistency and validity of the CNS through convergent validity by correlating its results to the Environmental Identity Scale (EID) as proposed in the literature (Brugger et al., 2011; Olivos et al., 2013; Olivos and Clayton, 2017). A positive correlation was expected regarding the connectedness and EID measures.

Method

Participants

In this study, 153 people from the general population participated voluntarily and anonymously (7.9% margin of error with regard to the reference population). Of these, 24.2% were students, 54.9% had a professional activity, and 7% were unemployed. Women made up 58.8% of the sample. Regarding their age, 63.4% were between 18 and 29 years. 26.1% between 30 and 49 years and 10.5% were more than 50 years old ($M = 30.5$; $SD = 10.75$).

Material and Procedure

A self-administered questionnaire was used, similar to the questionnaire of Study 1, composed by the CNS and EID. The subjects were debriefed by telling them the aims of the study and their informed consent to participate was obtained. The administration of the scales took about 15 min. The CNS consisted of 11 items (three items were eliminated, 4, 12, and 14, according to the results of the EFA of Study 1) on a five-point scale, ranging from "completely disagree" to "completely agree." The EID (Clayton, 2003) consisted of 24 items on a five-point scale, ranging from "completely disagree" to "completely agree," to measure the relationship between self and nature.

A confirmatory factor analysis (CFA) was conducted to validate the factorial structure with R. We kept the 11 items that had acceptable indicators in the CFA. The maximum likelihood method was selected to test the model. To assess the fit of the model, χ^2, the Comparative Fit Index (CFI), the Tucker Lewis Index (TLI), the Goodness of Fit Index (GFI), the Standardized Root Mean Square Residual (SRMR), and the Root Mean Square Error of Approximation (RMSEA) were examined. Lastly, the saturation coefficients among items and the latent variables were examined. A value superior to 0.90 for the CFI, GFI, and the TLI is sufficient (Tucker and Lewis, 1973; Bentler, 1992; Schumacher and Lomax, 1996). A RMSEA and SRMR lower than 0.08 (Browne and Cudeck, 1993; MacCallum et al., 1996; Pui-Wa and Qiong, 2007) is admitted. Concerning the use of χ^2, it is possible that the tested model does not fit the data correctly, but that χ^2 accepts it because of the size of the sample (Pui-Wa and Qiong, 2007). For this reason, Wheaton et al. (1977) suggest that a relative chi-squared (χ^2/df or CMIN/df) is also computed. A χ^2/df ratio < 3.00 represents a correct fit.

Results

CFA and Reliability Analysis

The reliability of the scale was estimated by calculating the Cronbach's alpha coefficient and composite reliability (CR, Raykov, 1997) for CNS. The CNS showed a good level of internal reliability ($\alpha = 0.85$; CR = 0.88), as did the EID ($\alpha = 0.93$). The tested model fitted the data correctly, except TLI, which is lightly under the expected threshold [RMSEA $_{(90\%CI)} = 0.095$ $_{(0.07-0.12)}$; CFI = 0.909; TLI = 0.887; GFI = 0.923; SRMR = 0.052]. Because of a significant χ^2 ($p < 0.001$), we examined the χ^2/df ratio. With a value of 2.35, it can be considered correct.

Correlation

The correlation between the CNS and EID ($r = 0.763$; $p < 0.001$) was positive and statistically significant, indicating the convergent validity of the CNS.

STUDY 3

This study aimed first to confirm the single factorial structure of the CNS in a second sample. In addition, we sought to assess the internal consistency (Cronbach's alpha) and validity of the CNS: for convergent validity, CNS would correlate positively with the EID and EGO (Amérigo et al., 2007); for discriminant validity, the CNS would correlate negatively with ANT (Amérigo et al., 2007); for predictive validity, the CNS would predict scores of the wellbeing scale (MHC-SF, Keyes, 2009) as well as the frequency of contact with nature.

Method

Participants

In this study, 322 participants were distributed into two samples. The first sample (A) was composed of 267 students from a French university; 85% were women and the average age was $M = 19.60$

($SD = 3.75$) years. The second sample (B) was 55 students from the same university, who completed the instruments twice; 61.8% were women and the average age was $M = 22.24$ ($SD = 5.04$) years.

Material and Procedure

The instrument used for both samples was a self-administered questionnaire composed of the following scales: the CNS (Mayer and Frantz, 2004) and the EID Scale (Clayton, 2003), the same scales as in Study 2; two scales to measure environmental concerns, ANT (to assess the convergent validity of the CNS) and EGO (to assess the convergent validity), in the version of Amérigo et al. (2007), composed of five items on a five-point scale, ranging from "completely disagree" to "completely agree"; the Mental Health Continuum Short Form (MHC-SF, Keyes, 2009), applied in similar investigations and obtaining good psychometric indicators (Aragonés et al., 2011), which consists of 14 items measuring Hedonic Wellbeing (MHC.H – pleasure-related or experienced emotions) and Eudaimonic Wellbeing (MHC.E – related to psychological development and personal

TABLE 1 | Exploratory factor analysis of principal components, reliability index and corresponding descriptive statistics of the CNS.

	Study 1 ($N = 204$)					
	M	***SD***	**Asymmetry[a]**	**Kurtosis[b]**	**α***	**FL[c]**
1. Je me sens souvent en union avec la nature qui m'entoure [I often feel a sense of oneness with the natural world around me]	3.45	0.98	−0.55	−0.11	0.78	0.63
2. Je pense à la nature comme à une communauté à laquelle j'appartiens [I think of the natural world as a community to which I belong]	3.37	1.01	−0.51	−0.24	0.77	0.74
3. Je reconnais et apprécie l'intelligence des autres êtres vivants [I recognize and appreciate the intelligence of other living organisms]	3.93	0.87	−1.07	1.75	0.78	0.59
4. Je me sens souvent déconnecté de la nature [I often feel disconnected from nature]	2.49	0.96	0.43	−0.26	0.82	−0.13
5. Quand je pense à ma vie, je m'imagine faisant partie d'un cycle de vie plus large [When I think of my life, I imagine myself to be part of a larger cyclical process of living]	3.32	1.08	−0.40	−0.46	0.77	0.58
6. Je me sens souvent un lien de parenté avec les animaux et les plantes [I often feel a kinship with animals and plants]	2.65	1.22	0.17	−0.99	0.76	0.72
7. Je me considère comme faisant partie de la Terre de la même façon qu'elle fait partie de moi [I feel as though I belong to the Earth as equally as it belongs to me]	3.03	1.18	−0.31	−0.80	0.76	0.67
8. Je comprends très bien comment mes actions ont un effet sur le monde naturel [I have a deep understanding of how my actions affect the natural world]	3.84	0.95	−1.07	1.25	0.79	0.38
9. Je me sens souvent comme faisant partie d'un écosystème plus large [I often feel part of the web of life]	3.60	1.00	−0.61	0.07	0.77	0.66
10. Je pense que tous les habitants de la Terre, humains et non humains, partagent une «force vitale» commune [I feel that all inhabitants of Earth, human and nonhuman, share a common 'life force']	3.19	1.06	−0.42	−0.28	0.78	0.54
11. Tout comme l'arbre fait partie de la forêt, je me sens comme faisant partie de la nature [Like a tree can be part of a forest, I feel embedded within the broader natural world]	3.36	1.01	−0.50	−0.13	0.76	0.77
12. Lorsque je pense à ma place sur Terre, je me considère comme faisant partie de l'espèce supérieure [When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature]	2.30	1.06	0.62	−0.24	0.83	−0.17
13. J'ai souvent l'impression que je ne suis qu' une petite partie de la nature qui m'entoure et que je ne suis pas plus important que l'herbe sur le sol ou les oiseaux dans les arbres [I often feel like I am only a small part of the natural world around me and that I am no more important than the grass on the ground or the birds in the trees]	3.50	1.13	−0.44	−0.71	0.78	0.60
14. Mon bien-être personnel est indépendant du bien-être du monde naturel [My personal welfare is independent of the welfare of the natural world]	2.62	1.01	0.051	−0.82	0.82	−0.03

[a] *Standard error asymmetry = 0.170;* [b] *Standard error kurtosis = 0.339; *Cronbach's alpha if items are deleted;* [c] *Forced extraction of a single factor (Test of goodness of fit: $\chi^2 = 208.639$; $df = 77$, $p < 0.00$. $\chi^2/df = 2.71$).*

growth), and a whole general wellbeing index; lastly, the variable "contact with nature" was operationalized with three modalities (never, occasionally, and frequently) of activities in natural places (e.g., " Do you realize activities in touch with nature during your spare time, like picnics, walks on the beach or in a park, hiking, etc.?").

All these scales were adapted to French using the two-way translation procedure. The subjects were debriefed by telling them the aims of the study and their informed consent to participate was obtained. Each application lasted on average 20 min and was carried out by both samples at the beginning of a class. Sample B completed the questionnaire again 2 weeks after the first time (for the test–retest reliability).

Analysis

Data analysis was carried out for descriptive (means, standard deviation, kurtosis, and asymmetry index) and psychometric (reliability and factor analysis) studies of the scale, including test–retest for the CNS and EID with sample B. Correlations and mean difference analyses were performed to test convergent (EID and EGO) and discriminant (ANT) validity. A regression analysis also tested the predictive validity of the MHC-SF scale, the same as the correlation between the CNS and contact with nature. A CFA was used to verify the factorial structure of the CNS as in Study 2.

Results

CFA of the CNS and Reliability Analysis

A CFA with sample A ($n = 267$) was carried out. The tested model fitted the data correctly, except TLI, which is lightly under the expected threshold [RMSEA $_{(90\%\ CI)} = 0.071$ $_{(0.05-0.08)}$; CFI = 0.912; TLI = 0.890; GFI = 0.902; SRMR = 0.051). Because of a significant χ^2 ($p < 0.001$), we examined the χ^2/df ratio (115.595/44). With a value of 2.62, it can be considered correct. We observed that the indices were correct and improved compared to Study 2, especially the RMSEA that was correct this time (<0.08).

All scales reached a good internal reliability score in sample A (see **Table 2**).

The test–retest analysis with answers of sample B (see **Table 3**) showed a good level of reliability too for the CNS [$r = 0.774$; $p < 0.001$; $t(54) = 0.2160$; $p = 0.830$] and EID [$r = 0.865$; $p < 0.001$; $t(54) = -1.30$; $p = 0.198$].

Correlations and Regression

To provide support for the convergent and discriminant validity of the CNS scale, its average score was correlated with the scores of the other complementary measures such as the EID and MHC, the two scales of environmental concerns (ANT and EGO) and the measure of frequency of contact with nature (CN). The results are presented in **Table 4**.

The correlations between the CNS and EID were positive and statistically significant, thus consistent with what was expected. Furthermore, the CNS correlated positively with EGO and negatively with ANT, showing the expected relationships with these environmental concerns. The correlations were weak and not significant with Wellbeing but, as expected, positive and significant with the sub-dimension of MHC.E. The regression analysis confirmed the predictability of MHC.E from the CNS and EID (see **Table 5**).

Finally, the correlation with the frequency of contact with nature was statistically significant and positive ($r = 0.348$, $p < 0.001$). Moreover, the mean difference analysis in the score of the CNS by contact with nature showed statistically significant results ($t = 4.431$; $df = 320$; $p < 0.001$), suggesting that

TABLE 2 | Descriptive statistics and reliability (sample A, $n = 267$).

	M	*SD*	Asymmetry	Kurtosis	α
CNS	3.34	0.55	−0.033[a]	−0.269[b]	0.800
EID	3.26	0.58	−0.230	−0.275	0.904
EGO	3.84	0.71	−0.550	−0.119	0.792
ANT	2.25	0.75	0.629	0.428	0.749
MHC	3.30	0.47	−0.518	0.599	0.797
MHC.H	3.77	0.60	−0.809	1.696	0.730
MHC.E	3.17	0.49	−0.432	0.461	0.743

[a] *Standard error asymmetry = 0.136;* [b] *Standard error kurtosis = 0.271; CNS, Connectedness to Nature Scale; EID, environmental identity; EGO, egobiocentrism; ANT, anthropocentrism; MHC, Mental Health Continuum, Short Form; MHC-H, Hedonic; MHC-E, Eudaimonic.*

TABLE 3 | Test–retest reliability of the CNS and EID (sample B, $n = 55$).

	M	*r*	*t*	*p*
CNS	3.33	0.774***	0.216	0.830
CNS - POST	3.32			
EID	3.25	0.865***	−1.303	0.198
EID - POST	3.31			

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

TABLE 4 | Correlation between variables for convergent and divergent validity (sample A, $n = 267$).

	1	2	3	4	5	6	7
1. CNS	–						
2. EID	0.701**	–					
3. EGO	0.596**	0.714**	–				
4. ANT	−0.234**	−0.206**	−0.294**	–			
5. MHC	0.095	0.079	0.063	0.085	–		
6. MHC-H	0.014	−0.034	−0.036	0.037	0.719**	–	
7. MHC-E	0.110*	0.108	0.088	0.091	0.973**	0.539**	–
8. CN	0.348**	0.499**	0.392**	−0.126*	0.085	0.067	0.081

*$p < 0.05$; **$p < 0.01$, ***$p < 0.001$ (bilateral). CN, contact with nature.*

TABLE 5 | Regression analysis to predict MHC-E from the CNS and EID.

Step	Variable	*R*	ΔR^2	*F*	β
1	CNS	0.702	0.493	257.511**	0.702**
2	CNS	0.710	0.504	6.191**	0.607**
	EID				0.143*

*$p < 0.05$; **$p < 0.01$, ***$p < 0.001$.

participants who had taken part in activities involving contact with nature experienced higher levels of connectedness to nature ($M = 3.41$; $SD = 0.54$) than participants who had not ($M = 3.09$; $SD = 0.52$).

The results indicate that the CNS has good psychometric properties, which improved after some items were deleted (items 4, 12, and 14). The coherent correlations between the measures of connectedness and environmental concerns and EID suggest that people connected to nature value the positive effects of each personal experience with nature, within which they feel explicitly included, and do not subordinate it to human needs.

DISCUSSION

These studies have enabled the verification of the internal positive consistency of the CNS, in the same way as the authors of the original scale in other investigations (Mayer and Frantz, 2004; Frantz et al., 2005; Mayer et al., 2009), yet within a psychometrically acceptable range (Cortina, 1993; George and Mallery, 2003). This scale is evidently stable and the comparison of its scores with EID and environmental concerns (ANT, EGO) shows evidence of its convergent and discriminant validity, as well as providing an opportunity to propose conceptual questions that might guide new research concerning connectedness to nature in French-speaking contexts, where this subject is gaining interest.

The specific results suggested the elimination of items 4, 12, and 14 ("I often feel disconnected from nature," "When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature" and "My personal welfare is independent of the welfare of the natural world"; Mayer and Frantz, 2004, p. 513) because of their lower loading weight (Hair et al., 1999) and because the consistency markers of the scale improved after the elimination of these items. The CFA showed that, without these items, the scale gave good marks of reliability as well as a good fit of its overall factor structure. In the same way as other psychometric studies, which have suggested the advantage of deleting some items in specific cultural contexts (Olivos et al., 2011; Pasca et al., 2017), this result demonstrates the interest of proposing a new version of this scale, in order to obtain the best psychometric qualities in the French version.

As expected, the correlation between the CNS and EID was also positive, contributing to the validity of both measures. However, these results should be analyzed with caution. Despite the fact that the EID has obtained higher reliability values than in this investigation (Clayton, 2003), more studies have been published on the EID that cast doubt on its psychometric properties and factorial structure (Olivos and Aragonés, 2011; Clayton, 2012). Furthermore, despite both scales referring to a type of relationship of identification with the natural environment, in the case of connectedness their authors proposed that there is an underlying idea of a biological disposition favorable to nature (biophilia), and thus of universal occurrence. Other studies could be lead in order to verify this hypothesis within the French context, such as for example the biological disposition of connectedness, which suggests a restoring effect of natural environments (Mayer et al., 2009).

A significant correlation was observed between the scores of the CNS and those of environmental concerns. In the case of ANT, the correlation was negative, as anticipated, because an instrumental valuation of nature is clearly opposed to the idea suggested in connectedness. In the case of EGO, the correlation was positive, which is coherent with connectedness due to the valuation it makes of the relationship between the human being and nature as a whole.

Positive and significant correlations with the frequency of contact with nature indicated that the more connected people feel to nature, the more they will try to keep in contact with it. Unfortunately, the disappointing results of the relationship with wellbeing prevent us from concluding that this connection with nature involves a feeling of wellbeing. However, the positive and significant although weak correlation with Eudemonic Wellbeing is an important topic for environmental psychology research. Even if hedonic experiences have been more frequently studied, the eudemonic dimension of wellbeing is more closely linked to the development of positive and complex identities. Besides, this eudemonic dimension is linked to subjective connections with nature (Arnocky et al., 2007; Leary et al., 2008; Clayton, 2012; Ryff and Singer, 2013; Olivos and Aragonés, 2014; Olivos and Ernst, 2018).

On the basis of this study, it can be concluded that the CNS is a valid and reliable measure of connectedness, useful for research in psychology concerning the processes of environmental concerns, the restoring effect of natural environments, the perception of natural risks, etc., as well as being a valid tool for the study of connectedness in a French-speaking context. This version of 11 items proposed at the end of the study, could be very well integrated to the analysis of the relation between connectedness to nature with other dimensions as well-being, environmental concerns and even perception of natural risks. Nevertheless, some limits must be underlined. Actually, participants are not representative of French population, even if the margins of error of the sampling are relatively low. On the same way, marked cultural differences between French-speaking countries should also be taken into account during future applications. Actually, the sharing of a common language does not cancel the cultural diversity in the meaning attributed to some built, being able to make results vary. Anyway, this psychometric French speaking version of CNS, allows to initiate a systematic research for its adaptation in other French-speaking regions.

ETHICS STATEMENT

These studies were approved by the ethical board of the Psychology Faculty of University of Nantes with written informed consent from all subjects.

AUTHOR CONTRIBUTIONS

ON: work conception, research design, data collection, data analysis, data interpretation, paper arrangement and revision, writing, and submission. PO: research design, data analysis, data interpretation, paper arrangement and revision, and writing. GF-B: data collection, research design, data interpretation, paper arrangement and revision, and writing.

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The Human–Nature Experience: A Phenomenological-Psychoanalytic Perspective

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Drawing upon phenomenology and psychoanalytic concepts, we explore and explicate participants' lived experience of the natural world. The authors draw upon Husserl's description of consciousness as intentionality and his later work on the life-world, in exploring experiences which provide a basis for a psychochoanalytic understanding of the human–nature experience. Unstructured interviews were undertaken with nine participants, each of whom regarded nature as being significant for their sense of wellbeing. The lived experiences were explicated drawing upon the two processes: Giorgi's descriptive phenomenological psychological methodology and psychoanalytic researcher reflexivity. Data analysis and explication involved the following steps: (1) a thorough reading of each interview transcript, (2) breaking data into parts by demarcating meaning units, (3) organizing data by translating meaning units into units of psychological experience through coding, and (4) arriving at a summary of the data which involved organizing and reviewing units of psychological experience. The process of reflection led to the formulation of an essential psychological structure of participants' lived experience of the natural world. We argue that the human–nature relationship can be conceived in terms of psychoanalytic concepts, and in particular, constructs based upon an understanding of the primacy of attachment relationships. The natural world is elucidated as (a) nature being experienced as a primary attachment, (b) nature experienced as a secure base, (c) nature experienced as twinship, (d) nature experienced as containing, and (e) nature experienced as embodied. This paper extends previous empirical descriptions of the human–nature relationship by incorporating psychoanalytic processes and theory into a theoretically informed qualitative methodological stance. Beyond the traditional notion of nature as something 'out there' that we can interact with for cognitive or emotional restoration, participants in this study described the experience of nature as being integral to their sense of self. This study suggests that experiences that facilitate immersion in nature provide opportunities for the development of an integrated sense of self that has a profound impact on a participant's sense of wellbeing. The findings further demonstrate the convergence between phenomenology and psychoanalytic constructs which offers a richness to our understanding the subjectivity of participants and their relationship with nature, a perspective not often attainable through more traditional quantitative research methodologies.

Keywords: phenomenology, natural world, nature, psychoanalysis, reflexivity, life-world

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INTRODUCTION

Our understanding of the relationship between human beings and the natural world has been of increasing interest to researchers over the past five decades. This is particularly evident in the proliferation of research exploring the effects of nature contact and feelings of connection to nature on human health and wellbeing, and environmental attitudes and behaviors. Greater proximity to, and feelings of connection with the natural world are seen to promote physical health, and psychological wellbeing including mood state, and community cohesion (Maas et al., 2009; Shanahan et al., 2016).

As we become increasingly engaged with a digital world, there is an argument that we have become more disconnected from the natural world. This disconnect from the physicality and enrichment associated with the natural world has impacts on both psychological and physical wellbeing where recreational sitting has been found to be related to raised mortality and cardiovascular disease risk (Stamatakis et al., 2011). Poignantly, the psychological and physical illnesses which characterize distress in many "advanced economies" are identified by some researchers as treatable in part by nature contact, for example, depression (Bratman et al., 2012; Shanahan et al., 2016), cardiovascular disease (Maas et al., 2009; Kardan et al., 2015), and symptoms of stress including high blood pressure (Brown et al., 2013). This paper aims to add to current perspectives on the human–nature relationship by exploring the lived experience of nature with individuals who regard their relationship with the natural world as important for their psychological health and wellbeing.Phenomenological interview data is further explicated through a lens of psychoanalytic theory.

Wellbeing and the Nature-Human Relationship

For a number of decades, studies examining the nature-human relationship have found a positive relationship between experiences of nature and psychological health and wellbeing (e.g., Ulrich et al., 1991; Kaplan, 1995; Korpela et al., 2001, 2014). The major theoretical frameworks drawn upon to explain the observed link include Biophilia (Wilson, 1984), Attention restoration theory (ART) (Kaplan, 1993), Stress reduction theory (SRT) (Ulrich et al., 1991), and Place attachment theory (Giuliani and Feldman, 1993; Giuliani, 2003). Biophilia proposes that human beings have an innate affiliation with the natural world which is in turn fundamental to psychological and other domains of wellbeing (Kellert, 1997). From a SRT perspective interactions in natural environments reduce stress built up as a result of time spent in urban and everyday environments. Specifically, SRT claims that human beings have an evolutionary connection with nature and that specific characteristics of nature (complexity, depth, absence of threat) provide solice and the observed restorative benefits. While the SRT and Biophilic frameworks have made a considerable contribution to our understanding of the relationship between human beings and nature, critics point out that for a number of reasons these evolutionary notions do not stand up to scrutiny (Joye and van den Berg, 2011; Brymer et al., 2014). Attention restoration theory suggests that some environments are more conducive to restoring mental fatigue resulting from everyday urban lifestyles. Specifically, the attentional demands of everyday environments require deliberate focus which ultimately results in fatigue. The natural world on the other hand restores cognitive resources and the subsequent ability to focus because attention is held with reduced requirement of effort. A critical review of ART found only partial evidence for the efficacy of ART as an explanatory model (Ohly et al., 2016). While popular, ART might not be able to fully explain the genesis of wellbeing benefits arising out of the human–nature relationship (Hartig and Jahncke, 2017). Alternatively, an evolutionary perspective may be conceptualized in terms of cognitive processes, referred to a motivation and valuation (Mercado-Doménech et al., 2017). Motivation is thus a complex process involving both cognitive and implicit processes which play a part in the potential survival value of the human–nature process.

Place attachment theory is a multifaceted framework that proposes human beings develop emotional bonds with a real or imagined place. While not directly developed to explore the human–nature relationship from a wellbeing perspective the framework suggests that wellbeing can be enhanced through the effective interactions of individual characteristics and characteristics of particular places. Place attachment theory suggests that when compared to urban environments the natural world is rich in characteristics that facilitate positive emotional bonds and therefore wellbeing. Often these bonds are developed in childhood and brought forward into adulthood as central to individual experiences of wellbeing (Scannell and Gifford, 2010). However, strong bonds with place can also have negative impacts such as when competing needs for the same place result in conflict (Giuliani, 2003). Further, while place attachment theory has been linked to aspects of psychological wellbeing (Scannell and Gifford, 2016) the notion of 'place' in place attachment does not specifically refer to nature and might for example include home, even if home is heavily urbanized. The precise characteristics of nature that support positive emotional attachment with respect to psychological wellbeing are difficult to define.

There are a number of limitations to the above notions. For example, critics have pointed out that for the most part the above frameworks stem from positivist and cognitive notions and suggest that nature is a thing separate from human beings that impact on people and provide benefits to human beings (Seamon, 1982, 2000). From a phenomenological perspective the above notions adhere to Cartesian notions of 'subject' and object' which fails to acknowledge the co-constitution of the experience of being-with or part-of nature (Schroeder, 2007). While the value of the theoretical frameworks should be recognized they might also be limited in their capacity to provide a complete explanation of the experience of wellbeing derived from engagement with the natural world (Seamon, 1982). For example, a phenomenological perspective appreciated the multi-sensory nature of reaching out in relation to the natural world (Schafer, 1977). The notion that soundscapes within urban environments have different qualities to soundscapes in natural environments

has implications for wellbeing. Specifically, Schafer (1977) noted that human beings experience sounds in urban contexts as cluttered where individual sounds merge into a non-discernable noise. Sounds in natural environments on the other hand are individually clear and easily heard. From this perspective human auditory perception is attuned to information in natural soundscapes rather than urban soundscapes (Seamon, 1982). Phenomenology has long provided insights into the human–nature relationship that have implications for explicating the experience of wellbeing, most often through the investigations of human beings as embedded in place (e.g., Tuan, 1974; Relph, 1976). For example, Tuan's notion of topophilia suggests that individual psychological wellbeing is linked to preferences for, and experiences of, specific types of place (Heimer, 2005). A study undertaken by Ogunseitan (2005) found strong links between those who scored high in a topophilia rating with psychological wellbeing with the presence of ecodiversity being most important. Despite the research undertaken from a phenomenological perspective that has explored the human–nature relationship and the implications for wellbeing from these findings little research has specifically set out to explore the phenomenology of the human–nature relationship from a psychological wellbeing perspective. The following section briefly discusses some of the conceptual and attitudinal overlap between phenomenology and psychoanalytic processes.

Phenomenology and Psychoanalytic Theory

Dilthey (1991) argued that if we are to extend our understanding of being, human science must seek to examine phenomena from a place of humble inspection and invite *original fullness* and richness of experience. According to Dilthey, understanding or *verstehen* necessitates the employment of all our capacities, and in this way a *verstehen* science is distinguished from pure intellectual understanding or *verstand*. Phenomenology counters the deterministic heart of conventional empiricism, and seeks to "reflect on the visceral texture of experience, the sensuous perceiving of life, as it is 'given' to the experiencer, pregnant with layers of implicit meaning" (Finlay, 2011, p. 4).

The idea that phenomenology seeks to illuminate the layers of lived experience bears striking resemblance to psychoanalysis, which also seeks to explicate and understand the lived experience of the analysand through appropriation of his or her reality. For example, early in his writings, Freud (1915) identified the importance of neutrality, abstinence, and anonymity on behalf of the analyst. Embodiment of abstinence, anonymity, and neutrality in psychoanalysis protects against the imposition of the analyst's own subjective view of reality and importantly, contains the analyst's countertransference. In particular, neutrality on the part of the analyst ensures openness to new understandings of the analysand's lived experience (Schafer, 1992). Similarly, Bion (1967) advocated beginning every analytic session "without memory or desire" to safeguard against the intrusion of the analyst's own assumptions, preconceptions, and projections. In this regard, the analyst represents a convergence between the methodologies of phenomenology and psychoanalysis.

While not universally accepted, there is an argument that phenomenology and psychoanalytic theory are complementary, in that psychoanalytic theory and practice represents a science of human subjectivity. Wertz provides both an in-depth account of phenomenology as a science of consciousness addressing questions of meaning, values, and purpose and also the methodological overlap between phenomenology and psychoanalysis (Wertz, 1986, 2016). He suggests that to reject the analytic process and relegate psychoanalysis to the periphery of scientific methodology is to impede our understanding of human experience. In supporting a radical recognition of the limits of psychology as a quantitative discipline, mimicking the methods which have proven successful in the natural sciences, he laments that psychology "will remain lost in explanatory theory and affiliations with other sciences without methods capable of delivering him to . . . . . the encounter with living persons" (Wertz, 1986, p. 599). The intersection of phenomenology and psychoanalysis thus provides a common pathway to explore human subjectivity. The current paper proposes an integrative process seeking a fuller understanding of human relatedness in the context of nature.

Psychoanalytic theory is an overarching term encompassing a range of perspectives, with contemporary theory being influenced by object relations and relational theorists, who adopt a two-person analytic perspective, and recognize the significance of intersubjectivity. That is, the caricature of the traditional analyst abiding by neutrality, has been replaced by an empathic approach sensitive to the "here-and-now" relationship between self and other. Furthermore, the approach is phenomenological, in the sense of privileging the immediate experience of the participants-in-relationship. This perspective has been incorporated into both self psychology, and the development of relational psychoanalysis. Self psychology prioritizes the integrity of the self, and draws upon constructs such as self integration, twinship, and mirroring, to explain the ways in which the individual achieves self integration. Relational psychoanalysis provides greater salience to the self-other relationship. The internalized templates deriving from these relationships, and the significance of these interpersonal experiences on psychic functioning are considered fundamental in constituting human experience (Mitchell and Aron, 1999). In contrast to the focus of classical psychoanalysis which privileged subjectivity and inner forces of the isolated mind, contemporary psychoanalysis privileges lived intersubjectivity. Key features of the approach, which guide our understanding of human phenomena include an appreciation of human development, with reference to the notions of embodiment, containment, and attachment, and ideas around the development of self, which is seen as potentially fragile, but achieves a sense of integration and coherence through our relationships. The relational perspective proposes that human experience can be understood in terms of projective identification, which in turn values counter transference as a key component of understanding "the other." This notion is consistent with Husserl's original emphasis upon the *Lebenswelt*, or lifeworld in which the direct experience of all players in human experience is valued.

Increasingly, psychoanalytic theory and processes are being incorporated into qualitative research (see Frosh et al., 2003; Midgley, 2006; Holmes, 2012). A number of studies have demonstrated the use of countertransference-inspired researcher reflexivity to illuminate aspects of human experience that may not emerge in traditional research interviews (see Clarke, 2002; Lucey et al., 2003), such as psychological defenses. For example, research by Walsh and Shulman (2007) suggested that splitting represents a useful construct to understand the ways in which migrants defend against the psychic pain associated with the loss of home, acculturative stress, and the task of restoring a sense of self.

Psychoanalytic interpretations of interview data, drawing upon contemporary perspectives, offers a novel perspective on the human relationship with the natural world and further, demonstrates the applicability of psychoanalytic theory to qualitative research. The aim of the current paper is to offer an enriched perspective on the lived human experience of the natural world, by drawing upon phenomenology and psychoanalytic constructs.

The current research draws upon countertransference-inspired researcher reflexivity to elucidate the nuances of the human–nature relationship. This involves drawing upon our own emotional response to interview data to appropriate participant's lived experience of the natural world and make meaning of this experience. The position taken is perhaps best captured by child psychotherapist Alvarez (1985), in her writings on the notion of neutrality in the context of psychotherapy: "The achievement of sufficient distance from the patient to think, yet not so much distance that empathic sensitivity and counter-transference receptivity get lost" (Alvarez, 1985, p. 88). Countertransference, founded upon the concept of projective identification, provides a grounding for highlighting the experience of the researcher in accessing their own responses in arriving at an understanding of the other.

The integrative methodological approach used is inspired by the work of Wertz (1986, 2005), Finlay (2011), and Holmes (2012), all of whom advocate for thoughtful integration of research methodologies that are traditionally regarded as standalone, in the pursuit of understanding human experience. Whilst the application of psychoanalytic theory to psychological research is not entirely novel, this paper occupies unique ground in applying psychoanalytic theory to the lived human experience of the natural world.

MATERIALS AND METHODS

Participants

Nine participants were interviewed as part of a larger study investigating the lived experience of nature (Glab, 2017, unpublished). Participants were recruited using a snowballing process, and all participants were over the age of 18 with the majority of participants aged between late 20 s and mid 30 s. Inclusion criteria required that participants needed to have lived experience of the natural world and to regard the natural world as being fundamental to their sense of health and wellbeing. Participation was voluntary.

Data Collection Procedure

The study was approved by the QUT Human Ethics Committee. All participants gave written informed consent in accordance with the Declaration of Helsinki prior to interviews being conducted. Interviews were conducted in person (n = 7) or via video conference calls due to the physical location of participants at the time (n = 2). Interviews ranged from 40 to 110 min in length and were recorded on a digital audio recorder. Notes were made immediately following each interview, with regard to the researcher's felt sense of interviewees, affective shifts, and other non-verbal cues observed during interviews. Interviews were then transcribed and explicated.

Interview Process

Interviews were guided by openness, curiosity, and presence to what was being expressed by participants. Drawing upon Gallagher's description of phenomenology as returning to "the thing themselves" and the primacy of experience of the lifeworld (Lebenswelt) (Gallagher, 2012), the interviewer sought to engage with the interviewee and structure the familiar as unfamiliar, and open for exploration. Specifically, interviewees were initially invited to describe their lived experience of the natural world (i.e., *please tell me about your lived experience of the natural world*). Open-ended, non-leading questions and prompts were used judiciously to clarify meaning or to encourage elaboration. Minimal encouragers, such as "please tell me more," or "please elaborate" were used to convey the interviewer's presence to participants. The interviewer prioritized the interviewee's sense of safety in the interview and created, as far as was possible, a space within which they were encouraged to reflect on their experience of nature. A typical prompt may have been "we are interested in the immediacy of your experience, please tell us more."

Data Analysis

A two-stage process, drawing upon phenomenology and psychoanalytic theory, was used to explicate and make meaning of the transcribed data. The appropriateness of drawing upon both these traditions is well articulated by Wertz (1993) in which he argues for a convergence of these two traditions, pointing to the common commitment to the irreducible nature of mental life, the bracketing of theories and preconceptions, the necessity for self-reflection and empathy, and privileging a relational theory of meaning. The first stage, informed by Giorgi's (2009, p. 2) descriptive phenomenological psychological method, which in turn draws upon Husserl's development of phenomenology, involved a five stage process. These stages were: (1) collection of verbal data, (2) a thorough reading of each interview transcript, (3) breaking data into parts by demarcating meaning units, (4) organizing data by translating meaning units into units of psychological experience through coding, and (5) arriving at a summary of the data which involved organizing and reviewing units of psychological experience. This process of reflection led to the formulation of an essential psychological structure of the lived experience of the natural world.

The second stage of analysis involved an iterative process during which key themes identified through the initial

phenomenological explication were reconsidered and reconceptualised from a psychodynamic stance. This process involved four stages: (a) reading through the data a second time, from a stance informed by relational psychodynamic theory and constructs, (b) noting both participant and researcher responses to the content of the data and the codes used to demarcate the data, (c) organizing overarching relational themes to reflect themes which emerge from the data drawing upon relational psychoanalytic theory (for example, *nature experienced as a primary attachment),* and (d) explicating the data in relation to the overarching themes identified above. From this process, parallels between psychic and emotional experience of interpersonal relationships, and psychic experience and emotional aspects of the natural world were identified and explicated. Parallels that emerged as prominent are discussed below.

Methodological integrity was based upon the processes recommended by Levitt et al. (2017), involving: (a) fidelity to the subject matter, and (b) utility in achieving research goals. Fidelity to the subject matter required that the researchers were consistent during each of the two phases of the research, and maintaining allegiance to the phenomenon, in this instance, to the lived-experience of the participants. Similarly, understandings of psychoanalytic concepts were shared within the research team, to ensure fidelity to the constructs as developed within the theory which informed the second stage of the explication. Utility on achieving research goals involved the systematic application of the research methodology for each of the stages in the process of explication. This involved initially following the process articulated by Giorgi (2009), in his description of phenomenological research in psychology. The second stage involved the explicit adoption of the psychoanalytic stance in the explication of the findings. The validity of the reflexive process and subsequent theme development was ensured through a process of ongoing reflection and discussion between members of the research team during the data analytic process. The process continued until there was significant agreement on the emergent findings which formed the basis of the results of the study. During each of these stages, the researchers maintained a focus upon the specific research question which underpinned the study. Giorgi emphasizes the basic assumptions of phenomenology, with his focus on the notions of "bracketing", intentionality, and rigor. He has thus been critical of alternative approaches which he regards as less rigorous, such as Interpretive Phenomenological Analysis (IPA), which he critiques on the basis of the philosophical foundations underpinning the approach and the lack of rigor associated with the analytic process (Giorgi, 2011). More specifically, Giorgi takes the view that the term "phenomenological" has been adopted by IPA theorists with little regard to the nature of "bracketing of the natural attitude" which is seen as fundamental to Husserl's rendition of phenomenology nor the process of the phenomenological psychological reduction. He further criticizes IPA as being inductive as opposed to Husserl's notion of phenomenology being intuitive and descriptive. In terms of the methodological process followed, Giorgi is critical of IPA's "hesitation to proclaim fixed methods" which are seen as detracting from the scientific criteria of objectivity or intersubjectivity (Giorgi, 2011, p. 195).

RESULTS

The aim of this paper was to make meaning of the lived experience of wellbeing from experiences with the natural world through both a phenomenological descriptive stance and a psychoanalytic lens. Participants engaged in unstructured interviews guided by both phenomenological and psychoanalytic principles of curiosity, neutrality, and empathy. Researcher reflexivity played a key role making meaning of the lived experience as articulated by participants. This process led to a rich understanding which may not have emerged otherwise. Excerpts from interviews have been used to illustrate results. This process led to the identification of the following key themes (a) nature experienced as primary attachment; (b) natural world as secure base; (c) natural world as twinship; (d) natural world as containing environment; (e) natural world as sensory-emotional milieu.

Researcher Observations of Interviewees

Making use of the interviewer's own experience of participants during the interview process is privileged in both phenomenological and psychoanalytic approaches. Given that the current paper draws upon phenomenology and psychoanalytic theory, inclusion of the interviewer's emotional experience of participants during interview is seen as adding value by more deeply illuminating participant feeling expressed within interviews. In his writings about the unconscious, Freud reflected on the manifestation of experience in psychoanalysis suggesting that significance of experience is often reflected in paradoxically small gesture or behaviors. He wrote: "Are there not very important things which can only reveal themselves, under certain conditions and certain times, by quite feeble indications?" (Freud, 1924, p. 27).

Participants were observed speaking about the natural world with profound feeling. Even before participants had given voice to lived experience of the natural world, their faces and bodies gave expression to their experience of the natural world. Participants were observed to close their eyes and smile as they reflected on their experience of the natural world. Some participants held their hands to their chests, while others were observed as subtly hugging themselves when remembering particular experiences with the natural world. Interviews were characterized by a reliable warmth that emanated from participants as they spoke about their respective experience of the natural world. Several participants were observed to hum as memories of the natural world were brought to consciousness. Two participants became tearful, and gesturing to their tears, articulated feeling overwhelmed by their affection for the natural world. When participants described experiencing a sense of vitality in the natural world, a parallel process was observed such that both participant and interviewer became animated and expressive, both in voice and physical movement.

Across interviews, participants described experiences of feeling held in the context of the natural world. The notion of a holding environment, originally conceived by Winnicott (1960), refers to the maternal provision of an environment meeting the needs of the entirely dependent infant. Holding refers not only to the physical holding or cradling of the infant, but also to sufficient meeting of needs that fosters continuity of being-in-the-world that abets integration and the development of a coherent self. Winnicott (1960, p. 47) wrote that the primary function of the holding environment is "the reduction to a minimum of impingements to which the infant must react with resultant annihilation of personal being." Holding thus bears similarities to Heidegger's (1962) notion of *das man* or they-self, such that the 'I' is experienced as indivisible from the world. Similarly, holding connotes an experience of oneness between mother and baby, in which the infant experiences himself as an extension of his mother, rather than separate to his mother.

The term *containment* is thus used interchangeably with *held* and *holding* as participants used both terms to describe their experience within nature. However, in contemporary psychoanalytic literature *containment* and *holding* refer to different developmental processes, though are commonly conflated (Wright, 2005). Bion (1962) in his description of containment conceives the infant as having awareness of his mother as being separate or outside of her or him -self. In the context of this paper, holding and containment are used interchangeably to describe the participant's experience of self as integrated and coherent in the context of the natural world.

The following section describes the findings that emerged from the two-stage methodology previously described. Illustrative excerpts are taken from interview transcripts and provide the reader exemplars, which are then interrogated from a psychoanalytic perspective.

Natural World Experienced as Primary Attachment

The experience of the natural world emerged as being experienced as a primary attachment. The term primary attachment, derived from object relations theory, refers to a primary "attachment figure" which in this case, is metaphorical (Wolf, 2002). This overarching theme emerged from the following natural meaning units: experience of nature as part of childhood; nature as nourishing; essential for individual wellbeing; longing for nature, and sense of loss at destruction of nature.

The notion of primary attachment is seen in the following excerpt:

> *Well, you know they call it Mother Nature. That's an appropriate term. It [natural world] is where I come from, so I'm connecting back to myself by connecting with nature because I came from it* (Jen, 30 years old).

The experience of the natural world emerged for participants as serving a similar function to an attachment figure or self object. In particular, the notion of a self object, which is core to human identity, captures the dynamic relationship as described by the participant. The natural world is experienced as a psychic artifact allowing the individual to recalibrate and gain a renewed sense of self. In the above excerpt, the participant articulates an experience of connecting back to herself when spending time with the natural world. Her description suggests that time spent away from the natural world may be experienced as time spent away from the self, and that a return to the natural world marks a return to the self. A number of participants suggested that the natural world may function as a good self object most often associated with childhood and adolescence, and remains part of their self structure into adulthood.

For some participants it is the significance of the natural world in meeting self object needs that makes the destruction of the natural environment particularly distressing, as illustrated in the following excerpt.

> *When I was five, we moved to the outer suburbs of Brisbane, which then would have qualified as semi-rural. That area feels completely different now, and it feels painful to drive out there now. There are stands trees that are missing, houses where there were previously rolling hills speckled with horses, unmarked roads. I hate to see the space that has been left behind by trees removed, and replaced by bitumen or houses or fences. It reminds of me Avatar, the film, when they tear down the Home Tree, and the people are screaming. It's like their hearts are on fire at the loss of this beautiful thing* (Hannah, 28 years old).

Hannah describes experiencing psychic pain in response to the urbanization and destruction of the area she grew up in. She finds it painful to expose herself to the visible signs of development and to the loss of the landscape of her childhood. Her experience of loss in response to destruction of the natural environment, which was described by several participants, reflects the traumatic loss of environmental self object support. For the individuals who participated in the current research, the natural world forms part of their endopsychic structure similarly to the way in which human self objects are part of emotional infrastructure. The natural world represents one of a suite of internalized objects, thus the loss of the natural world may evoke a similar kind of distress that one may experience at the loss of a human self object or attachment figure.

Natural World Experienced as Secure Base

Attachment is founded upon the concept of a secure base, providing a grounding for human experience. The very notion of human experience being founded in the process of reflection draws upon the human capacity to make sense of lived experience, often occurring within the context of a sense of security in the relationship with the "other." In the most primitive terms, this occurs at birth as the young baby attaches to the "other" for nurturance and safety, and continues throughout life. In the context of the current study, experience of the natural world as secure base is founded upon the following codes: experience of freedom in nature; return to nature; affording of

play and exploration; nature as home, and sense of belonging in nature.

The overarching theme of the natural world being experienced as a secure base is expressed in the following:

> *I think people talk about the natural world as something completely separate to us, but we are nature as well and I think we just forget that. . . Nature is like, 'You're welcome.' It always feels like home. It really is a return to* (Daisy, 27 years old).

The above excerpt illuminates the natural world as indivisible from the embodied architecture of the individual. Similar to the previous excerpt, Daisy eschews the common perception of the natural world independent of self and references "collective forgetfulness." In keeping with contemporary psychoanalytic conceptions of relationality, her language undermines notions of subject and object, as she speaks about the natural world as relationship, when she refers to the natural world as 'home.' The experience of both oneness and separateness with the natural world is reminiscent of early infantile experiences of attachment figures, in that the attachment figure functions as an extension of the infant self.

> *It's definitely that I need to relate to it [natural world] from when I wake up. If I haven't got a window open because it's too cold to get up or whatever, then it's unnerving. I need to be able to see outside. I really relate to it from a feeling sense. I need to feel the sun beating down on me and hear the birds. . . It's comforting to be able to hear it in the morning, to be able to hear the birds and see the leaves outside the window. I guess it's like a homecoming, and it you're removed from it for too long, then it becomes disconcerting* (Elle, 27 years old).

In this quote Elle expresses her need to relate to the natural world experientially as she becomes conscious of being awake. She describes her need to relate to the natural world as multi-sensory, and experiences separation from the natural world as unnerving. Her sensory attunement to the natural world as being experience-near alleviates anxiety. Needing to be in proximity to the natural world bears likeness to the concept of proximity seeking in attachment theory. Thus the participant seeks closeness to the natural world (i.e., the attachment figure), which provides a necessary and needed sense of comfort. Further, she has learned through experience that proximity to the natural world offers a sense of safety, best understood in terms of primal attachment needs. Repeated episodes of attachment figure availability, which in this case may be opening her bedroom window to hear the birds and look out into the tree canopy, leads to the development of self characterized by internal working models about self and others. Elle's lived experience informs a direct perception of nature as reliable, comforting and secure.

Natural World Experienced as Twinship

Twinship refers to a self psychology construct used to explain human development, and more commonly refers to a non-dualistic and primary desire of a young person, to feel alikeness with other human beings (Wolf, 2002). Over time, the individual is believed to tolerate greater differences between the self and "the other." Similarly, interviewees reflected a parallel dynamic where participants expressed a desire to identify with nature experientially. This theme emerged from the following codes: experience of kinship with nature; love in relationship with nature; oneness with nature; self as part of nature, and nature as inspiring. These codes could be seen as cohering around a mutual finding process between person and nature. It is suggested that the experience of twinship between participant and the natural world can be understood as functioning similarly to twinship relatedness in an analytic dyad in meeting the participant's need for essential alikeness, but without there being a mutual finding process.

> *I am not separate from the intelligence of nature. . . the biology of my body holds the intelligence that I am revering in nature. The intelligence that knows how to maintain cells in my legs – I share that intelligence with nature* (Rebecca, 31 years old).

In the above excerpt, the participant gives voice to the shared, intelligence of the natural world and her own body. She regards the natural world and its inherent intelligence with reverence. She observes that the intelligence she admires in the natural world is of the same order as that of her own bodily intelligence. She finds herself *in* the intelligence of nature, because she *is* the intelligence of nature. The experience of finding oneself in another is one of the hallmarks of twinship. To find oneself in another, in the same way that a child may find herself in the face of her mother or in the gestures of his father, offers an experience of essential alikeness. Thus, the participant may be afforded an experience of admiration for her own biological intelligence – the same intelligence that she reveres in the natural world.

> *I guess there's a sense of being stripped back, brought back, returned to the world. I think that it's kind of like, the intelligence that exists within nature – that is nature – is that which makes me possible. I experience a feeling of being kindred with nature* (Hannah, 28 years old).

Similar to the previous excerpt, the participant references an essential likeness between herself and the natural world. She articulates an experience of feeling kindred with the natural world, which in other words, may be expressed as feeling that she *is* nature *among* nature. Hannah's experience of being nature among nature is not dissimilar to the self psychology concept of twinship, which Kohut (1984, p. 200) described as "confirmation of the feeling that one is a human being among other human beings." However, in this case, rather than being human amongst humans, the twinship experience pertains to the feeling that one is nature among nature.

Natural World Experienced as Containing

The notion of containment lies at the core of contemporary psychodynamic theory and practice, which refers in part, to the containment of the individual, that is, the process of providing a sense of safety as the person experiences emotional containment

of their affective experiences, and also in the course of human development, where the parent, often the mother, provides a soothing environment for the child, and over time, the child is said to internalize this experience of containment (Wolf, 2002). In the current study, the notion of the natural world being experienced as containing was identified through the following codes: experience of nature as containing; nature as grounding; nature as perspective-giving; presence with nature, and vulnerability or sense of fear in nature. The overarching theme is evident in the following:

> *I think the feeling range. . . the spectrum of feelings that you get in nature, and nature acts as a container for experiencing all those things. Almost like a therapeutic experience, it holds that space for you. And it's only you to experience that, it's not like you're experiencing that with another human and having to navigate their feelings as well. It's you with your feelings in that space* (Jen, 30 years old).

The above excerpt illuminates the natural world as a containing space in which the participant feels that she can experience a range of feelings without fear of a disproportionate, inappropriate or invalidating human response. She describes the natural world as offering a therapeutic experience, and gives voice to the idea that her space in the natural world is hers alone. There is no requirement for management of her own emotional experience, or the emotional experience of another human being, which is the aim of good psychotherapy. In the context of an analytic dyad, the patients' experience is privileged with the analyst only offering his or her experience as a means by which to better understand the patients' experience. It is the role of the analyst to provide a containing space for the patient to express his or her experience, without fear of criticism or consequence. Though in the context of the natural world there may be consequences for carelessness, the natural world represents an emotionally safe space akin to the therapeutic environment.

In her writings about the intersection of human experience and the natural world, Kiewa (1994) suggested that one of the benefits of spending time in the natural world is the concrete and immediate feedback from nature. She describes "the consequences of actions are even-handed in fundamentally different ways from those human interactions in other settings" (p. 187). In the current research, participants described experiencing a sense of safety when walking through forests or swimming in the ocean, despite possessing awareness of the dangers that exist in these natural environments. The following excerpt is illustrative:

> *I guess there is this feeling of safety and reliability I guess. Like I know exactly how I would feel if I were among those woods. . . it's as though nature is reliable in always being there. . . I mean, nature is inherently unpredictable in terms of weather and other natural phenomena, but it's sort of predictably unpredictable. And there's consistency in that* (Hannah, 28 years old).

Similarly, another participant described a feeling of safety in the natural world despite knowing that her safety is not guaranteed: "It's safe. It's an emotionally safe space, maybe it's not physically safe all the time but it's emotionally safe" (Lou, 28 years old).

These excerpts illuminate experiences of psychic safety (or containment) in the context of an otherwise unpredictable physical environment. Participants describe the natural world as a place of constant and reliable containment within which they experience themselves as held. Although the natural world may not offer the kind of conscious attainment that a mother may offer her child, there appears to be something about the reliability of the natural world that promotes a sense of containment.

Natural World Experienced as Embodied

The natural world was experienced by participants as being primarily sensory and emotional, which we refer to as embodied. This mode of being-in-the-world was identified through the following codes: experience of cellular connection; urban claustrophobia; sensory experience in nature, and nature as felt. The overarching theme is well articulated in the following:

> *I love when I just go from seeing trees and grass, to really seeing the grass and trees. Once I just decided to smell the ground and [laughs] it smelled amazing. I don't know, I can only think that my relationship [with nature] is that I experience joy from interacting with nature, whether it be just laying on the grass and feeling the sun on my skin, and just like, soaking it in, in that moment* (Jen, 30 years old).

Another participant gave meaning to her experience of nature thus:

> *It's a complete sense of belonging. Like, 'Ah, this is me. I remember now. I am from this, this is my home. It is like taking a beautiful, gentle breath and exhaling modern trappings. Sort of like cellular return. It kind of feels like my cells are returned to themselves, reminded of their beautiful simplicity within the context of the complexity of the whole* (Hannah, 28 years old).

The above excerpts are two of several, in which participants described sensory-emotional experiences with the natural world. Several participants gave voice to sensory experiences that were associated with feelings of familiarity, belonging, and of being known by the natural world. Kohut (1984) wrote:

> *The mere presence of people in a child's surroundings – their voices and body odors, the emotions they express, the noises they produce as they engage in human activities, the specific aroma of the food they prepare and eat – creates a security in the child, a sense of belonging and participating, that cannot be explained in terms of a mirroring response or a merger with ideals* (p. 200).

The rich sensory milieu of the natural world affords similar experiences of familiarity and comfort, particularly for individuals whose relationship with the natural world was

forged during infancy and/or early childhood. Contemporary philosopher and author de Botton (2015) writes about the significance of sensory experience during childhood. He writes of one of the characters:

> *The fundamentals of Esther's childhood will be stored not so much in the events as in sensory memories: of being held close to someone's chest, certain slants of light at particular times of day, of smells, types of biscuits, textures of carpet, the distant, incomprehensible, soothing sound of her parents' voices in the car during long night-time drives, and an underlying feeling that she has a right to exist and reasons to go on to hope* (p. 110).

His description captures the visceral nature of early sensory experience, particularly in terms of those that evoke a sense of comfort and familiarity. It is suggested that similar experiences of comfort and belonging occur in the natural world, particularly for individuals whose relationship with the natural world has significant psychic import.

DISCUSSION

The aim of this paper was to explicate the lived human experience of the natural world using a novel two-stage analytic process. Data gathered as part of a larger phenomenological analysis was subjected to interrogation from a contemporary psychoanalytic perspective, with interview excerpts used to illustrate psychoanalytic interpretations of the human–nature relationship. The findings suggest that relationship with the natural world can be understood drawing upon common relational psychoanalytic concepts to make sense of participants' lived experience of nature. The application of psychoanalytic theory to further interrogate phenomenological descriptions illuminated aspects of the natural world as being of significance in the development and maintenance of a healthy and coherent sense of self, particularly for individuals who identify as having a meaningful and ongoing relationship with the natural world.

The study draws upon phenomenological methodological principles with a view to explicating the lived-experience of nature. Both phenomenology and psychoanalysis are based upon an epistemology which seeks to gain an understanding of human experience. Drawing upon psychodynamic understandings provided an additional perspective, which we viewed as enriching our understanding of the experience of nature. That is, the natural world may be understood in terms of a primary attachment relationship, involving what object-relationship analysts call a good self object, or significant other, both in terms of felt experience and psychic importance. Participants consistently identified the natural world as a source of tranquility and comfort. The natural world was illuminated as a space in which a sense of belonging, cohesion, and containment was experienced. Collectively, participants described experiences of returning to self, homecoming, and familiarity with the natural world that restored psychic equilibrium. Drawing upon both a phenomenological and psychoanalytic perspective provides both insights into the life-world of the participants, not accessible through either framework on its own, and also demonstrates the feasibility of an emerging methodology characterized by the emergence of psychoanalytic and phenomenological theory, which in turn, share a common approach to the exploration of the life-world of the participant, and privileges and idiographic approach as an initial step in scholarly understanding of human experience (Wertz, 1986).

Participants identified that being with the natural world healed feelings of unease and rehabilitated an eroded sense of self, much like the embrace of a significant other. As Kohut (1984, p. 77) wrote of psychotherapy, "The essence of the psychoanalytic cure resides in a patient's newly acquired ability to identify and seek out appropriate self objects as they present themselves in his realistic surroundings and to be sustained by them." Participants articulated being able to recognize their need for immersion in the natural world after experiencing deterioration of self-continuity and self-cohesion.

Conscious engagement with the natural world may be understood by drawing upon psychotherapy constructs drawn from both contemporary object relations theory, and self psychology. In other words, the natural world offers a similarly validating experience, as discussed in the psychotherapy literature, in that the natural world neither interferes with, nor gratifies, nor casts aspersions about lived experience. For example:

> [Regarding connecting with the natural world] *I guess it's similar to when you really genuinely hug a person. . . and you take the time and we don't do that with humans very often. I guess because we have so much other crap going on in our brains with other humans, but you don't get that with nature. . . . . A tree is not going to talk to you or judge you* (Jen, 30 years old).

Whereas the fallibility of a human self object may lead to self object failure, the natural world simply is. To the extent that the natural world simply is, it cannot offer interpretations or actively participate in the promotion of psychic insight. We argue that the self is consolidated through a stable self-object bond with the natural world, particularly when the individual's lived experience of the natural world is imbued with memory and positive associations facilitated by significant emotional involvement in the original event (Curci et al., 2015). Furthermore, there can be no interpretation or misinterpretation of the natural world as intending harm - it simply is. Arguably, a person may experience narcissistic injury in the form of failing to summit a peak, climb a tree, or navigate terrain. For example, if a person regards herself as physically capable or competent at navigating hostile terrain, and she is not able to demonstrate these skills to herself, she may experience psychic discomfort. However, in not having to account for the mind of the other as in interpersonal experiences, the task of making sense of this discomfort is simpler in the natural world.

The natural world may be experienced as restoring psychic equilibrium. It does not aggravate narcissistic injury nor does it threaten sense of self. It is experienced as predictably changeable,

egalitarian, and uninterested in criticism or judgement. Nature is associated with nostalgia as the relationship is imbued with childhood memories, learning, and shared experiences with loved ones. It is a touchstone that we seek out to anchor ourselves and to restore our sense of self.

We propose that the notions presented in this study, drawing upon both phenomenology and contemporary psychoanalysis are particularly significant in the context of an increasingly distressed and often alienated population. In synthesizing the themes explicated in the study, we may see an analogy in Mahler's notion of early symbiosis and the process of separation and individuation (Mahler et al., 1973). Of course, individuation is an important part of human development, where separation refers to the individual's sense of identity. At the same time, through attachment, the infant internalizes the loving and approving "other" which in turn, contributes to successful social and emotional development and to healthy proximity seeking over the course of the person's life. While the language of self psychology which has informed sections of the paper is sometimes clumsy, the paper has explored the ways in which relationship with nature may be experienced in terms of: primary attachment; as secure base; as twinship; as a containing environment; and as a sensory-emotional milieu. In each of these ways of relating, nature provides a basis for a "safe base" enabling the individual to explore and develop a sense of self in the confines of a safe relationship where ruptures may be attended to, managed and repaired as needed.

In essence, we have argued for the possibility that the natural world may function similarly to a secure attachment relationship, particularly in terms of the ways in which the individual experiences his or her self in the natural world, which in turn raises the importance of nature contact from an early age. Participants describe notions, such as feeling tranquil, relaxed and emotional restoration captured by Biophilia, ART, SRT, topophilia and place theories. However, the notions of topophilia and place as concepts are described in terms of nature out there and separate from humanity, places that we move to or through, places that facilitate emotional experiences. Equally, the notion of nature as something separate from humanity providing space to restore or realize emotional bonds has been effectively explored through Biophilia, ART and SRT. However, participants in this study indicate that, when focused on wellbeing, experiences of nature are beyond something out there and more than an emotional affiliation or a place to experience positive emotional or cognitive restoration. Instead, nature as expressed by those who experience wellbeing through nature, is experienced as family or part of self and in some way inseparable from self. Experiences of nature are described as contributing to an integrated sense of self. Participants sense of nature is multi-sensory and seems to reflect a comfortable attunement to information within the human–nature relationship which is often contrasted to human-human relationship. If an ongoing relationship with the natural world affords such a profound sense of belonging, comfort, and containment, there is even greater argument for immersive engagement with the natural world, particularly in the context of an increasingly nature-alienated global population.

Limitations

Several limitations are noted. Application of psychoanalytic constructs to phenomenological data is novel. Traditionally, phenomenology rejects the application of theory to phenomena. Thus the task of harnessing both phenomenology and psychoanalytic theory toward explicating the lived experience of the natural world has required a two stage analytical process, during which lived experience has been identified, and the constructs, drawn from psychoanalytical constructs, have been utilized to make sense of the data.

The intersection of phenomenology and psychology is complex. Firstly, the convergence between phenomenology in psychological research and practice, and psychoanalytic concepts affords rich understanding of human experience. We are in agreement with scholars who have argued that this approach makes the nuances of experience accessible in ways not possible, either by methodologies based upon other disciplines, or a single approach such as phenomenology alone (Wertz, 1986). Secondly, this endeavor is inherently messy, intuitive rather than systematic, and thus replication can be difficult to achieve. However, our aim is to get close to human experience and to make sense of those experiences by drawing upon appropriate theoretical constructs. We have argued that contemporary psychoanalytical constructs are suitable for this purpose.

Future Directions

The current findings suggest that the relationship between human beings and the natural world is significant, particularly in terms of psychic experience. The exploration of the human–nature relationship is particularly salient in the shadow of an increasingly disconnected global population. We argue for the need to continue to seek to understand the human experience of the natural world, and with this understanding, find ways to cultivate relationships between human beings and the rest of the natural world. It is not sufficient to know that nature contact is good for us - we already know this and yet the disconnect between contemporary sense of selfhood in urban environments and the natural world grows. Future research may benefit by focusing upon understanding the human–nature relationship, and use this insight to return to a fuller experience of our relationship with the natural world.

There is a need for integrative methodological approaches to further our understanding of human experience. While empirical methodologies may afford explanation of phenomena through postulation of abstract models and theories, phenomenology conceived as a human science lends itself to integrative models of enquiry. We have aimed to demonstrate that with alternative analytic procedures drawing upon phenomenological and psychoanalytic research, the vicissitudes of human experience may begin to be understood.

CONCLUSION

This paper achieves two important objectives. First it demonstrates the utility of a novel methodology which draws upon both phenomenology as a rigorous descriptive science, and

contemporary psychoanalytic theory and process to offer a rich and alternative perspective on a critically important relationship: our relationship with the natural world. Secondly, the findings extend our understanding of human experience as going beyond the traditional domains of early human-human attachment, and additional interpersonal relationships, which is at the center of much psychoanalytic reasoning, but as incorporating the relationship between human-beings and nature as being a profound component of human existence The use of researcher reflexivity to make meaning of the human–nature relationship illuminated parallels between relational psychoanalytic concepts and experience with the natural world. We argue further that the salience of the human–nature relationship, as articulated in this study may be of particular significance in the context of increasing mental health concerns and the rising incidence of chronic and stress-related disease. Encouraging deep and immediate relationships with the natural world may well represent one way of reinstating the centrality of nature in the lives of all human endeavor as we reclaim the term "mother nature."

AUTHOR CONTRIBUTIONS

RS, HG, and EB were responsible for conceptualizing the study, were involved in the write up, and take responsibility for the final manuscript. RS provided training in the methodology and assisted with interviews. EB provided guidance to the field of environmental psychology. HG conducted the majority of the interviews, transcribed all interviews, and undertook the first analysis of all transcripts. EB and RS checked coding and analysis.

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Enhancing Health and Wellbeing through Immersion in Nature: A Conceptual Perspective Combining the Stoic and Buddhist Traditions

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INTRODUCTION

A growing body of evidence from a wide range of fields indicates that physical activity in nature improves psychological health and wellbeing (Pretty et al., 2005; Howell et al., 2013; Passmore and Howell, 2014). For example, Passmore and Howell (2014) found that both eudemonic wellbeing and hedonic tone were enhanced after a 2-week outdoor activities intervention. Mitchell (2013) found an association between the regular use of natural environments for leisure activities and a lower risk of mental health issues. Carrus et al. (2015) found that contact with green space in a school environment positively influenced cognitive performance, social behavior, and affect. Improved health and wellbeing has also been associated with feelings of emotional connection to nature (Brown and Kasser, 2005; Nisbet et al., 2011; Capaldi et al., 2015; Martyn and Brymer, 2016). For example, Martyn and Brymer (2016) found that higher nature relatedness was related to low state and trait somatic and cognitive anxiety. However, as Mitchell (2013) recognized the association between wellbeing and nature might be more complex than initially understood. Despite the number of studies showing improvements in psychological health and wellbeing through activities undertaken in the presence of nature and feelings of connection to nature we are still unclear about how the relationship between people and the natural environment enhances wellbeing (Brymer et al., 2014; Korpela et al., 2014; Brymer and Davids, 2016; Yeh et al., 2016; von Lindern, 2017). This is significant because understanding how this relationship enhances health and wellbeing is important for designing effective interventions. In this paper we present a conceptual framework for understanding *how* to enhance the wellbeing benefits of nature-based experiences by drawing on principles from Stoic and Buddhist traditions. Specifically, we consider the stoic idea of *oikeiōsis*, which Nussbaum (2009) refers to as the process of the human complex attunement to the intention of the universe and the Theravāda Buddhist concept of mind awakening as abandoning of self. Both concepts seek human wellbeing and flourishing through participation in nature. We (1) show how the philosophical understandings from the Stoic and Buddhist traditions can be combined and practically applied to understand and enhance wellbeing; and (2) describe a concise system of navigating in the world, with the aim of enhancing health and wellbeing in humans.

CURRENT EXPLANATIONS OF THE HUMAN-NATURE RELATIONSHIP

In recent years there has been a wealth of evidence demonstrating that engagement with the natural environment benefits human health and wellbeing (Brymer et al., 2010; Herzog and Strevey, 2015; Lymeus et al., 2017). The indication being that nature-based experiences might present a unique route to lasting and meaningful wellbeing outcomes. This has led some researchers to suggest that time spent in nature might be as effective as more traditional social, psychological, or exercise interventions (Barton et al., 2012; Lymeus et al., 2017). Currently, there are few viable theoretical explanations for the relationship between experiences in the natural environment and positive changes in psychological wellbeing (Brymer et al., 2014; von Lindern et al., 2016). Although some operational descriptions have implicated a possible role for neurophysiological mechanisms and improvements in self-control, self-mastery and exposure to positive social support and environments, no clear and testable theoretical framework has been proposed to explain how wellbeing might emerge from engaging in nature-based activities (Brymer et al., 2014; von Lindern et al., 2016).

To date, theoretical frameworks and philosophical foundations typically utilized to guide research focus either on the attributes of the person or the characteristics of the environment and include Attention Restoration Theory ART (Kaplan and Kaplan, 1989) and the Biophilia hypothesis (Wilson, 1984). ART asserts that the natural world has the capacity to reduce attentional fatigue that stems from demands placed on our cognitive resources from modern lifestyles. The natural world has the ability to effortlessly hold our attention (i.e., soft fascination) and restore our cognitive resources (von Lindern et al., 2016; Lymeus et al., 2017). The Biophilia hypothesis (Wilson, 1984) suggests that we have a primordial connection with the natural world that predisposes us to respond positively to exposure to the natural environment. However, as these frameworks do not effectively determine *how* the relationship between human beings and nature benefits human health and wellbeing they are not able to provide guidance for the health professional wishing to include nature as an intervention. Furthermore, recent research suggests that the relationship might be more complex than suggested by ART or Biophilia (von Lindern et al., 2016; von Lindern, 2017). For example, Lymeus et al. (2017) found that nature images enhanced salutogenic processes and mindfulness practice for those beginning mindfulness training. A recent meta-analysis (McMahan and Estes, 2015) suggested that the beneficial effects of the natural environment on emotional wellbeing are driven primarily by increases in positive affect, and only to a lesser extent decreases in negative affect. This finding is at odds with ART (Kaplan and Kaplan, 1989) and the focus on the reduction of negative affect as the primary mechanism for enhanced wellbeing in the context of exposure to the natural world. The authors suggest that further exploration of the relationship between the natural world and human wellbeing is needed to "help clarify the manner in which nature contributes to optimal human feeling and functioning" (McMahan and Estes, 2015, p. 6).

In addition to critical perspectives on how each of the theoretical frameworks are traditionally employed to explain research findings, critiques of the current theoretical focus on the link between nature and wellbeing point to a fundamental problem preventing the development of more nuanced understandings (Brymer et al., 2014). To date much of the research exploring the relationship between human beings and the rest of the natural world has remained in the deterministic traditions relying on the Cartesian notion of "subject" and object' (Brymer and Schweitzer, 2017). From this perceptive nature is most often considered an object for the benefit of people and understanding how benefits happen is about understanding the impact of the object (i.e., natural environment) on the subject (i.e., people) (Shanahan et al., 2016). This perspective of "nature" as the physical world outside our skin (except artificial technologically created objects) has been critiqued as fundamentally flawed (Fisher, 2002). Instead Fisher describes a notion whereby people are part of nature and therefore at a fundamental level being human is also being nature. However, the pull of modern western culture tends to focus on how we are separate from or estranged from nature as opposed to being part of nature (Fisher, 2002; Brymer et al., 2009; Brymer and Schweitzer, 2017). Natural environments are most often perceived to be "places" with minimal human interference (Vining et al., 2008). For ancient philosophers of most Greek and Eastern schools, nature includes people. Nature is understood as a process of life, of which human beings are an immanent part. Returning to nature and remembering that we are nature is essential for health and wellbeing. In the present paper we will use term "natural environment" to describe the outdoor natural environment, and "nature" to describe process of life operating both outside and inside of us.

A theoretical clarification of how nature might enhance health and wellbeing that can guide interventions for the future is urgently needed (Brymer et al., 2014; Yeh et al., 2016). In this paper we argue that often overlooked philosophical perspectives from the Buddhist and Stoic traditions provide a solid framework to guide intervention designers. To do this we first introduce the Stoic and Buddhist notions most relevant to understanding how the human–nature relationship might enhance wellbeing. Then we explicate the philosophies more deeply to demonstrate the appropriateness of the concepts. Finally, we introduce a particular way of combining the teachings from Buddhist and Stoic thought in everyday life.

AN INTRODUCTION TO THE STOIC AND BUDDHIST PHILOSOPHY

Two schools of philosophical practice which perceive immersion in nature as crucial for human flourishing are the Stoic school and Buddhist school. The Stoic school was established by the Greek philosopher Zeno of Citium, in fourth century BCE and the Buddhist school was founded by Gautama Buddha, most probably in the fifth century BCE. Stoic philosophy identifies two possible existential and psychological states for human beings. These states are described as the *ordinary* person state and the

philosopher state. From the Stoic perspective a person in the ordinary state is prone to common mistakes in thinking and condemned to suffering. Being in the ordinary state signifies a person who does not make an effort to understand the laws of nature and thus cannot achieve realization or flourishing (Nussbaum, 2009). The philosopher state of being, on the other hand, signifies a person who leads an examined life and who can flourish because of their comprehension of and subordination to the laws of nature. Understanding in this context is more than an intellectual practice. It is an embodied process of attuning to nature, which engages both mind and body, and results in what Stoics call *conversion*. To put it in words of French philosopher Pierre Hadot:

> For the Stoics, it was sensible reality itself that was capable of this movement of conversion. The entire universe, living and reasonable, animated by the Logos, was endowed with a vibratory movement running from the interior to the exterior and from the exterior to the interior. Conversion of the philosophical soul was then extended to the conversion of the universe and, finally, of universal reason (Hadot, 1968, p. 981).

This means that the philosopher flourishes by attuning to the rhythms of nature, and thereby eliminating barriers between self and the natural environment.

Buddhist schools offer a similar perspective and propose that there are two radically different states possible for humans: *unenlightened* and *enlightened*. The enlightened state requires a psychosomatic effort through meditation. The ideal consequence of this meditation is a life without psychological irritations which comes about as a result of mental changes. Similar to the Stoic position this process requires attuning to nature, technically known in the Buddhist scriptures as a collection of dhammas (Gethin, 2004), where illusion and conceptual superstition are overcome. The epistemological capacity which is required to attune to the process of life is called "investigation." Effective investigation (Pāli: *dhamma vicaya*) is attuned to the rhythms of nature. Being present in physical nature enhances such an investigation. Wooded areas are considered the most conductive environment for meditation throughout the whole of the Pāli canon. According to the Theravāda school of Buddhism, meditating on and in the natural environment facilitates a focus on "truth" as differentiated from the artificial, conventional, or conceptual. The author of the classic contemporary Buddhist phenomenology and meditation handbooks Pandita writes:

> Investigation shows us the characteristics of *paramattha dhamma*, or ultimate realities, which simply means objects that can be experienced directly without the mediation of concepts (Pandita, 1992, p. 105).

For both traditions the only way to reach the state of awakening or flourishing is to surrender to natural laws. Stoicism and Buddhism propose that human flourishing is not achieved by ego expression, but rather by adjustment to the natural world, including the rhythms of the natural environment. In this paper we argue that a fusion of these similar concepts from Buddhist and Stoic philosophy provides a comprehensive picture of *how* the natural environment might enhance human wellbeing. In the following sections we expand on these concepts and show how the adjustments might be facilitated.

Stoic Thought

There are a number of fundamental Stoic principles that guide the understanding of how to achieve flourishing: *oikeiō sis* (attuning to natural rhythms of the universe), *ataraxia* (tranquility), *conversion* (return to natural balance). *Oikeiō sis* is defined by the Stoics as recognizing the dynamics of reality and drawing from it happiness and strength. Nussbaum (2009) defines *oikeiō sis* as the human adjustment to the natural rhythms of the universe, which operate at a cosmic level, a natural environment level and human consciousness level. The adjustment entails an experiential relationship with nature or going into nature in an open manner which, if successfully achieved, results in a conversion. Errors of thinking attributed to human culture in all its manifestations are considered to be the main barriers to achieving this conversion.

The notion of *oikeiō sis* refers to the original stoic notion that humanity's highest aim is to live in accordance with the nature of the universe. This also means living in accordance with virtue, understood as building essential features of character, such as courage or temperance. According to the Stoic principles human beings are particles of the Universe and a person in the philosopher state of being has a duty to act according to this truth (Diogenes, in Dorandi, 2013). *Ataraxia* describes the process of attaining tranquility by attuning to nature, even when this might feel uncomfortable. For example, while many people would like life to be stable and would like to feel safe, the Stoic argument is that this longing should be abandoned, and instead people should see reality as it is; a process of constant flux. To achieve *ataraxia* a person in the philosopher state should:

> Acquire the contemplative way of seeing how all things change into one another, and constantly attend to it, and exercise thyself about this part [of philosophy]. For nothing is so much adapted to produce magnanimity (Marcus Aurelius Antoninus, cited in Long, 2007, p. 262).

Exercises as those proposed by Marcus Aurelius in the quote above are not about intellectual entertainment, but rather they are about directing our attention to nature around us and within us (Hadot, 1998, p. 129). A person in the philosopher state needs to (1) consciously direct attention to what changes in the environment rather than on what remains stable, (2) repeat this focus as often as possible in order to make it a habit, (3) repeat in thoughts or in writing, philosophical statements, which suggest that reality is changing all the time. Hadot writes:

> Elsewhere, Marcus writes (V, 23): Think often of how quickly beings and events pass and disappear; for substance is like a river in perpetual flux. If, Marcus adds, we can recognize that all this flux of things and events is alien to us, then we will be "raised above the tangled web of Destiny." To be sure, our body and our vital breath are swept along by this flux, and both our representations of things which are received into the body and

> our vital breath belong to this flux, because they are produced by causes outside of us (Hadot, 1998, p. 118).

The anticipated outcome is an emotional state called magnanimity, which is considered pleasant and unselfish, and involves non-attachment and acceptance of change. The same notion of directing attention to change rather than stability is often given to Buddhist adepts at particular stages of meditation, which leads to the insight technically known as an "insight into arising and passing away" (Pandita, 1992, p. 271). The insight reflects the ability to attune attention to the direct experience of the rhythms of life. In turn this leads to the subsequent "insight into dissolution" (Pandita, 1992, p. 271) or the attunement to the rhythms of life and the reality of constant flux.

Buddhist Thought

Buddhist principles have been linked to reconnecting self as part of nature (Panno et al., 2017). In Buddhism the important aspects relevant to this discussion are *bojjhaṅgā* (factors of awakening) and *dhamma* (nature). Meditative practice facilitates knowledge of the constant changing pattern of nature. The postulated psychological effect is detachment from anything (since attachment to anything results in suffering). The factors leading to the awakening are known by the common name *bojjhaṅgā* (the characteristics of awakening). These are:

1. Sati–mindfulness, clarity.
2. Dhamma vicaya–investigation (curiosity to understand unobvious connections between objects of experience).
3. Viriya–vitality.
4. Pīti–joy.
5. Passadhi–happiness,
6. Samādhi–concentration,
7. Upekkhā–equanimity.

One particular tradition within Theravāda school of Buddhism, called the Thai Forest Tradition, emphasizes the fact that all the seven factors are naturally developed through immersion in the natural environment (Fisher, 2013). Very similar psychological effects, such as relaxation, enhanced creativity and concentration, and joy are described by participants exposed to nature (Nisbet et al., 2011; Capaldi et al., 2015; Panno et al., 2017). The development of the *bojjhaṅgā*, which results in awakening (*nibbāna*), has been shown to be similar to the stoic notion of conversion. Fisher writes:

> Buddha insisted humans can understand their inner workings only by dispassionately observing themselves as part of nature. If we can look at how our reactions fit into the larger context of nature we can see how desire and aversion trigger our discontent. The Buddha suggested that by understanding the natural roots of desire and aversion these forces will begin to weaken, taking discontent with them (Fisher, 2013, p. 740).

Achieving enlightenment is often referred to in Buddhist scripts as "seeing dhammas," and "dhammas" means in the original Pāli language: "nature of a thing" or "phenomenon" (Nyanatiloka, 1997, p. 55). "Dhamma" also means Buddha's teachings. Their purpose is to facilitate attunement to the process of life, which subsequently also results in the removal of self-deception. Gethin (2004) identified that the word "dhamma" also means the truth realized by the practice of the Buddhist path. Again, as in Stoic thought, being in full attunement with nature, means full realization of human potential and the realization of absolute health and wellbeing.

A CONCISE SYSTEM OF NAVIGATING IN THE WORLD BASED ON THE MERGE OF STOIC AND BUDDHIST TEACHINGS

Both Stoic and Buddhist philosophical schools turn to nature, including the natural environment, as salvation from suffering and promotion of wellbeing. They search for access to an intelligence beyond individual self and refute the importance of conceptual, conventional knowledge shared by common people involved in everyday customs and ego-based ways of thinking. Positive transformation (conversion, awakening) requires that a person transcends this common way of navigating in the world. In the following passages we; (1) pinpoint specific factors in the relationship between humans and the rest of the natural environment that enable this transformation and, (2) describe a practical process for navigating in the world which employs this knowledge in order to enhance the health and wellbeing of those who use it.

The practice that opens access to the wisdom of the Stoic and Buddhist traditions, attuning to the process of life, can be summarized as questioning *self* as our identity by studying and exercising our co-dependence with the rest of the process of life. This has been termed as getting access to "Open Source Intelligence" (OSI) (Fabjański, 2014, 2016) which describes a way of knowing that is not ego or brain focused but is a function of the whole environment. Access to this way of knowing involves all three important aspects of the ancient practices introduced above. They are:

i. cognitive interventions, such as contemplations;
ii. exposing oneself mindfully to natural patterns and rhythms of nature;
iii. giving up anthropomorphic perception by developing, what we call submorphic mindfulness (definition below).

The practice of attuning to the process of life consists of all these kinds of interventions. The first and the second kind are also present in contemporary coaching and psychotherapy. Cognitive interventions such as examining our beliefs and assumptions and finding ways of thinking that enhance our wellbeing are common threads in many modern therapeutic interventions (Westbrook et al., 2008). In the practice of attunement to the process of life these interventions act as preparatory exercises, which destroy, or at least weaken the intellectual barrier between self and the process of life. This preparatory phase involves (in addition to what is offered by traditional therapies) philosophical investigations, such as considering the notion of *telos* or goal of life. The second category of intervention, exposing oneself

to the natural patterns of nature, can be described as an advanced form of mindfulness. This aspect facilitates a complete awareness of what is happening in our field of experience (as in regular mindfulness) (Kabat-Zinn, 2005) and involves conscious attuning to the rhythms of nature, which can be best achieved though physical interactions with the natural environment. Unlike interventions from the first category, these interventions do not employ thinking or visualizing, but utilize exercises based on sensory perception.

The third intervention, termed submorphic mindfulness (Grec. *morphē*–form, shape), stems from meditation processes such as "The Path of Purification" and employs practices such as attending to the awareness of the four elements (fire, earth, water, and wind). This intervention requires that the participant attunes their attention to objectless, changing phenomena, such as the heat or coldness in our body (the element of fire), hardness and softness (the element of earth), moisture (the element of water), or feeling of pushing (the wind element) rather than compact objects, perceived in everyday life as separate entities, such as glass or stone or tree. Concepts and definitions are replaced by awareness of the characteristics of the elements through senses rather than verbal descriptions. A modern Buddhist meditation manual describes the process in the following way:

> To discern pushing, begin by being aware, through the sense of touch, of pushing in the center of the head as you breathe in and out. When you can feel it, concentrate on it until it becomes clear to your mind. Then move your awareness to a part of the body nearby, and look for pushing there. This way you will slowly be able to discern pushing first in the head, then the neck, the trunk of the body, the arms, and the legs and feet. Do it again and again, many times, until wherever you place your awareness in the body you see pushing easily (Pa-Auk, 2000, p. 116).

Submorphic mindfulness is not just about introspection. It consists of two parts: (1) proprioceptive observing of sensations within our body, such as the four elements (earth, air, water, and fire), as well as (2) observing the same elements outside of the body in natural environments by sense perception, such as touching, hearing, and seeing. Anthropomorphic perspectives and the artificial barriers between human beings and the environment are questioned. In this way the intervention intends to facilitate the realization that the perceived division between the mental and physical, and human beings and the environment is not real. Rather these concepts are considered coupled.

In summary, what we have called the OSI hypothesis shares with the biophilia hypothesis the view that there is an instinctive bond between human beings and other living systems. But the OSI hypothesis, completely abandons the anthropomorphic perspective. While attuning to the process of life a person perceives reality, including her/his own body, as much as possible, as a part of a bigger, natural and evolutionary process. What is present in this process is human consciousness, but also bacteria, viruses, scents, and vibrations. They are all equally important. This is a process-centric view, in which the human being is seen only as a temporary sub-system of the whole. OSI transcends organismic identities of any such sub-systems, human or otherwise.

CONCLUSION

A fusion of philosophical perspectives from the Stoic and Buddhist schools of thought suggests that nature might enhance health and wellbeing by facilitating a way of being that attunes to the inherent process of nature, a process similar to mindfulness. This way of being can be enhanced with specific practices designed to facilitate a deeper and more profound realization and acceptance of nature's way of being and that humans are just part of a larger ever changing process. The practice of attuning to the process of life, based on the OSI hypothesis, combines three kinds of interventions, stemming from Stoic and Buddhist schools (cognitive interventions, such as contemplations; exposing oneself mindfully to natural patterns and rhythms of nature; giving up anthropomorphic perception by developing submorphic mindfulness), which taken together facilitates a coherent system of navigating in the world.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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30 Days Wild and the Relationships Between Engagement With Nature's Beauty, Nature Connectedness and Well-Being

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Recent research suggests that engagement with natural beauty (EWNB) is key to the well-being benefits of nature connectedness. The Wildlife Trust's *30 Days Wild* campaign provides a large-scale intervention for improving public engagement with nature and its beauty. The effect of *30 Days Wild* participation on levels of EWNB and the relationship between EWNB, nature connectedness and happiness was evaluated during the 2017 campaign. Of the 49,000 people who signed up to the campaign, 308 people fully completed measures of EWNB, nature connection, health, happiness, and conservation behaviors at baseline, post-30 days and post-2 months. There were sustained and significant increases for scores in nature connection, health, happiness, and conservation behaviors. In addition, *30 Days Wild* was the first intervention found to increase EWNB. Further, the significant increase in EWNB mediated the relationship between the increases in nature connectedness and happiness. In a supplementary study to understand the well-being benefits further (n = 153), emotional regulation was found to mediate the relationship between nature connectedness and happiness, but EWNB and emotional regulation were not related. The links between nature's beauty, nature connectedness and well-being are discussed within an account of affect-regulation.

Keywords: nature, nature connectedness, emotion regulation, beauty, restoration, well-being

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INTRODUCTION

"The exceeding beauty of the earth, in her splendour of life, yields a new thought with every petal. The hours when the mind is absorbed by beauty are the only hours when we really live"

Richard Jefferies, "The Pageant of Summer."

The beauty of nature is a fundamental aspect of the human relationship with the wider natural world. Our cultural history contains continual references to nature's beauty, and aesthetics have long been considered by research into human–nature relationships. Kaplan (1987) proposed that human preference for natural scenes has an evolutionary basis; our attentional resources were attuned to cues within the natural environment in order to enhance our survival. Therefore, humans have a preference for natural forms and Ulrich (1983) argued that our aesthetic response to natural forms is central to our understanding of human–nature relationships. Kellert's nine values of Biophilia also include an aesthetic dimension (Kellert, 1993). More recently, engagement with

natural beauty (EWNB) has been noted as a key factor in the well-being benefits nature brings (Zhang et al., 2014a). This paper will briefly consider beauty, before introducing nature's beauty and the relationship with nature connectedness and well-being within the context of affect regulation. Results from an evaluation of a large-scale public engagement with a nature campaign, "*30 Days Wild*," will be presented considering the effect of taking part in *30 Days Wild* on happiness, health, conservation behaviors, nature connectedness, and EWNB. To further the understanding of well-being benefits of nature connectedness the paper also considers the relationship between happiness, EWNB, nature connectedness, and emotional regulation.

Beauty and Its Benefits

Beauty has been a topic of human thought for millennia, with Western philosophy considering beauty as a fundamental aspect of human being. Beauty is a perceptual experience of fluency and resulting pleasure and it has been suggested that the same psychological processes underlie judgements of beauty and truth (Reber et al., 2004). Beauty provides pleasure without utility and before reasoning, yet Kaplan (1987) noted how aesthetics guide human behavior with far-reaching consequences. Beauty lies within the characteristics of the object, and the interaction between the object and the person's cognitive and affective processes. Diessner and Steiner (2017) note that although love and beauty are inextricably linked, the importance of beauty has to be defended.

Research evidence shows that an appreciation of beauty generally (rather than specifically natural beauty) is positively associated with prosociality and well-being (Martínez-Martí et al., 2016). In an online empirical study, Proyer et al. (2016) found increased levels of happiness at three time points after participants noted "beautiful things" in human behavior, nature and generally, the design did not allow the functional type of beauty to be identified. Given the benefits, there have been attempts to develop interventions to improve the appreciation of beauty, although Proyer et al. (2016) noted a lack of intervention studies on appreciation of beauty, both human and nature focussed. Martínez-Martí et al. (2014), using a qualitative evaluation, found that a 3-week web-based intervention improved well-being and appreciation of beauty generally.

Nature's Beauty

Rather than nature's beauty, the focus of Western philosophy has tended to focus on beauty in art (Diessner et al., 2008). As noted above, an evolutionary basis is theorized to account for the human preference for natural scenes. In the first published study focussing on improving EWNB, Diessner et al. (2015) found that ten "directed-attention beauty walks" increased the noticing of natural beauty, but no significant difference in trait EWNB was found. Diessner and Steiner (2017) found that an intervention could increase overall appreciation of beauty, but once again this did not produce a significant increase in EWNB. These studies used the Engagement with Beauty scale developed by Diessner et al. (2008). This scale includes an EWNB sub-scale with questions on noticing nature's beauty, but also emotional and spiritual feelings, and the physical feelings when perceiving beauty in nature that can be related to pre-cognitive physiological responses and affect. Diessner suggests that the scale measures trait engagement with beauty, and such traits by definition are stable across time and environments.

Nature's Beauty and Nature Connectedness

A small body of recent research has indicated that EWNB is key to the well-being benefits of nature connectedness, a psychological construct that describes a closer affective relationship with nature. Indeed, Zhang et al. (2014a) stated that "connectedness with nature only predicts well-being when individuals are also *emotionally* attuned to nature's beauty" (p. 55). However, although aesthetics is included as a value of biophilia (Kellert, 1993), there is limited understanding of the links between nature connectedness and natural beauty. Gregory Bateson proposed that greater connection to nature and the wider ecology depended upon aesthetic experience (Charlton, 2008). In a thematic analysis of a personal journey, Richardson and Hallam (2013) found that nature connectedness reflected a personal fulfillment in the landscape that was manifested through an engagement with the beauty of nature. It has also been found that nature's beauty is often seen as a "good thing" in everyday nature (Richardson et al., 2015). Lumber et al. (2017) found that engagement with aesthetics within nature consistently mediated the relationship between the moralistic values and nature connectedness.

Returning to the role of nature's beauty and nature connectedness in well-being, Zhang et al. (2014a) found that the positive relationship between a connection with nature and satisfaction with life was only significant for those people attuned and engaged with nature's beauty. People who experience positive emotion when seeing beauty in nature have higher well-being. Secondly, Zhang et al. (2014b) found that pro-social, or helping behaviors such as empathy and generosity were, once again, found to be linked to engagement with nature's beauty. First, in those people disposed to perceive beauty in nature, and then to people exposed to beautiful images of nature. More recently, Capaldi et al. (2017) investigated the relationship between nature connectedness and EWNB in three cultures, Canadian, Japanese, and Russian students. They found that EWNB and nature connectedness were positively associated with well-being measures. Their analysis suggested that EWNB has a positive affect on well-being through promotion of a stronger connection with nature. They also noted more support for a mediation model, rather than Zhang's moderation account.

Nature's Beauty, Connectedness, Affect-Regulation, and Well-Being

There is a need to understand how being emotionally attuned to nature's beauty and nature connectedness are related to well-being. A body of emotional regulation research evidences the links to well-being (Gross, 2013; DeSteno et al., 2013). Korpela et al. (2018) note how the role of nature in affect regulation is

often overlooked and describe the relationship between affect regulation and well-being. Korpela et al. (2018) call for further study into environmental affect regulation strategies. Richardson et al. (2016b) demonstrated how responses to nature exposure can be linked to affect regulation by considering the three-circle model of emotion (Gilbert, 2009). Similarly, research into responses to engaging with nature's beauty by Song et al. (2017) and Chirico et al. (2017) match those observed during forest bathing and accounted for by the three-circle model. The three-circle model contains three dimensions of our affect regulation system that help explain how we can experience threat, drive and contentment.

Ulrich (1983) provides further insight into the relationship between aesthetic and affective response to nature, noting that affect precedes cognition, we feel before we think when sensing nature. The eventual cognitive appraisal of the scene is informed by both the initial affective reaction and by culture and experience to create a post-cognitive affective state which impacts on motivation, action, and behavior.

Previous research suggests that affective response to nature's beauty will mediate the relationship between nature connectedness and the positive affect based well-being outcome of happiness. Finally, the construct of nature connectedness also has a basis in affect and is associated with a range of well-being benefits (for a review see Richardson et al., 2017). As Capaldi et al. (2017) suggest that nature connectedness is the route by which EWNB brings well-being, there is a need to consider the mechanism by which nature connectedness brings well-being. Given the suggestion, supported by the findings of Gidlow et al. (2016), that the well-being benefits of nature connectedness are not adequately described by attention-restoration (ART) and stress reduction theories developed to explain the benefits of nature exposure (Capaldi et al., 2017) the present paper also considers potential links between nature connectedness, well-being and affect regulation through data from a supplementary study. This also allows the relationship between EWNB and affect regulation to be considered.

30 Days Wild

30 Days Wild is a large-scale longitudinal nature engagement campaign developed by The Wildlife Trusts to encourage people in the United Kingdom to value nature more highly during their everyday living. It engages people with nature by asking them to interact with nature every day for one month. A wide range of potential activities are suggested across various themes and levels. The four main types are noticing (e.g., take a moment to watch a butterfly), sharing (e.g., sharing experiences and feelings via social media), doing (e.g., pro-nature behaviors such as leaving a wild area in the garden) and connecting (e.g., nature based arts). These vary in resource requirements, level of dedication and time required to provide 101 "Random Acts of Wildness" on a dedicated website and campaign booklet. As a live campaign, The Wildlife Trusts also worked to encourage participation throughout the campaign using specific *30 Days Wild* social-media accounts and blogs. These were very active, with 107,522 #30DaysWild tweets, 29,669 Instagram photos posted and 11,523 Facebook group users. In 2015 12,400 people signed up for *30 Days Wild*, followed by 25,000 people in 2016. The previous published evaluation presented the data from the first year of the campaign (2015 data) and found sustained increases in happiness, health, connection to nature and pro-nature behaviors (Richardson et al., 2016a). The present evaluation focuses on the data from the third year of the campaign (2017) and asks a number of research questions to replicate and extend the previously found effects on happiness, health, connection to nature and pro-nature behaviors by including a measure of EWNB in the standard in-campaign evaluation questions for the first time. Then, to extend the understanding of the campaign benefits in the context of emotion regulation, supplementary data was collected given the restrictions of the in-campaign evaluation. Therefore, the present paper asks three research questions, two within the evaluation: (i) Does taking part in *30 Days Wild* have an effect on happiness, health, conservation behaviors, nature connectedness and EWNB? (ii) Does EWNB mediate the relationship between nature connectedness and well-being? A third research question is addressed in a supplementary study: (iii) What is the relationship between nature connectedness, EWNB, happiness and emotional regulation?

MATERIALS AND METHODS

Design

As detailed in previous *30 Days Wild* work (Richardson et al., 2016a), the evaluation uses a 1 × 3 (A-B-B) repeated measures design with self-reported scores taken at three time-points: pre-participation, post-participation and follow-up at 2 months post completion. The approach has a long history of successful use in non-medical research (Sanson-Fisher et al., 2007), particularly where an intervention has little potential for harm (Bonell et al., 2011). The clear rationale, theoretical basis, and defined outcomes, meet public health intervention checklist criteria (Des Jarlais et al., 2004). The approach is able to provide strong evidence that an intervention is effective within a public health context (Rychetnik et al., 2002). As with similar large-scale health promotion campaigns (Pollard et al., 2008) and applied nature intervention evaluations (Bruni et al., 2017) a randomized controlled trial (RCT) was not a practical option. Further, the chosen design approach is known to be acceptable when measures are relatively stable over time (Bonell et al., 2011). For example, in the United Kingdom, happiness remains constant through the summer with variation in early Spring and late Autumn being small (e.g., approximately 1%; ONS, 2012).

The tone and length of the standard in-campaign evaluation means traditional psychometric scales aren't suitable for inclusion. Therefore, to supplement the evaluation and answer the third research question, a short cross-sectional supplementary study including a measure of emotional regulation was conducted to explore the links between emotion regulation, nature connectedness and EWNB. This data was collected via an online questionnaire from a separate sample recruited via social-media and Internet discussion forums.

Participants

Of the 49,000 people who formally signed up for the June 2017 running of *30 Days Wild*, 8,442 (93.7% White, 6.3% other or not stated) aged between 18 and 85 successfully completed the baseline pre-participation survey during the sign-up process (e.g., May 2017). The mean age was 43.37 (*SD* = 12.78), with 1,098 males and 7,344 females. Three-hundred and eight people (93.2% White, 6.8% other or not stated) progressed and responded to invitations to complete both the post-participation survey in July and the follow-up survey in September. The mean age was 49.51 (*SD* = 14.17), with 48 males and 260 females. A further 153 participants aged between 18 and 75 took part in the cross-sectional supplementary study. The mean age was 45.78 (*SD* = 11.74) with 97 females and 56 males taking part.

Materials

As detailed in previous *30 Days Wild* work (Richardson et al., 2016a), a survey framed as a "Wildness Quiz" was used to evaluate the affect of the campaign on participants. As a public engagement campaign, the communications style was maintained in order to engage participants and this, together with the framing as a "Wildness Quiz," also had the benefit of helping to reduce potential demand characteristics. The style and purpose of the campaign required that the survey could not be extensive and include traditional psychometric scales. Single item measures are routinely used to monitor population well-being by the United Kingdom's Office for National Statistics (ONS, 2012).

In addition to questions about age and gender, the survey measured nature connectedness, EWNB, health and well-being and pro-nature behavior. A single question on general happiness, "In general, do you feel happy?" with an 11-point scale response was used to measure well-being. It offers a reliable and valid measure of well-being for community surveys (Abdel-Khalek, 2006) and has been shown to correlate highly with multi-item well-being scales (e.g., Oxford Happiness Index and Satisfaction with Life Scale). Similarly, a single item worded, "In general, would you say your health is" was used to measure health with participants responding on a 5-point rating scale from Poor to Excellent. This approach has been used successfully in previous research, for example, Ostrove et al. (2000). Nature connectedness was measured with an online implementation of the single item inclusion of nature in self (INS) scale (Schultz, 2001). The standard wording was used, with the question introduced as being about "you and nature," with a short definition of nature provided. The INS represents "self" and "nature" within two circles. Participants select the level of overlap, or interconnection that best describes their relationship and interconnection with the natural environment. The 4-item natural beauty sub-scale from the Engagement with Beauty scale developed by Diessner et al. (2008) was also used with participants responding on a 7-item "very unlike me" to "very much like me" scale. The four questions are: I notice beauty in one or more aspects of nature; When perceiving beauty in nature I feel changes in my body, such as a lump in my throat, an expansion in my chest, faster heart beat, or other bodily responses; When perceiving beauty in nature I feel emotional, it "moves me," such as feeling a sense of awe, or wonder or excitement or admiration or upliftment; When perceiving beauty in nature I feel something like a spiritual experience, perhaps a sense of oneness, or being united with the universe, or a love of the entire world. Pro-nature conservation behavior was measured via five questions that asked about participants' actions using "Yes, I do this" and "No, I don't do this" as response options. The five questions were: I put food out to feed garden birds; I move insects if they are in danger; I grow flowers and plants that birds and insects will like; I am a member of a wildlife or nature organization (e.g., Wildlife Trust, RSPB, WWF, etc.); I do conservation work away from home (e.g., Wildlife Trust Volunteer, etc.).

As noted, the short "Wildness Quiz" format of the in-campaign evaluation means traditional psychometric scales aren't suitable for including in the main evaluation. Therefore, the difficulties in emotion regulation scale (DERS) was included in a supplementary study. This study adapted the consent and debrief information in the main evaluation and included all of the above measures plus the 16-item DERS (Bjureberg et al., 2016). DERS has been found to be associated with measures relevant to the benefits of nature connectedness and affect regulation (e.g., generalized anxiety disorder and psychophysiological measures such as heart rate variability; Berna et al., 2014).

Ethics Statement

All participants provided informed consent, recorded via an online tick box labeled "Yes – I accept" that followed a written brief on a "Your Consent" page. The Psychology Research Ethics Committee at the University of Derby approved the evaluation and consent procedure. The Ethics Committee at the University of Derby also approved the supplementary study including the additional measure.

Procedure

As detailed in previous *30 Days Wild* work (Richardson et al., 2016a), invitations to answer the questions were included in the sign-up process for *30 Days Wild*. Following the consent page participants completed the questions before being provided with a short debrief. Participants then took part in their selected *30 Days Wild* activities during June, in an unmonitored fashion. Participants who had completed the pre-participation survey were invited by e-mail to complete the post-participation and follow-up surveys in July and September. The cross-sectional supplementary study used opportunity sampling with participants following a link to an online consent page and debrief adapted from the main study.

Data Analysis

SPSS version 24 was used for all analyses. Differences between pre and post participation, and pre and follow-up results were investigated using paired samples *t*-tests. A 1 × 3 (Time) repeated measures ANOVA was used to investigate differences between all three time points. To explore the relationship between changes in nature connectedness, happiness, engagement with nature's beauty and emotion regulation, mediation analyses were conducted. As it has more power than the sobel or causal steps

tests, a bootstrapping approach with 5,000 bootstrap re-samples at a 95% confidence interval was used (Hayes, 2009).

RESULTS

Pre-participation Baseline Analysis

Mean and standard deviations by gender at baseline are provided in **Table 1**. Owing to the large disparity in participation between genders *t*-tests were conducted to ascertain if there are any differences that might provide an explanation. Significant differences at $p < 0.001$ are indicated in **Table 1**. Pearson correlations between the main measures were conducted and all were significant ($p < 0.01$; **Table 2**). Correlations repeated by gender are not included as significant results were identical and level of associations similar.

Does Taking Part in 30 Days Wild Have an Effect?

ANOVA analysis and pairwise comparisons revealed statistically significant increases from pre-participation baseline to post-participation were found for EWNB, nature connectedness, health, happiness, and conservation behaviors (**Tables 3**, 4). Similarly, there were significant increases from pre-participation baseline to follow-up for the same measures (**Tables 3**, 4).

Does EWNB Mediate the Relationship Between Nature Connectedness and Well-Being?

Following previous research (e.g., Capaldi et al., 2017) mediation analysis on the pre to post-participation change data was conducted using improvement in nature connectedness as a predictor of improvement in happiness, with improvement in EWNB as a mediator. The model met the criteria for mediation (Baron and Kenny, 1986), with both sobel and bootstrap results showing the indirect effect to be significant (**Table 5**).

To provide wider context for the mediation analysis and to explore the relationship between the various measures and improvement in happiness over June, multiple regression analysis was used. The independent variables (IVs) or predictors were all baseline measures and age in the first block, followed by changes

TABLE 1 | Mean and standard deviations for baseline measures by gender.

	Female			Male			Total		
	Mean	***N***	***SD***	**Mean**	***N***	***SD***	**Mean**	***N***	***SD***
Age	42.85*	7,344	12.54	46.86*	1,098	13.75	43.37	8,442	12.78
Nature Connection	50.50*	7,344	26.49	56.25*	1,098	28.31	51.25	8,442	26.8
Conservation Behaviors	2.62*	7,344	0.88	2.74*	1,098	0.92	2.64	8,442	0.88
Health	3.6	7,344	0.94	3.65	1,098	0.92	3.61	8,442	0.93
Happiness	7.24	7,344	1.7	7.22	1,098	1.78	7.24	8,442	1.71
EWNB	23.39*	7,344	3.97	22.33*	1,098	4.46	23.25	8,442	4.05

**Difference between males and female significant at the 0.01 level (2-tailed). EWNB, engagement with natural beauty.*

TABLE 2 | Correlation matrix for baseline measures.

	Nature connection	**Conservation behaviors**	**Health**	**Happiness**	**EWNB**
Nature connection	1				
Conservation behaviors	0.284**	1			
Health	0.080**	0.079**	1		
Happiness	0.157**	0.154**	0.507**	1	
EWNB	0.312**	0.270**	0.060**	0.133**	1

***Correlation is significant at the 0.01 level (2-tailed). EWNB, engagement with natural beauty.*

TABLE 3 | Pre, post-participation and follow-up mean and standard deviations for the four outcome measures.

	Pre-participation		Post-participation		Follow-up	
	Mean	***SD***	**Mean**	***SD***	**Mean**	***SD***
Connection to nature	56.75	25.93	64.29	23.99	64.42	22.80
Conservation behaviors	2.82	0.83	2.95	0.73	2.93	0.76
Health	3.62	0.96	3.76	0.93	3.82	0.95
Happiness	7.50	1.58	7.78	1.51	7.87	1.49
EWNB	23.88	3.43	24.38	3.43	24.51	3.38

EWNB, engagement with natural beauty.

TABLE 4 | Summary of paired *t*-tests and repeated measures ANOVA analyses.

	Pre to Post		Pre to Follow-up		1 × 3 ANOVA		
	***T*(307)**	***d***	***T*(307)**	***d***	***F***	***df***	η^2
Connection to nature	5.15	0.30	5.03	0.31	20.54	1.75, 536.00	0.06
Conservation behaviors	4.23	0.17	3.05	0.14	9.70	1.86, 572.12	0.03
Health	3.77	0.15	5.07	0.21	14.73	2, 614	0.05
Happiness	4.03	0.18	5.07	0.24	16.08	1.92, 591.73	0.05
EWNB	3.37	0.15	4.01	0.19	10.22	1.94, 596.17	.03

All significant at $p < 0.01$. EWNB, engagement with natural beauty.

TABLE 5 | Mediation analysis for changes in happiness, nature connection, and EWNB (5000 Bootstrap Samples).

	β	***SE***	***t***	***p***
Nature connection to happiness: Total effect	0.009	0.003	3.273	<0.01
Nature connection to EWNB	0.017	0.006	2.914	<0.01
EWNB to happiness controlling for nature connection	0.075	0.026	2.904	<0.01
Nature connection to happiness controlling for EWNB: Direct effect	0.007	0.003	2.791	<0.01
	Z	***p***	**LL95%CI**	**UL95%CI**
Indirect sobel and bootstrap effects	2.000	0.046	0.0001	0.003

EWNB, engagement with natural beauty.

TABLE 6 | Predictors of improvement in happiness.

	β	***SE***	***t***	***p***
Age	0.021	0.005	0.386	0.700
Baseline nature connectedness	−0.046	0.003	−0.653	0.514
Baseline health	0.128	0.072	2.220	0.027
Baseline conservation behaviors	−0.047	0.079	−0.864	0.388
Baseline EWNB	0.180	0.024	2.601	0.010
Baseline happiness	−0.479	0.047	−7.745	0.000
Change in nature connectedness	0.076	0.003	1.204	0.230
Change in EWNB	0.213	0.026	3.706	0.000

EWNB, engagement with natural beauty.

in nature connection and EWNB with change in happiness as the DV. The results show that the model including the change in nature connection and EWNB accounted for 23.9% of the variance in happiness improvement, with $R = 0.51$ and Adjusted $R^2 = 0.24$, $F(9,298) = 11.703$, $p < 0.01$. See **Table 6** for a breakdown of IV results.

What Is the Relationship Between Nature Connectedness, EWNB, Emotional Regulation, and Happiness?

Pearson correlations were conducted between the measures of nature connectedness (INS), emotional regulation (DERS), EWNB and happiness (single-item) administered in the supplementary study and are shown in **Table 7**. This analysis suggested that the relationship between nature connectedness, happiness, and emotional regulation could be explored further using mediation analysis. Nature connectedness was entered as a predictor of happiness, with emotional regulation as a mediator. The model met the criteria for mediation, with both sobel and bootstrap results showing the indirect effect to be significant (**Table 8**).

TABLE 7 | Correlation matrix for the supplementary measures.

	EWNB	**Nature connection**	**DERS**	**Happiness**
EWNB	1			
Nature connection	0.432**	1		
DERS	0.004	−0.297**	1	
Happiness	0.117	0.318**	−0.549**	1

***Correlation is significant at the 0.01 level (2-tailed). N = 153.*
EWNB, engagement with natural beauty; DERS, difficulties in emotion regulation scale.

DISCUSSION

The present evaluation considered the effects of taking part in *30 Days Wild* on happiness, health, conservation behaviors, nature connectedness, and EWNB to see if previous results were replicated. Then the analysis focussed on the relationships between happiness, EWNB, nature connectedness and emotional regulation.

Does Taking Part in 30 Days Wild Have an Effect?

The results of the previous evaluation (Richardson et al., 2016a) were replicated with the analysis finding significant increases from pre-participation baseline to post-participation

TABLE 8 | Mediation analysis of nature connection, DERS and happiness (5000 Bootstrap Samples).

	β	*SE*	*t*	*p*
Nature connection to happiness: Total effect	0.360	0.088	4.120	<0.01
Nature connection to DERS	−2.317	0.606	−3.821	<0.01
DERS to happiness controlling for nature connection	−0.073	0.010	−7.121	<0.01
Nature connection to happiness controlling for DERS: Direct effect	0.192	0.080	2.422	<0.05
	Z	***p***	**LL95%CI**	**UL95%CI**
Indirect sobel and bootstrap effects	3.341	0.001	0.070	0.292

EWNB, engagement with natural beauty; DERS, difficulties in emotion regulation scale.

for nature connectedness, health, happiness, and conservation behaviors. There were also significant and sustained increases from pre-participation baseline to follow-up for the same measures. In a new finding, a significant and sustained increase in EWNB was found, making *30 Days Wild* the first intervention to increase EWNB (Diessner and Steiner, 2017). Although significant, the increase is modest, which can be explained by the scale measuring trait engagement with beauty (Diessner et al., 2008). As the first work to show an increase in EWNB, there is a need for further work to confirm such findings and consider the mechanism for the increase. For example, it is worth considering what the increase is in. The four questions in the EWNB scale are wide ranging, from noticing to physiological responses, emotion, spirituality, and aspects of nature connectedness. Therefore, it is possible that participating in *30 Days Wild* could increase sensitivity, or encourage participants' to take greater notice of nature's beauty, which may affect aspects of connectedness to nature, physiological and emotional responses. Or the campaign could help people notice their own physiological and emotional responses to nature, thus increasing engagement and appreciation of its beauty. Further quantitative and qualitative work could investigate these mechanisms.

Does EWNB Mediate the Relationship Between Nature Connectedness and Well-Being?

The role of EWNB can be further considered through considering the relationship to well-being and nature connectedness. Further analysis showed that the increase in EWNB mediated the relationship between the increases in nature connectedness and happiness. The results provide support for the work of Zhang et al. (2014a) and Capaldi et al. (2017) showing that engagement with nature's beauty is emerging as a key factor in the positive relationship between nature connectedness and well-being. Capaldi et al. (2017) propose that EWNB promotes nature connectedness to bring well-being. As noted above, the EWNB scale items include aspects of nature connectedness, noticing beauty, emotion, and spirituality. Indeed, there is a theoretical background that suggests nature's beauty is a key part of the human relationship with nature. Aesthetics has been identified as a value of biophilia (Kellert, 1993), which mediates the relationship between compassion for nature and nature connectedness (Lumber et al., 2017) and beauty is a key theme when developing nature connectedness (Richardson and Hallam, 2013; Richardson et al., 2015). However, Zhang et al. (2014a) performed analysis that suggested the two were not a single construct. This is supported by the regression analysis which shows that EWNB, rather than nature connectedness, was a key predictor of the change in happiness.

Clearly, EWNB has a positive relationship with feelings such as happiness and the links between EWNB and emotion can be considered. Previous research (Richardson et al., 2016b; Chirico et al., 2017; Song et al., 2017) shows that engagement with nature and its beauty can be linked to affect regulation by considering the three-circle model of emotion (Gilbert, 2009). The three-circle model suggests that engaging with nature's beauty can bring feelings of joy and calm, positive emotions that bring well-being through promoting emotional balance (Gilbert, 2009; Richardson et al., 2016b). Joy and calm can also be mapped onto the positive and relaxing reactions to nature noted by Ulrich (1983) and within psycho-physiological stress recovery theory (PSRT; Ulrich et al., 1991). This suggests that EWNB can bring well-being and restoration through emotional balance and reducing stress.

What Is the Relationship Between Nature Connectedness, EWNB, Emotional Regulation, and Happiness?

Capaldi et al. (2017) suggest that EWNB affects well-being by promoting nature connectedness. Results from Gidlow et al. (2016) show that nature connectedness was not significantly correlated with restorative experience or cognitive function in green spaces, suggesting existing theories that explain the benefits of nature exposure (ART and PSRT) do not fully explain the benefits of nature connectedness. Therefore, there is a need to understand the mechanisms by which nature connectedness is linked to well-being. Given the affective relationship at the heart of nature connectedness and the need to note the role of nature in affect regulation (Korpela et al., 2018), supplementary data was collected to explore the links between nature connectedness, happiness, EWNB, and emotional regulation. The correlation analysis showed that those with difficulties in emotional regulation had a lower connection with nature and lower happiness. Interestingly, difficulty in emotional regulation was not associated with EWNB, supporting the distinction between EWNB and nature connectedness. However,

a relationship might have been expected given the affect related questions in the EWNB scale and the responses to viewing nature's beauty (Song et al., 2017). Mediation analysis indicated that emotional regulation mediated the relationship between nature connectedness and happiness, as EWNB mediated the relationship between nature connectedness and happiness in the earlier analysis. This is the first evidence linking affect regulation to the well-being benefits of nature connectedness. Consistent with the Polyvagal theory of Porges (2007) those people who have greater difficulties in affect regulation take longer to rebalance their emotions (Berna et al., 2014). Further, nature connectedness is known to be related to lower anxiety (Martyn and Brymer, 2016), a condition known to be associated with delayed physiological response following emotion elicitation (Berna et al., 2014). Finally, given EWNB and difficulty in emotional regulation were not related, but both have a role in mediating the relationship between nature connectedness and happiness, there is a suggestion that EWNB and emotional regulation interact with the relationship between nature connectedness and happiness through different mechanisms. Potentially, through affect regulation for nature connectedness and through cognitive mechanisms such as processing fluency (Reber et al., 2004) and being attuned (Kaplan, 1987) to nature's beauty. However, these are likely to have complex and multi factorial underpinnings that require further research.

LIMITATIONS AND CONCLUSION

The evaluation of *30 Days Wild* is interesting as it is a public engagement campaign. However, despite good design practice, the evaluation does have limitations. These include the pre-post design (e.g., engagement EWNB was found to increase over time rather than in comparison to a control group) and the measures are intentionally short within the framework of a "Wildness Quiz." There is also a high attrition rate, particularly from the baseline where the questions are an option from the sign-up process, rather a follow-up response by email. Therefore, the results may not fully reflect the outcomes of the majority of those taking part. The campaign is also self-directed and the activities of the 49,000 participants are not tracked, therefore adherence with the campaign cannot be formally measured, although given the attrition it is likely follow-up respondents are those who engaged with the campaign. The participants are also overwhelmingly female, which is an interesting finding in itself. Clearly, *30 Days Wild* appeals more to women than men and there is a need to explore the reasons for this and potential ways to engage men with nature for well-being. The large sample size did allow some significant differences between the genders to be identified, although proportionally these were relatively small, other than males scoring approximately ten percent higher on nature connectedness, which could well be a reflection of the higher age of male participants. These limitations mean that the results and conclusions should be treated with some caution, although the replication of core findings is positive. Finally, the scale and success of the campaign at a time when there are calls for large scale upstream nature based interventions for health warrants publication of the findings in order to inform the further research required.

To conclude, the replication of the improvements in nature connectedness, happiness, health, and conservation behaviors gives greater confidence in the success of *30 Days Wild* within a public health context. Further, the paper presents a significant and sustained increase in EWNB and previous research into the relationship between EWNB, nature connectedness and happiness is supported. The paper also presents new data on the links between nature connectedness, EWNB and affect regulation which gives some initial insight into the pathways to well-being. From an applied perspective, the relationships show that well-being in nature is not just about visits and exposure to nature. Rather, there is a need to engage in an affective relationship, to notice and become sensitive to nature's beauty to access the wider benefits of nature connectedness and well-being.

DATA AVAILABILITY

The raw data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation, to any qualified researcher.

AUTHOR CONTRIBUTIONS

MR and KM contributed to the design of the evaluation. MR performed the statistical analysis and wrote the first draft of the manuscript. KM contributed to manuscript revision, read and approved the submitted version.

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Nature-Based Guided Imagery as an Intervention for State Anxiety

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Anxiety is a significant mental health issue in modern society and empirical research into effective interventions to address anxiety has been extensive. Spending time in nature is one approach that has demonstrated anxiolytic effects. However, in some situations and contexts spending time in nature in order to reduce anxiety symptoms may not be possible. For example, in therapeutic settings delivered in a space with no access or exposure to any nature stimuli in the immediate surrounding environment. Guided imagery (GI) has also proven to be effective for reducing anxiety symptoms. Thus, nature-based GI might help to overcome the limitation of access to nature and strengthen the impact of GI interventions. The current study investigated the effectiveness of nature-based GI on anxiety reduction. Participants (n = 48, 18 males, 30 females, M_{age} = 34.54, SD_{age} = 12.91, age range = 19 – 71 years) with moderate levels of either trait or state anxiety as measured by the state-trait anxiety inventory (STAI) were recruited. Participants undertook both a nature-based GI session and a traditional non-nature-based GI session and their pre- and post- state anxiety levels were measured in each GI session. It was anticipated that post state anxiety scores would be significantly lower for both GI conditions and that a significantly greater anxiety reduction would be found in the nature-based GI than the urban-based GI. A two-way analysis of variance for repeated measures revealed results that supported both hypotheses. This study was the first to compare a nature based GI intervention with a traditional (non-nature based) GI intervention. Findings indicate that nature-based GI interventions are effective anxiety management interventions that have the added benefit of being cost-effective and easily accessible.

Keywords: anxiety, nature, guided imagery, anxiolytic, state-trait anxiety inventory

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INTRODUCTION

Anxiety is described as one of the world's most debilitating mental health issues (World Health Organisation, 2011) and the development of effective interventions is fundamental to its successful management. In recent years there has been a considerable amount of research showing that nature benefits psychological health and wellbeing, including some research that indicates spending time in natural spaces is an effective intervention for the management of anxiety symptoms (Wheeler et al., 2012; Carrus et al., 2017; Fabjanski and Brymer, 2017; Lawton et al., 2017; Panno et al., 2017; Yeh et al., 2017; Schweitzer et al., 2018). However, a limitation of this approach is that contact with nature may not always be possible and some contexts and situations might make contact with nature more challenging. For example, living in high density urban environments or where therapy is undertaken in a confined room with no direct access to the natural world.

Guided imagery (GI) has been used as an effective intervention for anxiety by generating relaxing states through mental processes (Martin et al., 1999; Holmes and Mathews, 2005; Apóstolo and Kolcaba, 2009). An explicit addition of the natural environment to a GI process might serve to overcome the issue of physical access to nature and enhance the anxiolytic benefits of the GI process. Interventions using GI of nature might be an accessible and cost-effective intervention for anxiety reduction, as well as lend support for the growing evidence of the benefits of nature on mental well-being. This study is the first to investigate whether nature-based GI is an effective intervention for state anxiety. Findings have implications for the design and administration of effective anxiety interventions.

Nature and Anxiety

Research indicates that nature can facilitate various positive psychological health and wellbeing outcomes (Wheeler et al., 2012; Carrus et al., 2017; Fabjanski and Brymer, 2017; Lawton et al., 2017; Panno et al., 2017; Yeh et al., 2017; Schweitzer et al., 2018). For example, experiences in nature have been shown to enhance vitality (Ryan et al., 2010), happiness (Capaldi et al., 2014), mood and self-esteem (Barton et al., 2011), and reduce stress (Kaplan, 1995). In recent years studies have found a link between nature and lower levels of anxiety and its antecedents (MIND, 2007; Mackay and Neill, 2010; Martyn and Brymer, 2014; Bratman et al., 2015a,b). For the most part research has focused on (1) the anxiolytic benefits of exercise in nature or (2) the relationship between feeling connected to nature and anxiety. Feeling connected to nature has been linked with lower overall anxiety. For example, a study conducted by Martyn and Brymer (2014) found that individuals with higher levels of connection to nature had significantly lower levels of overall state and trait cognitive anxiety (Martyn and Brymer, 2014). In particular, they found that physical familiarity with nature (experiential connection) was most significantly linked to lower anxiety. Lawton et al. (2017) compared levels of anxiety for regular indoor exercisers against regular outdoor exercisers and also found that physical familiarity with nature was most strongly linked to lower anxiety scores. They noted that exercising regularly outdoors predicted lower anxiety levels whereas exercising indoors predicted higher somatic anxiety. Both studies highlighted a correlation between an individual's trait-based, subjective relationship with nature and low anxiety levels, thus providing evidence for a connection between nature and low anxiety. The study by Lawton et al. (2017) also suggested that spending time in nature augments the anxiolytic benefits of physical activity. However, neither study offered insights into nature's capacity to act as a therapeutic intervention for anxiety.

Studies focusing on the relationship between physical activity in nature and anxiety have also found strong indicators for the anxiolytic benefits of nature. For example, a study commissioned by MIND (2007) reported that 71% of participants who walked in nature recorded less tension, whereas 50% of participants reported increased feelings of tension after a shopping center walk. Whilst this studies did not directly measure anxiety reduction, lowered stress and tension from engagement with nature alludes to nature's potential anxiety reducing effects, as chronic levels of stress can result in anxiety (Vyas et al., 2004) and tension is a symptom of anxiety (American Psychiatric Association, 2013). Mackay and Neill (2010) found that exercising in green environments resulted in moderate short-term reductions in state anxiety. Greater anxiety reduction was experienced by those who perceived that they were exercising in more natural environments. Intensity and duration of physical activity did not impact state anxiety measures (Mackay and Neill, 2010). The authors suggested that 'green' environments are more likely to be restorative. Bratman et al. (2015a,b) argued that the anxiolytic effects of nature might come about because nature provides a rich set of the sensory stimuli that holds attention and reduces the harmful effects of rumination. Both Mackay and Neill (2010) and Bratman et al. (2015a,b) pointed out that research was needed to unpick the mechanisms by which nature experiences reduce anxiety.

While causal mechanisms are still unclear the above studies demonstrate a relation between nature and anxiety, and that physical exposure to the natural world may have the capacity to contribute to a decrease in anxiety states. However, as previously stated, direct contact with nature may not be possible and thus the question arises as to whether imagery of the natural world, through the process of GI, can lead to a reduction in anxiety.

Guided Imagery and Anxiety

Guided imagery involves external instructional guidance to allow the internal generation of images (Hart, 2008), which invoke visual, auditory, haptic and taste-smell experiences as well triggering behavioral and physiological responses (Arbuthnott et al., 2001; Ji et al., 2016). GI can be utilized to encourage desired emotional and physical effects (Hart, 2008). Research has shown that under some circumstances, GI events are experienced as actual events (Kealy and Arbuthnott, 2003). This may be because the characteristics of the representations of GI events, such as the sensory and contextual detail, are similar to actual events. Further, there is evidence that visual mental imagery and visual perception share similar representations and are similarly processed (Borst and Kosslyn, 2008). Given the delivered and suggestive nature of GI, and its strong focus on contextual and sensory engagement, greater perceptual detail of the image is generated, creating a less discriminate difference between a real and imagined representation (Arbuthnott et al., 2002). Boschker et al. (2002) pointed out that in some instances while the processes involved in imagery and actual experiences are very similar the neuropsychological data suggests that imagery is not an exact representation of the real-world experience. Further, in these instances, imagery might actually be more effective than experiencing the real context because in imagery a participant might not focus on the unpleasant aspects of the context and instead focus on the most meaningful environmental characteristics. They use an ecological model to argue that the mutuality between person and environment is represented in imagery as the person actively imagines the realization of particular action possibilities. Interestingly, they assessed for demand characteristics in their study and found that while participants who were told that imagery did not work reported significantly lower capacity to imagine and reproduce an action,

they were still able to reproduce the action as required. Boschker et al. (2002) concluded that while demand characteristics were influential, they were only partially important.

Numerous studies, across a wide range of populations, have demonstrated a link between GI and anxiety (Ayres and Hopf, 1985; Speck, 1990; Stephens, 1992; Rees, 1995; Casida and Lemanski, 2010; Thomas and Sethares, 2010; Vineeta et al., 2010; Serra et al., 2012). For example, a study conducted by Holmes and Mathews (2005) found that imagery of aversive events led to greater reporting of increased anxiety, as opposed to when the same aversive events were described verbally. The researchers concluded that imagery is especially powerful for anxiety symptoms because anxiety is a foundational 'perceptually based emotion' (p. 496) more likely to be responsive to perceptual-sensory representation than representational systems (e.g., language) that evolved later than these basic emotions. A review carried out by Holmes and Mathews (2010) concluded that imagery acts as an 'emotional amplifier' (p. 359) with the capacity to modify emotional states.

As an intervention for anxiety, there is a strong evidence base for GI in anxiety management (Ji et al., 2016) in a variety of contexts. For example with nursing students (Speck, 1990; Stephens, 1992), patients coping with medical-related anxiety (Casida and Lemanski, 2010; Thomas and Sethares, 2010; Vineeta et al., 2010; Serra et al., 2012), first time mothers (Rees, 1995), and individuals with speech anxiety (Ayres and Hopf, 1985). For example, Serra et al. (2012) conducted 30-min GI sessions with patients undertaking radiation treatment. The GI sessions started with systematic breath awareness, followed by visualization of a place where the patients felt most safe and comfortable. Examples of this place were given, including a favorite beach, park or any other location that patients found peaceful. However, it is not clear from the methodology as to whether these visualized places were verified to determine the specific content of the imagery experienced by the patients. Patients were then asked to concentrate on the sensory aspects associated with their image. The average number of GI sessions undertaken by participants in this study was between one and four, and anxiety measures were taken at the first session and the last session. The study found that participants reported a reduction in anxiety between the first session and the last session, with 86% of the participants describing the GI sessions as helpful (Serra et al., 2012). One study (Parnabas and Mahamood, 2012) that explored the relationship between visualizing imagery, nature and anxiety found that athletes who experienced higher levels of visualized green-space imagery experienced lower levels of competitive state anxiety. However, as many of the GI protocols in the above studies included phrases that actively encouraged participants to relax it is also possible that outcomes obtained were due to these instructions, making it difficult to ascertain whether anxiety reduction emerged from nature or the state of relaxation activated. Despite the potential links between imagery of nature and anxiety reduction, we were unable to find any studies that directly sought to investigate nature-based GI as an intervention for anxiety.

While these abovementioned studies did not explicitly and solely utilize imagery of the natural world within the GI process, they point to an intriguing possibility that GI using nature might provide augmented outcomes. In theory, the ecological explanation of how GI facilitates a multi-sensory focus on aspects of the imagined environment perceived to be most safe or comfortable, suggests that GI of both urban and natural environments have anxiolytic potential. From an ecological perspective GI using nature might be more effective because the natural world contains a richer multi-sensory landscape (Brymer et al., 2014; Yeh et al., 2016) and from an evolutionary perspective human perceptual systems are more likely attuned to information in the natural environment than the urban environment.

The Current Study

Nature-based GI and its effectiveness in anxiety reduction is important to investigate as an intervention as it can serve to enhance the use of GI for anxiety reduction and overcome problems with regards to access to nature. The overall aim of the current study was to investigate whether nature-based GI reduces state anxiety. Two hypotheses were proposed. Hypothesis one posited that GI as a process itself reduces anxiety. Hypothesis two proposed that a nature-based GI would be more effective at reducing anxiety than a non-nature-based GI experience. As an individual's relationship to nature or their ability to create mental images may influence their nature-based GI experience, measures of connectedness to nature, relatedness to nature and vividness of mental imagery were also obtained to assess any possible impact on the results.

MATERIALS AND METHODS

This study used a within-group design to compare a non-nature based GI intervention for anxiety with a nature-based GI intervention for anxiety. In order to compare the extent of anxiety reduction between the current study's two interventions, a two-way repeated measures design ANOVA was employed. The within-group factors were the condition (nature vs. non-nature) and the time (pre vs. post). Order effects were checked via a counterbalance design of a two-way mixed design ANOVA. The between group factor was the order in which the participants undertook the condition; that is, participants were randomly assigned and either took the nature or non-nature condition first.

Participants

A total of 48 participants completed the study in its entirety (18 males, 30 females, M_{age} = 34.54, SD_{age} = 12.91, age range = 19 – 71 years), 95.8% of participants resided in Australia and 4.2% resided in South-East Asia. Participants identified with a range of ethnic backgrounds (Caucasian = 67%; South-East Asian = 27%; Indigenous Australian = 2%; South European = 2%; Mixed = 2%). Eighteen participants took part in the first GI condition but not the second. Within the urban condition, 13 participants did not go on to complete the nature condition, 11 of these provided a baseline measure of anxiety. These 11 participants' pre-intervention anxiety scores were compared to the remaining participants who completed the entire study. These participants did not differ significantly in their anxiety score and

hence, their exclusion from the data set did not introduce undue bias, $t(57) = 0.14$, $p = 0.889$. Within the nature condition, five participants did not go on to complete the urban condition, with three of these providing a baseline measure of anxiety. Two of these participants scored the minimal possible score on the measure and therefore, possibly had less investment in continuing in an intervention designed to reduce anxiety, despite initially meeting screening requirements for a presence of anxiety symptoms.

To qualify for the study participants needed to be 18 years or over, and suffering anxiety symptoms. These requirements were assessed through an online screening questionnaire, which asked for the participant's age and calculated the participant's trait and state anxiety levels based on the State-Trait Anxiety Inventory (STAI) (Spielberger, 1983). The STAI manual (Spielberger et al., 1983) indicates that higher scores reflect higher anxiety, and suggests a cut-off score of 39 to differentiate between high and low anxiety. Normative data for the general Australian adult population suggest a normative STAI mean of 33 and 36 for state and trait anxiety, respectively (Crawford et al., 2011). The current study did not focus purely on clinical anxiety levels or a specific group, which carry varying cut-off points depending on the population. The current study set the cut-off score at 39, as this score suggests truly elevated levels of anxiety in individuals of the general Australian adult population. Any reduction from a score of 39 or more, would allow for significant changes in anxiety to be identified.

Participants were recruited online via a range of platforms and would have been aware of what the study entailed as the recruitment flyer was titled, 'The role of nature in reducing anxiety through GI.' Recruitment through social media platforms included posting the study details in Facebook pages and LinkedIn groups which could be identified as psychology or nature interest groups. Requests to external organizations to promote the study on their websites included private psychology practices and environmental organizations which showed interest in the mental health benefits of nature. A university study recruitment forum also advertised the study, offering first year psychology students course credit for completing the study. No monetary or other compensatory incentives were offered to participants. Data collection for the study was conducted anonymously and entirely online, with participants able to undertake participation at home, in their own time.

Apparatus and Instruments

The study was conducted online using quantitative questionnaires and one qualitative question. The qualitative question was included to identify the type of environment imagined for each GI intervention in order to investigate compliance and identify themes. The question, 'what images did you see in your mind?' was worded as a broad open question to allow for a wide range of possible responses and to minimize the chance of leading responses.

Anxiety

The State-Trait Anxiety Inventory (STAI; Spielberger, 1983) is a 40 item self-report questionnaire that assesses state and trait anxiety levels. The 20 items assessing trait anxiety were used in the screening process to determine participant suitability to the study. These items require participants to report on a 4-point scale how frequently they experienced anxiety-related feelings and cognitions (1: Almost never; 4: Almost always). Example items include, 'I am a steady person' and 'I lack self-confidence.' The 20 items that measured anxiety as an emotional state were also used in the initial screening process for participant suitability. Items in this section required that participants respond to on a 4-point scale (1: Not at all; 4: Very much so) based on their feelings of anxiety 'right now.' Example items include, 'I feel at ease' and 'I feel upset.' The STAI was utilized for its brevity and excellent psychometric properties; construct validity is supported (Spielberger, 1983) and test–retest reliability has been found to be 0.97 for trait anxiety and 0.45 for state anxiety (Metzger, 1976).

Vividness of Imagery

Marks' Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973) is a self-report measure of vividness of mental, visual images. Participants are required to imagine 4 suggested scenes and then self-rate the vividness of their visual imagery on select details on a 5-point scale [1: Perfectly clear and as vivid as normal vision; 5: No image at all (only "knowing" that you are thinking of the object)]. Example items include asking participants to visualize a rising sun and rating their ability to vividly visualize the certain details, such as 'The sky clears and surrounds the sun with blueness' and 'A rainbow appears.' The VVIQ has demonstrated an internal consistency of 0.88, as measured by Cronbach's alpha (McKelvie, 1995).

Connectedness to Nature

The Connectedness to Nature Scale (CNS; Mayer and Frantz, 2004) measures an individual's trait levels of emotional connection to nature. The scale consists of 14 items and responses are rated on a 5-point Likert scale (1: strongly agree; 5: strongly disagree). Example items include, 'I feel a kinship with animals and plants' and 'I often feel disconnected from nature.' The CNS has been found to have good validity and to be reliable ($\alpha = 0.82$) (Mayer and Frantz, 2004).

Relatedness to Nature

The Nature Relatedness Scale (NRS; Nisbet et al., 2009) is a 21-item scale that assesses the affective, cognitive and experiential aspects of individuals' connection to nature. Responses are rated on a 5-point Likert scale (1: strongly disagree; 5: strongly agree). Example items include, 'I am very aware of environmental issues' and 'I think a lot about the suffering of animals.' The Nature Relatedness Scale has been found to have good validity and high reliability ($\alpha = 0.87$) (Nisbet et al., 2009).

Guided Imagery Audios

Two GI audios were used as the intervention conditions. Both GIs were identical in process but differed in content; that is, one was the GI of a nature environment and the other was GI of an urban environment. The scripts were developed by the researchers in collaboration with a specially-trained psychologist who utilized mental GI in their professional practice. The process of script

development firstly involved planning the script, by the steps outlined by Williams et al. (2013). This involved considering who will be using the script, the content of the imagery, the reasons for utilizing the script and consideration that the script will be delivered through an audio recording (Williams et al., 2013). As the recommendations by Williams et al. (2013) were intended for developing scripts for competitive athletes, the researchers used these steps as a guide and adjusted the athlete-related content to reflect the development of an urban- and nature-based GI script. General information on creating positive mental imagery (Stein, 2013), as well as the guidelines of the PETTLEP (Physical, Environment, Task, Timing, Learning, Emotion and Perspective) Model of Imagery (Holmes and Collins, 2001), were considered and the researchers studied a wide range of imagery scripts for further generation of ideas and to identify common and relevant elements. The GI scripts were then drafted based on the considerations and knowledge gained from the planning stage. The draft scripts were then reviewed by another psychology professional and feedback was incorporated to create the final, completed scripts. The final scripts were pilot tested on a volunteer, who did not recommend any further changes to the script.

The scripts focused on guiding participants to mentally engage with the environment through their senses. Neither script made any suggestions intended to actively invoke a state of relaxation, as the focus of the study was on the effect of the environment on anxiety, within a GI experience. Participants were asked, as part of the GI session, to take themselves to a place in nature or in an urban environment of their choosing, rather than being placed in a particular environment. This was important so as not to influence the environment in any way. However, in the urban-based GI session, participants were provided with examples of a possible urban environment. This was framed as follows: 'Take yourself to a place in an urban environment of your choice. This may be a house you like, a new apartment building or a shopping mall, for example.' The scripts were voice recorded and made into the form of a downloadable mp3 audio file, which participants could download and listen to from any listening device. No music or other sounds were included in the audio. The length of the GI audio was approximately 10 min.

Intervention

The interventions in this study were the two GI sessions; one of which consisted of a nature-based environment, and another of an urban-based environment. Each participant undertook both conditions. Participants were randomly allocated to either the nature or the urban condition as the initial intervention: 23 undertook the nature-based condition first and the urban-based GI second, and 25 undertook the urban-based GI first and the nature-based GI second.

Procedure

Screening and Information Gathering Phase

University ethical approval for human research was obtained prior to conducting the study. The entire study was conducted online. Successfully recruited participants completed a consent form which outlined eligibility requirements (i.e., age and current experience of anxiety), potential associated risks (such as exposure to natural/urban environments) and methods of management (contact details of psychological support services), and management of confidentiality (i.e., provided email addresses would be destroyed at the conclusion of the study). Once participants provided consent, participants generated an individual anonymous code which would be used to match participants to the results obtained from their future participation. The STAI was then administered and participants who scored ≥ 39 on either the trait or state anxiety scale qualified for the study. Demographic details and email addresses of the qualifying participants were then obtained. These participants then completed the VVIQ (Marks, 1973), the CNS (Mayer and Frantz, 2004) and the NRS (Nisbet et al., 2009). Participants were then emailed, at random, either the nature-based GI or urban-based GI audio, along with a set of emailed instructions, directing them to listen to the attached GI audio within the next week.

First Guided Imagery Session

Just before the participants undertook the first GI session, they were instructed to fill out a STAI questionnaire to assess their state anxiety. As mentioned above, the use of the STAI is appropriate for this study as it is an effective measure of state anxiety (Metzger, 1976; Spielberger, 1983) and its brevity allows it to be easily administered. Participants were then asked to undertake this GI session in a quiet environment where they would not be interrupted. Upon completion of the GI session, participants filled out another STAI questionnaire to measure their state anxiety after the GI session. Participants were also asked to provide key words to describe the content of the imagery generated in their minds. This information was obtained in order to verify that the imagery content related to the appropriate environmental category.

Second Guided Imagery Session

One week after the completion of the first GI experience, participants were sent the second GI audio file which contained the GI condition that they had not yet undertaken. The process for this second GI experience was the same as the first; i.e., pre- and post-state anxiety scores were obtained at the time the participant undertook the GI session and participants were asked to provide brief descriptions of their generated imagery content. Only participants who completed both GI sessions were included in the final analysis.

Data Analysis

Quantitative data were prioritized over qualitative data (Hanson et al., 2005) and analyzed using the Statistical Package for the Social Sciences (SPSS). The quantitative data were checked for missing values. Little MCAR's test returned an insignificant result, $\chi^2 = 3.64$, $p(8) = 0.89$ indicating that any missing value was completely random. Therefore, missing data was imputed using Estimation Maximization to create replacement values for missing data. A two-way mixed-design ANOVA was run to check for order effects, followed by the implementation of a two-way repeated measures ANOVA to determine the main analysis. Qualitative comments were thematically analyzed (Creswell,

2009). Comments were initially read to gather a sense of the overall experience. Topics were clustered by similarity and codes assigned. Descriptive categories were employed to reflect the aim of the study (Shaughnessy et al., 2009). Codes were cross checked by two researchers in an attempt to enhance reliability. Finally, quantitative and qualitative data were integrated to assist overall interpretation of results (Creswell, 2009).

RESULTS

The overall aim of the current study was to determine whether a nature-based GI experience was effective in reducing anxiety. The following analyses tested the hypotheses proposing that the process of GI itself reduces anxiety and that nature-based GI is more effective than non-nature-based GI at anxiety reduction.

The Shapiro–Wilk, F_{max} and Levene's tests revealed that the assumptions for normality and homogeneity of variance were not violated. A two-way mixed-design ANOVA was employed and the impact of order effects were assessed. No interaction was found, Pillai's trace = 0.007, $F(1,46) = 0.32$, $p = 0.57$, $\eta_p^2 = 0.007$. This finding indicates that the order in which each condition was undertaken did not impact the results. Therefore, the two orders were combined to examine the main analysis and to maximize power. Similarly, gender differences were explored with no significant gender by treatment effects found, $F(1,46) = 0.005$, $p = 0.946$. Hence, analysis results based on the total sample are presented rather than gender stratified results. Correlations between pre-post change scores for the Urban and Nature conditions and scores on the CNS, NRS and VVIQ were examined and minimal relationships were found (r ranging from.01 to.12). Therefore, in the interests of maximizing power, given the small sample size, these three variables were not used as covariates in the subsequent ANOVA analyses.

A two-way repeated measures ANOVA was undertaken and a significant interaction effect was found between the condition (nature vs. urban) and time (pre vs. post), Pillai's trace = 0.101, $F(1,47) = 5.29$, $p = 0.026$, $\eta_p^2 = 0.101$. This indicates that the pre-post change in participants' anxiety levels was significantly greater for those in the nature condition than those in the urban condition.

The results reveal that both conditions were in themselves significantly effective in reducing anxiety. In the nature condition, the reduction in anxiety from before the participants undertook the condition to after the condition was significant, Pillai's trace = 0.436, $F(1,47) = 37.06$, $p < 0.001$, $M_{diff} = -10.10$, 95% CI [−13.47, −6.73], $\eta_p^2 = 0.436$. In the urban condition, there was a significant reduction in anxiety from the pre-condition to the post-condition, Pillai's trace = 0.342, $F(1,47) = 24.40$, $p < 0.001$, $M_{diff} = -6.77$, 95% CI [−9.52, −4.01], $\eta_p^2 = 0.342$. See **Table 1** for pre- and post-anxiety mean scores for both nature and urban conditions. See **Figure 1** for a graphical representation of the change in pre- and post-anxiety mean scores for both nature and urban conditions. **Tables 2**, **3** outline the themes and key phrases of the imagery generated in the nature-based GI and urban-based GI, respectively.

TABLE 1 | Table of means for pre and post condition state anxiety scores.

	Pre		Post	
Condition	***M* (*SD*)**	**95% CI**	***M* (*SD*)**	**95% CI**
Nature (n = 48)	44.16 (11.90)	[40.71, 47.62]	34.06 (10.80)	[30.93, 37.20]
Urban (n = 48)	42.27 (11.39)	[38.96, 45.57]	35.50 (11.46)	[32.17, 38.83]

CI, confidence interval.

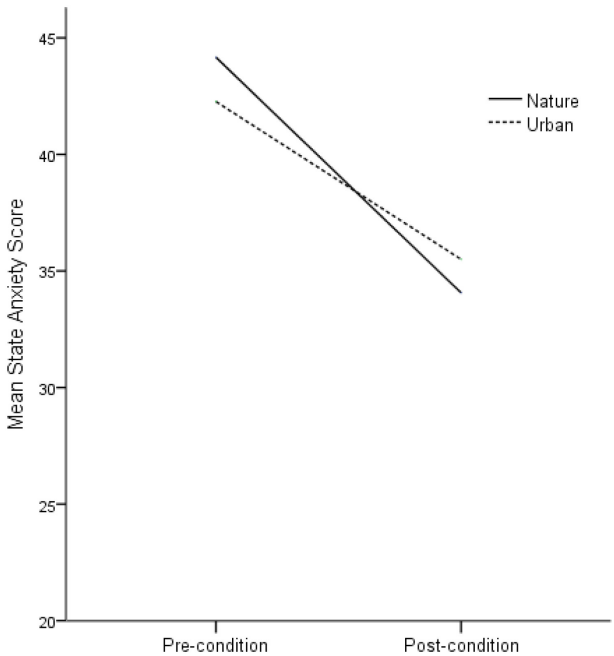

FIGURE 1 | Pre to post changes in mean anxiety scores for nature and urban-based guided imagery intervention. Minimum score on state anxiety = 20.

DISCUSSION

The present study aimed to investigate the effect of a nature-based GI intervention on state anxiety reduction. Two hypotheses were proposed. Hypothesis one posited that GI reduces anxiety. Hypothesis two proposed that a nature-based GI would be more effective at reducing anxiety than a non-nature-based GI experience. Both hypotheses were upheld. Hypothesis one was supported as the results revealed that GI as a process reduced anxiety for participants in this study, as both the nature and urban GI conditions significantly reduced state anxiety. While it is always possible that just taking part in the study facilitated anxiety reduction, this finding aligns with the literature on GI and its ability to effectively reduce anxiety (Ayres and Hopf, 1985; Speck, 1990; Stephens, 1992; Rees, 1995; Casida and Lemanski, 2010; Thomas and Sethares, 2010; Vineeta et al., 2010; Serra et al., 2012). These results did not seem to be dependent on gender, imagery capacity or feelings of connection to nature. The mechanisms behind GI may provide further explanation of the results of the current study. One contributing factor for this reduction in

TABLE 2 | Thematic category development of qualitative data from nature-based guided imagery.

Theme	Sub theme	Characteristic phrases
Water features	Beach	"Beach at the end of a cave," "a beautiful beach I've been to before," "beach environment – Fraser Island," "looking out at the beach," "on a beach sitting in the sand"
	Body of water (lake, river, ocean)	"River system leading to the ocean with reeds sprouting from the water," "by a river"
	Waterfall	"Near waterfall," "bottom of waterfall"
Mountain features	Mountains	"Blue mountains," "green rolling mountains," "mountains near childhood home," "on top of a mountain"
Meadows and bush landscapes	Green area	"A grassy area near a river" "large green field surrounded by some hills," "green meadow overlooking river and mountains," "camping area. . .opposite green grassed area"
	Bush	"in Australian bush," "where bush met trees"
	Nature landscapes/ elements combination	"Forest and mountains in the background, and a field in the foreground which led to a clear blue lake"
Trees and forests	Forest/ Rainforest	"rainforest trail," "a pine forest with a creek," "walking in a forest near a lake," "forest with trees and bark," "forest and lake covered in snow," "tropical rainforest," "rainforest track," "forest next to grandmother's farmhouse"
Backyard nature	Backyard	"In my backyard having an outdoor bath," "backyard sitting in a recliner chair with my dog taking a nap beside me"

TABLE 3 | Thematic category development of qualitative data from urban-based guided imagery.

Theme	Sub theme	Characteristic phrases
Home	Home	"Within my own home," "current home," "on my veranda of my previous home on acreage," "childhood property with an ocean view and large leafy trees," "small house," "house that I used to live in," "our townhouse," "front door of my house," "my townhouse complex"
	Apartment	"My apartment," "new apartment building atrium area," "outside an apartment building in a garden," "rental apartment backyard"
Urban social	Café	"Alfresco café," "busy café," "an arcade of shops, cafes. . .I could smell coffee and all sorts of aromas coming from food"
	City	"City buildings," "in the middle of the city shopping mall," "city then forest," "city, people, crowds, sidewalk. . .bustling, busy"
	Shopping center/mall area	"In the middle of the city shopping mall," "Queen Street mall," "outside a shopping center on a sunny warm day," "shopping mall where I used to work," "Chadstone shopping center in Melbourne, which is a busy area full of different shops and people walking around," "an arcade of shops, cafés"
	Street	"Urban street scene beside a university campus," "tree lined street"
Urban nature		"City then forest," "tree lined street," "in my backyard having an outdoor bath," "colors of the room are white. . .there's a window, in a wood frame, with the scenery outside is a lake, soft-blue sky," "neighborhood, along a quiet road, near the forest," "outside an apartment building in a garden," "new apartment building atrium area"

anxiety may be due to the proposed 'special link' between imagery and anxiety whereby mental imagery seems to be especially useful for working with both the physiological and psychological symptoms of anxiety (Holmes and Mathews, 2005). Holmes and Mathews (2005, 2010) argued that foundational emotions such as anxiety were more readily manipulated though imagery, when compared to verbal representation, because imagery and the real experience both facilitate similar immediate perceptual experiences and directly influence similar emotional systems in the brain. Participants in this study were asked to evoke sensory experiences of the internally generated environment. For example, participants were asked to notice the smells and sounds in the environment that they had imagined. This focus on sensory detail by way of visual, auditory and tactile experiences allowed for greater perceptual detail of the generated image (Arbuthnott et al., 2001, 2002). This aligns with research that suggests that GI produces similar sensory responses as living the experience for real (Arbuthnott et al., 2002). Experiencing the 'imagined' environment as if it were real might facilitate similar reactions to being in the real environment. The ecological approach proposed by Boschker et al. (2002) suggests that the imagery process allows a participant to realize positive action possibilities within an 'imagined' environment. Participants are likely to have focused on the 'best' bits of the environment, ignoring the uncomfortable aspects. As participants knew that the study was intended to investigate anxiety reducing interventions participants might have actively imagined environments (urban and nature) that invoked anxiolytic experiences or safety and comfort (Serra et al., 2012). The current study did not assess the details of the GI experienced by the participants in depth, nor did it ascertain participants' real-life responses to the particular environment they chose to experience. It may be possible that just taking part in the study facilitated anxiety reduction as participants knew they were taking part in a study examining the use of GI for anxiety. However, this still highlights the opportunity for further research into specific mechanisms underlying the reduction in anxiety brought about by both nature-based and urban-based GI experiences, such as the role of perception, sensory focus,

memory associations and relationship to particular natural and urban environments.

Hypothesis two proposed that nature-based GI would be more effective at reducing state anxiety than the non-nature-based GI. The results supported this hypothesis. This reflects similar conclusions from previous studies comparing nature to urban conditions, which found that exposure to natural scenes triggered responses that may contribute to anxiety reduction, and does so to a greater extent than urban scenes (Ulrich, 1979, 1981; Parsons et al., 1998; Laumann et al., 2003; Bratman et al., 2015a,b). Participants were instructed to generate internal images of a natural environment of their own choice, and research has shown nature experiences can lead to lower heart rate, greater stress recovery and increase positive affect (Ulrich, 1979, 1981; Parsons et al., 1998; Laumann et al., 2003). It is possible that the action possibilities in the nature GI session provided a richer set of sensory-perceptual experiences that facilitated these positive responses and collectively contributed to the greater decrease in anxiety, perhaps facilitating reduced rumination (Bratman et al., 2015a,b). Interestingly, some participants included an aspect of urban nature within their urban imagery condition, though not vice versa (see **Table 3**). This is interesting for two reasons: first, though we feel the influence might be minimal, inclusion of nature in the urban condition might have contributed to the overall effects of the urban condition. Second, even though participants were explicitly asked to imagine urban areas, and given examples of urban scenes, participants still voluntarily brought aspects of nature into the experience. If, as noted above, participants invoked action possibilities that mirror safe and comfortable environments, it is interesting that, at least for some participants, even urban nature might provide imagined action possibilities that result in lower anxiety levels.

As the current study was the first study to investigate nature-based GI as an intervention for anxiety, it focused on the immediate effects of the guided-imagery experience on state anxiety. Future studies may want to explore the more long-term effects of nature-based GI interventions on anxiety levels by focusing on trait anxiety or the role of possible comorbidities, such as depression, on short and long-term outcomes. Further to this, future studies may also want to explore the effectiveness of nature-based GI on reducing anxiety for a clinical population, as participants in the current study displayed various levels of state anxiety. Additionally, the final participant pool for the current study mainly consisted of Australian participants, despite the study's capacity to reach a more diverse population through its online recruitment process. These participants may have imagined aspects of the Australian landscape, which may be associated with more wide-open, natural landscapes. This is only a hypothesis as participants were only asked to provide a brief description of the GI environment using key words. Hence, future studies may be interested in exploring the effectiveness of nature-based GI interventions with participant groups from different geographical regions, such as landscapes that are more mountainous or more 'urban-dense' natural environments, and ensuring that participants' GI environments adhere to specific environmental categories. Such research may help to highlight any possible differences between a range of natural environments on participants' anxiety levels, as well as possibly providing greater clarification on the anxiety-reducing effect of different levels of greenery within urban environments. Future studies may also want to consider assessing the impact of the GI intervention with a non-contextual control group in order to further understand the imagery effects in different background contexts, as well as incorporating manipulation checks to ensure that participants experienced the GI exercise as anticipated.

The current study has demonstrated that nature-based GI is effective in reducing anxiety. It has also demonstrated that anxiety-reducing effects can emerge from imagery of the natural world itself without the need to incorporate suggestive relaxation cues, which is a common element in guided-imagery scripts. Future research could undertake a deeper exploration of the possible mechanisms underlying the reduction in anxiety seen in participants who experience nature-based GI and perhaps also investigate the efficacy of GI against similar interventions such as mindfulness training. Individuals with high trait mindfulness could be more responsive to GI interventions than individuals with low trait mindfulness because they are likely to pay more attention to presented stimuli. In this way, trait mindfulness might enhance the GI intervention. This could be achieved through comparative studies and qualitative interviews with the participants about their GI experiences.

Findings from this study have a number of implications. The most important implication of this study is that it highlights the many issues that require clarification in future studies. These directions for further research include disentangling the imagery effects of different locations and background contexts, differentiating the imagery effects of various levels of nature imagery and ascertaining the impact of previous experiences of the natural world on an individual's anxiety-reduction. Practical implications from this study are fourfold. Firstly, imagery of nature can be appropriately incorporated into the design and administration of effective anxiety interventions whether they include nature or not. Secondly, health professionals can be confident in continuing to utilize the common intervention of guided-imagery, but better cater for nature-components of the exercise to suit the client's personal affiliation to the natural world. This is because these findings have demonstrated that the content and features imagined by the individual during the guided-imagery experience is more important than the process itself. Thus, clinicians can seek to determine the relationship their clients have with particular natural environments and incorporate this knowledge into their GI-based interventions. Similarly, the knowledge that allowing individuals to create their own version of the environment, as opposed to situating them in a pre-determined environment, may be helpful in better aiding anxiety-reducing effects. Thirdly, nature-based GI can be undertaken anywhere as it can be experienced in the form of an audio recording, requiring only a listening device. This means that individuals can undertake nature-based GI outside of therapy, which in turn overcomes issues of access to therapy, such as waiting lists, limited therapy sessions or therapy costs, or barriers to therapy interventions that require direct contact with nature. Finally, the results of this study provide additional

support for the growing body of evidence emerging in support of nature and its role in psychological well-being.

CONCLUSION

Contact with nature has been shown to have anxiolytic effects. However, it may not always be possible to experience nature directly. GI has been used as an effective intervention for anxiety. This study set out to investigate the outcomes of using GI of nature as an intervention for anxiety. Results indicated that GI and nature-based GI were effective anxiety interventions. However, nature-based GI proved to be most effective. This finding has a number of practical implications and adds support to the growing evidence based that and enhanced human-nature relationship is important for psychological health and wellbeing. Evidence suggests that psychological interventions designed to develop positive experiences and boost positive behavior would be more effective if they enhanced the human-nature relationship in direct terms. However, if this is not possible then imagery of nature also has positive benefits.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of Queensland University of Technology, research ethics. The protocol was approved by the Queensland University of Technology research ethics committee.

AUTHOR CONTRIBUTIONS

JN and EB contributed to design and analysis and article development. JN lead data gathering and analysis.

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Can Simulated Green Exercise Improve Recovery From Acute Mental Stress?

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This exploratory study enhances previous research into green exercise and addresses a gap in the research by exploring the contribution of individual and combined senses in the recovery of mood and stress after a psychological stressor, whilst rigorously controlling exercise intensity. The hypotheses were: (i) recovery of mood and stress from a state of psychological stress would be greater following simulated green exercise compared to rest, (ii) green exercise would facilitate better recovery than exercise alone, (iii) these effects would remain 10 min following intervention, and (iv) visual stimuli alone would enhance recovery from a state of psychological stress compared to sound. Fifty participants were randomly assigned to one of five groups: REST, exercise, exercise with nature sounds, exercise with nature visual and exercise with nature sound and visual. An initial visit to obtain predicted peak power output values and to familiarize participants with the equipment being used was followed by a second visit, where participants experienced one test condition. Baseline measures of heart rate, blood pressure, total mood disturbance (TMD), and perceived stress were taken, before participants completed a stressor based on the Trier Social Stress test. Measures of heart rate and blood pressure were recorded in the last 30 s of the stressor to assess efficacy of the stressor. Immediately post stressor, measures of mood and perceived stress were taken followed by the intervention assigned (one of five described above). Measures of mood and perceived stress were taken again immediately post intervention and 10 min post intervention. Results showed that green exercise improved mood and stress scores more than exercise alone or REST. For both TMD and perceived stress, improvements in all simulated nature conditions were significantly improved compared to REST or exercise alone immediately post intervention. There were no significant changes 10 min post intervention in either mood or perceived stress compared to immediately post intervention values in any of the groups. This study suggests that environmental exercise settings including nature sounds, visual or both combined should be considered as important in the use of exercise as a therapeutic activity or recovery from acute psychological stress.

Keywords: green exercise, stress, mood, recovery, sensation, perception, nature, psychological

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INTRODUCTION

Psychological stress is defined as "a state of mental or emotional strain or tension resulting from adverse or demanding circumstances" (English Oxford Living Dictionaries [EOLD], 2018). Although stress tolerance varies between individuals due to the appraisal of the stressor, prolonged exposure to stress is considered a risk factor of poor health, due to the sustained physiological changes in response to the psychological demands (Mental Health Foundation [MHF], 2018). The psychological stress response is mediated by a cascade of hormones from the central nervous system and peripheral organs (Chrousos, 2009). Chronic psychological stress increases risk of health problems including cardiovascular, neurological, and mental ill health (including depression) (Oken et al., 2015).

Mental ill-health is one of largest factors in global disease burden, with depression the leading cause of disability (Vos et al., 2015). Each year in the United Kingdom, around 12 million adults seek medical advice about their mental health, many relating to anxiety and depression, which are often associated with, or triggered by, high levels of stress (Mental Health Foundation [MHF], 2018). In 2016/17 work-related stress alone was responsible for 12.5 million lost work days in the United Kingdom, accounting for half of all absences due to ill health (Health Safety Executive [HSE], 2017). Longitudinal studies and systematic reviews have indicated that work-related stress is associated with anxiety, depression, heart disease and some musculoskeletal disorders (Health Safety Executive [HSE], 2017). A clearer understanding of the interventions that ameliorate stress and enhance recovery is needed (Danielsson et al., 2012), especially given the wider negative consequences it has on individual health, society and the economy (Health Safety Executive [HSE], 2017).

Nature and green environments contribute to an enhanced level of physical and mental health (Ward Thompson et al., 2012; Gladwell et al., 2013; Hartig et al., 2014; Pearson and Craig, 2014; Akpinar et al., 2016; van den Berg et al., 2016; Douglas et al., 2017; Ekkel and de Vries, 2017; Wood et al., 2017; Hazer et al., 2018). Over the last decade, epidemiological studies have shown positive associations between quantity of local green space and improved health outcomes (Mitchell and Popham, 2008; Maas et al., 2009; Beyer et al., 2014; Kardan et al., 2015; Ward Thompson et al., 2016). Being in green spaces may relieve stress since lower perceived stress has been associated with greater weekly exposure to green spaces (Hazer et al., 2018). Thus, links between engagement with green spaces and wide-ranging health benefits have become a focal point for research.

It has been suggested that modern day humans have an innate connection with nature and living things due to our hunter-gatherer past (Kellert and Wilson, 1995). Natural environments can be enjoyed without having to deliberately focus attention, concentrate or expend mental effort. This has led some to claim exposure to nature has restorative effects on mental fatigue and attention (Kaplan, 1995; Berman et al., 2008). Nature and natural environments have been found to counteract the negative effects of stress, specifically with respect to stress recovery (Brown et al., 2013), mental fatigue reduction (Berman et al., 2008, 2012; Taylor and Kuo, 2009), and cognitive restoration (Kaplan, 1995; Grahn and Stigsdotter, 2003; Berto, 2005; Bowler et al., 2010; Rogerson and Barton, 2015).

Direct contact with nature is not necessary for it to facilitate recovery from stress. Viewing nature through a window (Ulrich, 1984; Kaplan, 2001), by means of still or moving images projected onto a screen (Brown et al., 2013; Wooller et al., 2015), and through virtual reality (Annerstedt et al., 2013) have all improved recovery from acute stress. Viewing images of nature 10 min prior to being subjected to an acute mental stressor was sufficient to positively affect the recovery of the autonomic system (Brown et al., 2013). Recovery from a virtual reality version of the Trier Social Stress Test (TSST) was found to be best when exposed to a simulated natural environment comprising both sounds and images, rather than just images of nature or a control condition absent of all nature images and sounds (Annerstedt et al., 2013). Using similar sensory isolation methods combined with moderate intensity cycling, positive effects on mood were found when the simulated green environment included both video graphic and auditory components (Wooller et al., 2015). Unexpectedly, the largest mood improvement occurred when the sounds of nature were excluded from the simulation compared to the removal of the sight or smell of nature (Wooller et al., 2015).

Exercise performed in conjunction with exposure to nature is known as green exercise (Pretty et al., 2005) and has been associated with a variety of psychological and physiological benefits (White et al., 2013; Weng and Chiang, 2014). Green exercise improves mood, attention and physiological markers such as heart rate, blood pressure and cortisol compared to exercise in built man-made environments (Focht, 2009; Li et al., 2011; Thompson Coon et al., 2011; Rogerson and Barton, 2015). While these and other effects of green exercise are well documented, less is known about which senses might have the greatest contribution to the reported outcomes. Previous green exercise research showing beneficial effects on attention and psychological recovery (Focht, 2009; Li et al., 2011; Thompson Coon et al., 2011; Rogerson and Barton, 2015) can be furthered by investigating in more detail the contribution of individual senses and multi-sensory integration in situations where a state of stress has been intentionally induced. Using simulated green exercise in a laboratory environment minimizes less controllable variables such as the weather, terrain and contact with other people, whilst enabling control of the exercise intensity, mode and stimulated senses.

The purpose of this exploratory study was to investigate the effects of simulated green exercise used as a recovery intervention following exposure to acute mental stress on immediate mood and stress levels and whether any recovery effects persisted following a further 10 min of rest. Additionally, to explore the influence of visual and auditory senses, these senses were manipulated to allow sight or sound to be the main contributing sense during the green exercise simulation. The olfactory sense was excluded for this study as previous work showed that smell had a limited impact on the green exercise outcomes (Wooller et al., 2015). The hypotheses were that: (i) recovery of mood and stress from a state of psychological stress would be greater following simulated green exercise compared to resting recovery,

(ii) simulated green exercise would facilitate better recovery compared to exercise alone, (iii) these effects would remain 10 min following simulated green exercise, and (iv) visual stimuli alone would enhance recovery of mood and stress from a state of psychological stress compared to sound.

MATERIALS AND METHODS

Participants

Fifty healthy participants were recruited for this study (Age 27.2 ± 10.2 years; Stature 173.8 ± 9.1 cm; Body Mass 78.3 ± 16.4 kg; Body Mass Index 25.8 ± 4.7 kg.m^2) constituted of 34 males (Age 25.7 ± 9.5 years; Stature 178.4 ± 6.2 cm; Body Mass 83.3 ± 15.8 kg; Body Mass Index 26.2 ± 4.9 kg.m^2) and 16 females (Age 30.4 ± 11.3 years; Stature 164.2 ± 6.1 cm; Body Mass 67.5 ± 11.9 kg; Body Mass Index 25.0 ± 4.3 kg.m^2). Only healthy individuals free from chronic conditions, injury and illness were permitted to take part, this was verified by use of a physical activity readiness questionnaire (PAR-Q). Written informed consent was provided by all participants and the study and its associated procedures were approved by the University of Essex ethics committee.

Design

A between-subjects experimental design was used in which participants attended the laboratory on two occasions. The first visit was to establish participants estimated peak power output (EPPO) using a CatEye ergociser (EC-1600, CatEye Co., Ltd., Osaka, Japan). On the second visit participants were randomly allocated to one of five stress recovery groups: (i) Rest, (ii) Cycling without nature simulation, (iii) Cycling with simulated nature sounds, (iv) Cycling with simulated nature video, or (v) Cycling with simulated nature sounds and video combined. Quota sampling methods were used to ensure an even number of participants (n = 10) per condition. Participants were not aware of their grouping prior to the recovery intervention. Further, the tester inducing the stress was not aware of the group the participant was in.

During the second visit, participants carried out a stress induction task (described in Stress Induction) followed by 5 min of moderate intensity cycling under the simulated green exercise conditions associated with the condition they had been assigned to (see Stress Recovery Interventions). A variety of dependent variables were recorded including mood, perceived stress, heart rate and blood pressure. All measurements were taken before and after the stress induction task. Mood and perceived stress were also taken immediately after the green exercise cycling task, and 10 min after resting recovery. The measurement trials in relation to the stress induction task, recovery intervention and further 10 min rest period are indicated above the x-axis on **Figure 1**.

Cycling Ergometry

During the first visit, EPPO was calculated using the YMCA bicycle submaximal fitness test (Golding et al., 1989) programmed into a CatEye ergociser as used by Rogerson et al. (2016). During the experimental conditions, a 100p/100k Ergoselect cycle ergometer (Ergoline, Bitz, Germany) was used. The Ergoselect allowed stringent control of exercise intensity, by continually adjusting pedaling cadence to maintain constant intensity wattage. Exercise intensity was set at 40% EPPO, in accordance with previous methods used to replicate moderate exercise (Wooller et al., 2015).

Stress Induction

Each participant individually carried out a TSST in accordance with the methods of Kirschbaum et al. (1993). Participants were first taken into a plain room where two testers, seated behind a table, explained the test. Participants were instructed to stand on a marker positioned on the floor in front of the testers which they were told was necessary for video capture purposes. Participants were bought into the room at a time when they could see one of the testers adjusting the camera equipment, which was visible from the marker position. At the end of all testing, participants were debriefed that in fact no recordings were made, and that the presence of the camera was intended to add to their stress. The testers explained to participants that they would be required to complete a mathematics and English task but provided no further details. Participants were then invited to wait outside of the room and permitted 5 min to mentally prepare themselves for the upcoming tasks.

After 5 min, participants were bought back into the room. The testers were instructed to show no signs of emotion or assist the participants in anyway. One tester administered a mathematics task, which required the participant to count backward by 13 from 1677. In the event of a mistake, a loud beep was sounded, and the participant was instructed to start again from 1677. The second tester administered an English task, which required participants to spell words, ranging from seven to ten letters long, backward. Again, in the event of a mistake a loud beep was sounded, and the participant was asked to spell that word again. Each task lasted for 5 min and participants were randomly assigned to order counterbalanced tasks.

Stress Recovery Interventions

Each participant performed one of five stress recovery interventions according to the condition they had been randomly assigned. Standardization of the recovery environment, to minimize confounding or extraneous effects on the dependent variables, was achieved by having participants complete all conditions in identical laboratory settings, seated on a cycling ergometer positioned in front of a projector screen. All recovery interventions lasted for 5 min which has previously been found sufficient for green exercise effects to occur (Barton and Pretty, 2010; Wooller et al., 2015).

Participants in the rest condition sat quietly on the cycle ergometer in front of a gray screen. During exercise without simulated nature, participants cycled at 40% EPPO in front of a gray screen. In the three remaining simulated nature cycling conditions, participants cycled at 40% either a gray screen and the soundtrack of birdsong (simulated nature sounds only), video images of nature but no sounds played (simulated nature scenes only) or while both the simulated sounds and video images of nature were presented.

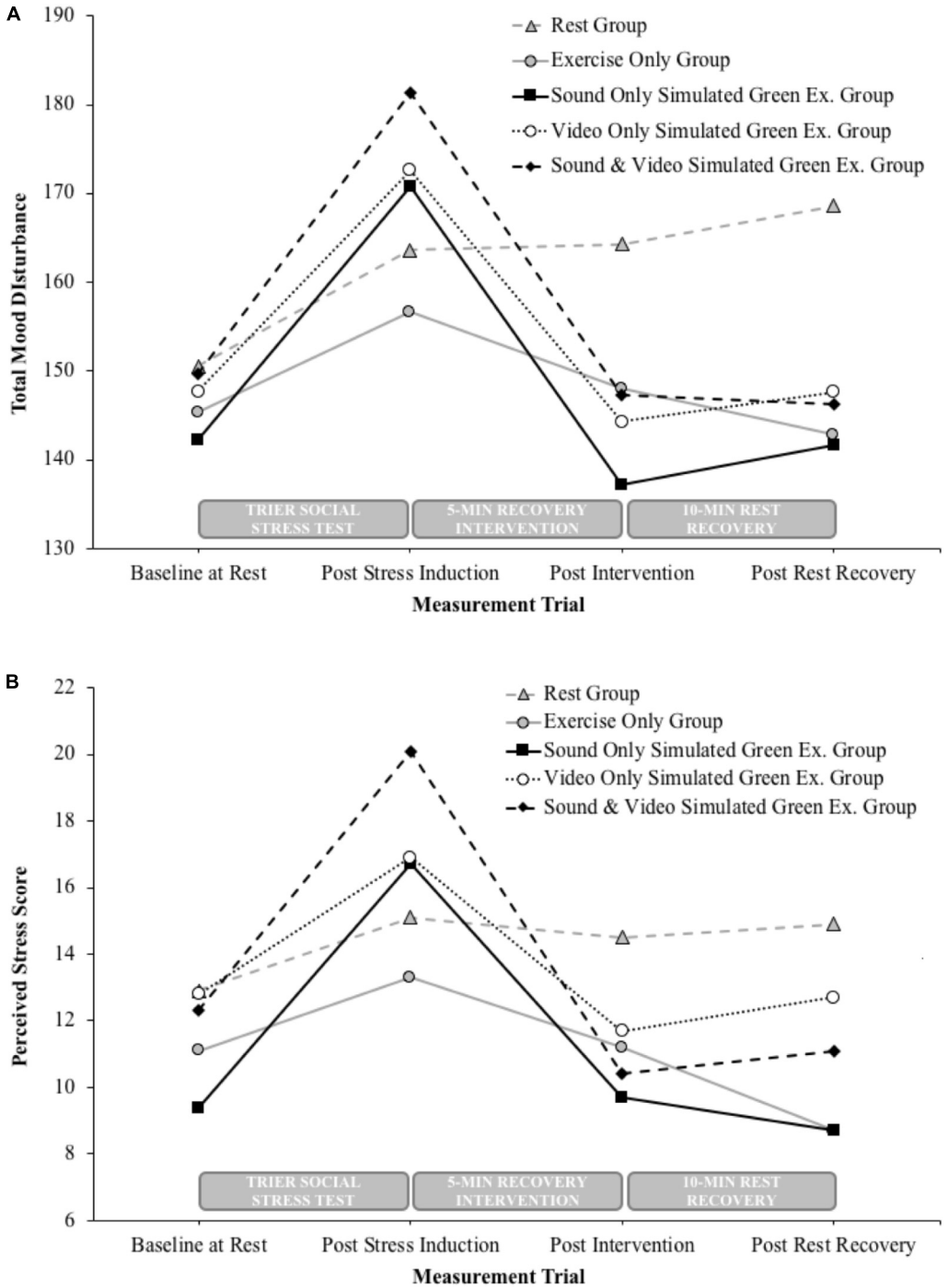

FIGURE 1 | Between group changes in total mood disturbance **(A)** and perceived stress **(B)** following the stress induction task, 5-min recovery intervention and 10-min resting recovery.

Nature sounds and images were taken from a commercially available exercise DVD (Fitness Journeys – through the forest, Isis Asia Ltd., Manila, Philippines) and projected onto a large screen positioned approximately 150 cm in front of the participant. Video image size was 180.3 cm × 92.5 cm and 126 cm from the ground. To ensure an environment where no other people or moving vehicles were present, the last 5 min of the DVD chapter "Redwoods and Oaks" was used. Playback speed simulated moving at approximately 20 $km.hr^{-1}$ which, together with the proximity of the screen to the participant, gave a realistic simulated cycling experience of forward movement. This DVD and screen set up had been used

in our laboratories in a previous study conducted (Wooller et al., 2015).

Dependent variables were captured immediately after each stress recovery intervention and then participants were asked to rest in silence in front of a gray projector screen while remaining seated on the cycle ergometer for a further 10 min. Dependent variables were recorded again at the end of the 10 min rest period.

Psychological and Physiological Measurements

Mood State

The shortened "right now" version of the Profile of Mood States (POMS) questionnaire (McNair et al., 1971, 1992) was used to measure mood. This version uses a 30-point item, scored using a five-point Likert scale ranging from "0 = Not at all" to "4 = Extremely." Subscale scores for Tension, Depression, Anger, Vigor, Fatigue and Confusion were calculated. Total mood disturbance (TMD) was then calculated by subtracting the vigor score for from the sum of the other five subscales. This gave an overall value for TMD between 112 and 282, giving an indication of overall mood with higher TMD suggesting lower mood. POMS was measured four times: (i) baseline on arrival; (ii) immediately after the stress induction task; (iii) immediately after the recovery intervention, and (iv) after 10 min of rest.

Stress Measures

Stress was measured using the Perceived Stress Scale (PSS) (Cohen et al., 1983; Cohen and Williamson, 1988). PSS comprises ten statement items to measure an individual's self-appraisal of how potentially stressful their life is (Cohen and Williamson, 1988). A modified version of the ten item PSS was used, in accordance with (Rogerson et al., 2015), to measure 'right now' state measurements of perceived stress. Item statements such as 'In the last month, how often have you been upset because of something that happened unexpectedly?' was edited to say 'I feel upset,' with an accompanying instruction asking participants to 'indicate how you feel right now, at this moment.' On the original PSS responses were made using a Likert scale scored from 0 – 'Never' to 4 – 'Very Often.' The modified PSS used descriptors instead from 0 – 'Strongly Disagree' to 4 – 'Strongly Agree.' The range of aggregated scores was 0–40 with higher scores indicate a greater level of stress. PSS was administered at the same time points as POMS described above.

Heart Rate and Blood Pressure Measures

Heart rate (HR) and blood pressure (BP) were recorded at baseline and throughout the stressor using a Mobil-O-Graph 24 h PWA Monitor (I.E.M. GmbH, Stolberg, Germany) to establish physiological. The recorder was set to measure HR and BP every 2 min, the minimum time interval available (only data for the last 30 s of the stressor was used).

Statistical Analysis

A manipulation check was carried out using a series of mixed two-way (5 × 2) ANOVAs to test whether the stress induction task had actually provoked negative changes in heart rate, blood pressure, mood and perceived stress as intended. The between-subjects factor was the recovery condition participants were assigned to, and the within-subjects factor was the measurement trial (pre- versus post-Trier Social Stressor measurement).

Total mood disturbance and PSS changes following the 5 min stress recovery intervention and 10 min rest period were analyzed using mixed two-way (5 × 3) ANOVAs. The between-subjects factor was the recovery condition participants were assigned to, and the within-subjects factor was the measurement trial (post stress induction task, post stress recovery intervention and post 10 min recovery). Two-way (5 × 3) ANCOVAs, using baseline scores as a covariate, were used to examine mood and PSS changes once individual variation in acute stress responses had been controlled for.

An alpha level of 0.05 was used to indicate statistical significance in all ANOVA and ANCOVA tests and where sphericity assumptions were violated, Greenhouse-Geisser outcomes are reported as indicated by adjusted degrees of freedom. Significant interactions were followed up using *post hoc* paired samples *t*-tests separately for each group to examine changes in mood and perceived stress before and after the recovery intervention, and after the 10 min rest recovery period. A Bonferroni corrected alpha level of 0.013 was used to indicate significance. Effect sizes are reported as eta-squared (η^2) and partial eta-squared ($\eta_p{}^2$). All data analysis was conducted using SPSS v 24 (IBM Inc., New York NY, United States).

RESULTS

Missing Data Imputation

Of the 50 participants, three (6%) had missing data. TMD data for all four trials were complete, however, among the PSS data there was one response missing from the post stress induction trial and two responses missing from the post recovery intervention trial equating to total missing PSS data of 1.5% (3/200).

Missing items were filled using iterative Markov Chain Monte Carlo multiple imputation methods incorporating linear regression to scale variables using a maximum of 10 iterations. The imputation model was constrained to produce integers only within the possible PSS minimum and maximum score range of 0 to 40, respectively, ensuring the imputed values corresponded with the PSS response scoring system. All missing data was resolved, and the resultant imputed dataset was used for all further analysis.

Manipulation Check of the Trier Social Stress Test

The TSST provoked changes in heart rate ($F_{1,42}$ = 29.7, $P < 0.0001$, $\eta_p{}^2$ = 0.41); systolic blood pressure ($F_{1,42}$ = 44.4, $P < 0.0001$, $\eta_p{}^2$ = 0.51); diastolic blood pressure ($F_{1,42}$ = 97.3, $P < 0.0001$, $\eta_p{}^2$ = 0.70); TMD score ($F_{1,45}$ = 33.0, $P < 0.0001$, $\eta_p{}^2$ = 0.42); and PSS score ($F_{1,43}$ = 47.2, $P < 0.0001$, $\eta_p{}^2$ = 0.49). As indicated in **Table 1**, all dependent variables significantly decreased, apart from TMD which increased (i.e., a

TABLE 1 | Changes in total mood disturbance and perceived stress following the strees induction task, 5 min recovery intervention and 10 min resting recovery.

	Baseline	Post stressor		Post intervention		Post 10-min rest recovery	
	Absolute values	Absolute values	Δ From baseline	Absolute values	Δ From post stressor	Absolute values	Δ From post stressor
Total mood disturbance							
Rest	150.5 ± 19.8	163.6 ± 28.7*	13.1 ± 30.4	164.3 ± 29.6	0.7 ± 12.4	168.6 ± 32.4	5.0 ± 14.5
Exercise only	145.3 ± 19.6	156.6 ± 26.4*	11.3 ± 14.0	148.0 ± 25.2	−8.6 ± 16.2	142.8 ± 15.7†	−13.8 ± 13.7
sound only	142.3 ± 15.8	170.8 ± 36.1*	28.5 ± 24.1	137.2 ± 13.2†	−33.6 ± 24.3	141.7 ± 21.4†	−29.1 ± 25.0
Video only	147.7 ± 13.1	172.6 ± 23.9*	23.0 ± 16.4	144.3 ± 12.0†	−28.3 ± 16.7	147.6 ± 15.4†	−25.0 ± 18.5
Sound and video	149.6 ± 18.4	181.3 ± 36.9*	34.6 ± 43.1	147.3 ± 16.3†	−34.0 ± 36.7	146.3 ± 20.5†	−35.0 ± 24.9
Perceived stress							
Rest	12.9 ± 5.7	15.1 ± 6.7*	2.3 ± 5.2	14.5 ± 6.7	−0.6 ± 4.6	14.9 ± 7.6	−0.2 ± 4.2
Exercise only	11.1 ± 8.4	13.3 ± 8.0*	3.2 ± 3.4	11.2 ± 8.1	−2.6 ± 4.1	8.7 ± 7.1†	−4.6 ± 3.0
Sound only	9.4 ± 5.8	16.7 ± 10.1*	6.6 ± 7.9	9.7 ± 5.6†	−7.1 ± 6.8	8.7 ± 6.3†	−8.0 ± 9.2
Video only	12.8 ± 4.3	16.9 ± 2.5*	4.1 ± 4.1	11.7 ± 1.9†	−5.2 ± 2.9	12.7 ± 2.3†	−4.2 ± 3.8
Sound and video	12.3 ± 3.4	20.1 ± 4.1*	3.2 ± 5.4	10.4 ± 4.7†	−8.4 ± 8.1	11.1 ± 4.3†	−7.7 ± 6.7

**Indicates a significant increase post stressor compared to baseline ($P < 0.0001$); †indicates significant reduction compared to post stress induction outcomes. All outcomes reported as mean ± 1 SD.*

decrease in mood) ($P < 0.001$). This indicates that a raised state of acute stress had been induced as intended.

Recovery of Total Mood Disturbance

A two-way (5 × 3) ANOVA revealed an interaction effect between the intervention group and post stress task trial changes in TMD. This was accompanied by a trial main effect but no group main effect. Controlling for baseline TMD using a two-way (5 × 3) ANCOVA, produced a similar strength group-by-trial interaction, however, the trial main effect, although still significant, was diminished. Statistical outcomes are reported in **Table 2**.

Post hoc analyses showed reductions in TMD after 5 min of cycling among the nature sound group ($t_9 = 4.4$, $P = 0.001$, $\eta^2 = 0.68$, 95% CI = 16.2–51.0), nature video group ($t_9 = 5.4$, $P < 0.0001$, $\eta^2 = 0.76$, 95% CI = 16.4–40.2), and the combined nature sounds and video group ($t_9 = 2.9$, $P = 0.009$, $\eta^2 = 0.49$, 95% CI = 7.8–60.2). Over a subsequent 10 min resting recovery period, there was no further significant TMD change among the sound group ($t_9 = -0.8$, $P = 0.222$, $\eta^2 = 0.07$, 95% CI = −17.2–8.2), video group ($t_9 = -1.2$, $P = 0.136$, $\eta^2 = 0.13$, 95% CI = −9.7–3.1) or combined sound and video group ($t_9 = 0.2$, $P = 0.43$, $\eta^2 < 0.01$, 95% CI = −11.3–13.4). There was no significant TMD change in the exercise only group or the rest group following the initial 5 min recovery intervention period, however, compared to the post stressor measurements the exercise only group did exhibit lower TMD over a subsequent 10 min resting recovery period ($t_9 = 3.2$, $P = 0.006$, $\eta^2 < 0.53$, 95% CI = 4.0–23.6). Mean changes in TMD are given in **Table 1** and presented in **Figure 1A**.

Recovery of Perceived Stress

A two-way (5 × 3) ANOVA revealed an interaction effect between the intervention group and post stress task trial changes in PSS. This was accompanied by a trial main effect but no group main effect. Controlling for baseline PSS using a two-way (5 × 3) ANCOVA, produced a similar strength group-by-trial interaction, however, the trial main effect, although still significant, was diminished. Statistical outcomes are reported in **Table 2**.

Post hoc analyses showed reductions in PSS after 5 min of cycling among the nature sound group ($t_9 = 3.2$, $P = 0.005$, $\eta^2 = 0.54$, 95% CI = 2.1–11.9), nature video group ($t_9 = 5.8$, $P < 0.0001$, $\eta^2 = 0.79$, 95% CI = 3.2–7.2) and the combined nature sounds and video group ($t_9 = 4.5$, $P = 0.001$, $\eta^2 = 0.69$, 95% CI = 4.8–14.6). Over a subsequent 10 min resting recovery period, there was no further significant PSS change among the sound group ($t_9 = 0.7$, $P = 0.248$, $\eta^2 = 0.05$, 95% CI = −2.2–4.2), video group ($t_9 = -1.3$, $P = 0.115$, $\eta^2 = 0.16$, 95% CI = −2.8–0.8) or combined sound and video group ($t_9 = -0.7$, $P = 0.26$, $\eta^2 = 0.05$, 95% CI = −3.1–1.7). There was no significant PSS change in the exercise only group or the rest group following the initial 5 min recovery intervention period, however, compared to the post stressor measurements the exercise only group did exhibit lower PSS ($t_9 = 4.8$, $P = 0.001$, $\eta^2 < 0.72$, 95% CI = 2.4–6.8). Mean changes in PSS are given in **Table 1** and presented in **Figure 1B**.

DISCUSSION

A key finding of this exploratory study is that all variations of simulated green exercise were more effective than both rest and indoor cycling at recovering from an episode of induced acute stress. A further, important contribution this study makes, is to extend our understanding of the sensory basis of green exercise, a critical early step in trying to move toward more explanatory, mechanistic models. Since the senses are first in the cognitive information processing cascade, an important finding of the present study is that green exercise simulations involving visual feedback during cycling appear to have the strongest impact on mood and perceived stress recovery. It was also found that the positive states of recovery observed in all green exercise

TABLE 2 | Effect differences in post intervention TMD and PSS outcomes when baseline stress has (ANCOVA) and has not (ANOVA) been controlled for.

	Total mood disturbance				PSS			
	F	(df)	*P*	ηp2	*F*	(df)	*P*	ηp2
Trial main effects								
ANOVA	38.0	(1.6, 70.3)	<0.0001	0.46	36.0	(1.6, 71.6)	<0.0001	0.45
ANCOVA	7.0	(1.5, 68.3)	0.004	0.14	0.3	(1.6, 70.8)	0.76	0.01
Group main effects								
ANOVA	0.9	(4, 45)	0.50	0.07	0.9	(4, 45)	0.46	0.08
ANCOVA	0.4	(4, 44)	0.78	0.04	0.7	(4, 44)	0.60	0.06
Trial-by-group interactions								
ANOVA	4.1	(6.2, 70.3)	0.001	0.27	4.6	(6.4, 71.6)	0.0004	0.29
ANCOVA	4.0	(6.2, 68.3)	0.002	0.27	4.8	(6.4, 70.8)	0.0002	0.31

Non-integer degrees of freedom (df) values indicate use of Greenhouse-Geisser outcomes. Partial eta-squared (η_p^2) effect sizes are reported.

conditions, and to a lesser extent in the non-green exercise condition, were preserved during a subsequent 10 min rest period.

Green Exercise and Stress Recovery

The method of inducing an acute stress response that we used was effective as indicated in the significant increases in heart rate, blood pressure, mood disturbance and perceived stress. Inducing acute stress in this way is an important development in green exercise research because it carries high ecological validity in the sense that, owing to the complex array of stressors prevalent in contemporary society (Health Safety Executive [HSE], 2017; Mental Health Foundation [MHF], 2018), it is not uncommon for individuals to frequently experience sudden episodes of intense stress. In this context, our findings that green exercise facilitated recovery of mood and perceived stress quicker compared to those resting or exercise alone, has several important implications.

The first is that, notwithstanding the known barriers to readily accessing natural environments (Dahmann et al., 2010; Sister et al., 2010; Jennings et al., 2012), green exercise is an option that individuals may choose to quickly and effectively cope with stress. Consistent with previous findings (Taylor and Kuo, 2009; Barton and Pretty, 2010; Brown et al., 2013), we also found that green exercise was effective after just 5 min which adds to its viability as a coping strategy, particularly among those for whom the availability of time is a contributory stressor. For instance, those working in stressful environments with limited time to break such as teachers, drivers, construction workers, health professionals and many others.

The second important implication is that, as previously suggested (Barton and Pretty, 2010; Thompson Coon et al., 2011), our results indicate that experiencing nature can further enhance the psychological effects of exercise. Specifically, we observed improvements in TMD and PSS immediately following simulated green exercise conditions that were of a magnitude not seen in the exercise only condition. It is not that exercise is not effective but rather, as illustrated in **Figure 1**, seems to have a more gradual recovery course compared to the apparent immediate effects of green exercise. After only 5 min of green exercise, mood and perceived stress had, fallen back to baseline levels with just one exception, perceived stress in the simulated nature sound condition (**Table 1**). Interestingly, there appears to be a continued downward trend in both TMD and PSS in the 10-min post intervention suggesting a longer time period following the intervention should be explored, to better understand the enduring benefits of a single exposure to green exercise.

Controlling for variations in baseline mood and perceived stress only slightly dampened the interaction between recovery intervention and therapeutic effects (**Table 2**), and the *post hoc* analysis revealed very high effect sizes for all green exercise conditions. Consequently, we are able to report with high confidence, that green exercise was the best of all interventions we tested in recovering from acute stress.

Sensory Factors in Green Exercise and Stress Recovery

Green exercise undertaken outdoors has multi-sensory aspects (Franco et al., 2017). Simulating green exercise enabled exploration of the relative influence of visual and auditory stimuli on green exercise recovery from acute stress. Large effect sizes were found in all green exercise conditions indicating that nature simulations involving isolated auditory feedback, isolated visual feedback and combined audio-visual feedback are all effective in recovering from acute stress. Isolated visual feedback was found to have the greatest influence on mood and perceived stress, with very large effect sizes of >0.75 measured in both instances. This is not surprising given that vision is considered to be the dominant sense, as demonstrated in classic studies of the ventriloquist effect (Thurlow and Jack, 1973; Warren et al., 1981) and McGurk effect (McGurk and MacDonald, 1976). Studies exploring the benefits of nature have mainly focused on visual aspects (Franco et al., 2017), however, our previous study that occluded nature stimuli found removal of sound to have the greatest impact on mood in comparison to removal of visual cues (Wooller et al., 2015).

In the current study, it is less clear is why the green exercise effect for vision alone was stronger (according to effect size) than combined audio-visual simulation of nature. Counterintuitively, it appears that the compound effects of audio-visual simulation are not as strong a visual input alone. This is unexpected

given that audio-visual simulation is arguably more realistic than those simulation involving isolated audio or visual sensory inputs. A potential explanation might be found in the known complexities of cross-modal interactions on perception (Shams and Kim, 2010). Auditory emotional cues have, as the net result of competing task-relevant emotional priming and divided audio-visual attention demands, been found to enhance the processing of target visual information (Zeelenberg and Bocanegra, 2010). In the context of the green exercise simulations used in our study, the resultant effects on mood and perceived stress may therefore be due to the extent to which demands on attention compete with the cues from other senses. Since limited attentional capacity is divided in the audio-visual simulation, this might account for why the effect size was weaker compared to the isolated visual and auditory sensory conditions.

Another interesting and relevant body of work concerns cross-modal perceptual plasticity where enhanced sensory compensation has not only been found in those with visual or hearing impairments (Cecchetti et al., 2016) but also in those temporarily impaired, for instance through the use of a blindfold (Lee and Whitt, 2015). Cross-modal perceptual plasticity may in fact help explain why the effects were so strong in the isolated sensory conditions of our experiment, where auditory nature cues might have triggered relevant associated mental imagery of nature and vice-versa as previously reported (De Volder et al., 2001). What is clear is that, as our findings highlight, the sensory and perceptual mechanisms of the green exercise effect are most likely a product of complex cross-modal interactions and sensory compensatory processes that warrant further detailed investigation.

Future Directions

The current study contributes to the growing body of research that has shown the use of green exercise, as an intervention when either physical or psychological systems have been negatively affected, to be a beneficial factor in recovery (Tsunetsugu et al., 2007; Barton and Pretty, 2010; Thompson Coon et al., 2011; Gladwell et al., 2013). It also adds to the previous research into the mechanisms of green exercise effect by identifying the role of individual and combined senses (Alvarsson et al., 2010; Saadatmand et al., 2013; Aghaie et al., 2014; Rogerson and Barton, 2015; Wooller et al., 2015). We suggest that the use of nature sounds and sights in conjunction with exercise may well promote the recovery of TMD and PSS after a stressor. This could aid in the development of cost-effective stress reducing strategies both in the workplace and personal life. It is important, however, to establish in future studies how long the effects may be sustained, what constitutes the best "stimulus" for stress recovery and who might benefit. Future study designs should also consider the level of connectedness to nature participants have prior to starting the study (Mayer and Frantz, 2004; Capaldi et al., 2014). This would further current understanding of how different individuals may benefit from green exercise participation. Certainly, future green exercise studies should include exploration of the use of virtual reality as it can offer more immersive experiences than currently achieved within current laboratory studies, but still allows control of confounding factors. Multi-sensory and non-sensory elements should be included where possible. Further, green exercise should be conducted in "real" natural spaces, with different duration and types of exposure, e.g., including level of engagement with nature, in a range of different cohorts. Outcome measures should be recorded for over 24 h.

CONCLUSION

Exercise combined with nature, in whole or in part, can facilitate recovery of mood and perceived stress after an acute psychological stressor. The results indicate that exercise with nature sounds, nature visual or exercise with both nature sounds and visual are better for recovery from an acute stressor than rest or exercise alone, as shown by measures taken immediately post intervention and 10-min post intervention. Future work is required to explore the importance and mechanisms of each of the senses during exercise in contributing to improvements in TMD and PSS following a stressor. Overall, these results indicate that, environmental exercise settings which include nature sounds, visual nature or nature sounds with visual nature should be considered when using of exercise as a recovery from acute psychological stress and could be restorative of positive emotions which may help to buffer stress.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of University of Essex ethics committee. The protocol was approved by the Faculty of Science and Engineering ethical committee at the University of Essex. All subjects gave written informed consent in accordance with the Declaration of Helsinki.

AUTHOR CONTRIBUTIONS

JW contributed to the concept, design, data collection, and writing of this research manuscript. MR contributed to the data analysis and writing of this research manuscript. JB contributed to the concept and writing of this research manuscript. DM contributed to the concept, design, data analysis, and writing of this research manuscript. VG contributed to the concept and design and writing of this research manuscript.

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Experiencing Nature through Immersive Virtual Environments: Environmental Perceptions, Physical Engagement, and Affective Responses during a Simulated Nature Walk

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By combining physical activity and exposure to nature, *green exercise* can provide additional health benefits compared to physical activity alone. Immersive Virtual Environments (IVE) have emerged as a potentially valuable supplement to environmental and behavioral research, and might also provide new approaches to green exercise promotion. However, it is unknown to what extent green exercise in IVE can provide psychophysiological responses similar to those experienced in real natural environments. In this study, 26 healthy adults underwent three experimental conditions: nature walk, sitting-IVE, and treadmill-IVE. The nature walk took place on a paved trail along a large river. In the IVE conditions, the participants wore a head-mounted display with headphones reproducing a 360° video and audio of the nature walk, either sitting on a chair or walking on a manually driven treadmill. Measurements included environmental perceptions (presence and perceived environmental restorativeness – PER), physical engagement (walking speed, heart rate, and perceived exertion), and affective responses (enjoyment and affect). Additionally, qualitative information was collected through open-ended questions. The participants rated the IVEs with satisfactory levels of 'being there' and 'sense of reality,' but also reported discomforts such as 'flatness,' 'movement lag' and 'cyber sickness.' With equivalent heart rate and walking speed, participants reported higher perceived exertion in the IVEs than in the nature walk. The nature walk was associated with high enjoyment and enhanced affect. However, despite equivalent ratings of PER in the nature walk and in the IVEs, the latter were perceived as less enjoyable and gave rise to a poorer affect. Presence and PER did not differ between the two IVEs, although in the treadmill-IVE the negative affective responses had slightly smaller magnitude than in the sitting-IVE. In both the IVEs, the negative affective responses were mainly associated with cyber sickness, whereas PER was positively associated with enjoyment. From the qualitative analysis,

it emerged that poor postural control and lack of a holistic sensory experience can also hinder immersion in the IVE. The results indicate that IVE technology might in future be a useful instrument in green exercise research and promotion, but only if image quality and cyber sickness can be addressed.

Keywords: environmental perception, green exercise, physical activity promotion, restorative environments, virtual reality

INTRODUCTION

By combining physical activity and exposure to nature, green exercise can provide several health benefits (Pretty et al., 2003). Studies have, for example, shown that green exercise can provide greater benefits compared to physical activity performed indoors or in an urban setting, which include a reduction in psychophysiological stress and enhanced mental health (Bowler et al., 2010; Thompson Coon et al., 2011). In particular, a meta-analysis (Bowler et al., 2010) showed that green exercise studies consistently found significant reductions in negative emotional states such as fatigue, anger and sadness. Green exercise has also been consistently associated with lower perceived exertion compared to exercising indoors while at the same time inducing people to engage in more vigorous physical activity (Focht, 2009; Calogiuri et al., 2015). This implies that green exercise can increase the likelihood of higher exercise intensities being reached, which in turn can lead to a number of health benefits (Gladwell et al., 2013).

The attention-restoration theory (ART) of Kaplan (1989, 1995) has been used to explain the positive psychological effects of green exercise. ART postulates that some environments can elicit restoration from mental fatigue by triggering a spontaneous (and therefore effortless) form of attention, which is referred to as *fascination*. Some specific features of the natural world such as clouds in the sky or leaves in a breeze are hypothesized to have particular advantages in prompting attention-restoration mechanisms. Moreover, being outdoors in a natural environment can provide a sense of *being away* from everyday problems, thus contributing to restorative experiences. The theory specifies two additional components: *extent* and *compatibility,* the former representing the degree to which an environment is perceived as being coherently ordered and having substantial scope, while the latter represents the degree to which the environment matches a person's inclinations at the time. A number of studies have found that exercising in natural environments has greater potential for restoration compared to indoor (Hug et al., 2009; Calogiuri et al., 2016a) and urban (Bodin and Hartig, 2003; Hartig et al., 2003) environments, while also giving rise to improved cognitive performance (Hartig et al., 1991, 2003), enhanced psychological states (Hartig et al., 1991, 2003; Calogiuri et al., 2015), and reduction of psychophysical stress (Hartig et al., 2003; Aspinall et al., 2015; Calogiuri et al., 2015).

Immersive Virtual Environments (IVEs) consist of synthetic sensory information that provide a surrounding and continuous stream of stimuli, creating the illusory perception of being enclosed within and interacting with a real environment (Loomis et al., 1999; Smith, 2015). IVEs are becoming increasingly popular, especially in the form of head-mounted displays (HMD), a device with a motion sensor that allows a 360° vision of a virtual world while eliminating the visual contact with external reality. The popularity of IVEs and HMDs follows the introduction of relatively affordable technology that not only provides the opportunity to immerse oneself in pre-set IVEs, but also allows the creation of new IVEs using special 360° cameras and freely available and customizable applications. One of the potential advantages of HMD is that they can provide relatively intense immersive experiences. In IVE sciences, immersion is defined as the extent to which a computer-generated environment is "capable of delivering an inclusive, extensive, surrounding, and vivid illusion of reality to the senses of a human participant" (Slater and Wilbur, 1997), and it is commonly evaluated by assessing participants' feelings of presence. The concept of presence, i.e., the subjective feeling of "being in the virtual environment" (Slater and Wilbur, 1997), is therefore a key element in research related to the effectiveness of virtual reality technology, including (but not limited to) its application in the physical activity and exercise sciences (Pasco, 2013).

Green exercise research faces a number of challenges, especially in relation to the extent to which studies can control for possible confounders when comparing indoor and outdoor environments (Lee and Maheswaran, 2011; Rogerson et al., 2016). Different weather conditions and terrains (e.g., a paved trail as opposed to a treadmill), for example, might lead to differences in physical engagement and influence psychophysiological responses. IVEs, however, can engage research participants in highly controlled immersive environmental experiences (Smith, 2015). Furthermore, IVE could, in the future, provide a simple way of integrating experiences of nature into people's everyday lives, as well as supplement rehabilitation and health promotion programs: in an urbanized society, a large number of individuals do not (or cannot) engage in green exercise on a regular basis: recent estimates show that in Norway, for instance, almost half of the population do not engage in any green exercise in a typical week (Calogiuri et al., 2016b), while in the United Kingdom this reaches 80% (White et al., 2016). Yet the application of and research into this technology in relation to environmental or exercise sciences is still in its infancy. In particular it is not clear, in terms of participants' perceptions, to what extent IVE technology can reproduce life-like experiences of green exercise. Research suggests, for example, that watching images or videos of nature can provide a similar, although smaller, burst of positive affect compared with a walk in real nature (Plante et al., 2006; Mayer et al., 2009). Furthermore, positive psychophysiological and cognitive effects have also been demonstrated in a study by Valtchanov

et al. (2010), in which the participants were exposed to a virtual environment constructed as a photo-realistic forest (i.e., a high quality computer-generated representation of a forest). However, to the best of our knowledge, no research has yet investigated how people respond and interact with IVEs that are more encompassing and dynamic, such as watching a first-person 360° video of a nature walk.

Engaging in physical activity while being exposed to virtual nature might provide additional benefits: physical movement might contribute to more positive affective responses as compared with a sedentary exposure to virtual nature, as in fact physical activity alone is known to provide affective benefits (Ekkekakis et al., 2011); having the possibility of moving might also elicit more immersive experiences in the IVE, as this might provide greater engagement with the virtual environment; furthermore, physical movement might prevent discomfort caused by the gap between the movements of virtual self and the movements of the real self. Studies have previously tested experimental conditions in which participants exercised on a treadmill or a stationary bike while watching images or videos of nature displayed on a screen (Pretty et al., 2005; Plante et al., 2006; Akers et al., 2012; White et al., 2015; Yeh et al., 2017). However, despite attempts within the gaming industry to combine HMDs with special ergometers and other devices, how best to combine IVE and physical movement in a controlled research environment remains underexplored. Since the 1990s, using different types of IVE technology, researchers have studied how to integrate physical movement with exposure to IVEs and how IVEs can influence people's physical activity patterns (Slater et al., 1995; Jaffe et al., 2004; Sheik-Nainar and Kaber, 2007; Peruzzi et al., 2016). However, to the best of our knowledge, few of these studies have attempted to combine physical activity with HMDs and none of them has investigated whether the additional component of physical movement can actually elicit feelings of presence or positive psychological states to a greater extent than a sedentary exposure. Besides the interest in understanding the extent to which physical movement can elicit more immersive experiences, it is also important to consider the effects that exercising in IVE conditions might have on the way people move and exercise. Wearing a HDM might, for example, lead participants to walking or exercising at a slower pace than they would normally do in a real natural environment, reducing some of the potential benefits of simulated green exercise experiences. Moreover, because the subjective experience of exercise intensity is often associated with health outcomes as well as motivation for regular exercise (Ekkekakis et al., 2011), it is important to consider people's responses to simulated green exercise in terms of perceived exertion.

The purpose of the current study was to investigate the extent to which commercially available IVE technology used under laboratory conditions can simulate green exercise experience, reproducing similar psychophysiological responses. In addition, we investigated whether physical movement (i.e., walking on a treadmill) could elicit greater engagement with the virtual natural environment, leading to higher positive affective responses compared to sedentary exposure.

MATERIALS AND METHODS

Participants

Participants were recruited among students and employees at the Faculty of Social and Health Sciences at the Inland Norway University of Applied Sciences through announcements on the University's webpage and presentations to students during classes. The inclusion criteria for participation were: (1) age 20–45 years; (2) able to walk for 10 min outdoors and on a treadmill; (3) not being an elite athlete (i.e., individuals currently competing in sports at a national level or above). Initially, 65 individuals responded to the researchers' invitation, 34 of whom met the inclusion criteria and confirmed their intention to participate in the study. Eight individuals dropped-out (i.e., did not attend on the scheduled day of the experiment). Thus, the final sample included 26 participants (14 males, 12 females; age: 26 $\pm$ 8 years; BMI: 23.12 $\pm$ 5.03), all of whom completed the full set of experiments and assessments. All participants were informed in writing about the purpose of the study and associated risks before they provided their written consent. The study was approved by the Norwegian Centre for Research Data and was performed according to the Declaration of Helsinki.

IVE Technology

The IVE was constructed as a 360° video reproducing a nature walk in the exact same location used for the 'outdoor walk' condition; this allowed us to reduce confounders such as different characteristics of the two environments (see section "Design and Procedure"). The video was filmed using a Samsung gear 360 sm-c200 camera 2 days before the beginning of the experimentations. The audio was recorded simultaneously in order to capture sounds such as footsteps, the voices of people passing by and other natural events. The camera was mounted on a modified Yelangu s60t handheld stabilizer. The video was then run through two software stabilizing programs – first in Adobe After Effects CC 2017, Warp Stabilizer VFX and then in Samsung Gear 360 ActionDirector, build 1.0.0.2423, in order to further improve the stability of the images in the post-production phase. Finally, the video was adjusted for being viewed using a 360 VR video in Samsung Gear 360 ActionDirector. The playback was made via Samsung S7, with Android 7.0, mounted on a Samsung Gear VR mask. To reproduce the sounds and minimize external noises, during the experimentation participants wore a Sennheiser HD 201 headset together with the head-mounted display.

Design and Procedure

A schematic overview of the experimental design and data collection process is shown in **Figure 1**. All participants underwent three conditions: (a) a walk outdoors in a natural environment, (b) a sedentary exposure to a IVE video, and (c) a treadmill walk whilst being exposed to the same IVE video (**Figure 2**). Each condition lasted 10 min, as this span was previously shown to provide the largest effects on psychological outcomes in green exercise experiments (Barton and Pretty, 2010). Furthermore, according to the World Health Organization's guidelines, bouts of at least 10 min constitute the

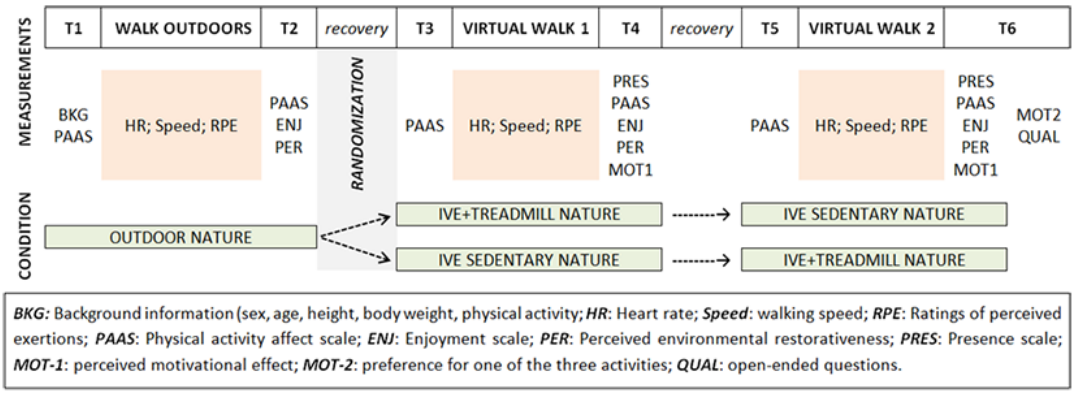

FIGURE 1 | Experimental design and data gathering organization.

FIGURE 2 | Experimental conditions: **(A)** Outdoor (walk in real nature); **(B)** Sitting-IVE (sedentary exposure to virtual walk in nature); **(C)** Treadmill-IVE (virtual walk in nature while walking on a manually activated treadmill). Written informed consent was obtained from the individual for the publication of these images.

minimum unit for health-enhancing physical activity (WHO, 2017). All participants completed the walk outdoors before undergoing the two other conditions, which were administered in a randomized counter-balanced order. Each participant underwent all three conditions on the same day, with a minimum break of 15 min provided between each condition in order for participants to recover from potential discomfort. After such time, participants were asked whether they felt sufficiently recovered and were comfortable to proceed with the experimentation, and additional resting time was provided if required. All experiments took place in the period between May 2nd and 10th 2017, with the IVE video recorded 2 days before the first session. The outdoor weather condition varied from sunny to overcast, with the temperature ranging between 7 and 17°C. The weather during the filming was sunny with a gentle breeze, which could be heard at times in the playback. The temperature in the laboratory was kept constant at 21°C.

The outdoor walk took place on a fairly straight paved trail along a large river in proximity to the university, where the IVE conditions were administered in the laboratory. The environment

also included some built elements, such as buildings and a football field. The participants met the researchers in a building by the trail and were individually accompanied by one of the researchers to the starting point of the walk. The participants were equipped with a wristwatch with a heart rate monitor and GPS (Garmin, Forerunner 310XT), which had an alarm set-up for ringing after 5 min. They were instructed to walk at a comfortable pace on the trail until the alarm rang, at which point they turned around and walked back to the starting point. At completion of the outdoor walk, the participants were accompanied to the laboratory. In the treadmill condition, the participants walked on a manually driven treadmill (Woodway, Curve) equipped with a structure for the participants to hold on to by placing their hands in front of them. Unlike engine-driven treadmills, manually driven treadmills are activated by a person moving their feet while walking, similar to what happens when walking over ground. In this way, the participants could control their pace in a spontaneous manner. All participants underwent a short trial of walking on the treadmill before starting the IVE condition. In the sitting condition, the participants sat on a chair, in a separate room within the laboratory.

TABLE 1 | Items used to assess presence in participants who underwent an IVE-based 'nature walk'[a].

Short name	Item
Being there	In the computer generated world I had the sense of 'being there'
Realism	I thought of the virtual environment as equal to the real environment
Sense of reality	The virtual world became more real or present to me compared to the real world. NB: by 'real world' we mean the room where you were undergoing the test
Awareness	During the 'virtual walk,' I often thought of the other person(s) in the room with me
Other persons	It would have been more enjoyable to engage with the 'virtual world' with no-one else in the room
External noises	Whilst I was doing the 'virtual walk,' I paid much attention to other noises around me in the room
Flatness	The virtual world appeared flat and missing in depth
Movement lag	The lag or delay between my movements and the moving in the 'virtual walk' were disturbing
Cyber sickness	During the 'virtual walk' I got dizzy

[a]*Each participant was exposed to the same IVE-based 'nature walks,' once while they sat on a chair and once while they walked on a manual treadmill.*

Instruments

Environmental Perceptions

Perceived environmental restorativeness was measured after completion of each condition using two subscales of the Perceived Restorativeness Scale (Hartig et al., 1997): 'fascination' (five items) and 'being away' (two items). The components 'extent' and 'compatibility' were not used, as preliminary testing suggested that these two items were not applicable to the IVE conditions and might have led to inaccurate assessments. Each item was rated on an 11-point Likert scale (0 = absolutely disagree, 10 = absolutely agree). When these questions were administered after the IVE conditions, a caption explicitly indicated "The following questions relate to the virtual environment." The scale showed, in general, adequate internal consistency for 'fascination' (α = 0.85–0.92), though poorer internal consistency was detected for the component 'being away' (α = 0.56–0.87). Additionally, eight items were used to assess the participants' feeling of presence after the two IVE conditions. Seven of these items were adapted from those used by Nichols et al. (2000), while an additional item was included that related to the extent to which participants experienced cyber sickness (**Table 1**). The items were formulated as statements, each participant being asked to rate the extent to which they agreed with each of them on an 11-point Likert scale (0 = absolutely disagree, 10 = absolutely agree).

Physical Engagement

Heart rate (HR) was continuously measured during all experimental conditions using a HR-monitor (Garmin, Forerunner 310XT), while ratings of perceived exertion (RPE) were measured immediately after completing each experimental condition using a Borg scale in a 20-point version (Borg, 1982). The walking speed was also recorded using the Garmin GPS and the treadmill computer in the outdoor and treadmill conditions, respectively.

Affective Responses

Enjoyment was measured after each experimental condition using a single item question: "On a scale from 0 to 10, how enjoyable is the activity you have engaged in?" Participants gave their answer on a numbered line (0 = not enjoyable at all; 10 = absolutely enjoyable). Additionally, participants' affective responses were assessed by administering the Physical Activity Affect Scale (PAAS) (Lox et al., 2000) immediately before and immediately after undergoing each experimental condition. The PAAS consists of 12 items corresponding to different emotions (e.g., "energetic," "calm," "miserable," and "tired") and placed them within four quadrants, in line with Russell's circumplex model of affect and arousal (Russell, 1980): positive affect, tranquility, negative affect, and fatigue. Each item was measured on a 5-point rating scale (0 = strongly disagree; 4 = strongly agree). Reliability analysis, showed reasonably adequate internal consistency for most assessments (α = 0.64–0.86), though somewhat poor levels of internal consistency were detected for negative affect in the pre-condition assessments (α = 0.46–0.52).

Qualitative Data

As little is known about how people respond to virtual experiences of nature, especially in relation to the technology used in this particular study, qualitative information was collected using a series of open-ended questions, which were presented to the participants after completion of all three conditions and quantitative measurements. Such questions, to which the participants responded in written form, were inspired by the structure of the quantitative assessments: a question was developed for each of the quantitative variables in order to explore the meaning behind participants' responses in more detail, for example: "*In the questionnaire, you were asked to report the extent to which you felt the environments were 'fascinating' and gave you feelings of 'being away.' Could you say how well (or how*

poorly) did the IVE video reproduce such characteristics, compared with the outdoor/real environment?" and "*When you answered the question about how 'enjoyable' the activity was, what determined where in the scale you put your mark? Please, describe the feelings you experienced in all three conditions separately.*"

Analyses

Data were first explored for distribution, possible outliers and missing values. A one-way repeated measurements analysis of variance (ANOVA) was used to establish possible effects of 'condition' (i.e., outdoor, sitting, and treadmill) for the different study variables. For the PAAS components, a factorial (two-way) repeated ANOVA was used to investigate possible pre-post changes in interaction with the experimental conditions. If significance was achieved in the within-subjects test, a *post hoc* analysis with Bonferroni's adjustment of alpha was applied in order to examine possible differences across the individual conditions. Additionally, Spearman's rank correlation coefficient (ρ) was used to examine possible associations among all study variables. The PAAS components were run into the correlation analysis in form of *delta* values (i.e., the difference between post-values and pre-values). All statistical analyses was carried out using IMB Statistics SPSS version 21 (IBM Corp., New York). Significance was set at $p < 0.05$.

The qualitative data were analyzed in accordance with the 'framework approach' (Gale et al., 2013), which provides clear steps for summarizing qualitative data in a way that sheds light on the participants' responses to the quantitative questions. The method is systematic and transparent and provides a clear trail from raw data to thematic codes and quotations. These aspects of the method contribute toward evaluating the trustworthiness of the analysis. In addition, the process allows for the inclusion of more than one researcher at various points to discuss the emerging framework of codes, categories and themes. In this study, discussion took place between three members of the team in order to arrive at a more refined version of comments. Initially, a coding frame relating to the different overarching domains of the questionnaire was used (i.e., presence, perceived environmental restorativeness, physical engagement, and affective responses). Reiterative reading and recoding of the data led to refinement of the coding frame and the development of overarching themes.

RESULTS

Presence and Perceived Environmental Restorativeness

No significant difference among the three conditions was found for the two components of perceived environmental restorativeness, 'fascination' [$F(2,22) = 2,89$; $p = 0.076$] and 'being away' [$F(2,22) = 2.41$; $p = 0.112$]. In relation to the feelings of presence assessed in concomitance with the IVE conditions, the participants reported high ratings of 'flatness' medium-high ratings of 'being there' and 'sense of reality,' low levels of realism as well as low levels for the items depicting external disturbances such as 'awareness,' 'other persons,' and 'noises.' Furthermore, the participants reported quite high ratings of 'movement lag' and especially 'cyber sickness' (**Figure 3**). The ANOVA showed no significant difference between the sitting and the treadmill condition for all the presence domains, apart from 'noises' [$F(2,24) = 11.60$; $p = 0.002$], which had significantly higher ratings in the treadmill condition compared with the sitting condition.

Significant correlations were found among the different domains of perceived environmental restorativeness and presence, though different patterns of association emerged in the sitting and the treadmill conditions (**Table 2**). 'Fascination' and 'being away' were highly correlated with each other in both the sitting and the treadmill conditions. 'Fascination' was positively associated with 'being there' and 'realism' in both the sitting and the treadmill conditions, whereas it was positively associated with 'sense of reality' and negatively associated with 'awareness' only in the treadmill condition. 'Being away' was positively associated with 'realism' in both, the sitting and the treadmill conditions, while it was associated with 'being there' only in the sitting condition and with 'sense of reality' and 'other persons' only in the treadmill condition. Moreover, in the sitting condition, 'being there' was positively correlated with 'realism' and 'sense of reality,' while 'awareness' was positively correlated with 'noises.' In the treadmill condition, 'being there' was negatively correlated with 'awareness' and 'movement lag,' 'movement lag' was positively correlated with 'flatness' and 'cyber sickness,' and 'flatness' and 'cyber sickness' were positively correlated with each other.

The qualitative data supported the quantitative results, showing that a number of factors could disrupt the sense of presence: the noise of the treadmill ($n = 9$; e.g., "*The noise from the treadmill was way too loud*"), the lag between the pace of the individual and the pace in the IVE video ($n = 13$; e.g., "*The discrepancy in the movements gave me a feeling of not having control*"), cyber sickness or other physical discomforts ($n = 19$; e.g., "*It made me dizzy and sick*"), and the poor quality of the imaging ($n = 21$; e.g., "*The video was very blurry*"). The poor quality of the video was especially related by several participants with other elements of presence, such as cyber sickness ($n = 4$; e.g., "*The poor quality of the video made me [feel] sick*"), a feeling of (not) 'being there' ($n = 6$; e.g., "*The poor quality of the video made it less real*"), and to a certain extent the perceived environmental restorativeness ($n = 1$; e.g., "*The [settings in the] IVE were fascinating, but the poor quality of the video reduced their potential*"). It also emerged that because the IVE conditions only provided visual and auditory cues, it tended to reduce the achievement of a comparative outdoor nature experience ($n = 5$; e.g., "*Air, smell, vision. [In the IVE conditions] I felt deprived of the elements of nature and senses*"). The additional element of movement (treadmill condition) did not appear to have helped people feel more engaged with the natural environment, although in some cases it elicited greater feelings of 'being there' ($n = 2$; e.g., "*[In the treadmill condition] you could really feel that you were in that place because you can move while you are watching the video*"). On the other hand, the element of movement did not seem to provide a consistent protection from experiencing cyber sickness; in fact, only four participants reported they felt less sick

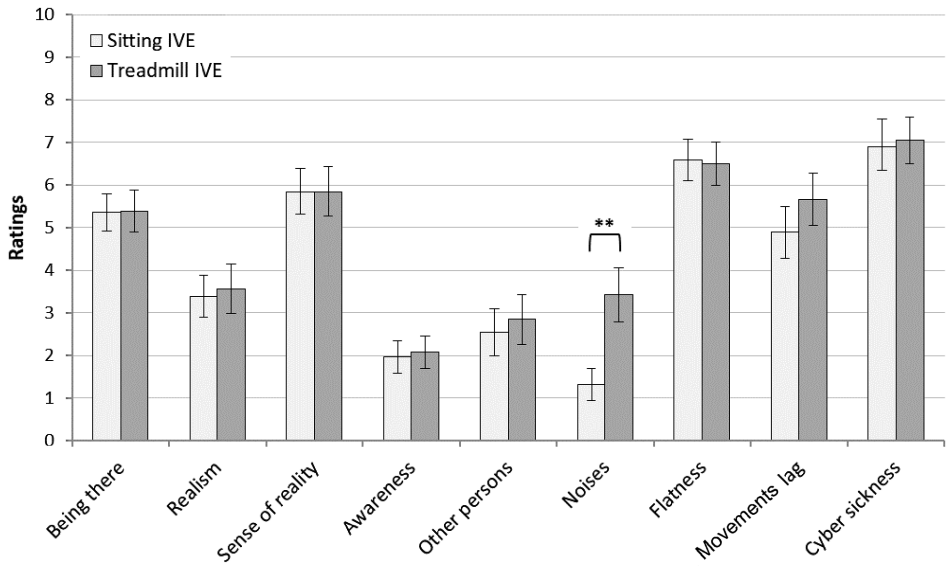

FIGURE 3 | Ratings of *presence* in a 'sitting-IVE' condition and a 'treadmill-IVE' condition (M ± SE; n = 26, repeated measurements). **$p < 0.001$ in a *post hoc* comparison of sitting vs. treadmill.

in the treadmill condition than in the sitting condition, while two reported the opposite, and the remaining reported that they felt sick in "both IVE conditions" ($n = 13$).

Physical Engagement

Significant differences across conditions for HR mean [$F(2,24) = 70.84$; $p < 0.001$] and HR max [$F(2,24) = 71.71$; $p < 0.001$] were found. The pairwise comparison found a significant difference when comparing the outdoor condition with the sitting condition ($p < 0.001$ for both variables), but not with the treadmill condition. Significant differences were also found when comparing the two IVE conditions with each other, with higher HR values in the treadmill condition as compared with the sitting ($p < 0.001$ for both variables; **Figure 4**). There were no differences in speed [min/km; $F(1,25) = 3.52$; $p = 0.072$] when comparing the outdoor and the treadmill condition. On the other hand, a significant effect across conditions was found for RPE [$F(2,23) = 17.84$; $p < 0.001$], with higher RPE values in the treadmill condition compared with both the outdoor ($p < 0.001$) and the sitting condition ($p = 0.003$), while no significant difference was found between the outdoor and the sitting condition (**Figure 4**). As shown in **Table 3**, both HR mean and HR max were positively associated with 'movement lag' in the sitting condition, while in the treadmill condition, RPE and HR mean were positively correlated with 'cyber sickness.'

From the qualitative data it emerged that the possibility of walking while being exposed to the IVE provided a 'sense of liberation' which made the participants feel less passive and more engaged with the virtual experience ($n = 8$; e.g., *"[In the treadmill condition] it was much better because I could move"*; *"[The sitting condition was] challenging and stressful as you can't move*"). On the other hand, some participants reported physical discomforts due to poor postural control during the treadmill condition ($n = 4$; e.g., "*[The treadmill condition] was very stressful and tiring because I had to hold on to the handlebar very hard*").

Affective Responses

Table 4 shows descriptive statistics for the affective responses, alongside the outcomes of the ANOVA and *post hoc* analysis. The ANOVA found significant differences across conditions for enjoyment, with a *post hoc* analysis showing that compared with the outdoor walk participants reported significantly less enjoyment in both the sitting and the treadmill conditions. The ANOVA also showed a significant interaction of 'pre-post' by 'condition' for positive affect, negative affect, and fatigue, whereas the interaction was not significant for tranquility. The affect profile assessed before the nature walk showed that the participants reported low ratings of negative affect, fatigue, and positive affect, whereas higher ratings were recorded for tranquility. A *post hoc* analysis applying a Bonferroni's correction of alpha showed an improvement of the affect profile after completing the outdoor walk, with a significant reduction of the ratings of negative affect and fatigue. In contrast, the profile of affect worsened after both IVE conditions, with a slightly larger magnitude in the sitting condition: the ratings for positive affect and tranquility reduced (change significant in both conditions), whereas the ratings of negative affect and fatigue increased (change significant only in the sitting condition). A *post hoc* comparison on delta values across the different conditions showed a significant difference between the outdoor walk and both the IVE conditions for all PAAS components, whereas when comparing the two IVE conditions with each other, it was found that the reduction in positive affect was significantly larger in the sitting than in the treadmill condition.

As shown in **Table 3**, 'cyber sickness' was consistently associated with negative affective responses: 'cyber sickness'

TABLE 2 | Spearman's correlation among different domains of environmental perceptions in participants exposed to an IVE video while sitting on a chair and while walking on a manually driven treadmill (M ± SE; $n = 26$, repeated measurements).

Sitting IVE	Fascination	Being away	Being there	Realism	Sense of reality	Awareness	Other persons	Noises	Flatness	Movement lag
Being away	0.76**									
Being there	0.70**	0.72**								
Realism	0.71**	0.44*	0.66**							
Sense of reality	0.19	0.19	0.43*	0.15						
Awareness	−0.09	0.04	−0.07	0.14	0.18					
Other persons	0.34	0.32	0.14	0.23	0.21	0.38				
Noises	−0.10	0.03	−0.21	0.11	0.04	0.73**	0.38			
Flatness	0.18	0.13	0.06	0.18	−0.17	0.25	0.14	0.15		
Movement lag	−0.19	0.02	−0.36	−0.30	0.04	0.18	0.32	0.22	0.16	
Cyber sickness	−0.20	−0.36	−0.06	−0.13	0.17	0.00	0.07	−0.32	0.20	0.11
Treadmill IVE	**Fascination**	**Being away**	**Being there**	**Realism**	**Sense of reality**	**Awareness**	**Other persons**	**Noises**	**Flatness**	**Movement lag**
Being away	0.73**									
Being there	0.54**	0.38								
Realism	0.51**	0.39*	0.37							
Sense of reality	0.41*	0.59**	0.37	0.31						
Awareness	−0.39*	−0.25	−0.39*	−0.27	0.07					
Other persons	0.14	0.41*	−0.11	0.18	0.35	0.28				
Noises	−0.04	0.05	−0.38	0.09	−0.13	0.38	0.27			
Flatness	0.02	0.02	−0.30	−0.04	−0.14	0.18	0.00	0.24		
Movement lag	−0.19	−0.22	−0.43*	−0.18	−0.01	0.17	0.26	−0.09	0.39*	
Cyber sickness	−0.07	−0.10	−0.29	0.00	−0.16	0.24	0.00	0.12	0.44*	0.47*

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

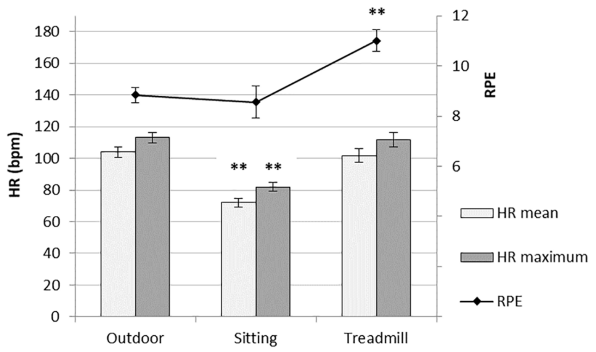

FIGURE 4 | Heart rate (mean and maximum) and Ratings of perceived exertion (RPE) in a walk outdoors, a 'sitting-IVE' condition, and a 'treadmill-IVE' condition (M ± SE; n = 26, repeated measurements). $^{**}p < 0.001$ in a *post hoc* comparison of the sitting or treadmill conditions with the outdoor condition, applying Bonferroni's adjustment of alpha.

was negatively correlated with enjoyment, positive affect, and tranquility, whereas it was positively correlated with negative affect and fatigue (the latter only in the treadmill condition). Significant correlations were found also between different psychological variables and 'being there,' 'realism,' 'sense of reality,' and 'fascination,' though with different patterns of association for the sitting and the treadmill condition (**Table 3**).

The different emotional responses experienced in the outdoor walk and the IVE conditions were also found in the qualitative data. For example, participants expressed positive emotions such as feeling "relaxed" and "happy" ($n = 13$) during the outdoor condition, whereas negative emotions such as feeling "stressed" and "tired" were expressed ($n = 10$) in relation to the IVE conditions. Furthermore, the IVE conditions were viewed as "boring" ($n = 4$), compared to "fun" ($n = 1$) and "great/amazing" ($n = 2$) for their experience outdoors. Furthermore, some participants made reference to the physical reactions experienced during the IVE conditions, especially cyber sickness, which was viewed as having had a strong influence on their affective experience (e.g., "*How I felt during the IVE condition – sick and dizzy – [determined my level of enjoyment]*"). Some participants reported, however, that the novelty of trying the IVE technology by itself provided some degree of enjoyment ($n = 3$; e.g., "*Just the fact that you are using virtual reality [made it enjoyable]*"). Only two participants reported that the element of movement in the treadmill conditions elicited more positive affective responses (e.g., "*The sitting IVE was boring . . . Moving while the video was playing [made it more enjoyable]*").

DISCUSSION

Our findings support, in part, the findings of previous studies showing that green exercise experiences in real natural environments, even in brief bouts (i.e., a 10-min walk), can lead to enhanced psychological states (Barton and Pretty, 2010; Bowler et al., 2010; Thompson Coon et al., 2011). We found in fact that the walk in real nature was associated with an enhanced profile of the participants' emotional state, specifically in relation to a reduction of fatigue and negative affect, alongside high ratings of enjoyment. On the other hand, despite the participants reporting levels of perceived environmental restorativeness ('fascination' and 'being away') and physical engagement equivalent to those experienced in the real nature walk, alongside reasonably high levels of some aspects of presence (e.g., 'being there' and 'sense of reality'), unlike the walk in real nature the IVEs led to *negative* affective responses. These latter findings differ from those of previous studies that have used *non-immersive* virtual nature in combination with physical activity, i.e., walking on a treadmill or cycling on a stationary bike whilst watching images or videos of nature projected on a screen (Pretty et al., 2005; Plante et al., 2006; Akers et al., 2012; White et al., 2015; Yeh et al., 2017). These studies found in fact that virtual nature can provide psychophysiological benefits such as improvement of affect states and restoration of mental fatigue. However, such benefits are not as large as those that can be obtained in real natural environments, as shown in studies that had participants visiting a real natural environment and/or viewing a video of the same nature (Plante et al., 2006; Mayer et al., 2009; Olafsdottir et al., 2017). Our findings also differ from those found by Valtchanov et al. (2010), which showed restorative effects in subjects who were exposed to an IVE using a HDM. It is, however, important to note some fundamental differences between our study and that of Valtchanov et al. (2010), which are likely to have played a role in the different outcomes of the two studies, especially resulting in our participants being more exposed to risk of incurring in cyber sickness: first, in the Valtchanov et al. (2010) study the participants sat at a computer station and controlled their movements using a mouse, whereas our participants were 'passive' observers of a first-person video; secondly, in the Valtchanov et al. (2010) study the HDM used allowed only a 65° vision, therefore not engaging the participants' *peripheral* vision.

The negative affective responses that emerged in our study seem to be mainly associated with participants' experience with IVE being commonly disrupted by the occurrence of cyber sickness. Cyber sickness is known to be a common problem with current IVE technology (Nichols et al., 2000), and a number of theories have been proposed to explain why it occurs. In spite of this, to date little is known about how to prevent it. Two of the most well-known theories on cyber sickness are the *sensory conflict theory*, which suggests cyber sickness is mainly caused by conflicting signals received by the visual and vestibular systems, and the *postural instability theory*, which states that long periods without postural control will cause cyber sickness (LaViola, 2000). In the present study, some participants reported that they struggled to maintain postural control during the treadmill condition, suggesting that postural control might indeed have contributed to the development of cyber sickness in some participants. However, triangulation of the qualitative and quantitative data revealed that those participants who reported challenges in maintaining postural control on the treadmill did not consistently report higher ratings of cyber sickness in the treadmill condition, and in all but one case, the ratings were *lower* than in the sitting condition. On the other hand, during the

TABLE 3 | Spearman's correlation of the different domains of presence and perceived environmental restorativeness with affective responses and physical engagement in participants exposed to an IVE video while sitting on a chair and while walking on a manual treadmill (M ± SE; $n = 26$, repeated measurements).

Sitting IVE	Fascination	Being away	Being there	Realism	Sense of reality	Awareness	Other persons	Noises	Flatness	Movement lag	Cyber sickness
HR mean	0.20	0.31	−0.02	−0.24	−0.03	−0.02	0.23	−0.03	0.24	0.45*	0.13
HR max	0.16	0.29	−0.00	−0.23	0.03	0.02	0.21	−0.07	0.40*	0.50**	0.23
RPE	−0.29	−0.44*	−0.10	−0.37	0.13	−0.15	−0.01	−0.33	−0.38	−0.11	0.38
Enjoyment	0.47*	0.46**	0.38	0.36	−0.10	0.03	0.02	0.18	−0.08	−0.24	−0.79**
Pos. affect (delta)	−0.09	0.09	−0.17	−0.16	−0.31	0.03	−0.01	0.19	−0.24	−0.15	−0.73**
Tranquility (delta)	0.18	0.29	0.10	0.46*	−0.34	0.20	0.05	0.45*	0.21	−0.15	−0.60**
Neg. affect (delta)	0.00	−0.12	0.07	0.11	0.25	−0.05	0.08	−0.20	−0.02	0.08	0.77**
Fatigue (delta)	0.39*	0.33	0.34	0.44*	0.02	0.10	0.27	0.10	0.20	0.04	0.05
Treadmill IVE	**Fascination**	**Being away**	**Being there**	**Realism**	**Sense of reality**	**Awareness**	**Other persons**	**Noises**	**Flatness**	**Movement lag**	**Cyber sickness**
Speed	0.07	0.06	0.37	−0.22	0.08	−0.13	−0.05	−0.18	−0.20	−0.35	−0.33
HR mean	0.08	−0.07	−0.18	0.07	0.16	0.29	0.21	0.28	0.11	0.30	0.40*
HR max	0.07	−0.07	−0.24	0.06	0.09	0.29	0.23	0.36	0.11	0.28	0.36
RPE	−0.16	−0.10	−0.05	0.17	−0.01	0.32	0.06	0.15	−0.08	0.16	0.41*
Enjoyment	0.54**	0.40*	0.80**	0.26	0.42*	−0.17	0.04	−0.23	−0.34	−0.62**	−0.52**
Pos. affect (delta)	0.14	0.14	0.02	0.19	0.09	−0.55**	−0.06	0.02	−0.16	−0.26	−0.56**
Tranquility (delta)	0.03	0.10	−0.08	0.01	−0.12	−0.51**	−0.17	−0.13	−0.17	−0.16	−0.52**
Neg. affect (delta)	0.25	0.32	−0.12	0.18	0.21	0.22	0.30	0.13	0.15	0.24	0.65**
Fatigue (delta)	−0.02	−0.10	0.05	−0.29	−0.11	0.26	0.06	0.00	−0.03	0.12	0.43*

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed). HR = Heart rate; RPE = Ratings of perceived exertion.

study it was noted that the participants who reported the highest levels of cyber sickness developed it very quickly after starting the IVE sessions. Again, triangulating the quantitative and qualitative data also revealed that, consistent with the sensory conflict theory, complaints of movement lag and flatness (i.e., poor quality of the imaging, including blurriness and lack of depth) were commonly associated with higher ratings of cyber sickness. This might also explain why the element of physical movement (treadmill condition) was unable to attenuate cyber sickness: in this condition, the participants still struggled with movement lag and flatness, which might have triggered a conflict between visual input and the vestibular system. It should be noted, however, that it is likely that inter-individual differences exist in why and how a person develops cyber sickness, and therefore different theories may be applicable to different individuals under diverse conditions (LaViola, 2000).

Our findings show that movement lag and, in particular, cyber sickness, also emerged as factors influencing the participants' affective responses, the latter being an important component underpinning green exercise behaviors as well as possibly mediating various health outcomes (Calogiuri and Chroni, 2014). Thus, this issue has important implications for studying the effectiveness of IVE technology in green exercise research. In a recent study, Kokkinara et al. (2016) demonstrated that watching a first-person IVE video of someone walking can create an illusory sense of agency (i.e., the subjective awareness of initiating, executing, and controlling an action), inducing a person to perceive that the movement is initiated by him or herself. It seems, however, that the discrepancy between a person's movements (or lack of movement, as in our sitting condition) and movements observed in the video can nevertheless result in uncomfortable, or even "frustrating" (as some participants defined it), conflicts between the 'real self' and the 'virtual self.' Cyber sickness had an even more dramatic impact on participants' psychophysiological responses, and was consistently associated with less enjoyment, reduced tranquility and positive affect, increased fatigue and negative affect, and (in the treadmill condition) higher HR and perceived exertion. The latter was especially surprising. Previous research shows that individuals tend to report higher RPE when walking/running on a treadmill as compared with walking/running outdoors (Harte and Eifert, 1995; Focht, 2009; Calogiuri et al., 2015). In the present study, it was hypothesized that being exposed to the IVE video whilst walking on the treadmill would have mitigated this effect by causing an 'attentional shift' from internal feelings of effort toward the virtual environment, which previous research suggests to be the reason for reporting lower RPE when engaging in green exercise as compared with indoor exercise (Harte and Eifert, 1995). The results, however, did not support this expectation. The higher perceived exertion might be linked to cyber sickness, but also the increased feelings of fatigue or the poor postural control that some participants experienced. The latter factor might, especially, have caused the participants to retain the attention focus toward internal feelings (e.g., keeping the balance of controlling the movements), therefore hindering the shift of focus towards the environment. More research is, however, needed in this field to better understand the reasons that underlie such phenomenon.

Despite the impact of cyber sickness and the different psychophysiological responses observed, our findings suggest some important lines of enquiry for future research and application in this area. In particular, we found that the IVE-related ratings of perceived environmental restorativeness (i.e., the extent to which the participants perceived the virtual environment as fascinating and providing the opportunity to experience 'being away') were quite consistently associated with

TABLE 4 | Affective responses to a walk outdoors in a real natural environment and two virtual nature walks (M ± SD; $n = 26$).

	Outdoor walk	Sitting IVE	Treadmill IVE	Pre vs. Post	Condition	Interaction
Enjoyment	7.69 ± 1.78	3.00 ± 2.59[a]	3.96 ± 2.32[a]	–	$F(2,24) = 29.93$**	–
Positive affect						
Pre	0.68 ± 0.16	0.62 ± 0.25[b]	0.57 ± 0.24[b]	$F(1,25) = 25.304$**	$F(2,50) = 20.232$**	$F(2,50) = 14.836$**
Post	0.70 ± 0.19	0.43 ± 0.25	0.49 ± 0.22			
Delta	0.02 ± 0.10	−0.19 ± 0.17[ac]	−0.08 ± 0.15[ac]			
Tranquility						
Pre	2.82 ± 0.91	2.59 ± 0.80[b]	2.54 ± 0.84[b]	$F(1,25) = 20.346$**	$F(2,50) = 14.114$**	$F(2,50) = 6.550$
Post	2.83 ± 0.75	2.03 ± 1.06	1.99 ± 0.89			
Delta	0.01 ± 0.67	−0.56 ± 0.69[a]	−0.55 ± 0.67[a]			
Negative affect						
Pre	0.32 ± 0.41[b]	0.29 ± 0.50[b]	0.28 ± 0.40	$F(1,25) = 8.824$	$F(2,50) = 5.430$*	$F(2,50) = 12.335$**
Post	0.18 ± 0.33	0.87 ± 1.01	0.58 ± 0.84			
Delta	−0.14 ± 0.21	0.58 ± 0.69[a]	0.29 ± 0.74[a]			
Fatigue						
Pre	0.86 ± 0.69[b]	0.76 ± 0.63[b]	0.69 ± 0.65	$F(1,25) = 2.345$	$F(2,50) = 2.117$	$F(2,50) = 12.106$**
Post	0.55 ± 0.55	1.15 ± 0.87	1.00 ± 0.81			
Delta	−0.31 ± 0.56	0.40 ± 0.63[a]	0.31 ± 0.71[a]			

*$p < 0.05$; **$p < 0.001$. [a]*Significant post hoc comparison with the outdoor walk, applying a Bonferroni's adjustment of alpha.* [b]*Significant post hoc pre-post comparison, applying a Bonferroni's adjustment of alpha.* [c]*Significant post hoc comparison between the two IVE conditions, applying a Bonferroni's adjustment of alpha.*

the rating of enjoyment the participants assigned to the IVE experiences. Perceived environmental restorativeness has been found to correlate with ratings of enjoyment during green exercise in real natural environments (Calogiuri et al., 2015). Thus, this finding suggests that in future studies it could be possible to elicit greater enjoyment by producing IVE videos showing natural environments with higher restorative value, as compared with the environment used in this particular study. Furthermore, it is likely that, in the relatively near future, technological developments will allow access to HMDs with higher resolution, which might also limit the occurrence of cyber sickness, and its consequent impact on affective responses.

Strengths and Limitations of the Study

The strength of our study is primarily ascribed to its novelty: to the best of our knowledge, this study is one of few using a HMD in combination with physical activity (i.e., walking on a treadmill), and the very first using such technology to simulate green exercise experiences. The within-subjects experimental design, with two different IVE conditions administered in counter-balanced order preceded by exposure to a corresponding real environment, also represents a strength of our study. Our design might, however, have led to some confounding effects: first, due to the large number of comparisons, we had to apply a restrictive significance level (i.e., Bonferroni's adjustment), which is likely to have increased the probability of incurring type-II errors; second, varying weather conditions might have influenced the participants' experience of the outdoor condition and, relatedly, the psychological outcomes. Most importantly, because the technology used in this study is quite novel, specific equipment that would have helped produce a more stable video was not available. We had to adapt a generic handheld stabilizer, but this was not optimal for a 360° camera, which is very light and symmetrical in shape: additional weights had to be added to the stabilizer, and we had to find solutions to avoid it rotating on its own axis. Furthermore, the program used to improve the stabilization of the video in post-production was at an early stage of development. The development of second-generation technology that will better address these challenges will increase possibilities in this field and might produce different findings.

CONCLUSION

Using commercially available IVE technology, we were unable to reproduce psychophysiological responses similar to those experienced during green exercise in a real natural environment. The main factors hindering positive psychophysiological responses during IVE-based green exercise were the occurrence of cyber sickness, the poor image quality, and the lack of a holistic engagement with the natural environment. The additional element of physical movement (i.e., walking on a treadmill) provided only limited benefit compared with the sedentary exposure to the virtual nature walk. IVE technology might in future be a useful instrument in green exercise research and promotion, but only if image quality and cyber sickness can be addressed. IVEs reproducing environments with higher restorative value might also contribute to more positive affective responses during IVE-based green exercise.

AUTHOR CONTRIBUTIONS

GC was the primary person responsible for the conception of the study and drafted the manuscript. SL and TR participated in the conception of the study, and provided major contributions in the conception of the experimental protocol and creation of the IVEs, respectively. KF and EB provided relevant administrative support, including carrying out the literature review, recruiting and maintaining contacts with the participants, and conducting the data analyses. GC, SL, KF, and EB also carried out the experimentations and data collection. MT provided substantial contributions to revision of the intellectual content and development of the qualitative analysis. All authors contributed to the writing up of the manuscript and have given approval to its final version.

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