Received: 4 May 2023 | Accepted: 18 January 2024

DOI: 10.1002/pan3.10639

PEOPLE AND NATURE | BRITISH ECOLOGICAL SOCIETY

RESEARCH ARTICLE

Exploring autonomous and controlled motivations for nature contact to maximise health benefits

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Funding information
Horizon Europe, Grant/Award Number: 101081420; Australian Government Department of Health and Aged Care, Medical Research Futures Fund, Grant/Award Number: GNT2023914; National Health and Medical Research Council, Grant/Award Number: GNT1192691; Australian Research Council, Grant/Award Number: FT220100857

Handling Editor: Ricardo Correia

Abstract

1. Increasing evidence indicates contact with nature supports mental, physical and social health. However, beyond a widely reported number of barriers to nature contact, the constellation of motivations for human contact with nature is under-theorised and under-studied.
2. We begin to develop indicators of autonomous and controlled motivations for nature contact informed by self-determination theory. These include intrinsic motivation (i.e. enjoyment), integrated regulation (alignment with identify and life goals), identified regulation (a means to an end), introjected regulation (emotional reasons like guilt avoidance) and external regulation (such as peer pressure). We compare these motivation indices in a nationally representative sample of 5082 adults in Australia in 2022 with the Nature Relatedness Scale (NR6), and also test associations between them and five outcomes: time spent in nature, smartphone use in nature, interest in nature prescriptions, physical activity and self-rated health. Statistical analyses were adjusted for potential confounding.
3. Results demonstrate people have complex mixtures of motivations with varying potency for visiting natural settings and the extent to which those motives are autonomous or controlled matters for what they do, and the benefits accrued. For example, our analyses show that more direct considerations of intrinsic, integrated and identified forms of autonomous motivation have superior explanatory power than the NR6 for time spent in nature, interest in nature prescriptions, adherence to physical activity recommendations and self-rated health.
4. External regulations emphasising peer approval were associated not only with no additional time in nature but also with more distractive activities when in natural environments, as defined by more smartphone and social media use while there. While introjected regulations emphasising guilt avoidance were associated

with increased nature contact, they were similarly associated with time spent on smartphones and social media when in natural environments, which has been shown to undermine restoration.

5. Synthesis and applications: We need to formally measure autonomous and controlled motivations for nature contact to better understand both why some people visit natural environments, and whether they are mindfully maximising the health benefits of those experiences. This will help to inform robust nature-based interventions that are acceptable, effective and sustainable for everyone.

KEYWORDS
green space, health, motivation, self-determination, smartphones, social media, well-being

1 | INTRODUCTION

Prevention and management of non-communicable diseases (NCDs) is hindered by low adherence to physical activity and other behavioural interventions that would otherwise promote both mental and physical health, because they are often perceived as complex, onerous and disruptive (Escolar-Reina et al., 2010). This is compounded by local environmental conditions that discourage positive behavioural changes in many ways (Sallis et al., 2012). Connecting people with places that support the integration of physical activity and other health promotion strategies is key to enhancing sustained improvements in physical fitness and permitting restoration from stressful demands of daily routines.

People in greener places tend to be more physically active (Astell-Burt et al., 2014; Feng et al., 2021; Giles-Corti et al., 2005; Remme et al., 2021; White et al., 2018). This evidence has influenced both urban planning (e.g. Sydney, Australia; City Of Sydney, 2021) and practitioner advocacy (e.g. 3–30–300 rule; Konijnendijk, 2022) to 'green' cities around the world. Complementing ambitions to increase and equalise green space access is the idea of (re)connecting people with natural environments via 'social prescription' mechanisms where health and social care professionals recommend patients and clients engage in activities such as community gardening as adjunct practices to routine medical care. Recent work shows that such nature-based social prescribing receives strong interest among people with high potential to benefit (Astell-Burt, Hipp, et al., 2023) and is also viewed as increasingly compelling by many health and social work professionals on the frontline of managing NCDs (Astell-Burt, Pappas, et al., 2022; Sherman et al., 2021; Tambyah et al., 2022). Promisingly, early evidence indicates that interventions which enable nature contact in persons who have previously had little may help to sustain regular walking and to improve mental, physical and social health (Astell-Burt, Hartig, et al., 2022; Nguyen et al., 2023). However, among those early studies, randomised trials of physical activity in parks reported mixed results (e.g. Litt et al., 2023; Muller-Riemenschneider et al., 2020; Plotnikoff et al., 2017).

While randomised trial-based evidence on equitable implementation, effectiveness and sustainability of nature prescriptions is in a nascent period, the current groundswell of enthusiasm for nature-based solutions for health and well-being has deep historical roots dating back to Hippocrates of Cos (460–370 BC), The Enlightenment, and the Romantic and Environmental movements (Crnic & Kondo, 2019; Garraty & Gay, 1972; Hartig et al., 2011). This is accompanied by advances in the understandings of environmental preferences (e.g. Appleton, 1975) and popularisation of ideas focussed on affinity for certain biotic components of natural environments (e.g. 'Biophilia', Wilson, 1986) and strengthened by theoretical development on the restorative processes linking nature contact with health including attention restoration theory (Kaplan & Kaplan, 1989), psycho-evolutionary Theory (Ulrich et al., 1991), relational and collective restoration theories (Hartig, 2021), and nature-based biopsychosocial resilience theory (White et al., 2023). Building upon this historical context, a nature prescription may be considered a recommendation from a credible and authoritative source that permits some individuals to exercise previously unfulfilled motivation to spend more time in nature, thereby attending to restorative health and social needs unmet by modern-day healthcare and related social welfare systems. A nature prescription may also help to build levels of motivation for behavioural change in some individuals who tend to be otherwise less motivated to seek out nature contact, though that warrants further research. In both scenarios, measuring motivations for nature contact is a key aspect of the process towards understanding mechanisms by which nature prescriptions may catalyse positive change and may also be an important focus for future interventions for health and pro-environmental behaviours (Astell-Burt, Pritchard, et al., 2023).

In this regard, there has been a tradition of investigating motivation for nature contact in the leisure sciences (Knopf, 1987; Manfredo et al., 1996) and related disciplines (e.g. public health and social sciences more widely; Birch et al., 2020; Hindley, 2020; Kingsley et al., 2019; Neal et al., 2015), often with explicit interest in understanding drivers of recreational activities within natural environments. Special emphasis has been placed upon intrinsic motivation (Webb & Karlis, 2017) that is, the extent that a person seeks contact and experiences with nature because of the enjoyment felt. In this vein, there has been a proliferation of scales

aiming to measure positive attitudes towards nature contact (Brügger et al., 2011), such as the Nature Connectedness Scale (Mayer & Frantz, 2004) and the Nature Relatedness Scale (Nisbet & Zelenski, 2013), the latter of which has been frequently shown to correlate with visits to green space (e.g. Astell-Burt & Feng, 2021; Lawton et al., 2017; Lin et al., 2023). But a potential issue with this literature, especially among those who think of humans as having a deep biophilic connection, is to assume a priori that when people have contact with nature they are automatically satisfying deeply held intrinsic needs, when in fact any given individual may be visiting nature for any number of reasons or motivations. Yes, for some people visiting nature may be based on intrinsic motivations of some kind, but this may not always be the case, such as when one is walking the family dog on a dark rainy winter's night because one must, not because one wants to. People may feel compelled to engage in certain behaviours through social pressure, obligation, or other conditioning factors that may come from oneself or through the influence of others (Bandura, 2013; Hagger & Chatzisarantis, 2009). If we are to make progress on understanding why people do and do not visit nature, and what activities they do or do not engage in when there, we need a far more nuanced understanding of their underlying motives. In an effort to meet this need we build on the insights of self-determination theory (SDT; Deci & Ryan, 2000; Ryan & Deci, 2000).

SDT has been used to fruitfully explain the range of motivations behind a variety of health-related behaviours (Hagger & Chatzisarantis, 2009). One strength of viewing nature visits in particular through an SDT lens is that it highlights motivations beyond health-related goals such as by fulfilling needs of relating meaningfully with community, place and the 'more than human world'. Further, it also highlights that contact with nature offers opportunities for strengthening and reinforcing senses of, for example, autonomy, competence, achievement and growth, by permitting freedom to wander, explore and discover. According to SDT, if these needs are met it would suggest that contact with nature may be *autonomously* motivated, inclusive of but not solely driven by intrinsic motivation and thereby more likely to sustain positive behavioural change (Deci & Ryan, 2000; Ryan & Deci, 2000). Perhaps most importantly for present purposes, adopting an SDT approach enables us to more clearly appreciate that *time* in nature is not necessarily interchangeable with *experience* in nature, because if one is only there for non-autonomous motives then any benefits are likely to be attenuated in both the short and long terms. More specifically, SDT posits that motivations span a continuum, with the most self-determining being intrinsic motivation and least self-determining being 'amotivation', where a person feels no autonomy, control or relatedness and is thus fully disengaged with the context or behaviour. Between these poles lie four types of extrinsic motivation where the person is still motivated to some extent, but this is influenced by external circumstances as opposed to being driven purely by what the person enjoys doing. In the context of nature visits, these types of extrinsic motivations are, in descending order of self-determination:

1. 'integrated regulation' (nature contact is a key part of a person's sense of identity and life goals);
2. 'identified regulation' (contact with nature is a means to achieve something valued, e.g. fitness);
3. 'introjected regulation' (nature contact is due to emotional reasons, e.g. to avoid feelings of guilt or to attain a contingent boost to self-worth);
4. 'external regulation' (contact with nature is sought for contingent rewards or to avoid punishments, e.g. peer, parental or spousal [dis]approval).

To date, most scales that have incorporated some elements of motivation for connecting with nature, lean towards autonomous forms of motivation (intrinsic, integrated and identified regulation). For instance, "My relationship to nature is an important part of who I am" in the Nature Relatedness Scale (Nisbet & Zelenski, 2013) aligns with integrated regulation, and perhaps "My ideal vacation spot would be a remote, wilderness area" speaks to the high level of enjoyment a person takes in natural settings (i.e. intrinsic motivation). Meanwhile, the Attitude Toward Spending Time in Nature Scale (Maddock et al., 2022), which builds on the Theory of Planned Behaviour (Ajzen, 2011) as opposed to SDT, tends to describe a mixture of emotional responses that might be aligned with identified or integrated regulation (e.g. "I feel healthier", "I feel good about myself"). However, neither of these scales provide definitive coverage of each form of autonomous motivation nor the introjected and external regulations that are described collectively as 'controlled motivations' by SDT (Deci & Ryan, 2000).

Understanding controlled motivations as distinct from autonomous motivations is important, as they are likely to be commonly experienced and may be exacerbated by health professionals, employers and even well-meaning colleagues, friends and family members. It has been argued elsewhere that outside childhood where the anticipation of and realised pleasure drives much of behaviour, actions taken by adults are often extrinsically motivated (Mullan & Markland, 1997). For example, an adult may often visit a park reluctantly even though they may not feel interested, but because their spouse or family doctor recommends that they go anyway for improving their fitness, or because friends want to meet there habitually and to decline may increase the perceived or real risk of ostracism. In the former example, a person may go because they want to avoid potential blame for their lack of fitness. In the latter, while some of their friends may enjoy being in the park for what it is, or as a nearby social setting that enables shared pleasurable experiences, this individual's behaviour is being externally regulated in sharp contrast with their negative attitude and/or unfavourable perception of the park. In both examples, given prior experimental and observational findings (Jiang et al., 2019; Tester-Jones et al., 2020), it is likely that the restorative potential of their time spent in the park was suboptimal. This may be because it is inconsistent with their underlying intrinsic motives and needs, previously intrinsic motives are "crowded out" by extrinsic ones (Frey & Jegen, 2001), or because the motivational inconsistency means they end up engaging in

sub-optimal behaviour that denies them experiences they may have benefited from (e.g. scrolling social media on a smartphone instead of paying attention to biodiversity; Richardson et al., 2018, 2022). In other words, and perhaps rather controversially with respect to the multiple and generally unchallenged accounts of psychologically restorative benefits, more time spent in natural settings driven by controlled forms of motivation may actually result in a net-negative for mental health and well-being for some individuals.

Whether enabling and empowering people to spend more time in nature for the sake of the senses of awe, wonder and enjoyment it can bring, with increases in physical activity and health promotion as favourable but unplanned consequence, or with those benefits set as explicit goals, is therefore likely to be subject to the types of motivation people are susceptible to. Such motivations are likely to vary from person to person and given previous work demonstrating variation in so-called 'relatedness' or 'connectedness' to nature, it would be naïve to assume that everyone has high intrinsic motivation for nature contact. As we have acknowledged, there have been many studies of mainly intrinsic motivations for nature contact over decades within the field of leisure studies, including some efforts towards scale development. Presently, we know of no established scales that can be used to distinguish autonomous and controlled motivations for nature contact in particular, and the consequences such variation might entail for people's experiences of nature and its benefits, including physical activity and health. Drawing from established work based on SDT in other fields (e.g. physical activity), scales can be developed to measure different motivations that people have for visiting natural settings. Such endeavours may inform and perhaps become foci for interventions to increase contact with nature in sustainable, psychologically nourishing ways. The purpose of our article is to harness existing data and explore the potential for developing new motivation scales for comparison with the 6-item Nature Relatedness Scale (NR6) and relevant outcomes including time in nature, physical activity, self-rated health and smartphone use in nature. We hypothesised the following:

1. Autonomous motivations are positively associated with the NR6, with at least 2 h per week in nature, adherence to physical activity guidelines, more favourable self-reported health and greater interest in a potential nature prescription;
2. Controlled motivations are associated with less time in nature, and among those who do visit natural settings with higher scores on the controlled motivation scales, there will be more use of smartphones while in nature (as an indication of a lack of interest in being there).

2 | METHOD

2.1 | Data

A nationally representative survey of 5082 Australian adults was conducted from 14 to 28 February 2022. The survey was conducted on randomly selected active Life in Australia™ panel members by the Social Research Centre. Participants were aged 18 years or older and were the sole respondents from the homes in which they lived. A total of 6400 active panel members were invited to participate in the survey and 5082 (79.4%) completed the survey. This included 4883 (79.5% response) completing online and 199 (78.0% response) completing offline via the telephone. The survey contained a standard set of demographic and socio-economic variables. Participants were living across all states and territories of Australia and provided with a $10 incentive as either a gift card, direct payment or a donation to charity. All surveys were conducted in English language only, with telephone completion facilitated by trained interviewers. The University of Wollongong HREC granted ethical approval for this study (2020/343).

2.2 | Measuring autonomous and controlled motivations for nature contact

Participants were asked to respond to a range of statements aligned with different types of regulation within autonomous (intrinsic, integrated and identified) and controlled (introjected and external) motivation. These statements were answered using a five-item Likert scale (strongly disagree to strongly agree). Each statement began with "I visit green and/or blue spaces because…" and comprised the following items:

Intrinsic	… it's fun … I enjoy the natural environment
Integrated	… being outdoors in nature is an important value to me … it feels important to me personally to accomplish this goal
Identified	… it is interesting to see the improvement in my health and wellbeing … it is a challenge to accomplish my goal … I feel like it's the best way to help myself … I believe it helps me feel better
Introjected	… I would feel bad about myself if I did not go … I would feel a sense of personal loss if I did not go … people would think I don't have a balanced lifestyle if I did not … I feel guilty if I do not go
External	… I worry that I would be blamed if I did not go … I feel like I have no choice, others make me go there … I want others to acknowledge that I am doing what I have been told I should do … others would judge me negatively if I did not go

Participant responses to each statement were scored 1–5. The common stem was inclusive of the variety of places, spaces, activities and experiences each participant may have had in green and/or blue spaces. The mean scores across all statements within each scale were then calculated for each participant. Cronbach alpha

coefficients were then calculated for each of the five scales to assess convergent validity, with 0.6 used for benchmarking.

Previously it has been customary to then collapse these scales into a single global score for each participant called a 'Relative Autonomy Index'. However, that approach was not taken in this developmental stage, in line with recommendations from Chemolli and Gagne, who suggest that doing so would ignore the complex multidimensionality of what motivates people to do things (Chemolli & Gagné, 2014).

2.3 | Nature Relatedness Scale

Participants were asked the Nisbet's 6-item Nature Relatedness Scale with the same five-item Likert scale responses: "For each of the following, please rate the extent to which you agree with each statement. Please respond as you really feel, rather than how you think "most people" feel:

a. My ideal vacation spot would be a remote, wilderness area;
b. I always think about how my actions affect the environment;
c. My connection to nature and the environment is a part of my spirituality;
d. I take notice of wildlife wherever I am;
e. My relationship to nature is an important part of who I am; and
f. I feel very connected to all living things and the earth."

Responses were then scored 1 (strongly disagree) to 5 (strongly agree) and the mean was calculated for each participant. Higher scores are purported to indicate a higher degree of relatedness to nature.

2.4 | Outcome variables

Five outcomes were assessed to define potentially contrasting influences of different motivations.

- Time spent in nature: This was measured using the question 'Approximately how many hours did you spend in green spaces and/or blue spaces in total over the last 7 days?' Responses were dichotomised with 2 h a week or more used as a cut-point (White et al., 2019).
- Smartphone use in nature: This variable was measured using responses to the question 'While visiting green and/or blue spaces, about how often do you email, use the internet, and browse and/or post on social media? (Constantly; Often; Sometimes; Rarely; Never)'. We aggregated 'constantly' and 'often' responses and contrasted them with 'sometimes', 'rarely' and 'never'.
- Interest in nature prescriptions: We examined to what extent each type of motivation was associated with interest in a nature prescription from a health professional, as measured using responses to the question: 'How likely would you be to visit green and/or blue spaces more often if your doctor suggested it would be good for your health? (very likely, likely, unlikely, very unlikely)'
- Physical activity: This was measured using responses to the statement: 'In the past week, on how many days have you done a total of 30 minutes or more of physical activity, which was enough to raise your breathing rate? This may include sport, exercise, and brisk walking or cycling for recreation or to get to and from places but should not include housework or physical activity that may be part of your job.' Participants who reported 5 days a week or more (i.e. current physical activity guidelines) were contrasted with those who reported fewer than five. Total physical activity was considered, rather than physical activity taking place exclusively within natural surroundings, to align with the health priority of being more active regardless of the setting. This would likely mean that for a potentially large number of people, adherence to physical activity guidelines would be concomitant with greater time in nature.
- Self-rated health: This was measured using participants responses to 'In general, how would you rate your overall health? (excellent, very good, good, fair, poor)'. Those responding 'fair' or 'poor' were grouped and compared with those who responded more favourably.

2.5 | Confounders

A range of factors may influence the degree of nature contact an individual might have and both self-rated health and physical activity. These included sex and age group, a broad indication of whether people were born in English-speaking or non-English-speaking countries if outside Australia, whether they were married or with a partner, employment status, their highest level of educational qualification and the annual combined income of the household in which they were resident. We also took into account the level of socio-economic disadvantage within the neighbourhood of residence, measured using the Socio-Economic Indexes For Areas (SEIFA) scale, developed from multiple Census variables by the Australian Bureau of Statistics.

2.6 | Statistical analyses

Interrelationships between each of the nature motivation scales and the NR6 were tested using Pearson correlation coefficients, with 0.8 used as an indication of multicollinearity. Mean NR6 and nature motivation scales were described across participants characteristics. Adjusted multilevel logistic regressions accounted for clustering of participants within major cities and regional areas ($n = 15$) to define odds ratios for the NR6 and each of the nature motivation scales as predictors of the five outcomes. Models were estimated using a Markov Chain Monte Carlo (MCMC) procedure in MLwIN

(Browne, 2005; Rasbash et al., 2000) with a 30,000 iteration burn-in period and 300,000 sample iterations. Contrasts in model fit identified by non-zero deviance information criterion (DIC) values were used to define whether adding each of the nature motivation scales into the model in substitution for the NR6 improved model fit, as defined by a reduction in the DIC of 10 or greater. Reductions between +9 and −9 indicated no definitive improvement in the nature motivation scales over the NR6, whereas a +10 increase in DIC denoted superiority of the NR6.

3 | RESULTS

3.1 | Convergent validity for measures of autonomous and controlled motivations for nature contact

All Cronbach alphas met a minimally sufficient standard (0.6+) to permit the nature motivation scales to proceed for further analysis in their current composition. The Cronbach alphas were high for intrinsic (0.7), identified (0.7), introjected (0.7) and especially for external (0.9) regulation scales but were lower for integrated regulation (0.6), indicating scope for improvement in future iterations.

Table 1 reports low to moderate levels of correlation between most of the nature motivation scales and the NR6. This indicated that the NR6 is measuring some elements of intrinsic and integrated regulation, but none to a particularly high level. Lower correlations between the NR6 and introjected (0.24) and external regulation (−0.05) confirmed that controlled motivations are not well covered.

Exceptions to the reported low to moderate level of correlation included a coefficient of 0.60 between intrinsic and integrated regulation, and 0.72 between integrated and identified regulation. Interrelationships between each of these types of regulation were expected as they are collectively understood as autonomous motivation, though future work may focus on reducing these correlations.

External regulation was moderately correlated with introjected regulation, as expected because they are both sources of controlled motivation. Negative correlation between external and intrinsic regulation (−0.24) indicated that participants who reported greater enthusiasm for spending time in nature were less susceptible to extrinsic sources of motivation for the same outcome and vice-versa.

3.2 | Mean autonomous and controlled motivations for nature contact by participant characteristics

Mean NR6 and nature motivation scales were consistently higher among participants who spent upward of 2 h per week in nature compared to those who spent less, except for external regulation where the mean difference was negligible (Table 2). A similarly positive pattern was observed when distinguishing participants adhering to physical activity guidelines from those who were not, but here the means for external regulation were patterned more substantially in the opposite direction. There was little difference in means for NR6 or introjected regulation between participants in good and not good self-rated health. Mean levels of autonomous motivation were lower in participants in not good health, whereas mean external regulation was higher.

Those who reported often or constant use of the internet and social media during visits to nature, compared to those who used it only sometimes, rarely, or never, had higher mean external and introjected regulation, and lower mean NR6, intrinsic and integrated regulation. Mean levels of NR6, all sources of autonomous motivation and introjected regulation were higher among people who were interested in a nature prescription from a health professional. In comparison, there was no clear difference in mean external regulation between those who were likely and unlikely to accept a nature prescription from a health professional.

There was little geographical variation in NR6 or any of the nature motivation scales between major cities and regional areas, and similarly only minor differences by age group (Table 3). Mean NR6 and autonomous motivation were higher for females than males, whereas external regulation was the opposite.

Participants with higher levels of education also tended to have higher mean NR6 and autonomous motivation and lower mean

TABLE 1 Pearson correlation coefficients for the NR6 and each of the nature motivation scales.

	Nature motivation scales				
Variable	**Intrinsic**	**Integrated**	**Identified**	**Introjected**	**External**
NR6	0.47***	0.47***	0.35***	0.24***	−0.05***
Nature motivation scales					
Intrinsic		0.60***	0.52***	0.25***	−0.24***
Integrated			0.72***	0.49***	0.01
Identified				0.53***	0.13***
Introjected					0.49***

Abbreviation: NR6, Nature-Relatedness Scale.

*$p < 0.05$.

**$p < 0.01$.

***$p < 0.001$.

TABLE 2 Mean Nature Relatedness Scale (NR6) and nature motivation scales for each study outcome.

			Nature motivation scales				
Variables/categories	***n***	**NR6**	**Intrinsic**	**Integrated**	**Identified**	**Introjected**	**External**
Mean (*SE*)							
Time spent in nature (hours in week)							
<2 h	1492	3.44 (0.019)	3.76 (0.019)	3.19 (0.022)	3.15 (0.020)	2.35 (0.018)	1.86 (0.018)
≥2 h	3590	3.75 (0.012)***	4.18 (0.010)***	3.72 (0.013)***	3.48 (0.011)***	2.65 (0.012)***	1.80 (0.011)**
Use of internet/social media							
Once a day to never	4592	3.67 (0.011)	4.07 (0.010)	3.58 (0.012)	3.39 (0.010)	2.55 (0.011)	1.79 (0.010)
Constantly/several time a day	490	3.56 (0.034)**	3.95 (0.033)***	3.47 (0.041)**	3.36 (0.036)	2.65 (0.037)*	2.08 (0.037)***
Interest in a nature prescription							
Unlikely or very unlikely	1108	3.55 (0.023)	3.84 (0.023)	3.28 (0.028)	3.09 (0.023)	2.39 (0.022)	1.79 (0.021)
Likely or very likely	3974	3.69 (0.011)***	4.12 (0.010)***	3.65 (0.012)***	3.47 (0.010)***	2.61 (0.011)***	1.82 (0.011)
Physical activity ≥ 30 min (days per week)							
0–4 days	3519	3.61 (0.012)	3.99 (0.011)	3.48 (0.014)	3.33 (0.012)	2.51 (0.012)	1.84 (0.012)
5–7 days	1563	3.76 (0.018)***	4.21 (0.015)***	3.77 (0.020)***	3.51 (0.017)***	2.68 (0.019)***	1.76 (0.017)***
Fair/poor self-reported health							
Good to excellent	3932	3.67 (0.012)	4.11 (0.010)	3.61 (0.013)	3.40 (0.011)	2.56 (0.012)	1.78 (0.011)
Poor to fair	1150	3.63 (0.021)	3.88 (0.020)***	3.44 (0.024)***	3.35 (0.021)*	2.56 (0.021)	1.93 (0.021)***

Note: Sample size $n = 5082$; p-value is for the overall ANOVA test, usual or Welch for unequal variances, where variances are tested by Bartlett.
Abbreviations: NR6, Nature Relatedness Scale; SE, standard error.
* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

external regulation. In contrast, those with higher annual household incomes had lower mean NR6 and lower introjected and external regulation, but negligible differences in autonomous motivation.

Among those working from home there was little difference in mean NR6 or any of the nature motivation scales compared with peers working onsite. Those who were employed had higher mean NR6 and external regulation, but lower mean intrinsic regulation. Mean NR6 varied little by area socio-economic circumstances, whereas external regulation was higher and intrinsic and integrated regulation was lower for participants in more disadvantaged areas.

For those in a couple, mean NR6 was lower than those living alone. No clear differences in any of the nature motivation scales were found by marital status. Participants born in countries where English was not a predominant language tended to have higher mean NR6, integrated, identified and external regulation than their peers born in Australia or in countries where English was widely spoken.

3.3 | Adjusted associations between NR6, nature motivation scales and study outcomes

Table 4 reports higher NR6 was associated with higher odds of at least 2 h per week spent in nature (OR = 1.82, 95% CI 1.66–1.99), adherence to physical activity guidelines (1.33, 95% CI 1.22–1.45), interest in a nature prescription (1.31, 95% CI 1.19–1.43) and lower odds of fair/poor self-rated health (0.89, 95% CI 0.81–0.98). Negative association between NR6 and the use of internet/social media while in nature was not statistically significant.

The odds of spending 2 h per week or more in nature were substantially higher for participants with higher intrinsic (2.69, 95% CI 2.42–3.00), integrated (2.27, 95% CI2.09–2.47), identified (2.16, 95% CI1.96–2.39) and introjected regulation (1.87, 95% CI 1.71–2.05); highest odds ratios were reported among the most self-determining of scales. A similar pattern was observed for adherence to physical activity guidelines, with higher odds among participants with higher intrinsic (1.83, 95% CI 1.65–2.04), integrated (1.61, 95% CI 1.48–1.74), identified (1.54, 95% CI 1.40–1.69) and introjected regulation (1.38, 95% CI 1.26–1.50). Higher external regulation was also associated with lower odds of adhering to physical activity guidelines (0.85, 95% CI 0.78–0.94), though the (10%) higher odds of spending 2 h or more per week in nature was not statistically significant. This finding may indicate that nature as a setting for restoration, whether that be with others or in solitude, may play an important role for individuals who are susceptible to social pressure or other forms of external regulation that would appear to have a potentially detrimental impact on physical activity.

TABLE 3 Mean Nature Relatedness Scale (NR6) and nature motivation scales for participant characteristics.

			Nature motivation scales				
Variables/categories	***n***	**NR6**	**Intrinsic**	**Integrated**	**Identified**	**Introjected**	**External**
Mean (*standard error*)							
Geography							
Greater Sydney	1013	3.62 (0.022)	4.06 (0.021)	3.56 (0.026)	3.39 (0.021)	2.59 (0.023)	1.83 (0.021)
Rest of NSW	612	3.71 (0.029)	4.07 (0.027)	3.61 (0.033)	3.36 (0.029)	2.56 (0.030)	1.78 (0.026)
Greater Melbourne	958	3.63 (0.025)	4.05 (0.021)	3.61 (0.026)	3.42 (0.022)	2.59 (0.024)	1.84 (0.023)
Rest of VIC	319	3.76 (0.043)	4.08 (0.038)	3.57 (0.045)	3.43 (0.037)	2.58 (0.040)	1.81 (0.035)
Greater Brisbane	512	3.61 (0.031)	3.96 (0.029)	3.48 (0.036)	3.34 (0.029)	2.52 (0.031)	1.85 (0.031)
Rest of QLD	494	3.67 (0.033)	4.10 (0.030)	3.58 (0.037)	3.35 (0.031)	2.57 (0.032)	1.79 (0.031)
Greater Adelaide	335	3.57 (0.040)	3.96 (0.040)	3.45 (0.047)	3.35 (0.037)	2.49 (0.038)	1.80 (0.034)
Rest of SA	77	3.68 (0.086)	3.97 (0.095)	3.58 (0.112)	3.35 (0.096)	2.51 (0.090)	1.77 (0.068)
Greater Perth	393	3.67 (0.037)	4.08 (0.031)	3.57 (0.039)	3.40 (0.034)	2.56 (0.035)	1.85 (0.035)
Rest of WA	88	3.88 (0.079)	4.15 (0.066)	3.71 (0.084)	3.43 (0.071)	2.59 (0.074)	1.90 (0.073)
Greater Hobart	68	3.76 (0.087)	4.21 (0.067)	3.62 (0.104)	3.49 (0.091)	2.57 (0.086)	1.79 (0.093)
Rest of TAS	63	3.86 (0.085)	4.16 (0.069)	3.65 (0.089)	3.43 (0.082)	2.52 (0.080)	1.75 (0.077)
Greater Darwin	20	3.53 (0.162)	4.15 (0.121)	3.40 (0.165)	3.23 (0.198)	2.35 (0.172)	1.83 (0.141)
Rest of NT	12	4.22 (0.255)	4.13 (0.214)	3.96 (0.179)	3.54 (0.264)	2.71 (0.230)	1.83 (0.251)
ACT	118	3.67 (0.074)***	4.13 (0.057)**	3.53 (0.079)	3.31 (0.064)	2.51 (0.064)	1.60 (0.053)*
Age (years)							
18–24	220	3.49 (0.047)	4.03 (0.049)	3.40 (0.063)	3.38 (0.051)	2.61 (0.058)	1.98 (0.055)
25–34	585	3.49 (0.031)	4.04 (0.030)	3.49 (0.039)	3.36 (0.031)	2.57 (0.033)	1.84 (0.031)
35–44	761	3.62 (0.026)	4.13 (0.024)	3.54 (0.031)	3.45 (0.025)	2.56 (0.028)	1.84 (0.027)
45–54	796	3.72 (0.026)	4.10 (0.023)	3.59 (0.027)	3.44 (0.023)	2.55 (0.025)	1.78 (0.023)
55–64	1038	3.68 (0.023)	4.08 (0.020)	3.59 (0.025)	3.35 (0.020)	2.55 (0.022)	1.78 (0.020)
65+	1682	3.71 (0.017)***	3.99 (0.016)***	3.60 (0.019)**	3.36 (0.017)**	2.57 (0.016)	1.82 (0.015)**
Gender							
Male	2218	3.58 (0.015)	3.97 (0.014)	3.47 (0.017)	3.30 (0.015)	2.55 (0.015)	1.85 (0.015)
Female	2864	3.72 (0.014)***	4.12 (0.012)***	3.64 (0.015)***	3.45 (0.012)***	2.57 (0.013)	1.79 (0.013)***
Education							
School	1215	3.58 (0.022)	3.93 (0.019)	3.45 (0.024)	3.33 (0.021)	2.54 (0.021)	1.92 (0.020)
Diploma	1288	3.69 (0.020)	4.03 (0.019)	3.56 (0.023)	3.38 (0.019)	2.56 (0.020)	1.86 (0.018)
University	2408	3.68 (0.015)	4.15 (0.013)	3.63 (0.016)	3.42 (0.014)	2.57 (0.015)	1.72 (0.014)
Missing	171	3.71 (0.056)***	3.86 (0.055)***	3.51 (0.063)***	3.33 (0.055)**	2.63 (0.054)	1.96 (0.050)***
Income (AUD)							
0–29 K	741	3.78 (0.026)	3.95 (0.026)	3.58 (0.030)	3.41 (0.027)	2.60 (0.026)	1.97 (0.026)
30–69 K	1449	3.70 (0.019)	4.01 (0.017)	3.56 (0.022)	3.38 (0.019)	2.56 (0.019)	1.85 (0.018)
70–100 K	773	3.67 (0.026)	4.11 (0.024)	3.61 (0.029)	3.41 (0.024)	2.59 (0.027)	1.80 (0.025)
100 K+	1780	3.56 (0.017)	4.13 (0.015)	3.55 (0.019)	3.38 (0.016)	2.54 (0.017)	1.73 (0.015)
Missing	339	3.68 (0.039)***	3.98 (0.037)***	3.55 (0.045)	3.34 (0.038)	2.54 (0.039)	1.84 (0.037)***
Work status with working from home							
Working, never from home	1257	3.62 (0.020)	4.06 (0.019)	3.52 (0.023)	3.37 (0.019)	2.53 (0.021)	1.85 (0.019)
Working, sometimes from home	457	3.66 (0.035)	4.17 (0.028)	3.58 (0.040)	3.40 (0.031)	2.56 (0.036)	1.76 (0.033)
Working, often from home	339	3.64 (0.040)	4.13 (0.034)	3.60 (0.044)	3.42 (0.037)	2.56 (0.040)	1.78 (0.038)

TABLE 3 (Continued)

Variables/categories	*n*	NR6	Nature motivation scales				
			Intrinsic	Integrated	Identified	Introjected	External
Working, always from home	757	3.59 (0.028)	4.12 (0.023)	3.58 (0.030)	3.45 (0.026)	2.59 (0.027)	1.78 (0.025)
Unemployed	238	3.68 (0.050)	3.89 (0.046)	3.41 (0.057)	3.35 (0.047)	2.51 (0.052)	2.00 (0.052)
Retired	1689	3.71 (0.017)	4.02 (0.015)	3.62 (0.019)	3.36 (0.017)	2.58 (0.017)	1.79 (0.015)
Sick/disabled	161	3.69 (0.060)	3.80 (0.064)	3.41 (0.069)	3.33 (0.063)	2.54 (0.053)	1.95 (0.057)
Other or missing	184	3.68 (0.058)	4.05 (0.051)***	3.57 (0.059)***	3.44 (0.049)	2.57 (0.056)	1.83 (0.056)***
ALD (area level disadvantage, quintiles)							
1 (affluent)	1372	3.65 (0.019)	4.11 (0.017)	3.59 (0.022)	3.38 (0.018)	2.56 (0.020)	1.73 (0.018)
2	1031	3.64 (0.023)	4.08 (0.020)	3.62 (0.024)	3.41 (0.021)	2.59 (0.022)	1.82 (0.021)
3	1017	3.67 (0.023)	4.07 (0.021)	3.56 (0.026)	3.40 (0.022)	2.56 (0.023)	1.82 (0.021)
4	892	3.69 (0.024)	4.02 (0.022)	3.54 (0.027)	3.40 (0.023)	2.59 (0.024)	1.86 (0.023)
5 (disadvantaged)	770	3.65 (0.026)	3.94 (0.026)***	3.49 (0.030)*	3.33 (0.026)	2.51 (0.026)	1.91 (0.026)***
Marital status							
Couple	3330	3.63 (0.012)	4.07 (0.011)	3.57 (0.014)	3.38 (0.012)	2.56 (0.012)	1.81 (0.012)
Not a couple	1752	3.71 (0.018)***	4.02 (0.017)**	3.57 (0.020)	3.40 (0.017)	2.57 (0.018)	1.82 (0.016)
Country of birth group							
Australia	3627	3.64 (0.012)	4.05 (0.011)	3.55 (0.014)	3.36 (0.012)	2.56 (0.012)	1.80 (0.011)
Other English-speaking country	677	3.63 (0.028)	4.08 (0.025)	3.60 (0.032)	3.39 (0.026)	2.59 (0.027)	1.75 (0.024)
Other non-English-speaking country	778	3.76 (0.026)***	4.07 (0.023)	3.64 (0.029)*	3.49 (0.024)***	2.56 (0.027)	1.95 (0.027)***

Note: Sample size $n = 5082$; p-value is for the overall ANOVA test, usual or Welch for unequal variances, where variances are tested by Bartlett.
Abbreviation: NR6, Nature Relatedness Scale.
*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

Higher odds of interest in nature prescriptions were observed across all nature motivation scales, with only those for external regulation failing to achieve statistical significance. The odds of nature prescription interest were particularly high for participants with higher identified motivation (2.19, 95% CI 1.99, 2.43) and descending in potency for intrinsic (1.80, 95% CI 1.63, 1.99), integrated (1.71, 95% CI 1.57, 1.86) and introjected (1.55, 95% CI 1.41, 1.71) forms of regulation. Lower odds of fair/poor self-rated health were reported among participants with higher intrinsic (0.66, 95% CI 0.60–0.74) and integrated (0.79, 95% CI 0.73–0.86) regulation, and higher external regulation (1.27, 95% CI 1.14–1.40). A similar pattern was reported for the use of internet/social media while in nature, with lower odds for intrinsic regulation (0.74, 95% CI 0.64–0.85) and higher odds for introjected (1.20, 95% CI 1.06–1.36) and external regulation (1.71, 95% CI 1.49–1.95).

Substituting each of the nature motivation scales individually for the NR6 improved model fit for most outcomes, as identified by reductions in DIC equal to or exceeding −10. Exceptions were for increases in DIC (+10) observed for the external regulation scale in association with time spent in nature, interest in a nature prescription, and physical activity. Different nature motivations scales, however, were more important for different outcomes. Clear improvements in model fit were reported when substituting any of the autonomous motivation scales (intrinsic, integrated and identified) or, to a lesser extent, introjected regulation, for the time spent in nature, physical activity and nature prescription interest. In each of these cases, the addition of the external regulation scale worsened model fit. In contrast, for self-rated health, substituting external regulation, or intrinsic or integrated regulation, all improved model fit relative to NR6. The external regulation scale also made the biggest improvement in model fit of all the motivation scales when the outcome denoted use of internet/social media while in natural environments.

4 | DISCUSSION

Long distances, poor accessibility, time scarcity, and a lack of company or felt safety are among the many reasons front of mind when we consider why so many people spend so little time in nature. The status quo is disastrous not only from public health and health equity perspectives (Astell-Burt, Hartig, et al., 2022; Markevych et al., 2017) but also from the point of view of addressing our climate crisis; people who are not interested in spending time with nature are less likely to take the personal and collective actions necessary

TABLE 4 Multilevel models to assess the association between the NR6, nature motivation scales and each of the study outcomes, adjusted for confounding.

		Nature motivation scales				
Variable/category	**NR6**	**Intrinsic**	**Integrated**	**Identified**	**Introjected**	**External**
Odds ratio (95% credible interval)						
Time spent in nature (hours in week)	1.82 (1.66, 1.99)***	2.69 (2.42, 3.00)***	2.27 (2.09, 2.47)***	2.16 (1.96, 2.39)***	1.87 (1.71, 2.05)***	0.97 (0.89, 1.07)
DIC (ΔDIC from NR6 model)	5795	5601 (−194)	5566 (−229)	5709 (−86)	5776 (−19)	5968 (+173)
Use of internet/social media	0.88 (0.77, 1.00)	0.74 (0.64, 0.85)***	0.89 (0.80, 1.00)	0.92 (0.80, 1.05)	1.20 (1.06, 1.36)**	1.71 (1.49, 1.95)***
DIC (ΔDIC from NR6 model)	3012	2999 (−13)	3012 (0)	3014 (+2)	3009 (−3)	2954 (−58)
Interest in a nature prescription	1.31 (1.19, 1.43)***	1.80 (1.63, 1.99)***	1.71 (1.57, 1.86)***	2.19 (1.99, 2.43)***	1.55 (1.41, 1.71)***	1.10 (0.99, 1.22)
DIC (ΔDIC from NR6 model)	5247	5154 (−93)	5120 (−127)	5035 (−212)	5196 (−51)	5274 (+27)
Physical activity ≥ 30 min (days per week)	1.33 (1.22, 1.45)***	1.83 (1.65, 2.04)***	1.61 (1.48, 1.74)***	1.54 (1.40, 1.69)***	1.38 (1.26, 1.50)***	0.85 (0.78, 0.94)***
DIC (ΔDIC from NR6 model)	6171	6078 (−93)	6076 (−95)	6132 (−39)	6159 (−12)	6203 (+32)
Fair/poor self-rated health	0.89 (0.81, 0.98)*	0.66 (0.60, 0.74)***	0.79 (0.73, 0.86)***	0.91 (0.83, 1.01)	0.99 (0.90, 1.09)	1.27 (1.15, 1.40)***
DIC (ΔDIC from NR6 model)	5143	5088 (−55)	5120 (−23)	5146 (+3)	5149 (+6)	5127 (−16)

Note: Time spent in nature (hours in week): ≥2 h versus <2 h; Physical activity ≥30 min (days per week): 5–7 days versus 0–4 days; Self-rated health: fair to poor versus good to excellent; Use of internet/social media: constantly/often versus once a day to never; Likely to visit green/blue space on doctor advice: likely or very likely versus unlikely or very unlikely; Sample size $n = 5082$; MCMC procedure using MLwiN with 30,000 burn-in and 300,000 sample iterations. Confidence intervals are credible intervals; All models are fitted with covariates: sex, education, household income, employment status, work and marital status, country of birth and area level disadvantage (quintiles of SEIFA, the higher the more disadvantaged) at baseline; Random effects (RE) are intercepts associated with capital areas and the rest of states and territories in Australia; variance is given on log scale. ΔDIC is calculated by subtraction the DIC of the NR6 model; then the negative ΔDIC indicates the better model, while the positive—the opposite.

Abbreviations: DIC, deviance information criterion;NR6, Nature-Relatedness Scale.

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

to heal our planet (Mackay & Schmitt, 2019). While not disregarding or lessening the importance of these and other barriers, we have shown that a range of motivations evidently shape nature contact including, though not limited to, personal enjoyment. We have also shown that many different types and levels of motivation go beyond nature contact, potentially modifying the potential for restorative experiences. The bottom line from our study is that people have complex mixtures of motivations with varying potency for visiting natural settings, and the extent to which those motives are autonomous or controlled matters for what they choose to do and the benefits accrued.

Specifically, our findings demonstrated positive associations between autonomous motivations and time in nature, interest in a nature prescription and physical activity, all of which are desirable outcomes. Autonomous motivations were also negatively associated with fair/poor self-rated health, and use of the internet/social media while visiting nature, which are also favourable given how people feel about their health in general is predictor of mortality (Idler & Benyamini, 1997), and the benefits of time spent in nature can be undermined by use of portable technologies (Jiang et al., 2019). These findings indicate that interventions capable of increasing autonomous motivations for nature contact may yield an array of health and social benefits. The particularly strong result for identified regulation and the odds of welcoming a nature prescription indicates that the source of interest in this form of intervention is not only among those who already enjoy time in nature or consider it as part of their identity but also among those who recognise it as a means of achieving other goals they find meaningful.

The finding for autonomous motivations was not the mirror opposite for controlled motivations, with somewhat mixed results observed between introjected and external regulations. Positive associations were reported for introjected regulation with not only time in nature, interest in a nature prescription, and physical activity, *but also* use of the internet/social media while in nature. This indicates that interventions which manipulate emotions to instrument behavioural change, such as visiting nature spaces to avoid feelings of guilt rather than for reasons due to enjoyment, identity or goal-achievement, may not only have some potency but might also result in negative consequences. Higher external regulation had no apparent impact on time in nature and was associated with increased use of internet/social media, higher odds of fair/poor self-rated health and less physical activity. Moreover, negative correlation between intrinsic and external regulations may indicate that those who are motivated to spend time in nature because of the enjoyment it brings might also be less susceptible to social pressure and other forms of external regulation, at least in this specific context. Clearly, further (experimental) research would be helpful to examine these findings in greater detail. Currently, this indicates that interventions which motivate time in nature through use of contingent rewards, such as the affirmation of others, may not only have little bearing on achievement of the desired outcome (i.e. increasing contact with nature) but may also have multiple undesirable consequences (Tester-Jones et al., 2020). In sum, we find controlled motivations may have variable effectiveness and could undermine potential health benefits.

Our analyses also show that more direct considerations of intrinsic, integrated and identified forms of autonomous motivation have superior explanatory power than the NR6 for time spent in nature, interest in nature prescriptions, adherence to physical activity recommendations and self-rated health. This is important as the NR6 and similar indicators of nature 'connectedness' or 'relatedness' might logically be a focus for interventions to increase nature contact. However, this misses the crux of the matter, which is that the NR6 and similar measures are unable to differentiate between intrinsic motivation nurtured through accumulated experiences since the earliest years in life that may be difficult to modify (Vitale et al., 2022), from other autonomous motivations that are alternative—and potentially more achievable—targets for intervention in adults. That being said, it is worth noting that NR6 was positively associated with time in nature, adherence to physical activity guidelines and interest in a nature prescription, with lower odds of fair/poor self-rated health in line with prior research (Pritchard et al., 2020), and not associated with internet/social media use in nature.

Provided a more focussed measurement of integrated or identified motivations are used, it may be that there can be some success in synergy; for instance, a nature prescription programme might be co-designed and implemented to wrap increased nature contact around an activity that a group of people who currently spend little time in natural environments already find highly intellectually or socially stimulating, such as music, crafts or sports. Some refer to this as 'temptation bundling' (Milkman et al., 2014) and it may be that in concert with appropriate levels of talking therapies from trained health professionals, such interventions may not only increase nature contact but also strengthen intrinsic motivations for it over a longer term through familiarity. This hypothesis remains speculative at present, though with the demonstrated public interest in nature prescriptions (Astell-Burt, Hipp, et al., 2023) and the substantial investments made in them such as in Canada (Sherman et al., 2021), we suggest that it could be an important line for future enquiry with potentially international impact.

Our key findings highlight the need for careful consideration of how interventions to enable more contact with nature are marketed, prescribed and implemented, lest negative yet entirely foreseeable consequences occur. Most notably, our study reported external regulations emphasising social pressure and peer approval were associated not only with no (statistically significant) additional time in nature but also with more distractive activities when a person happens to be in natural environments, as defined by higher odds of often or constant internet and social media browsing while there. While introjected regulations emphasising guilt avoidance and contingent rewards were associated with increased nature contact, they were similarly associated with time spent on smartphones and social media. Acknowledging that the use of social media and smartphones while in natural environments may be the only opportunity

to do so for some individuals living in overcrowded accommodation or other situations, these results not only broadly align with similar findings from a previous international cross-sectional study, in which perceived social pressure to visit nature was associated with higher likelihood of visitation, but also lower visit happiness and higher visit anxiety (Tester-Jones et al., 2020). These results are also buttressed by a randomised trial that showed portable technologies such as smartphones can undermine the restorative benefits of nature contact (Jiang et al., 2019). Collectively, this may repudiate the digital gamification of outdoor nature contact and should provide pause for thought among developers of smartphone wellness apps purporting to motivate and measure time in nature. Furthermore, it ought to raise questions on what is being incentivised by smartphone applications and their impacts on autonomous motivations for nature contact; a sense of social pressure may serve to attenuate or nullify enjoyment of nature (Richardson et al., 2018).

Our study is limited by cross-sectional data and it is plausible that while motivations for nature contact may be predominantly shaped by experiences in childhood, nature contact in adulthood catalysed by controlled motivations has potential to become more autonomous over time through experience and processes of meaning making developed both individually and with others. For example, a person may initially spend more time in nature due to social pressure from a companion who feels it would be good for them, perhaps by joining a community garden or other activity. They may also be acting to avoid feelings of guilt, for not helping a close friend who might be the prime beneficiary of such visits (e.g. as a contributor to their recovery from significant health misadventure). Over time and through the ritual of regular, frequent contact that might be coupled with novel and unexpectedly enjoyable experiences, especially with significant others, one might find their motivation for nature contact becoming more autonomously motivated and self-determined through time; a process referred to as *internalisation* (Deci et al., 1994). This might be a worthy focus for future longitudinal studies.

The common stem of "I visit green and/or blue spaces because…" was necessarily agnostic to simultaneously accommodate the numerous different types of places and spaces encountered and the activities and experiences eventuating within them. This was on the basis that increasing contact with nature would, on balance, be a net positive for health for most people regardless of where or how that took place. Two points are worth raising at this juncture. First, we acknowledge that some people may misunderstand, misreport or even not recognise their own motives (Wilson, 2004). Second, the range of autonomous and controlled motivations reported may vary from those defined by the common stem, were more specific details of any given activities highlighted in the question. For instance, one may detest the thought of any form of physical activity, only participating intentionally through introjected or external regulations. But that same individual may also take great enjoyment and identify closely with nature contact enabled via gardening, whether in solitude or as part of a community (Kingsley et al., 2023), and become more physically active in nature without it being preferential or an explicit goal.

The measures of nature motivations are exploratory and currently do not permit insight into how one form of regulation may be a precursor for another, so this might be a focus for future longitudinal research. Relatedly, low to moderate correlations between the five nature motivation scales might be strengthened in the process, to address potential overlap of interpretation for some items. For example, correlation between introjected and external regulations was 0.49. This is unsurprising, since introjected regulation involves actions to avoid feeling guilt or to obtain contingent self-worth, and external regulation involves actions to avoid punishment or to gain rewards; both punishment feeding guilt on the one hand, and rewards feeding contingent self-worth on the other, are natural bedfellows. We classified the statements "people would think I don't have a balanced lifestyle if I did not" and "others would judge me negatively if I did not go" as indicative of introjected and external regulations, respectively. Although prima facie similar, the focus on being viewed as having a balanced lifestyle as a socially desirable characteristic in the former item was felt to be more aligned with pursuing contingent self-worth. In contrast, negative judgements from others whose views mattered in the latter item was more akin to avoiding ostracism or other socially oriented punishments. We acknowledge the potential for other interpretations and suggest our analyses provide a starting point for formal scale development through routine pathways, which might adopt a similar path followed by Maddock et al. (2022).

For other variables in our analyses, we have attempted to use the best available measures where possible, such as a commonly used and validated single-item measure of physical activity (Milton et al., 2011). However, we acknowledge that it would have been preferable to also have objectively measured physical activity data acquired through the use of an accelerometer to provide robust confirmation of those findings. Our study benefits from analyses of a nationally representative sample of adult population of Australia that may not square strongly with populations living in contrasting cultural, economic and climatic contexts; similar studies in other countries are encouraged.

Further theorising and longitudinal analyses will also prove fruitful for understanding the extent to which many different types of motivations for nature contact are entrenched from an early age (Vitale et al., 2022) or are amenable to change across the life course and common events that occur, such as household relocations, labour market transitions, and relationship formations and dissolutions. Whether nurtured early on or continuously shaped by circumstances, it would be worthwhile to examine how different motivations for nature contact are formed and the relative contributions of personal, social and environmental antecedent factors. This will help to discern the plasticity of these motivations with respect to the planning and timing of experiments on autonomous motivations in particular. Finally, in addition to identifying how to intervene sustainably where autonomous motivations for nature contact are low, instances of incongruence between high autonomous motivations and a dearth of localised opportunities or lack of capacities to attend to those needs may have major consequences for mental,

physical and social health and ought to be a critical focus for further research (Astell-Burt, Hartig, et al., 2022).

As it stands, the current study demonstrates that motivations for nature contact are plural and that differentiating between them matters, but we do not yet have a definitive way of operationalising this. There is a need for a formal SDT-informed development of nature motivation scales to help us more fully understand the constellations of reasons why some people visit nature while others do not, and to plan interventions intended to enable everyone to reap the rewards of durable investments in greening that are being made in cities around the world.

AUTHOR CONTRIBUTIONS

Thomas Astell-Burt conceptualised the paper and wrote the first and final drafts. Thomas Astell-Burt and Xiaoqi Feng acquired funding for the study. Xiaoqi Feng co-designed the survey and analytical strategy and provided critical editing and revisions. Michael Navakatikyan conducted the data management and statistical analyses and provided critical editing and revisions under Thomas Astell-Burt's supervision. Mathew P. White provided critical editing and revisions. All authors provide final approval of the version to be published.

ACKNOWLEDGEMENTS

We would like to express our thanks to Professor Terry Hartig and an anonymous peer reviewer who provided highly constructive and thought-provoking reviews, which contributed to significant improvements being made to our final manuscript. Open access publishing facilitated by University of Wollongong, as part of the Wiley - University of Wollongong agreement via the Council of Australian University Librarians.

FUNDING INFORMATION

Astell-Burt is supported by an Australian Research Council (ARC) Future Fellowship (FT220100857). Feng and Astell-Burt are supported by a National Health and Medical Research Council (NHMRC) and UK Research Innovation (UKRI) Built Environment and Prevention grant (GNT1192691) and an Australian Government Department of Health and Aged Care, Medical Research Futures Fund Effective Treatments and Therapies grant (GNT2023914). White and Astell-Burt acknowledge the support of the Horizon Europe grant #: 101081420 (Building individual and community RESilience thrOugh NATurE-based therapies—RESONATE) during the development of this manuscript.

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare. Thomas Astell-Burt is an Associate Editor for *People and Nature* but was not involved in the peer review and decision-making process.

DATA AVAILABILITY STATEMENT

The data are not currently publicly available as it is part of an ongoing longitudinal study. Researchers interested in collaboration involving this data are encouraged to contact the corresponding author directly.

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How to cite this article: Astell-Burt, T., Navakatikyan, M., White, M. P., & Feng, X. (2024). Exploring autonomous and controlled motivations for nature contact to maximise health benefits. *People and Nature*, *00*, 1–16. https://doi.org/10.1002/pan3.10639