Recalling autobiographical memories of nature moments for improved positive affect

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Abstract

Nature-based interventions have been associated with improved positive affect. The ability to improve positive affect can be considered a preventative skill, helping to manage emotions and strengthen coping responses, leading to greater psychological wellbeing. However, many circumstances can make accessing natural environments difficult. As urban residents face lockdowns, uncertainty, and isolation the ability to provide accessible and equitable mental health interventions to improve mood has become increasingly important. A variety of brief mental imagery techniques have been shown to promote positive affect, and some of these can be easily practiced at home. However, the most optimal imagery content for improving mood — and the cognitive mechanisms underlying these mental imagery effects on mood — remain unclear. Combining two instinctive forms of imagery content in an online randomised experiment, we compare how remembering (vs. imagining) moments in natural versus urban environments in a guided mental imagery task influences positive affect as measured by the Positive Affect and Negative Affect Scale (PANAS). Results from 740 English speaking adults indicate that people who use nature-based imagery, compared to urban-based imagery feel more positive. This effect did not depend on whether the imagery was remembered or imagined. Additionally, exploratory analysis indicated nature-based imagery resulted in higher levels of perceived restoration and nature connectedness. We discuss the theoretical implications of these findings and explore promising directions toward development of a simple, and effective, mental imagery intervention for improving mood and wellbeing.

Keywords: Positive Affect, Mental Imagery, Autobiographical Memory, Nature, Processing Fluency

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any University, and, to the best of my knowledge, this thesis contains no material previously published except where due reference is made. I give permission for the digital version of this thesis to be made available on the web search engines, unless permission has been granted by the School to restrict access for a period of time.

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Contribution Statement

In writing this thesis, my supervisor and I collaborated to generate research questions of interest and design the appropriate methodology. I conducted the literature search and completed the ethics application. Dr Amanda Taylor and Dr Michael Proeve kindly trialled and improved our intervention. My supervisor and I designed the Qualtrics survey based on my selection of variables and their measures, and I distributed the survey to three online participant pools. My supervisor created the video example of the imagery task. The cost of the crowd sourcing platform 'Prolific' was funded by my *Faculty of Health and Medical Sciences Honours Scholarship 2021*. My supervisor and I collaborated to tidy the data in preparation for analysis in R. I conducted all analyses independently with guidance from my supervisor in using R Notebooks. My supervisor assisted me with conceptual understanding and interpretation of Generalised Linear Models and Covariate analysis, then I interpreted results. I wrote the thesis.

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A few key people have helped me get through this challenging year culminating in the production of my dream thesis. Finding the courage to stick to my passions in environment and psychology has been challenging, self-reflexive and powerful. I thank my supervisor, Dr Rachel Searston. Working with Dr Searston on this project has been inspiring and a lot of fun. I learned ‘good science’ and bravery, as we launched into a collaborative journey starting with an exciting idea of ‘bringing nature to mind’. I thank my family and friends. Constantly encouraging and proud, I am forever grateful for the space I have been given to follow my dream. I thank Dad. He is the source of my courage and self-belief. And of course, Nature, without a doubt the source of my creativity and psychological wellbeing. Thank you for taking care of me by letting me take care of you.

Chapter 1

> It is really in ourselves, in our emotions and in our memories, that we can find our healing space. For the most powerful of healing places is in the brain and in the mind.
>
> - *Healing Spaces* Esther. M. Sternberg, 2009

Pause for a moment and take a deep breath…...

Now take yourself back to a memorable moment in your life when you were in a natural environment. This may be a beach or mountains, a tree filled park, or a backyard garden, for example. This moment should be related to a specific experience that you can clearly remember, where you felt close to things in nature…...

Nature-based[1] interventions have been associated with many salubrious benefits (e.g., Bratman et al., 2019; Kuo & Faber-Taylor, 2004; Lackey et al., 2019; Mygind et al., 2021; Twohig_Bennet & Jones, 2018). Specific to psychological wellbeing this includes self-reported feelings of restoration (Corazon et al., 2019), indicators of prosocial behaviour (Putra et al., 2020; Zhang et al., 2014), reduced violent behaviours (Kuo & Sullivan, 2001), improved cognitive performance (Stevenson et al., 2018), eudiamonic and hedonic wellbeing (Capaldi, 2014; Pritchard et al., 2020) and increased positive affect (McMahan & Estes, 2015). Mechanisms underlying the benefits derived from exposure to natural environments, include physical (air quality, sunlight, exercise, socialising) and biological pathways (microbiome, phytoncides, immune function) (Hartig et al., 2014; Kuo, 2015; Robinson & Breed, 2020; Stanhope et al., 2020). Importantly, simulated nature-based interventions indicate there is a significant contribution of psychological mechanisms, presumably

[1] For the purposes of this thesis, natural environments/nature includes any area - bluespace (water), or greenspace (trees) - that contains unmanaged natural wilderness, and any urban or managed elements of nature e.g., gardens, pets, a field, or park. The terms simulated/virtual/indirect natural environments refers to any lab-based, or indoor elements of nature e.g., views, pot plants, visual technologies, and mental imagery.

operating in isolation when the physical components of nature are controlled (Nguyen & Brymer, 2018; Ulrich et al., 1991; White et al., 2018).

Experiments using images, videos, documentaries, radio programmes, virtual reality and immersive technologies have consistently shown that psychological benefits, including affective responses, can be reproduced virtually, albeit to a lesser degree than ‘real’ exposure to natural environments (Breves & Heber, 2020; Calogiuri et al., 2018; Mayer et al., 2009). As more than 50% of the global population now lives in cities, spending time in wild, natural environments is fast becoming an unattainable luxury for many people (United Nations; 2018). Preference for indoor work and entertainment, poor urban planning, mobility and time issues, hospitalisation, incarceration, detention, or being in lockdown due to COVID-19, can all put the benefits of natural environments out of reach when needed the most (Mayer et al., 2009). It has been argued that for people facing barriers to nature contact, nature simulations may serve as ‘real’ nature substitutes (Brymer et al. 2019; Nguyen and Brymer, 2018; Calogiuri et al., 2018; Levi & Kocher, 1999). Unfortunately, in simulated nature experiments the greatest benefits come from multimodal, immersive technologies which are expensive, or not readily available (Breves & Heber, 2020; White et al., 2018).

In this randomised controlled experiment, we test a mental imagery intervention for simulating exposure to the natural environment and measure the effect of this intervention on mood, relative to a control condition involving mental simulation of urban environments. Many guided imagery procedures involve visualising an unfamiliar scene that has been predetermined by fabricated imagery scripts or future thinking cues (Tarrant, 1996; see Figure 1 for examples) However, the vivid, multimodal, and emotional phenomenal experience captured in autobiographical memories (Speer & Delgado, 2017) may be a superior ‘immersive’ nature-based mental imagery intervention, relative to imagining scenes, when attempting to influence mood (Seebauer et al., 2016; Tarrant, 1996). Therefore, we also manipulated the type of mental imagery intervention, comparing autobiographical memory — in which individuals bring the natural environment to mind through their personal memories — to an imagined condition. To our knowledge this study is the first to investigate

Figure 1

Examples of Imagery Scripts

A

Imagine that you are walking across a field of fresh green grass on a warm spring day. You feel the softness of the grass beneath your feet, the warmth of the air on your skin, and hear the sound of birds singing in the distance. You are moving toward a large tree that is near a creek. When you reach the tree, you sit down with your back supported by the trunk. Listening to the soft sound of running water in the creek, you notice that you are filled with a sense of well-being.

B

Cue: Imagine Madonna being at the university next year (this example is taken from Experiment 2).
"Madonna enters the main hall of my university. It is huge … it looks like a Greek theatre. The desk is indeed in the lowest, central part of the hall and the chairs are positioned all around it like an amphitheatre. The hall is empty … maybe there should be a lecture … Madonna sits on the desk and little by little the students start to arrive to join the lecture. Nobody recognizes her at the entrance … she is indeed without makeup and so nobody recognizes her. Only after a while someone notices her and gradually you can start to hear a buzz in the background and gradually it becomes louder and louder. In few seconds the hall is a mess and six bodyguards … but they look like normal persons … they wear normal clothes…enter the hall and start to halt the students who starts to ask for autographs on their notebooks, newspapers … They all take pictures with their telephones. Then Madonna will start to sings and an applause will explode".

autobiographical memory as a mental imagery intervention for simulating affective nature-based experiences.

Note. Panel A: An imaginary guided imagery script (Arbuthnott et al., 2001). Panel B: A Self-irrelevant Future Event cue, followed by participant response (DeVito et al., 2012).

1.1 Improving Mood

Positive affect can be defined as a conscious state of subjective positive emotion or feeling, distinct from negative affect (Diener & Emmons, 1985; Watson et al., 1988). Mood has been differentiated from emotion as a more persistent state (Diener et al., 2015), however in this study we will use affect, emotion and mood interchangeably. Positive affect is often characterised by an arousal dimension, related to reward and dopamine pathways, and includes feelings such as excitement, alertness, and curiosity (Holden et al., 2017). People low in positive affect appear lethargic, unenthusiastic, and depressed. A second dimension of positive affect, also described as low negative affect (a discussion beyond the scope of this paper), is characterised by contentment and related to oxytocin and parasympathetic activity (Holden et al., 2017; Watson et al., 1988). Emotions include feeling calm, safe, and relaxed. Metacognitive feelings, often described as liking, pleasant, or warm, tend to be experienced momentarily, immediately after exposure to a stimulus (Speer et al., 2014). Evidence has shown that repeated positive-emotion practice can be employed to counter negative affect, and 'rewire' maladaptive neuronal pathways in negatively valenced mental health conditions, such as depression and post-traumatic stress disorder (Johnson et al., 2013; Pearson, 2019; Steel et al., 2020).

The ability to improve and maintain positive mood is important for the general population (Shanahan et al., 2019). Happily, most people in the world, even those living in difficult circumstances, are in a positive state most of the time (Diener et al., 2015). However, research is highlighting a concerning trend in measures of psychological wellbeing. For example, 20% of healthy adults in the United States felt they were languishing rather than flourishing (Sin & Lyubomirsky, 2009) and in Australia the number of people that have developed a diagnosis of anxiety or depression has steadily increased from 4.0 million Australians in 2014-15 to 4.8 million in 2018 (Australian Bureau of Statistics, 2018). Currently, there are fears that many more people are being stretched beyond their normal capacity to cope as Covid-19 exposes an unprecedented number of people to anxiety, loneliness, and sadness (World Health Organization (WHO), 2021; Munindradasa et al, 2021). As part of the WHO public health response (2021) it is recommended people *'Draw on skills you have used in the past that have helped you to manage previous life's adversities and use those skills to help you manage your emotions during the challenging time of this* *outbreak*'. The ability to improve positive affect can be considered a preventative skill, helping to manage emotions and strengthen coping responses (Tugade & Fredrickson 2007; Holden et al., 2017; Waugh, 2020). The skill of improving positive affect is optimised through awareness and active practice over time (Munindradasa et al, 2021). Re-playing positive experiences (Askelaund et al., 2019; Speer et al., 2014; Werner-Seidler et al., 2017) and spending time in natural environments (McMahan & Estes, 2015) have increasingly been recognised as interventions that can promote positive affect with minimal side-effects and equitable access (Clark et al., 2015; Hamann & Ivtzan, 2016; Lackey et al., 2019). We designed an initial investigation to determine if our brief, online, nature-based imagery intervention could improve mood and if so, whether it depended on autobiographical memories.

1.2 Autobiographical Memory Interventions for Improving Mood

Positive memory training can be delivered using guided imagery methods (Werner-Seidler et al., 2017). Guided imagery is an intentional generation of mental images that can be used to evoke a general psychophysiological state of relaxation (Nguyen & Brymer, 2018). It provides a scaffold for exploring the senses and emotions, encouraging awareness, and composure (Parnabas & Mahamood, 2011). An example is the Broad-minded Affective Coping intervention (BMAC; Tarrier, 2010) which been proposed as a cognitive-behavioural approach for promoting positive emotions with a small number of sound and promising empirical findings (Johnson et al., 2013; for review see Miguel-Alvaro et al., 2021).

When comparing self-report accounts of perceived sensations and temporospatial details, memories of real events contain stronger phenomenological characteristics than imagined events (Kealy & Arbuthnott, 2003; Thonnard et al., 2013; Zeidman & Macguire, 2016)). Moreover, memories are cognitively 'attached' to emotions making vivid, arousing events easier to recall, regardless of valence (Bower, 1981; Speer et al., 2014; Westerman et al., 1996). In healthy adults, memory has a positivity bias, meaning people perceive events in their lives as being mostly pleasant (Walker et al., 2003). Research shows that as positive memories are captured and recalled, they are associated with elevated dopamine levels, increasing the relevance of, and facilitating access to, that memory (Shohamy & Adcock, 2010). Although reward systems in the striatum are more likely to be triggered with autobiographical memory recall (Speer et al., 2014), they may also be triggered when constructing novel scenes because it is very difficult for people to resist drawing upon content from memory (Pearson, 2019). However, the extent to which an imagined event feels familiar may be used as an indicator of the degree of 'sampling from the past' (Holmes & Matthews, 2010). To our knowledge differences in positive affect outcomes between remembered and imagined mental imagery interventions have not been examined experimentally. A greater understanding of differences between intervention type may therefore contribute valuable new knowledge to positive memory training.

1.3 Nature-based Interventions For Improving Mood

Notably, people reminisce about meaningful past events as a natural strategy for improving and maintaining subjective wellbeing (Askelaund et al., 2019; Killingsworth & Gilbert, 2010). Similarly, people are drawn to natural environments as a natural strategy for improving positive mood, demonstrated recently during COVID-19. Data from 48 countries has shown an increase in park visitation of up to 350% (77% in South Australia), compared to the pre-pandemic baselines in January 2020 (Geng et al., 2021; Speirs, 2021; Venter et al., 2020). In a more structured way nature-based interventions, ranging from restorative 'forest bathing' to adventure therapy for troubled youth, are increasingly offered by the alternate health sector as methods for improving physical and mental health (for reviews see Harper, 2017 and Kotera et al., 2020). Recently mainstream health, government and industry sectors have begun to adopt nature-based initiatives reflecting the accumulating body of evidence and rising public demand (Brymer et al., 2019; Summers & Vivian, 2018). Councils are planning more green space (Nature Festival S.A., 2021; The City of Unley, 2020), new hospitals are incorporating natural spaces and outlooks (Cartledge, 2019), and some health practitioners are prescribing activities such as green exercise (Robinson & Breed, 2019), animal contact (Jones, et al., 2019) and gardening (National Health Service, n.d.) as adjunct therapies for chronic physical and mental health conditions (Twohig-Bennett, 2018; White et al., 2018; Van den Berg, 2017).

For those who cannot access green space or nature directly, reminiscing about a personal experience in nature may be a way to simulate exposure to the natural environment and generate positive mood (Tarrant, 1996). Tarrant (1996) used a questionnaire with a within-subjects experimental design, to prompt different recollections in 54 students. He found that when comparing recollections of outdoor experiences, recollections of classroom exams, and an autogenic relaxation method, thinking of outdoor experiences produced the highest positive affect. Similarly, another recent experiment compared the effect of a nature-based vs. urban-based guided imagery on reducing state anxiety (Nguyen & Brymer, 2018). The guided imagery audio-scripts which asked people to take themselves to a place in nature had a significantly larger effect on reducing state anxiety than the urban-based imagery (Nguyen & Brymer, 2018). In the current study we combine concepts from positive memory training and nature-based interventions to design a nature-based memory intervention, *Nature Moments*, and explore the effect it has on positive mood.

1.4 Theories of Nature-based Benefits

To date nature-based research has been largely cross-sectional, correlational, and atheoretical (Rupprecht, et al., 2015; Shanahan, et al., 2019; Tandon, et al., 2018). To gain confidence and respect of the mainstream health sector and government funding regulators, theories and mechanisms explaining nature-based benefits need to be improved and tested

(Bratman et al., 2019; Gullone, 2000; Houlden et al., 2018; Lackey et al., 2019; Wendelboe-Nelson et al., 2019). Currently, theories tend to be divided into three predominant categories; evolutionary, cultural, and biological (Steg & de Groot, 2018).

The *biophilia hypothesis* proposes that humans have an innate affinity for other forms of life (Wilson, 1984). Two of the most popular evolutionary theories derived from the Biophilia Hypothesis are Ulrich's (1983) Stress Reduction Theory (SRT), and the complimentary, Attention Restoration Theory (ART; Kaplan, 1995). Both are based on the restorative capacity of non-threatening natural environments. Ulrich suggests positive emotional responses associated with non-threatening natural environments serve an adaptive function where biologically-prepared learning genetically shapes preferences toward environments that previously offered opportunity and refuge to our ancestors (Appleton, 1975; Ulrich et al., 1991).

Cultural (Bell, 1999; Carlson, 2009; Gobster, 1999) and learning theories (Neal et al., 2006; Van den Berg et al., 1998) emerging from the social sciences suggest landscape preferences are being shaped by social, cultural, and personal experience over a much shorter timeframe. *Topophilia*, suggests experience and familiarity of the landscape drive preference for natural environments (Tuan, 1974). Topophilia suggest Pavlovian-type associations are formed between happiness and natural landscapes during nature-based recreation and vacations, while neutral or negative emotions are associated with urban landscapes where people reside and work (Collado & Manrique, 2020; Steg & de Groot, 2018). Interestingly, in 1997, Kellert proposed that biophilia could be shaped by culture and experiences, and Ulrich (1983) stated that connection and exposure to nature is essential for experiencing natures positive effects. These blended ideas have contributed to an ongoing demand for integration of multiple, synergistic theories which may vary with the type of nature-exposure and the population (Bell, 1999; Hartig et al., 2014).

More recently proposed, the Perceptual Fluency Account (PFA; Joye & Van den Berg, 2011) states that natural environments are evaluated positively because visual features common in natural environments are more coherent and so mentally processed more fluently than many urban scenes (Joye & Van den Berg, 2011). Specific natural landscape features that make cognitive processing easier include fractals (Hagerhall et al., 2004), high redundancy (Reber et al., 2004), and self-similarity (Mullin et al., 2017). However, visual features or visual perceptual fluency per se is not necessary for the beneficial effects of nature. This was recognised by Singer in 1966 '*A feeling response could also be elicited by imagining, or a vivid memory of, a natural setting'* . Positive affect has since been associated with nature sounds, natural scents, nature-based words, and nature-based mental imagery (Nguyen & Brymer, 2018; Menzel & Reece, 2021a).

In this study we explored the influence of the broader concept: *Processing Fluency*. Processing fluency is an umbrella term for all fluency types, including perceptual fluency, conceptual fluency (assigning meaning to a stimulus), and retrieval fluency (the subjective ease with which people can bring information to mind) (Graf et al., 2017; Gamblin, 2020). Just as sensorial features inherent in objects and scenes can give rise to perceptual fluency, other stimulus information such as coherency, priming, vividness, clarity, recency, and repeated exposure have been found to vary processing fluency (Schwartz, 1991). The mere-exposure effect, a well-established theory of retrieval fluency, proposes a stimulus for which an individual has repeated exposure, positive expectations, or favourable attributions, will be faster and easier to process (Reber et al., 2004; Zajonc, 2001). There is a striking resemblance between the mere-exposure effect and Tuans cultural *Topophilia hypothesis* which suggests experience and familiarity of the landscape drive preference for natural environments.

Processing fluency is thought to be hedonically marked (Winkielman et al., 2003) explaining metacognitive judgements of liking, pleasantness, warmth, preference, trust and beauty, as well as higher scores on composite affect scales such as the Positive and Negative Affect Schedule (PANAS: Watson et al., 1988), (for a review see Gamblin, 2020). Some authors suggest this hedonic marking of processing fluency may have an adaptive role in preferring known, safe environments, and promoting subjective wellbeing (Speer et al., 14; Wang & Chang, 2004). Importantly, the hedonic fluency model proposes that fluency is selectively positive (Winkielman et al., 2003) supporting the finding that exposure to natural environments is primarily associated with increase in positive affect, with little or no change in negative affect (McMahon & Estes, 2015).

In the present study, we hypothesise that processing fluency of natural environments may be accelerated because the stimulus is familiar (retrieval fluency), easier to perceive (perceptual fluency), and/or meaningful (conceptual fluency) resulting in implicit liking and preference. Ulrich himself stated that '*it is clear that engagement with nature can induce positive emotion and this goes beyond restoration after encountering negative affect*'.

1.5 The Current Study

The aim of this study was to determine if nature-based autobiographical memories could be used as a unique method for improving mood — in the absence of direct contact with external nature-based images or nature itself. The reason we asked this research question was to address the need for evidence-based, low-cost, low-risk, accessible and brief interventions, through which people, in a variety of living situations, can increase emotional well-being (Sin & Lyubomirsky, 2009). Accordingly, we compared effects on positive mood for mental imagery moments in natural environments to urban environments, for both imagined and remembered intervention types in an online, randomised, highly powered experiment. Theoretically, we structured our study within a processing fluency framework and included several relevant fluency-based explanatory covariates —liking, warmth, and familiarity — in our primary analysis.

Our Predictions:

1. In accordance with overall findings that exposure to natural environments improves mood (McMahan & Estes, 2015) we predict moments in natural settings will be associated with higher positive affect scores than moments in urban settings .
2. In the absence of previous studies, we draw upon research showing memories and imagined events differ in their phenomenal and emotional characteristics (e.g., Kealy & Arbuthnott, 2003; Walker, 2003) to predict that recalling autobiographical memories will be associated with higher positive affect scores than imagining novel scenarios.
3. In accordance with two previous studies finding positive affective responses to nature memories (Seebauer et al., 2016; Tarrant, 1996), we predict there will be an interaction between the mental imagery Content (natural vs urban) and intervention Type (memory vs imagined) conditions, showing greatest mood generated by nature moments will depend on memory.
4. In accordance with processing fluency literature suggesting hedonic marking of stimuli that are familiar (retrieval fluency), easier to perceive (perceptual fluency), and/or meaningful (conceptual fluency) (Winkielman & Cacioppo, 2001) we predict liking, warmth, and familiarity – three key indicators of processing fluency - will be significant moderators of the relationship between manipulations (type and content) and positive affect.

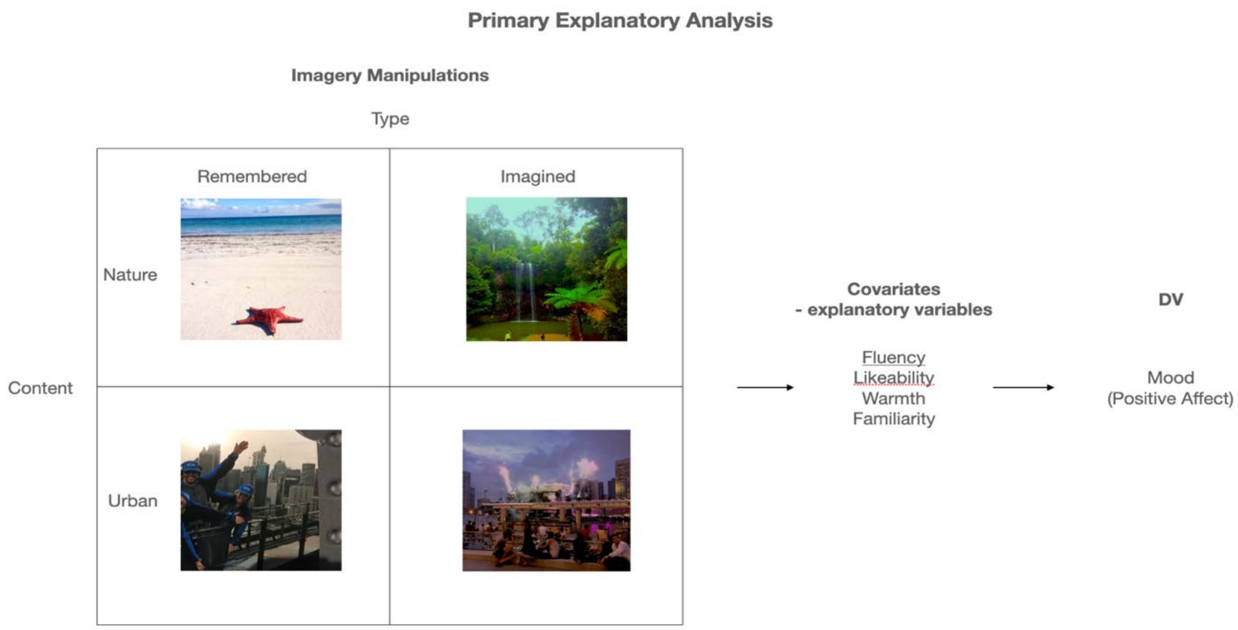
In addition to the primary analysis, we measured two covariates considered in the existing literature as potential modifiers of the effect of our mental imagery intervention on positive mood – vividness and valence (Sheldon & Levine, 2013; Van Dessel et al., 2020). Finally, we also explored the effects of our mental imagery interventions on two alternate outcome measures prominent in the nature-based literature –restoration and nature connectedness (Menardo et al., 2021; Whitburn et al., 2020).

Chapter 2: Method

The aim of this study was to determine if nature-based guided mental imagery might be used as an intervention for improving mood. Accordingly, we designed a randomised, 2 x 2 between-subjects experiment, manipulating the environment in which participants experienced their moments (Mental Imagery **Content**) and the type of mental imagery intervention they used (Intervention **Type**) (see Figure 2). Participants were randomly assigned to one of two ‘Content’ conditions: the first involved bringing a moment to mind that was situated in a natural environment (e.g., beach or mountains, a tree filled park, or a backyard garden) and the second involved bringing a moment to mind that was situated in an urban environment (e.g., house or apartment building, a city street, or a shopping mall). The urban condition served as the ‘control’ to the nature condition. Participants were also randomly assigned to one of two intervention ‘Type’ conditions: the first involved remembering a moment from the past and the second involved imagining a novel moment. If nature-based mental imagery can help to improve positive affect, this second manipulation allowed us to test if those benefits were specifically dependent on memory-based processes.

Figure 2

Nature Moments Experimental Design



2.1 Participants

740 participants (185 in each condition) completed our survey. The gender of the sample comprised 337 (46%) males, 395 (53%) females, 6 (0.8%) non-binary/third gender, and 2 participants who preferred not to report their gender (0.2%). The difference between gender groups on positive affect was not significant (p = 0.851). Participant age ranged from 18 to 80 (Mdn = 24, M = 28.65, SD = 11.60). A Pearson's correlation test showed age was not significantly correlated with positive affect (r = .05, p = .205, CI 95% [-0.03, 0.12]) (See Appendix A for details).

Participants were sampled from three English-speaking, adult populations: University of Adelaide first year psychology students via an online research participation system (9.5%), Australian national volunteers via email (9.5%), and international subscribers to the crowdsourcing internet marketplace 'Prolific' (81%). The Prolific Academic website (https://www.prolific.co/) is a resource for high quality, demographically diverse individuals who complete academic surveys for monetary compensation. First year psychology students received course credit. No incentives were offered to volunteers. Ethics approval was granted by the University of Adelaide, School of Psychology's Human Research Ethics Sub-Committee (21/27). All participants were directed to the Qualtrics website (https://www.qualtrics.com/au/) where they provided informed consent prior to completing the online survey in a quiet, private place of their choosing. The online survey was entitled '*BREEETHE: Can mental imagery affect how we feel?*' avoiding prior knowledge of the four randomised conditions. Data collection for the study took place over eight weeks and was anonymous.

An a priori power analysis indicated that 700 participants were required to detect our smallest effect size of interest Cohen's $d = 0.22$ with power .83 (PANGEA; Westfall, 2016). The small effect size was the average of conservative estimates based on related meta-analyses and experiments (e.g., Hitchcock et al., 2017; Lakens et al., 2018; McMahan & Estes, 2015). We considered a Type II error rate smaller than .20 (beta =.17) was an acceptable risk and were confident that our experiment had enough power to detect a meaningful difference between the two manipulations.

2.2 Measures

2.2.1 Dependent Variable 'Positive Mood' (Positive Affect)

Measures used to assess emotion have been found to moderate the effect of nature-based interventions on mood (McMahan & Estes, 2015). The largest effect sizes were associated with the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988, alpha of positive affect = .88). Consequently, we used the full 20-item PANAS scale to assess participants' current mood in this study. Participants rated the degree to which they were currently experiencing adjectives describing each mood state using a Likert-type scale ranging from 1 (very slightly or not at all) to 5 (extremely). Even though there is speculation that both nature and imagery interventions selectively improve positive affect in healthy adults (McMahan & Estes, 2015; Speer et al., 2014) we included the 10 negative affect scale adjectives to reduce extreme and neutral response bias. Responses to the 10 positive emotion words were averaged, to create a positive affect score, ranging between 5 and 50. Accordingly, improved mood is indicated by higher positive affect scores.

2.2.2 Covariates

Processing Fluency – Warmth, Liking, Familiarity

A 'warm glow' has been associated with the intrinsic reward system associated with positive affect, the affiliative system, and a sense of safety (Holden et al., 2017; Taufik et al., 2015). Specific to our study, it is thought that fluent processing resulting from a feeling of familiarity and perceived closeness, is associated with a feeling of warmth (Kim & Dempsey, 2018; Winkielman & Huber, 2009). We used the 'warmth' half of the Subjective Warmth and Competence Scales for Social Perception (Aragones et al., 2015, alpha = .82). The four adjectives (kind, pleasant, friendly, and warm) were embedded within the PANAS scale as they are rated on the same Likert-type scale from 1 (not at all) to 5 (extremely). The resulting amalgam of 24 'feeling' adjectives were randomised in the survey to reduce response bias. The ratings for the four items were subsequently extracted and summed to create an individual warmth score ranging from 4 (low) to 20 (high).

The most popular and reliable assessment of processing fluency is subjective liking (Gamblin, 2020; Graf et al., 2017). Assuming processing fluency is hedonically marked we expect greater perceptions of liking to be associated with positive affect (Winkielman et al., 2003). Familiarity has also been associated with processing fluency and used as a measure predominantly in studies investigating the mere exposure effect (Ng et al., 2020; Whittlesea, 1993). Metacognitive research has shown that single item subjective measures are valid instruments for assessing processing fluency and cognitive load (Graf et al., 2017). Moreover, single-item measures are a practical solution to avoiding fatigue in online surveys. We used recommended scales of 0 to 100 for both liking (not at all - very much), and familiarity (not at all familiar - extremely familiar).

Vividness

People are known to vary in the clarity or vividness of their mental imagery. Individual differences, mood disorders, a genetic condition aphantasia, and non-specific and semantic recall can all affect the vividness of mental imagery (Askelund et al., 2019; Pearson, 2019; Speer et al., 2014). We included the covariate 'vividness' as a potential moderator of the main effect on positive mood. We used a 'trial-by-trial' vividness rating (VR; Pearson et al., 2013). VR is a single response scale originating from the widely used, 16-item Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973) and has shown relative superior reliability (Runge et al., 2017). Participants rate vividness at a particular moment in time from (0) 'no image,' to (100) 'perfectly vivid'.

We used participants familiarity and vividness ratings as a manipulation check for the mental imagery remembering vs. imagining manipulation. Imagined moments should be less familiar and less vivid than remembered moments (Holmes & Matthews, 2010). Indeed, there was a statistically significant difference between remembered and imaginary conditions for both familiarity and vividness of imagery ($p < .001$ and $p < .001$, respectively) (see Appendix B for analysis).

Valence of the mental imagery content

Positive or negative emotional tone of the mental imagery content was indicated on a scale from extremely negative (-100) to extremely positive (100). In the imagery literature positive thoughts are used to generate positive affect, whereas spontaneous recall of negative experiences has been associated with psychological ill-health (Holmes & Matthews, 2010; Steel et al., 2020; Speer & Delgado, 2017). We included the covariate 'valence' as a potential moderator of the main effect on positive mood.

Cognitive Load – Restoration and Ease

To explore the effects of our manipulations on levels of restoration we included the established self-report ratings of 0 to 100 for *effort required to think of a moment* (very easy - very difficult), and perceived level of restoration (not at all – entirely restored) (Klepsch et al., 2017).

Connectedness

The Inclusion of Nature in Self Scale (INS; Schultz, 2001) was selected to measure nature connectedness. The INS scale is a single-item, graphical scale that assess the degree to which a person feels their life is interconnected with the natural environment. Seven diagrams show an incremental increase in the degree of overlap between a 'me-circle' and a 'nature-circle' (Appendix C). On a corresponding scale of 1 to 100, participants rated their relationship with nature, such that low scores indicate a perception of being unrelated to nature and high scores indicate a perception of being at one with nature. Along with practicality and simplicity, this instrument has shown excellent predictive and concurrent validity in assessing the cognitive dimension of nature connectedness (Braun & Dierkes, 2017; Kleespies et al., 2021; Mayer & Frantz, 2004; Tam, 2013).

To measure urban connectedness, we modified the INS graphical scale, as we could not locate an existing measure for urban connectedness. We include two circles, one labelled 'me' and the other labelled 'urban' and asked participants to also rate their relationship with urban areas on a scale of 1 to 100 (Appendix C). The INS scale is itself a modification of the 'Inclusion of Other in the Self Scale' (Aron et al., 1991) and other modifications of this scale have been applied successfully (e.g., Kleespies et al., 2021).

Time spent in nature (**Contact**) is considered a critical factor in developing nature connectedness (e.g., Lumber et al., 2017). To assess how much time participants spent in nature and urban environments 'day to day' we included the item: '*In an average week, how much 'awake' time do you spend in urban environments compared to natural environments?*' Contact was scored on a sliding scale as a percentage, where below 50% indicated more time in urban areas and over 50% indicated more time spent in nature.

As a manipulation check for the mental imagery content condition, we found the environment in which people spent their moment accurately reflected their level of connectedness ($p < .001$; see Table 6 for statistics). Additionally, we captured the year, location, and a short description of the moment in a text box titled '*Where did this moment take place and what were you doing?*'. Two participants in the memory condition illogically placed their memory in the future and a small proportion of participants reported discrepant mental imagery content: 31 responses (4%) indicated nature moments in urban manipulations and 5 responses (less than 1%) reported urban moments in nature manipulations. In summary, there was a meaningful difference in participant responses between nature and urban conditions even when retaining a large degree of natural variation in the kinds of moments participants brought to mind.

2.3 Imagery Task

The short imagery scripts were adapted from the 'Broad Minded Affective Coping' and '5 senses' techniques, with efforts to replicate words as much as possible across conditions (Tarrier). These scripts were then reviewed by clinical psychologists familiar with imagery techniques to further improve phrasing, clarity and readability. Prompts were included to encourage vivid, and specific imagery as these conditions are considered important for generating positive affect (Askelund et al., 2019; Sheldon & Levine, 2013; Williams & Broadbent, 1986). Environment prompts were based on thematic categories identified in a qualitative analysis of guided imagery task (Nguyen & Brymer, 2018), analysis of popularity of natural environments in the Natural

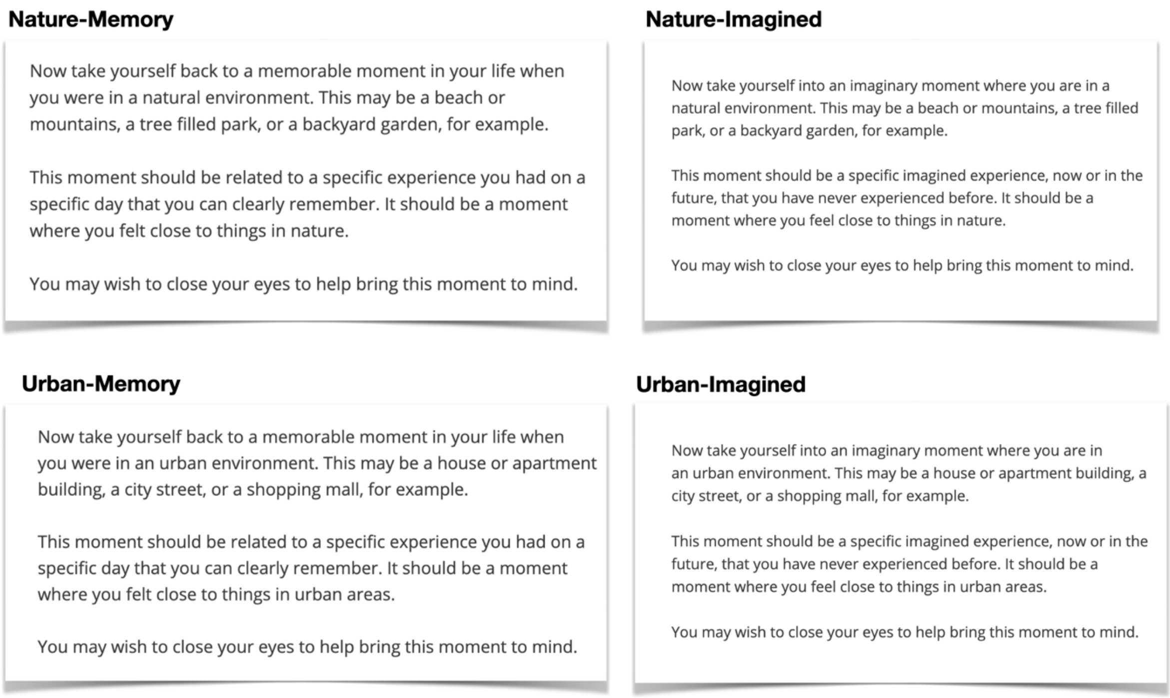
Environment Exposure Scales (NEES; Pensini et al., 2016) and theoretically based biophilic natural environments (Lumber et al., 2017).

2.4 Procedure

A web-link to the survey was provided to participants via an online invitation. Following the link directed participants to the information and consent page (Appendix D) after which they 'opted in' by pressing the 'next' button. Our survey was designed on the *Qualtrics* platform which automatically randomly assigned participants to one of the four conditions (these can be viewed in Figure 3).

Figure 3

Standardised mental imagery instructions for each experimental condition



Nature-Memory

Now take yourself back to a memorable moment in your life when you were in a natural environment. This may be a beach or mountains, a tree filled park, or a backyard garden, for example.

This moment should be related to a specific experience you had on a specific day that you can clearly remember. It should be a moment where you felt close to things in nature.

You may wish to close your eyes to help bring this moment to mind.

Nature-Imagined

Now take yourself into an imaginary moment where you are in a natural environment. This may be a beach or mountains, a tree filled park, or a backyard garden, for example.

This moment should be a specific imagined experience, now or in the future, that you have never experienced before. It should be a moment where you feel close to things in nature.

You may wish to close your eyes to help bring this moment to mind.

Urban-Memory

Now take yourself back to a memorable moment in your life when you were in an urban environment. This may be a house or apartment building, a city street, or a shopping mall, for example.

This moment should be related to a specific experience you had on a specific day that you can clearly remember. It should be a moment where you felt close to things in urban areas.

You may wish to close your eyes to help bring this moment to mind.

Urban-Imagined

Now take yourself into an imaginary moment where you are in an urban environment. This may be a house or apartment building, a city street, or a shopping mall, for example.

This moment should be a specific imagined experience, now or in the future, that you have never experienced before. It should be a moment where you feel close to things in urban areas.

You may wish to close your eyes to help bring this moment to mind.

Participants then spent the next few minutes engaged in the imagery task (Mean time spent bringing moment to mind = 40.1 seconds). After taking a deep breath to settle and focus on the task, the participants were asked to bring to mind a moment specific to their randomly assigned condition: Nature-Memory, Nature-Imagined, Urban-Memory, or Urban-Imagined. The next six questions were prompts to help participants explore the moment they brought to mind in greater sensory detail (Mean time spent thinking about their moment = 1 minute, 40.4 seconds). An example script depicting the nature-memory condition can be seen in Appendix E and a video example of the mental imagery task, can be viewed here: https://www.youtube.com/watch?v=P4iDs8L4jOQ. After completing the guided mental imagery task, participants were asked to rate how they felt in the moment they brought to mind, the year the moment took place, and write a short description of the moment including details of what they were doing and where they were. Following these questions, participants then rated the degree to which their moment felt familiar, vivid, restorative, easy to bring to mind, and how much they liked the task. They then completed the combined PANAS/Warmth scale, Inclusion of Nature/Urban in Self scales, and recorded how much relative time they spent in nature, in addition to their age and gender.

The imagery task was designed with timing elements to record time spent on each question and delay question submission to discourage less motivated participants from speeding through the task. Data showed that the whole survey was kept within the desired maximum of 10 minutes (Mdn = 7.53, M = 11.20, SD = 49.30 minutes). There was also no evidence of 'mechanical clicking' on the next button, indicating that participants were adequately engaged with the brief intervention.

2.5 Analysis Plan

All analyses were performed in R (version 4.0.3), using the rmarkdown and ggplot2 packages. The alpha level for all inferential statistics was set at .05 (Allaire et al., 2021; R Core Team, 2013; Wickham, 2016). We planned to conduct a two-way analysis of covariance (ANCOVA) to test for main effects of mental imagery content (Prediction 1) and intervention type (Prediction 2) on positive affect, and to probe a possible interaction between these variables (Prediction 3) while accounting for variation due to liking and warmth (Prediction 4). Analysis of covariance is a statistical technique that blends an analysis of variance model with linear regression and allows us to evaluate differences between experimental conditions while accounting for variance due to important theoretical covariates. We planned to include measures of liking and warmth as theoretical covariates in our analysis to explore the extent to which any effects of our Content and Intervention Type manipulations could be explained by variation in these measures of processing fluency. We also planned to explore the extent to which the vividness and valence of the moment participants brought to mind in the mental imagery task might impact our primary analysis. Finally, we planned to explore how our mental imagery intervention affected other measures of wellbeing typically seen in research on nature effect, such as feelings of restoration, and feelings of connection to the natural environment.

Chapter 3: Results

3.1 ANCOVA Assumptions

Linearity was determined by visual inspection of scatter plots. Homogeneity of regression slopes was satisfied by performing ANOVA tests finding the interaction terms, between the covariates and grouping variables (Mental Imagery Intervention Type and Mental Imagery Content), were not statistically significant, $p > 0.05$. However, the Shapiro Wilk test was significant ($p < 0.001$), so we could not assume normality of residuals (See Appendix F for detailed assumptions analysis). Much of the data was heavily negatively skewed (Table 1) which is a common problem when using rating measures and explains why our data violated the normality of residuals assumption (Peterson & Wilson, 1992). The most parsimonious solution was to analyse data using a Generalised Linear Model (GLM). The GLM is from a more general class of linear models that changes the relative distribution of the dependent variable using a link function. The link function doesn't touch the raw data, instead it works by transforming the model for the mean of the raw data, thus allowing for application of a suitable statistical model to non-normal data (Lo & Andrews, 2015). The appropriate family of GLM was chosen depending on the best fit with data distribution in each model (Bevans, 2021). Best fit was determined by 1) observing distribution of the dependent variable, 2) residual median approximating zero, and 3) smallest *Akaike's Information Criterion* value (AIC; Akaike, H., 1973) (Bevans, 2021). Details of the R code specifying GLM family used, link function, and model fit indices for our analyses can be viewed in Appendices.

Table 1

Median, Mean (Standard Deviation), and Skew of variables

	Median	Mean(SD)	Skew
Age	24.00	28.65(11.60)	1.73
PANAS Positive (0 - 50)	32.00	31.30(8.26)	-0.17
PANAS Negative (0 – 50)	32.00	31.30(8.26)	2.03
Familiarity (0 – 100)	76.50	70.27(26.34)	-0.99*
Liking (0 – 100)	88.00	82.40(19.36)	-1.51*
Warmth (0 – 20)	15.00	14.42(3.49)	-0.63*
Restoration (0 – 100)	72.00	69.64(21.78)	-0.92*
Ease (0 – 100)	65.00	60.17(27.17)	-0.26
Vividness (0 – 100)	80.00	79.41(16.07)	-1.04*
Valence (-100 – 100)	78	65.80(36.80)	-1.86*
Nature Connection (0 – 100)	67.00	64.60(20.65)	-0.37
Urban Connection (0 – 100)	52.00	55.92(23.24)	-0.19
Urban/Nature contact (0 – 100)	33.00	39.55(23.32)	0.56

Note. *moderate to large negative skew.

3.2 Correlations

All covariates of interest – liking, warmth, familiarity, vividness, valence, restoration and connectedness - were significantly positively correlated with positive affect (see Table 2). Effect sizes were moderate to strong for warmth, and moderate for liking, vividness, valence, restoration, and nature connectedness. Only weak correlations with positive affect were found for ease, urban connectedness, contact, and familiarity. Consequently, we did not consider these four poorly correlated variables as covariates in our analysis. Consistent with the literature there was only a very weak correlation between negative affect and positive affect supporting the concept of two distinct mood constructs (Watson et al., 1988).

Table 2

Correlation Matrix for Study Variables

Variable	Positive Affect	2	3	4	5	6	7	8	9	10	11
2.Negative Affect	-.09 [-0.16, -0.02]*										
3.Warmth	.69 [0.66, 0.73] ***	-.29									
4.Valence	.36 [0.30, 0.43] ***	-.34	.57								
5.Restoration	.41 [0.35, 0.47] ***	-.12	.50	.53							
6.Liking	.40 [0.34, 0.46] ***	-.19	.47	.56	.61						
7.Familiarity	.08 [0.01, 0.15]*	-.07	.14	.18	.23	.15					
8.Ease	.14 [0.08, 0.22] ***	-.15	.13	.15	.13	.17	.12				
9.Vividness	.29 [0.22, 0.35] ***	-.10	.24	.24	.36	.36	.28	.30			
10.Nature Connectedness	.26 [0.19, 0.33] ***	-.10	.20	.13	.22	.20	.14	.10	.24		
11.Urban Connectedness	.09 [0.02, 0.16]*	-.00	.07	.13	.06	.06	-.01	.05	.06	-.13	
12. Contact	.15 [0.08, 0.22] ***	.08	.08	-.02	.09	.02	.12	-.02	.10	.32	-.26

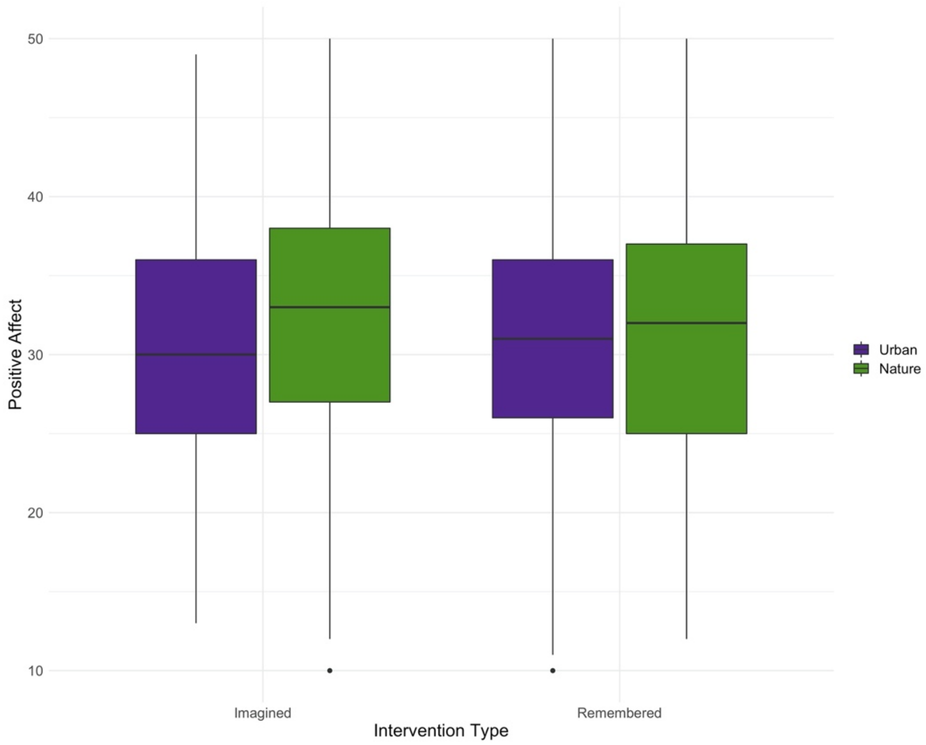
Note: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

3.3 Effects of Mental Imagery Intervention on Positive Affect

Descriptive statistics show participants positive affect scores were normally distributed, and variance across conditions is similar (see Figure 4 and Appendix G). The plot suggests a consistently higher median for nature conditions, relative to urban conditions, however the differences in medians for intervention type appear mixed. An Analysis of Variance (ANOVA) was conducted to test the extent to which nature-based mental imagery content increased positive affect (Prediction 1) and the extent to which this effect depended on remembered versus imagined mental imagery events (Prediction 2 and 3).

Figure 4

Boxplot Showing Main Effects of Mental Imagery on Positive Affect



Note. Y-axis = Restoration rating (0 - 100) for each condition, X-axis = 'Mental Imagery Intervention Type' (Imagined vs. Remembered), and colour purple = Mental Imagery Content 'Urban' or green = Mental Imagery Content 'Nature'.

The main effect of mental imagery content was significant, $F(1, 736) = 3.93$, $p = .048$, suggesting nature content ($M = 31.9$, $SD = 8.2$) resulted in greater positive affect compared to urban content ($M = 30.7$, $SD = 8.3$). However, the main effect of the intervention type was not significant, $F(1, 736) = 0.11$, $p = .745$, indicating no meaningful difference in positive affect scores between remembered ($M = 31.2$, $SD = 8.3$) and imagined intervention types ($M = 31.4$, $SD = 8.2$). The interaction was not significant, $F(1, 736) = 0.55$, $p = .457$.

3.4 Exploring Liking and Warmth as Covariates

Accounting for the processing fluency covariates, liking and warmth, a Generalised Linear Model showed a statistically significant main effect of the mental imagery intervention type (Remembering vs. Imagining) on participants positive affect scores. There was also a statistically significant main effect of mental imagery content (Nature vs. Urban) on participants positive affect scores. There was no significant interaction between mental imagery intervention type and mental imagery content. We refer to this model as the "*Fluency Model"* (see Table 3)[2].

Liking and warmth account for a significant proportion of the variance in positive affect (Z values = 3.79, and 22.10 respectively). If liking and warmth were removed from the *Fluency Model*, the effects of mental imagery intervention type and mental imagery content on positive affect were no longer significant. Similarly, when we fit a model accounting for just liking or warmth independently, there were no significant main effects of mental imagery intervention type and mental imagery content on positive affect (Table 3). Accounting for a proportion of unexplained variance with the covariates liking and warmth – two key

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[2] When we include covariates in the model the coefficients signs were reversed, conflicting with descriptive statistics. Erratic estimations may indicate either a multicollinearity problem (Dunn & Smyth, 2018; Wurm & Fisicaro, 2014; Zeraatkar et al., 2019), Simpson's paradox (suppression effect) or a poor statistical model fit for these data.

indicators of processing fluency - we observed small main effects of the mental imagery intervention type and mental imagery content on positive affect.

Table 3

Main Effects of Mental Imagery on Positive Affect Scores, Accounting for Covariates Liking and Warmth (Fluency Model), without covariates, and with Liking and Warmth independently

Covariates	Coefficient	Std. Error	Z(t) value	P value		Deviance Res. Mdn
Fluency Model						0.34
(Intercept)	5.94	1.09	5.43	<.001	***	
Liking	0.05	0.01	3.79	<.001	***	
Warmth	1.55	0.07	22.10	<.001	***	
Type(R)	-1.26	0.61	-2.06	0.040	*	
Content(N)	-1.23	0.63	-1.97	0.050	*	
Interaction Effect	1.04	0.87	1.20	.231		
No Covariates						0.43
(Intercept)	30.57	0.61	50.39	<.001	***	
Type(R)	0.25	0.86	0.30	.767		
Content(N)	1.65	0.86	1.93	.054		
Liking						0.70
(Intercept)	17.34	1.24	13.93	<.001	***	
Liking	0.18	0.01	11.88	<.001	***	
Type(R)	-0.87	0.79	-1.10	.273		
Content(N)	-0.38	0.80	-0.47	.638		
Warmth						0.34
(Intercept)	7.99	0.96	8.32	<.001	***	
Warmth	1.67	0.06	26.39	<.001	***	
Type(R)	-1.04	0.62	-1.69	.091		
Content(N)	-0.84	0.62	-1.36	.175		

Note: Generalised Linear Models were used for the analysis. Full R code and results can be viewed in Appendix H. Type (R) = mental imagery intervention type 'Remembered', Content (N) = mental imagery content 'Nature'.

*p<.05. **p<.01. ***p<.001.

In summary, thinking of natural environments and remembering personal moments have greater effects on positive affect than urban and imagined moments. These effects also appear to depend on how much participants liked — and how warm they felt — towards the content they were thinking about during the mental imagery task. Although the effect of mental imagery content (nature vs urban) on positive affect was robust to the different approach to modelling the data (ANOVA vs. GLM), the effect of mental imagery intervention type (remembered vs. imagined) was not and a significant effect was only present when fitting a GLM, accounting for covariates liking and warmth.

3.5 Exploring Valence and Vividness as Covariates

Both valence and vividness significantly contributed to variance in positive affect scores. When accounting for vividness there were no significant main effects of mental imagery intervention type and mental imagery content on positive mood. Similarly, when we account for valence (how participants felt in their moment - extremely negative to extremely positive) there were no significant main effects of mental imagery intervention type and mental imagery content on positive mood. These results indicate that, unlike the *Fluency Model*, adjusting for vividness or valence does not account for enough error variance to reveal underlying main effects (Table 4).

Table 4

Main Effects of Mental Imagery on Positive Affect Scores, Accounting for Covariates Vividness and Valence

Covariates	Coefficient	Std. Error	Z(t) value	P value	Deviance Res. Mdn
Vividness					0.73
(Intercept)	19.09	1.51	12.64	<.001	***
Vividness	0.15	0.02	8.23	<.001	***
Type(R)	-0.40	0.83	-0.48	.629	
Content(N)	1.35	0.82	1.64	.385	
Valence					0.61
(Intercept)	26.28	0.70	37.63	<.001	***
Valence	0.08	0.01	10.50	<.001	***
Type(R)	-0.63	0.81	-0.79	.431	
Content(N)	-0.53	0.83	-0.64	.520	

Note: Generalised Linear Models were used for the analysis. Full R code and results can be viewed in Appendix I. Type (R) = mental imagery intervention type 'Remembered', Content (N) = mental imagery content 'Nature'.

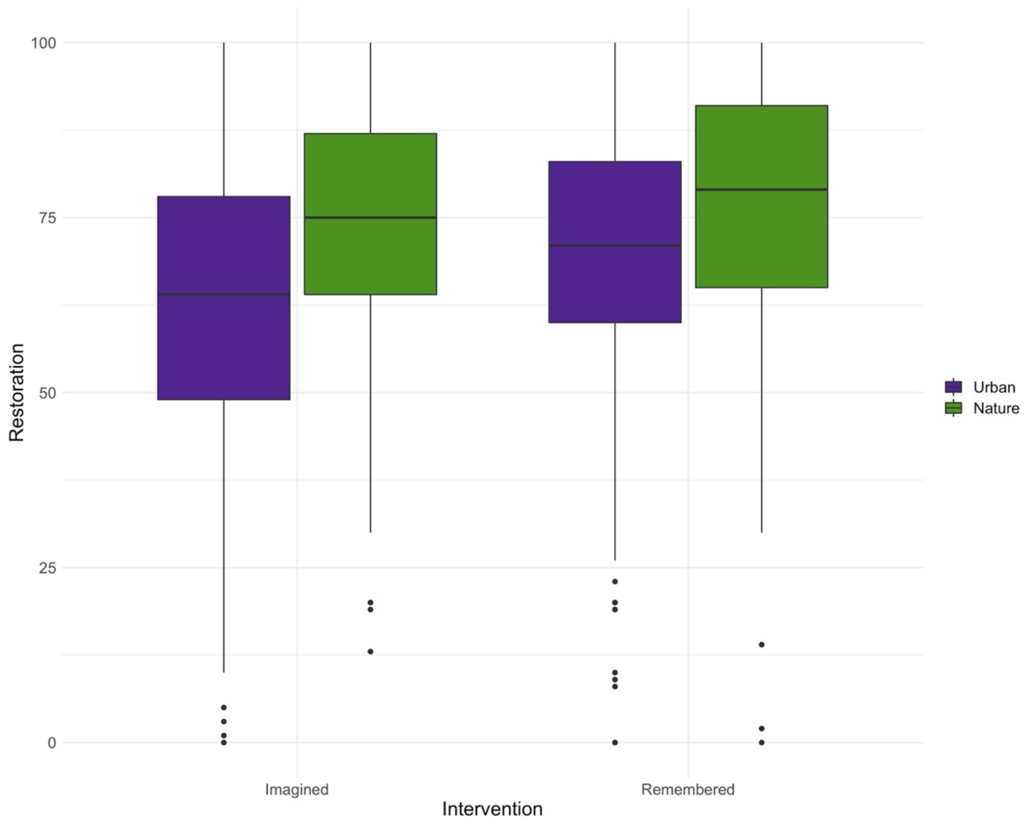
**p*<.05. ***p*<.01. ****p*<.001.

3.6 Effects of Mental Imagery on Feelings of Restoration

As shown in Figure 5, descriptive statistics indicate the distribution of restoration was negatively skewed with similar variance across conditions (Appendix J).

Figure 5

Boxplot Showing Main Effects of Mental Imagery on Restoration



Note. Y-axis = Restoration rating (0 - 100) for each condition, X-axis = 'Mental Imagery Intervention Type' (Imagined vs. Remembered), and colour purple = Mental Imagery Content 'Urban' or green = Mental Imagery Content 'Nature'.

As shown in Table 5, adjusting for ease of task, a Generalised Linear Model shows a significant main effect of mental imagery intervention type: Remembering (Mdn = 75.00, Mean = 72.11, SD = 21.28) vs. Imagining (Mdn = 70, Mean = 67.16, SD = 22.02) on participants rating of restoration. There was also a statistically significant main effect of mental imagery content: Nature (Mdn = 77, Mean = 74.81, SD = 18.75) vs. Urban (Mdn = 70, Mean = 64.46, SD = 23.34) on participants rating of restoration. There was also a significant interaction between Content and Type indicating that mental imagery in natural environments were more restorative than urban environments, and this effect was greater for remembering than imagining intervention types.

Table 5

Main Effects of Mental Imagery on Restoration, Accounting for Covariate Ease of Task

Covariates	Coefficient	Std. Error	Z(t) value	P value	Deviance Res. Mdn
Cognitive Load Model					0.31
(Intercept)	4.01	0.01	295.28	<.001	***
Ease	0.00	0.00	8.61	<.001	***
Type(R)	0.13	0.01	9.81	<.001	***
Content(N)	0.21	0.01	16.32	<.001	***
Interaction T*C	-0.11	0.02	-6.44	<.001	***
No covariates					0.28
(Intercept)	4.10	0.01	432.55	<.001	***
Type(R)	0.13	0.01	10.15	<.001	***
Content(N)	0.21	0.01	16.25	<.001	***
Interaction T*C	-0.11	0.02	-6.37	<.001	***

Note: Generalised Linear Models were used for the analysis. Full R code and results can be viewed in Appendix K. Type (R) = mental imagery intervention type 'Remembered', Content (N) = mental imagery content 'Nature', T = mental imagery intervention 'Type', C = mental imagery 'Content'.

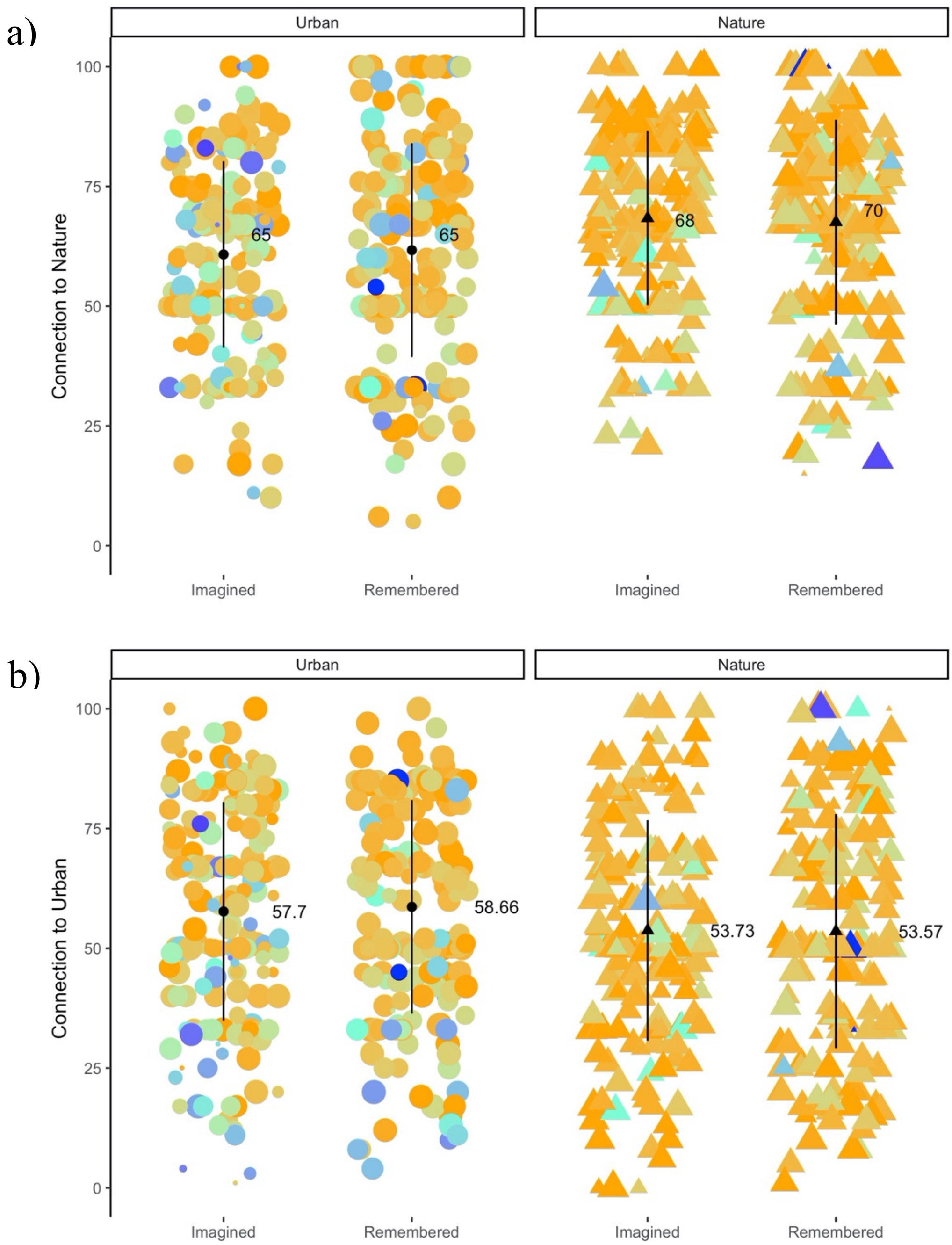
*p<.05. **p<.01. ***p<.001.

3.7 Effects of Mental Imagery on Nature and Urban Connectedness

As shown in Figure 6 and Appendix L, descriptive data showed a difference between nature connectedness in nature (Mdn = 69.50, Mean = 67.95, SD = 19.83) and urban mental imagery content (Mdn = 65.00, Mean = 61.25, SD = 20.93). Importantly, urban connectedness data revealed the opposite pattern between nature (Mdn = 50.00, Mean = 53.65, SD = 23.72) and urban mental imagery content (Mdn = 61.00, Mean = 58.18, SD = 22.54).

Figure 6

Jitter Plots Showing Main Effects of Mental Imagery on Connectedness



Note. Y-axis = a) Nature Connectedness, b) Urban Connectedness. X-axis (lower) = Mental Imagery Intervention Type (Imagined vs. Remembered). Secondary x-axis (upper) = Mental Imagery Content panels 'Urban' and 'Nature'. Colour orange = positive valence, blue = negative valence, shape circle = urban, triangle = nature, and size larger = more familiar, smaller = less familiar.

3.7.1 Nature Connectedness

As shown in Table 6, adjusting for weekly contact, a Generalised Linear Model (GLM) shows a statistically significant main effect of Content: Urban (Mdn = 65.0) vs. Nature (Mdn = 69.5) on nature connectedness. That is, participants experiencing nature moments felt more connected to nature than those experiencing urban moments. There was no statistically significant main effect of the mental imagery intervention Type: Imagining (Mdn = 67.0) vs. Remembering (Mdn = 67.0) on nature connectedness. There was no statistically significant interaction effect.

3.7.2 Urban Connectedness

As shown in Table 6, adjusting for weekly contact, a Generalised Linear Model shows a statistically significant main effect of Content: Urban (Mdn = 61) vs. Nature (Mdn = 50) on urban connectedness. That is, participants experiencing urban moments felt more connected to urban areas than those experiencing nature moments. There was no statistically significant main effect of the mental imagery intervention Type: Imagining (Mdn = 53) vs. Remembering (Mdn = 52) on urban connectedness. There was no statistically significant interaction effect.

In Summary: After adjusting for average time spent in nature vs. urban environments there was a statistically significant main effect of Content on nature connectedness and urban connectedness. Results indicate that the environment in which people spent their moment was accurately reflected in their feelings of connectedness to that environment after the manipulation. Moreover, by showing that the moment in a natural environment determined a congruent nature connectedness, our data shows a causal relationship between mental imagery content and connectedness in our participants. This finding is supported by research suggesting exposure to nature interventions increases nature connectedness (Richardson et al., 2020).

Table 6

Main Effects of Mental Imagery on Connectedness, Accounting for Covariate Contact

Variables	Coefficient	Std. Error	Z value	P value	Deviance Res. Median
Nature Connectedness					.355
Intercept	3.940	.012	321.623	<.001	***
Contact	.004	.000	22.029	<.001	***
Type(R)	.006	.013	.430	.668	
Content(N)	.116	.013	8.934	<.001	***
Interaction T*C	-.022	.018	-1.189	.234	
Urban Connectedness					.038
Intercept	4.232	.013	338.113	<.001	***
Contact	-.005	.000	-21.631	<.001	***
Type(R)	.026	.014	1.893	.058	
Content(N)	-.070	.014	-5.022	<.001	***
Interaction T*C	-.026	.020	-1.315	.118	

Note: Generalised Linear Models were used for the analysis. Full R code and results can be viewed in Appendix M. Type (R) = mental imagery intervention type ‘Remembered’, Content (N) = mental imagery content ‘Nature’, T = mental imagery intervention ‘Type’, C = mental imagery ‘Content’.

*p<.05. **p<.01. ***p<.001.

Chapter 4: Discussion

The aim of this study was to determine if recalling nature-based memories could be used as a method for improving mood. We predicted 1) Moments in natural settings will be associated with higher positive affect scores, relative to moments in urban settings, 2) Recalling autobiographical memories will be associated with higher positive affect , relative to imagining novel scenarios, 3) That there will be an interaction between the mental imagery intervention type (memory vs. imagined) and mental imagery content (nature vs. urban), and 4) Covariates liking, warmth, and familiarity – three key indicators of processing fluency - will be significant moderators of the relationship between manipulations (type and content) and positive affect. Our results supported predictions 1) and 4), partially supported prediction 2), but did not support prediction 3). In summary, although the effect of mental imagery content (nature vs urban) on positive affect was robust to the different approach to modelling the data (ANOVA vs. GLM), the effect of mental imagery intervention type (remembered vs. imagined) was not and a significant effect was only present when fitting a GLM, accounting for covariates liking and warmth.

4.1 Nature-based Interventions for Improving Mood

Our results replicate findings that nature-based interventions improve mood. The small effect size detected in our study is in accordance with the current literature concerning simulated nature exposure (Hartig et al., 2014). A meta-analysis found that overall exposure to simulated natural environments is associated with positive emotions but to a lesser degree than nature exposure *in situ* (r = .26 for lab-based simulations, compared to r = .31 for 'real' nature)(McMahan & Estes, 2015). Additionally, a recent study found liking ratings were associated with smaller effect sizes than alternate outcomes, such as restoration, after viewing nature-based images and words (Menzel & Reece, 2021). McMahan and Estes (2015) suggest that because positive affect is an essential component of other psychological measures, such as restoration and subjective wellbeing, it will be associated with the weakest effects (Capaldi et al., 2014; Menardo et al., 2021). Support was found for this concept in our study, as exploratory analysis suggested relatively stronger effects of the nature-based mental imagery on restoration and nature connectedness, relative to urban imagery.

An alternate explanation suggests that a more nuanced approach to studying positive affect is required. The construct *Positive Affect* is an inherently difficult emotion to study as it has a variety of definitions (implicit and explicit, automatic and evaluative, current and enduring, feelings to hedonic wellbeing), comprises multiple emotions across two dimensions (arousal and contentment), and is measured by a variety of instruments (e.g., Capaldi et al., 2014; Diener et al., 2015; Menzel & Reece, 2021b). Moreover, the theory of *situational specificity of discrete emotional responses* suggests it is difficult to match a 'suite of emotions' generated by a specific experience to one composite instrument (Lench, et al., 2011). Menzel and Reece's study (2021) found positive affect was significant higher when operationalised by liking ratings, but not significant when using the PANAS scale. Similarly, in our study the effects that nature-based memories had on mood, as defined by the PANAS instrument, depended on indicative ratings of liking and warmth.

Specific dimensions of positive affect may be associated with specific nature exposure types (Lackey et al., 2019). The PANAS items mostly assess the arousal, or 'active', dimension of positive affect and omit calm or relaxed feelings which are intuitively associated with many nature experiences (Zelenski, 2015). The perplexity surrounding the construct positive affect was illustrated in a study which divided nature-based recollections into 'active' (stimulating and involving physical exertion) and 'passive' past experiences (minimum risk, stress reducing and relaxing) and found passive 'recall' produced relatively higher positive affect scores, imprecisely measured by the 'active' PANAS scale (Tarrant, 1996). Accurate definition and operationalisation of the dependent variable 'positive affect' will help to understand which positive emotions are contingent on nature-based mental imagery (Lackey et al., 2019).

4.2 Autobiographical Memory Interventions for Improving Mood

In this study we found mixed results for the effects intervention type had on mood and no interaction between nature-based content and memory intervention type. The discrepancy between the PANAS scale and the key types of positive affect evoked by the memory vs. imagined manipulation may partially explain these results. We chose to operationalise positive affect, or mood, with the PANAS scale because it has been associated with the largest effect sizes in affective nature-based research (McMahan & Estes, 2015). Our study has shown that nature-based mental imagery produces a fleeting emotional response, indicated by metacognitive ratings of liking and warmth. Literature supports 'brief' and 'subtle' responses to processing fluency and suggests they may be easily eclipsed by conscious emotions derived from cognitive processing incorporating declarative information (Gamblin, 2020). An important finding in our study was that the metacognitive ratings provided a much clearer picture of the effects of the manipulations. Relevant to the mental imagery intervention type condition, we found ratings of familiarity and vividness were significantly higher in the remembered condition, compared to the imagined condition. This was expected from research showing memories are more familiar and vivid than imagined events (e.g., Sheldon & Levine, 2013; Stafford & Grimes, 2012) and used in our study as a manipulation check. Furthermore, descriptive statistics in our study suggested that remembered moments are easier to find, thought about longer, and, particularly in urban environments, participants felt warmer, more restored, liked the task more, and generated more positively valenced moments in the remembered condition, compared to imagining. These findings are supported by evidence that memory has a positivity bias (Walker et al., 2003) and generates a stronger emotional and perceptual imagery experience than imagining a novel event (Kealy & Arbuthnott, 2003).

4.3 Theories explaining Affective Effects of Nature-based Imagery

Our study is the first to explore nature-based interventions within a processing fluency framework. Importantly, proposing processing fluency as a mechanism for differential affect responses to various imagery content does not preclude evolutionary or sociocultural theories of nature preference. Rather it offers an underlying cognitive mechanism broader than, but inclusive of, the perceptual fluency account (Joye & Van Den Berg, 2011) through which adaptive and social theories may operate.

Sociocultural norms are powerful influencers of human behaviour and may occur over a few generations, or within one lifetime (Farrow et al., 2017; Steg & de Groot, 2018). Recent research on environmental preferences of young children, aged 4-11years, has shown a near linear development in natural environment preference with age, and this is correlated with parental preference (Meidenbaur et al., 2019). As the salience of nature's beauty, awareness of health benefits, and pro-environmental behaviour becomes normalised in mainstream western society, the notion of spending time outdoors is gaining some popularity in an urban society that traditionally spend up to 90% of their time indoors, and are largely disconnected from the natural world (Antonetti & Maklan, 2016; Batool et al., 2020; Casey & Scott, 2006; Evans & McCoy, 1998; Soga et al., 2018; Watson et al., 2020). Evidence supporting social learning theories does not rule out the genetic theory of biologically-programmed learning (Ulrich, 1986). Rapidly in psychology the *nature or nurture* debate is becoming irrelevant and it likely that both genetics and environment play a role in shaping preferences (Plomin, 1994). Complimenting these learning theories, functional adaptation is another common theme, highlighting affective feedback driving preference and approach behaviours for certain natural environments (e.g., Menzel and Reece 2021a; Steg & de Groot, 2018; Stafford & Grimes, 2012; Ulrich, 1983). Specific to nature-based imagery, processing fluency offers a parsimonious explanation for changes in affect. Thinking about safe and resourceful environments, which are socially acceptable, culturally salient, easy to perceive, and positively valenced, results in a ‘positive state of affairs’ for the cognitive system. This favourable condition acts as positive affective feedback for maintaining homeostasis in our biological system, and it feels warm and pleasant (Winkielman et al., 2003). The processing fluency theory was supported by our results showing effects of our manipulation on positive mood were dependent on covariates liking and warmth.

4.4 Strengths and Limitations

The measures used in this online survey comprised mainly of two types, single item subjective ratings and Likert-type, self-report scales. Both may be subject to validity threats inherent in self report measures (Whitburn et al., 2020). Metacognitive ratings have been criticised for being too narrow and subject to self-report biases, however, humans have been found to be surprisingly accurate in their metacognitive judgements of current emotional state (Graf et al., 2017).

Relying on self-report measures in our study resulted in negatively skewed data. As ANCOVA assumptions of normality were violated we used Generalised Linear Modelling which provided a reasonable fit for our data. As our study was an initial investigation, we purposefully included nine covariates of interest, and used single item ratings which allowed us to keep the survey short and engaging. Reducing the number of covariates in confirmatory research is advised to simplify data analysis and interpretation (Zeraatkar et al., 2019) and bootstrapping methods could be investigated as an alternate statistical method for non-normal data.

To date there is very little research published on improving positive mood in healthy adults with nature-based interventions (McMahan & Estes, 2015). As an exploratory study, and with a view to providing evidence for a simple, cheap, accessible, and brief method for the regular practice of improving and maintaining positive mood, our imagery script was not intended to be prescriptive. Although participants were guided to choose one of four conditions, they were free to choose the specific location, moment valence, and activity level of their moment, providing a degree of ecological validity. Randomisation and including covariates accounted for much of the error variance in our statistical analysis. However, this experiment still incurred considerable noise and differentiating between chance and actual differences between conditions was difficult. For example, refining variables in the experimental design to control for variation could be done by specifying valence of the mental imagery content. However, allowing our participants to choose valence raised interesting questions regarding the positivity bias in remembering conditions in our study, highlighting the benefits of participant choice.

We sampled three populations: first year psychology students, the general Australian population (volunteers), and the international prolific community (participants from most of the Organisation for Economic Co-operation and Development countries (OECD)). However, this reasonably broad range of participants, was constrained by requirements for English language and computer literacy. Additionally, we investigated effects of nature-based mental imagery on mood and our findings cannot be generalised to other types of nature exposure.

4.5 Further Studies

To better understand the effects of recalling nature-based memories and the role processing fluency plays, future research assessing automatic affective response outcomes, with a variety of objective, subjective and qualitative measures is recommended. Using a combination of objective and subjective measures evaluates unique and separable dimensions of positive affect for a more nuanced understanding (Gamblin, 2020; Pearson et al., 2013). For example, while facial expressions measured by electromyography have been shown to accurately reflect genuine affective outcomes, only subjective responses will show conscious awareness of those feelings by participants (Gamblin, 2020; Schwartz et al., 1976; Winkielman & Cacioppo, 2001). Other measures of affect include heart rate variability, skin temperature (warmth) and speech emotion recognition (Lech, et al., 2020; Taufik et al., 2014). Neuroimaging, electroencephalography, and pupil dynamics have also been used to identify affective neural networks activated by imagery content (Pearson, 2019; Speer et al., 2014). To further increase the ecological validity of the exposure to the natural environment, lab-based and online studies could be combined with experiential sampling and rich qualitative data (Frumkin et al., 2017; Glackin & Beale, 2018; MacKerron & Mourato, 2013; Mayer et al., 2009). Importantly, this refined study could then be extended to investigate the effects of nature-based memories on other psychological outcomes such as restoration and nature connectedness.

Further research is recommended to test the sociocultural influence on nature-based emotional outcomes. Using a culturally appropriate version of this experiment across cultures, including people with refugee background and First Nations peoples, could further probe claims that nature-based psychological benefits are universal (Burns, 2005). The effects on psychological wellbeing of a nature-based mental imagery intervention may be culturally diverse (Klain et al., 2017; McManus et al., 2014). Longitudinal studies could also be used to explore the role that social trends in western cultures might play on the effectiveness of nature-based interventions in this population.

Finally, as our ultimate aim would be to augment the development of an affective, nature-based imagery intervention, further research is needed to determine a nature-based imagery ‘dosage’. Eliciting an enduring positive change in mood, or emotional wellbeing, requires active practice of improving momentary affect over time (Munindradasa et al., 2021; Sin & Lyubomirsky, 2009). Repeated engagement with the brief imagery intervention could be trialled to determine if transferring the fleeting emotions of liking and warmth to a more enduring positive affect depends on regular exposure to nature-based imagery. Current research suggests brief interventions used to improve mood provide temporary effects that need to be incorporated into an ongoing mental health program to augment positive coping mechanisms and optimal emotional wellbeing (Sin & Lyubomirsky, 2009).

4.6 Conclusion

‘Bringing nature to mind’ is intuitive and equitable. A key finding in this study was that nature-based mental imagery can improve positive affect. Additionally, we introduced two promising new directions - remembering moments in nature and a processing fluency mechanism – that warrant further investigation. This study aimed to provide further evidence toward the development of a low-cost, low-risk, accessible and brief intervention that the non-clinical population could add to their daily mental health tool kit. Importantly, anonymous feedback from participants completing our survey suggest *Nature Moments* are enjoyable augmenting uptake in the real world (Figure 7).

Figure 7

Feedback from participants after completing the online mental imagery task

"I wish everything goes well with your study, I wanted to thank you for giving me this moment out of the blue to feel this peace <3"

"I just did your survey and have shared it. It was so beautiful to do, I loved it!"

Furthermore, we have shown that bringing nature to mind, even for a very brief period, can positively effect feelings of liking, warmth, restoration, and nature connectedness. It is well established that nature contact, and connection are important mediators of pro-environmental behaviour (Mackay & Schmitt, 2019). An important direction for further research is to determine whether participating in an intervention like *Nature Moments* will produce reciprocal benefits of improved human psychological wellbeing and greater respect for our natural world.

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Appendix A – Statistical Analysis for Age and Gender.

Figure A1

R code for Pearson's correlation between Age and Positive Affect

```
cor.test(mydata$PANAS.Positive.50, mydata$Age)
```

```
	Pearson's product-moment correlation

data:  mydata$PANAS.Positive.50 and mydata$Age
t = 1.2685, df = 738, p-value = 0.205
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.02551333  0.11831675
sample estimates:
       cor
0.04664346
```

Figure A2

Boxplot showing Positive Affect scores (y-axis) by Gender (x-axis)

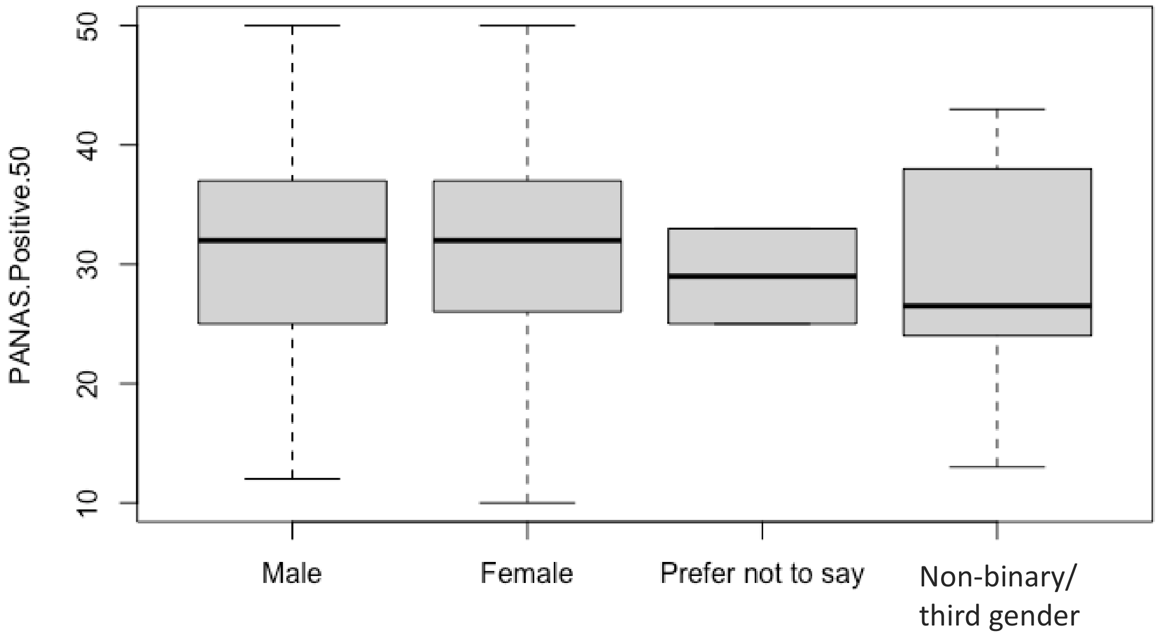


Figure A3

R code for ANOVA for Gender and Positive Affect

```
# Need ANOVA for 4 gender groups
levene_test(mydata, PANAS.Positive.50 ~ MFNUGender)
```

df1	df2	statistic	p
<int>	<int>	<dbl>	<dbl>
3	736	0.3845395	0.7641776

1 row

Hide

```
welch_anova_test(mydata, PANAS.Positive.50 ~ MFNUGender)
```

	.y.	n	statistic	DFn	DFd	p	method
	<chr>	<int>	<dbl>	<dbl>	<dbl>	<dbl>	<chr>
1	PANAS.Positive.50	740	0.26	3	4.208553	0.851	Welch ANOVA

1 row

Appendix B – Statistical Analysis for Manipulation Checks

Figure B1

Boxplot showing Familiarity Rating (y-axis) Intervention Type (x-axis)

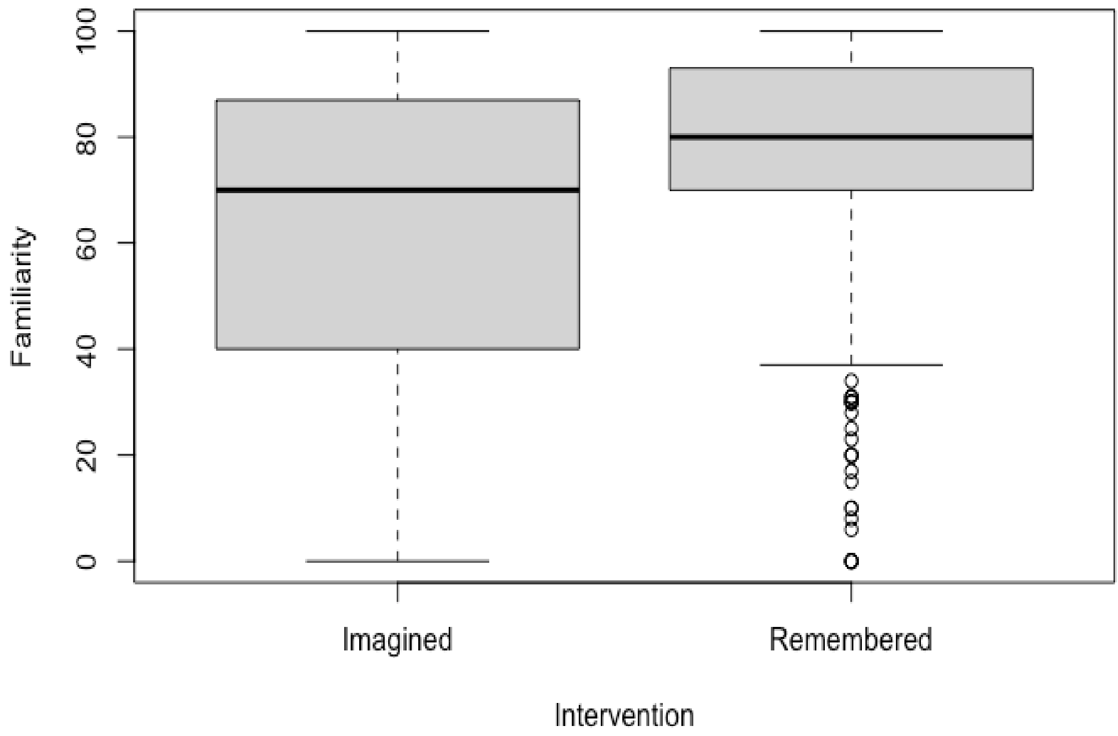


Figure B2

R code for Wilcoxon test for Familiarity by Intervention Type

```
#independentSamplesTTest(Familiarity ~ Intervention, my_experiment)
wilcox.test(Familiarity ~ Intervention, my_experiment)
```

```

	Wilcoxon rank sum test with continuity correction

data:  Familiarity by Intervention
W = 47840, p-value = 1.235e-12
alternative hypothesis: true location shift is not equal to 0
```

Appendix B – Statistical Analysis for Manipulation Checks Cont…

Figure B3

Boxplot showing Vividness Rating (y-axis) Intervention Type (x-axis)

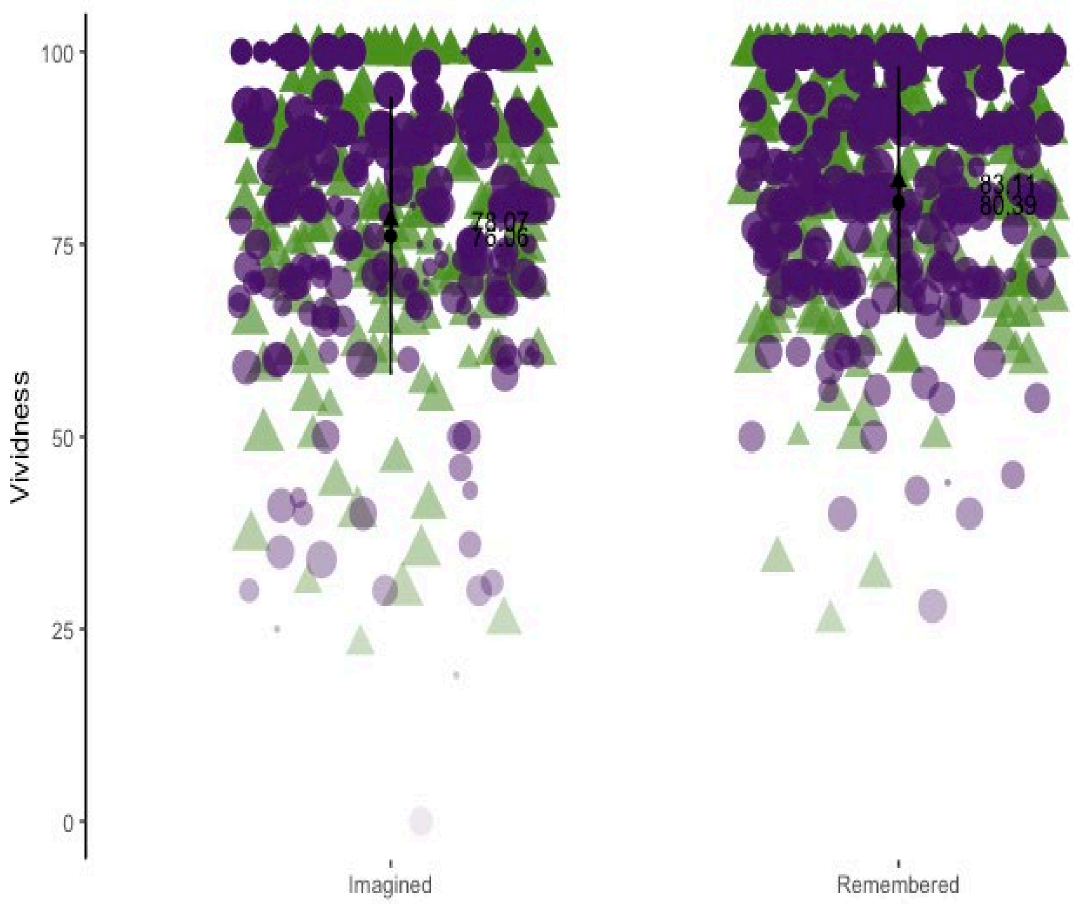


Figure B4

R code for Wilcoxon test for Vividness by Intervention

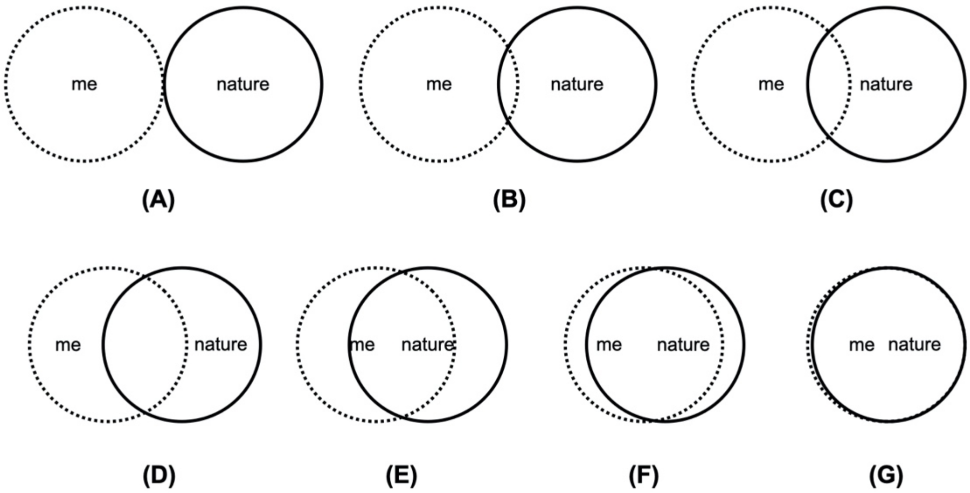
```
#independentSamplesTTest(Vividness ~ Intervention, my_experiment)
wilcox.test(Vividness ~ Intervention, my_experiment)
```

```
    Wilcoxon rank sum test with continuity correction

data:  Vividness by Intervention
W = 57796, p-value = 0.0002407
alternative hypothesis: true location shift is not equal to 0
```

Appendix C – Connectedness Scales

Figure C1

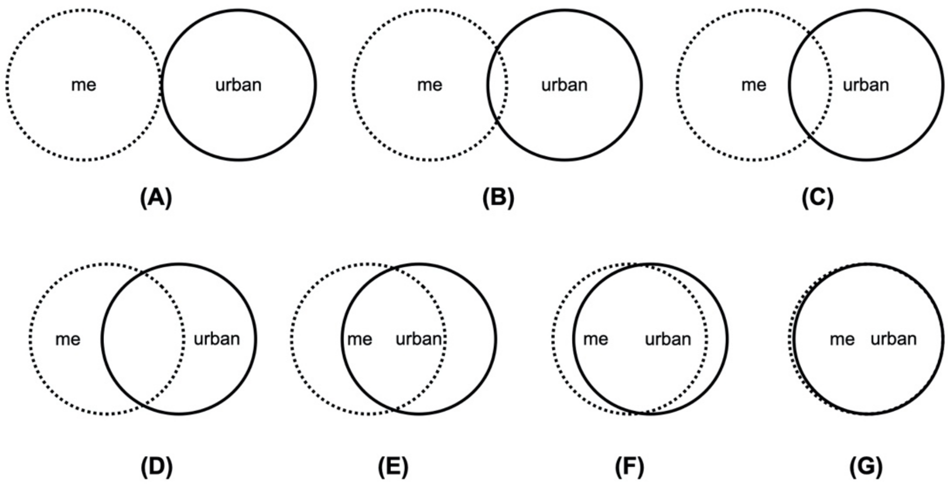
Inclusion of Nature in Self Scale (INS; Schultz, 2001)



Please choose the picture above that best describes your relationship with the natural environment. How interconnected are you with nature?

Figure C2

Modified scale for urban connectedness.



Please choose the picture above that best describes your relationship with the urban environment. How interconnected are you with urban areas?

Appendix D – Survey Information and Consent Form

INFORMATION SHEET

The purpose of the study The aim of this project is to understand how mental imagery might be used to improve mood. This research is being conducted by psychology honours student, Sue Conaghty, under the supervision of Dr Rachel Searston at the University of Adelaide in Australia. Email: sue.conaghty@student.adelaide.edu.au.

What's involved? You are invited to participate in a mental imagery task. Please make sure you can be comfortable and won't be disturbed for the 10 minutes it should take you to do this survey. You will be guided through a series of questions designed to help you immerse yourself in a moment, you have brought to mind. You will then rate your experience and how it made you feel, along with some short questions on how you engage with your environment and demographics.

Risks Your participation will help us to better understand how to develop interventions for improving wellbeing when restricted from spending time outdoors. There are no anticipated risks of participating that are greater than that of everyday living. If, however, you should find any question invasive or offensive, you are free to withdraw from the study at any time during your participation.

Confidentiality and security of data The data will be analysed and reported in such a way that responses will not be able to be linked to any individual. All data will be collected anonymously, and coded and publicly released in a way that makes identifying individual participants as difficult as possible. However, we cannot guarantee that it will be impossible to identify individual participants. For questions that request potentially identifying demographic information, respondents will always have the option to not respond.

Ethics approval This study has been approved by the School of Psychology Human Research Ethics Sub-Committee at the University of Adelaide (approval number: 21/27). If you wish to speak with an independent person regarding concerns or a complaint or your rights as a participant, please contact the Convenor of the School of Psychology Human Research Ethics Sub-Committee at: paul.delfabbro@adelaide.edu.au.

CONSENT FORM

1. I have read and understood the information regarding the current study and freely consent to taking part in this survey.

2. I have had the project and the potential risks and burdens fully explained to my satisfaction.

3. I understand that I can withdraw at any time up until submission of my responses.

4. I understand that all information collected will be anonymous and coded and publicly released in a way that makes uniquely identifying individual participants as difficult as possible.

4. I understand that, if I choose to provide certain information, my data may not be completely non-identifiable.

5. I have been advised as to what data are being collected, what the purpose is, and what will be done with the data upon completion of the research.

6. I agree that research data gathered as part of the study may be published provided that neither my name, nor other identifying information, is used.

7. I agree that the de-identified research data gathered as part of this study may be stored publicly and reused in other research projects.

Please indicate whether or not you are willing to participate in the study.

If you choose to participate in this study, press 'next'.

Appendix E - Example Imagery Script

For the next 5 minutes we will guide you through a mental imagery task that involves immersing yourself in an experience, in your head. Before we begin, take a moment to focus on your breathing. Every time you breath out let your body relax until you are resting comfortably.

Comfortable? Press ‘**next**’ when you are ready to begin.

-----------------------------------NEXT BUTTON --

Now take yourself back to a memorable moment in your life when you were in a natural environment. This moment should be related to a specific experience you had on a specific day that you can clearly remember. It should be a moment where you felt close to things in nature.

You may wish to close your eyes to help bring this moment to mind.

Do you have a moment that you can clearly remember? Press ’next’ when you do.

-----------------------------------NEXT BUTTON --

The next six pages have a question on them prompting you to explore different details about the moment you've just remembered. We want you to spend some time thinking about these questions in your head. Then the ‘next’ button will appear and you can press it when you are ready. Ready? Press ‘**next**’ to continue.

-----------------------------------NEXT BUTTON --

What could you see in that moment? What was in your surroundings?

-----------------------------------NEXT BUTTON --

What sounds could you hear? What was in the background noise?

-----------------------------------NEXT BUTTON --

Could you taste anything? What did it taste like?

-----------------------------------NEXT BUTTON --

Could you touch anything? Were you hot or cold?

-----------------------------------NEXT BUTTON --

What emotions were you experiencing?

-----------------------------------NEXT BUTTON --

How did you feel in your remembered moment? (Extremely negative – Extremely positive)

In what year did this moment take place?

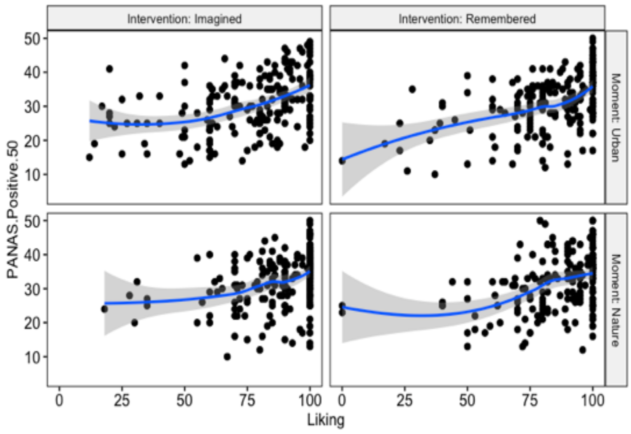
Where did this moment take place and what were you doing? Describe in the text box below (10 - 140 character limit).

Appendix F – ANCOVA Assumptions Analysis

Figure F1

R code for Linearity Assumption and Scatterplots for Positive Affect by Liking and Warmth

```
ggscatter(
  my_experiment, x = "Liking", y = "PANAS.Positive.50",
  facet.by  = c("Moment", "Intervention"),
  short.panel.labs = FALSE
  )+
  stat_smooth(method = "loess", span = 0.9)
ggsave(
  "plots/PA.L_scatter.jpeg",
  width = 18,
  height = 12,
  units = "cm"
)
```




```
ggscatter(
  my_experiment, x = "Warmth.20", y = "PANAS.Positive.50",
  facet.by  = c("Moment", "Intervention"),
  short.panel.labs = FALSE
  )+
  stat_smooth(method = "loess", span = 0.9)
ggsave(
  "plots/PA.W_scatter.jpeg",
  width = 18,
  height = 12,
  units = "cm"
)
```

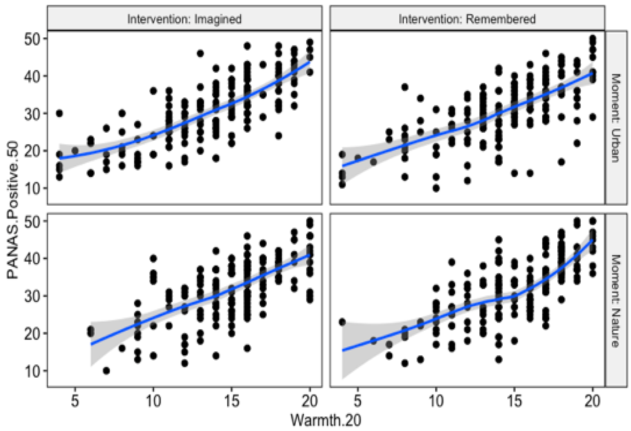


Figure F2

R code for Normality of Residuals Assumption

```
## Normality of Residuals Assumption
model_Fluency <- lm(PANAS.Positive.50 ~ Familiarity + Liking + Warmth.20 + Interventio
n*Moment, data = my_experiment) # Fit model

model.metrics_F <- augment(model_Fluency) %>%
  select(-.hat, -.sigma, -.fitted)
head(model.metrics_F, 3) # Inspect model
```

PANAS.Positive.50 <int>	Familiarity <int>	Liking <int>	Warmth.20 <int>	Intervention <fctr>	Moment <fctr>
33	80	80	15	Remembered	Nature
25	62	0	11	Remembered	Nature
43	72	82	19	Remembered	Nature

3 rows | 1-6 of 9 columns

Hide

```
shapiro_test(model.metrics_F$.resid)
```

variable <chr>	statistic <dbl>	p.value <dbl>
model.metrics_F$.resid	0.9924025	0.000783217

1 row

Appendix F – ANCOVA Assumptions Analysis cont……

Figure F3

R code for Homogeneity of Regression Slopes

```
my_experiment %>%
  anova_test(
    PANAS.Positive.50 ~ Liking + Intervention + Moment +
     Intervention*Moment + Liking*Intervention +
     Liking*Moment + Liking*Moment*Intervention
  )
```

```
Coefficient covariances computed by hccm()
```

```
ANOVA Table (type II tests)

                       Effect DFn DFd       F        p p<.05      ges
1                      Liking   1 732 140.731 8.16e-30     * 1.61e-01
2                Intervention   1 732   1.259 2.62e-01       2.00e-03
3                      Moment   1 732   0.017 8.95e-01       2.37e-05
4         Intervention:Moment   1 732   0.057 8.12e-01       7.74e-05
5         Liking:Intervention   1 732   1.041 3.08e-01       1.00e-03
6               Liking:Moment   1 732   0.047 8.28e-01       6.43e-05
7 Liking:Intervention:Moment   1 732   0.031 8.59e-01       4.30e-05
```

Hide

```
my_experiment %>%
  anova_test(
    PANAS.Positive.50 ~ Warmth.20 + Intervention + Moment +
     Intervention*Moment + Warmth.20*Intervention +
     Warmth.20*Moment + Warmth.20*Moment*Intervention
  )
```

```
Coefficient covariances computed by hccm()
```

```
ANOVA Table (type II tests)

                          Effect DFn DFd       F         p p<.05      ges
1                      Warmth.20   1 732 695.087 3.22e-108     * 4.87e-01
2                   Intervention   1 732   2.076  1.50e-01       3.00e-03
3                         Moment   1 732   1.055  3.05e-01       1.00e-03
4            Intervention:Moment   1 732   0.770  3.80e-01       1.00e-03
5         Warmth.20:Intervention   1 732   0.032  8.57e-01       4.41e-05
6               Warmth.20:Moment   1 732   0.796  3.73e-01       1.00e-03
7 Warmth.20:Intervention:Moment   1 732   0.881  3.48e-01       1.00e-03
```

Figure F4

R code for Homogeneity of Variance and Outliers

```
## Homogeneity of variances
model.metrics_F %>% levene_test(.resid ~ Moment*Intervention)
```

df1 <int>	df2 <int>	statistic <dbl>	p <dbl>
3	736	0.4534862	0.7149076

1 row

Hide

```
## Outliers
model.metrics_F %>%
  filter(abs(.std.resid) > 3) %>%
  as.data.frame()
```

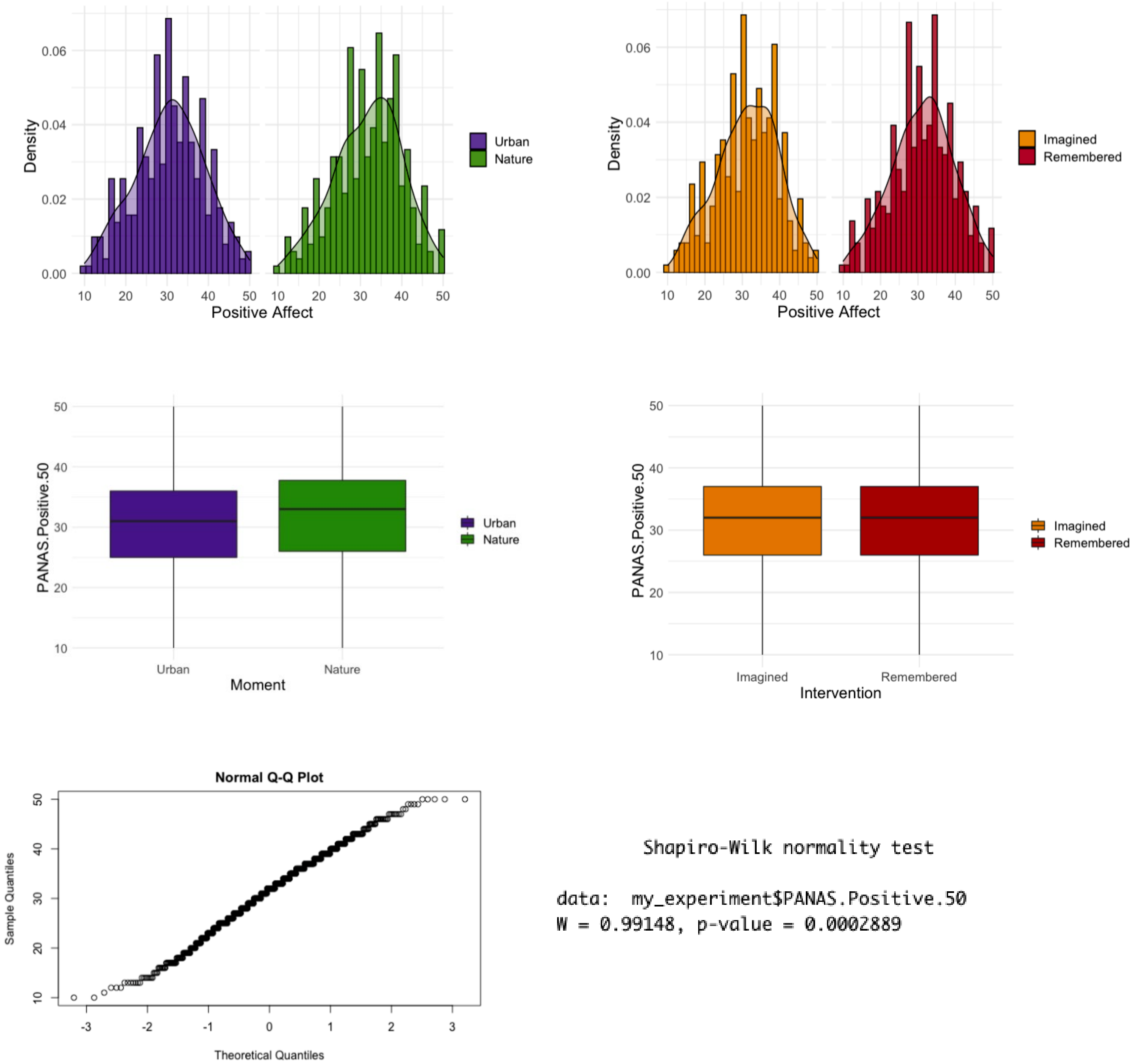
PANAS.Positive.50 <int>	Familiarity <int>	Liking <int>	Warmth.20 <int>	Intervention <fctr>	Moment <fctr>
17	81	96	18	Remembered	Urban
14	70	80	16	Remembered	Urban
16	20	81	16	Imagined	Nature

3 rows | 1-6 of 9 columns

Appendix G – Descriptive Statistics for Positive Affect

Figure G

Descriptive Statistics for Positive Affect



The Shapiro Wilk test was significant (p = 0.000). However, observation of the histogram and QQ plot demonstrated normality and Shapiro Wilk can be unreliable in large data set so we assumed relatively normal distribution based on descriptive statistics and Q-Q Plot.

Appendix H - Effects of Mental Imagery on Positive Affect

Figure H1

R code for Fluency Model

```
PA.WL_G <- glm(PANAS.Positive.50 ~ Liking + Warmth.20 + Intervention*Moment, family=gaussian, data = my_experimen
t)
summary(PA.WL_G)
```

```
Call:
glm(formula = PANAS.Positive.50 ~ Liking + Warmth.20 + Intervention *
    Moment, family = gaussian, data = my_experiment)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-20.2327   -3.5564    0.3369    4.1607   16.3926

Coefficients:
                                    Estimate Std. Error t value Pr(>|t|)
(Intercept)                          5.94193    1.09419   5.430 7.65e-08 ***
Liking                               0.04851    0.01281   3.786 0.000165 ***
Warmth.20                            1.54980    0.07011  22.104  < 2e-16 ***
InterventionRemembered              -1.26275    0.61436  -2.055 0.040194 *
MomentNature                        -1.22841    0.62516  -1.965 0.049797 *
InterventionRemembered:MomentNature  1.03990    0.86738   1.199 0.230957
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for gaussian family taken to be 34.38668)

    Null deviance: 50424  on 739  degrees of freedom
Residual deviance: 25240  on 734  degrees of freedom
AIC: 4725.9

Number of Fisher Scoring iterations: 2
```

Figure H2

R code for Manipulation on Positive Affect – no covariates

```
PA.L_G <- glm(PANAS.Positive.50 ~ Intervention*Moment, family=gaussian, data = my_experiment)
summary(PA.L_G)
```

```
Call:
glm(formula = PANAS.Positive.50 ~ Intervention * Moment, family = gaussian,
    data = my_experiment)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-22.2216   -5.5676    0.4297    5.5189   19.1784

Coefficients:
                                    Estimate Std. Error t value Pr(>|t|)
(Intercept)                          30.5676     0.6067  50.387   <2e-16 ***
InterventionRemembered                0.2541     0.8579   0.296   0.7672
MomentNature                          1.6541     0.8579   1.928   0.0542 .
InterventionRemembered:MomentNature  -0.9027     1.2133  -0.744   0.4571
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for gaussian family taken to be 68.08655)

    Null deviance: 50424  on 739  degrees of freedom
Residual deviance: 50112  on 736  degrees of freedom
AIC: 5229.4

Number of Fisher Scoring iterations: 2
```

Appendix H - Effects of Mental Imagery on Positive Affect cont...

Figure H3

R code for Manipulation on Positive Affect – Liking Only

```
PA.L_G <- glm(PANAS.Positive.50 ~ Liking + Intervention*Moment, family=gaussian, data = my_experiment)
summary(PA.L_G)
```

```
Call:
glm(formula = PANAS.Positive.50 ~ Liking + Intervention * Moment,
    family = gaussian, data = my_experiment)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-21.5073   -4.8963    0.7009    5.0448   20.1509

Coefficients:
                                    Estimate Std. Error t value Pr(>|t|)
(Intercept)                         17.34000    1.24468  13.931   <2e-16 ***
Liking                               0.17546    0.01477  11.878   <2e-16 ***
InterventionRemembered              -0.86887    0.79202  -1.097    0.273
MomentNature                        -0.37840    0.80476  -0.470    0.638
InterventionRemembered:MomentNature  0.48768    1.11823   0.436    0.663
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 57.19873)

    Null deviance: 50424  on 739  degrees of freedom
Residual deviance: 42041  on 735  degrees of freedom
AIC: 5101.4

Number of Fisher Scoring iterations: 2
```

Figure H4

R code for Manipulation on Positive Affect – Warmth Only

```
PA.W_G <- glm(PANAS.Positive.50 ~ Warmth.20 + Intervention*Moment, family=gaussian, data = my_experiment)
summary(PA.W_G)
```

```
Call:
glm(formula = PANAS.Positive.50 ~ Warmth.20 + Intervention *
    Moment, family = gaussian, data = my_experiment)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-19.9826   -3.6462    0.3453    4.3101   16.7053

Coefficients:
                                    Estimate Std. Error t value Pr(>|t|)
(Intercept)                          7.98918    0.95987   8.323 4.16e-16 ***
Warmth.20                            1.66880    0.06324  26.388  < 2e-16 ***
InterventionRemembered              -1.04490    0.61718  -1.693   0.0909 .
MomentNature                        -0.84463    0.62246  -1.357   0.1752
InterventionRemembered:MomentNature  0.77512    0.87237   0.889   0.3746
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 35.01066)

    Null deviance: 50424  on 739  degrees of freedom
Residual deviance: 25733  on 735  degrees of freedom
AIC: 4738.2

Number of Fisher Scoring iterations: 2
```

Appendix I - Effects of Mental Imagery on Positive Affect

Accounting for Vividness and Valence

Figure I1

R code for Manipulation on Positive Affect – Covariate Vividness

```
PA.V_G <- glm(PANAS.Positive.50 ~ Vividness + Intervention*Moment, family=gaussian, data = my_experiment)
summary(PA.V_G)
```

```
Call:
glm(formula = PANAS.Positive.50 ~ Vividness + Intervention *
    Moment, family = gaussian, data = my_experiment)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-21.6677   -5.4077    0.7286    5.1173   24.9059

Coefficients:
                                  Estimate Std. Error t value Pr(>|t|)
(Intercept)                       19.09407    1.51086  12.638  < 2e-16 ***
Vividness                          0.15085    0.01834   8.226 8.75e-16 ***
InterventionRemembered            -0.39908    0.82537  -0.484    0.629
MomentNature                       1.35073    0.82237   1.642    0.101
InterventionRemembered:MomentNature -1.01034    1.16191  -0.870    0.385
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for gaussian family taken to be 62.43097)

    Null deviance: 50424  on 739  degrees of freedom
Residual deviance: 45887  on 735  degrees of freedom
AIC: 5166.2

Number of Fisher Scoring iterations: 2
```

Figure I2

R code for Manipulation on Positive Affect – Covariate Valence

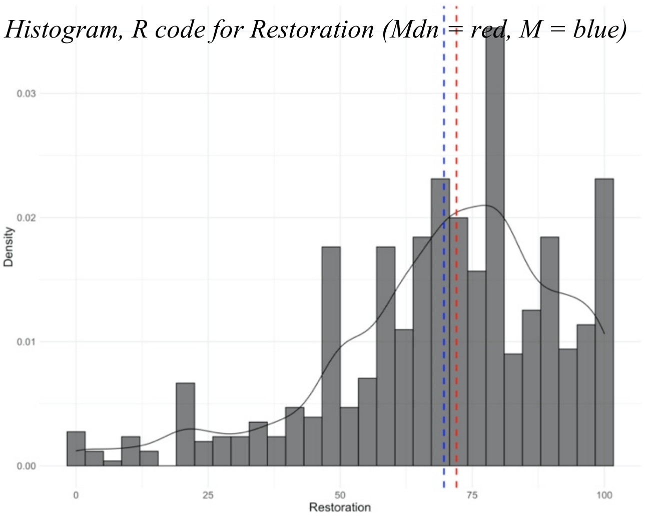
```
PA.Va_G <- glm(PANAS.Positive.50 ~ Valence + Intervention*Moment, family=gaussian, data = my_experiment)
summary(PA.Va_G)
```

```
Call:
glm(formula = PANAS.Positive.50 ~ Valence + Intervention * Moment,
    family = gaussian, data = my_experiment)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-22.8120   -5.0649    0.6111    5.1178   20.8825

Coefficients:
                                   Estimate Std. Error t value Pr(>|t|)
(Intercept)                        26.276339   0.698293  37.629   <2e-16 ***
Valence                             0.084151   0.008017  10.497   <2e-16 ***
InterventionRemembered             -0.634304   0.805073  -0.788    0.431
MomentNature                       -0.532953   0.827278  -0.644    0.520
InterventionRemembered:MomentNature  0.264945   1.137688   0.233    0.816
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for gaussian family taken to be 59.2907)

    Null deviance: 50424  on 739  degrees of freedom
Residual deviance: 43579  on 735  degrees of freedom
AIC: 5128

Number of Fisher Scoring iterations: 2
```

Appendix J – Descriptive Statistics for Restoration

Figure J1

Histogram, R code for Restoration (Mdn = red, M = blue)




```
# Restoration
sum_data <- my_experiment %>%
  group_by(Moment, Intervention) %>%
  summarise(
     median = median(Restoration),
     mean = mean(Restoration),
    sd = sd(Restoration)
  )
```

```
`summarise()` has grouped output by 'Moment'. You can override using the `.groups` argument.
```

Hide

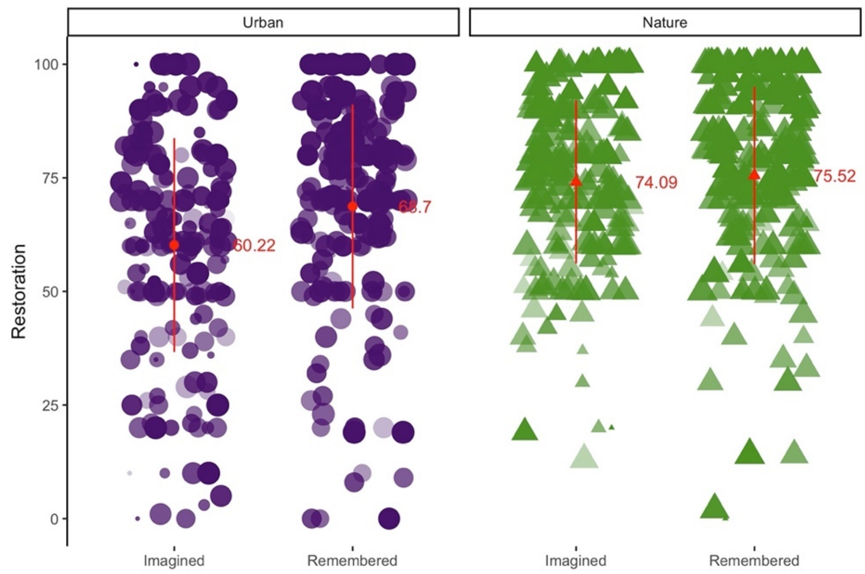
```
sum_data
```

Moment <fctr>	Intervention <fctr>	median <int>	mean <dbl>	sd <dbl>
Urban	Imagined	64	60.22162	23.52611
Urban	Remembered	71	68.70270	22.43356
Nature	Imagined	75	74.09189	17.95427
Nature	Remembered	79	75.52432	19.53650

4 rows

Figure J2

Scatterplot for Restoration (y-axis) and Intervention Type Manipulation (x-axis) and Imagery Content (secondary x-axis



Appendix K – Effects of Mental Imagery on Restoration

Figure K1

R code for Manipulation on Restoration – Covariate Ease of Task

```
glm.RE_P <- glm(Restoration ~ Ease + Intervention*Moment, family=poisson, data = my_experiment)
summary(glm.RE_P)
```

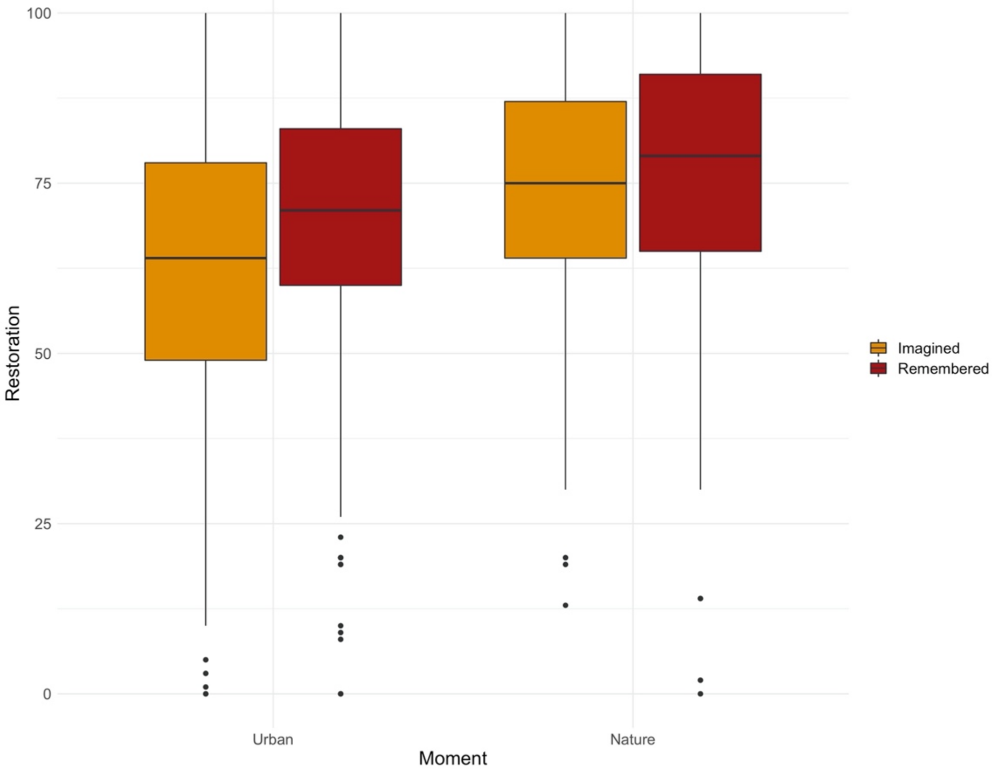
```
Call:
glm(formula = Restoration ~ Ease + Intervention * Moment, family = poisson,
    data = my_experiment)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-11.8688   -1.3625    0.3057    1.7006    4.9769

Coefficients:
                                      Estimate Std. Error z value Pr(>|z|)
(Intercept)                          4.0147251  0.0135963 295.282  < 2e-16 ***
Ease                                 0.0014062  0.0001632   8.614  < 2e-16 ***
InterventionRemembered               0.1274501  0.0129879   9.813  < 2e-16 ***
MomentNature                         0.2082113  0.0127564  16.322  < 2e-16 ***
InterventionRemembered:MomentNature -0.1139569  0.0176916  -6.441 1.18e-10 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 6267.8  on 739  degrees of freedom
Residual deviance: 5802.9  on 735  degrees of freedom
AIC: 10230

Number of Fisher Scoring iterations: 4
```

Hide

```
glm.R_P <- glm(Restoration ~ Intervention*Moment, family=poisson, data = my_experiment)
summary(glm.R_P)
```

Figure K2

Boxplot showing Restoration (y-axis) by Content (x-axis) and Intervention Type



Appendix L – Descriptive Statistics for Connectedness

Figure L1

Histogram for Nature Connectedness (Mdn = red, M = blue)

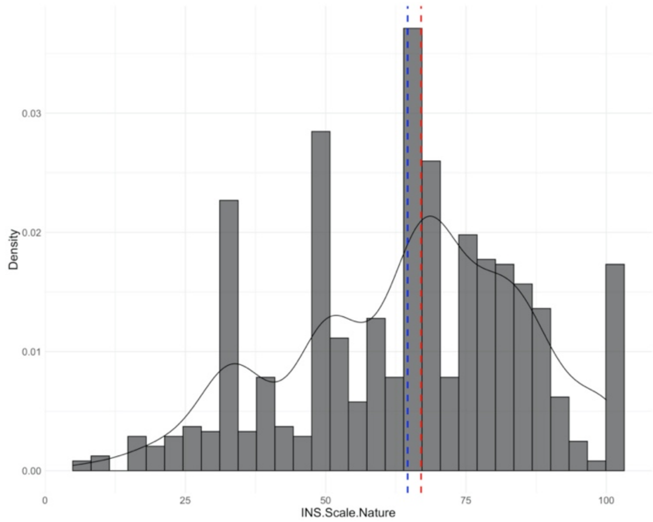


Figure L2

Histogram for Urban Connectedness (Mdn = red, M = blue)

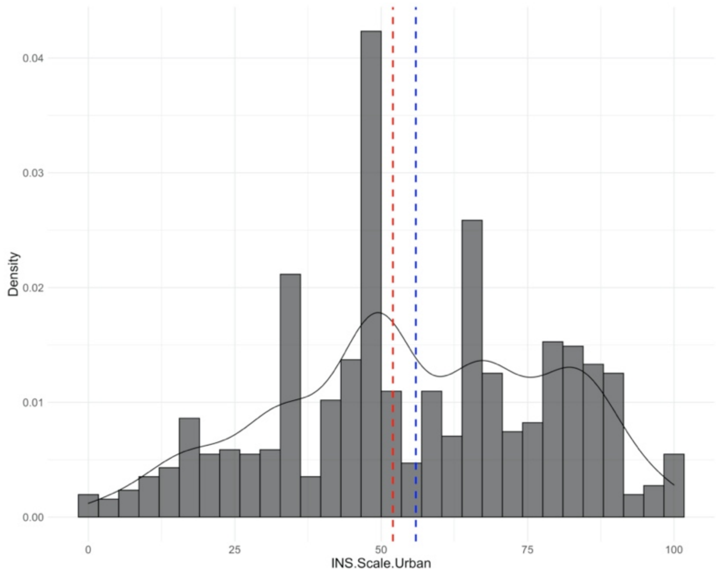


Table L1

Descriptive Statistics for Interactions between Connectedness and Manipulations: Mdn, Mean(SD)

Column Head	Nature	Urban	Remembered	Imagined
Nature Connectedness	69.5,68.0(19.8)	65.0,61.3(20.9)	67,64.6(19.2	67,64.6(22.0)
Urban Connectedness	50,53.7(23.7)	61,58.2(22.5)	52,56.1(23.5)	53,55.7(23.0)

Appendix M – Effects of Mental Imagery on Nature Connectedness

Figure M1

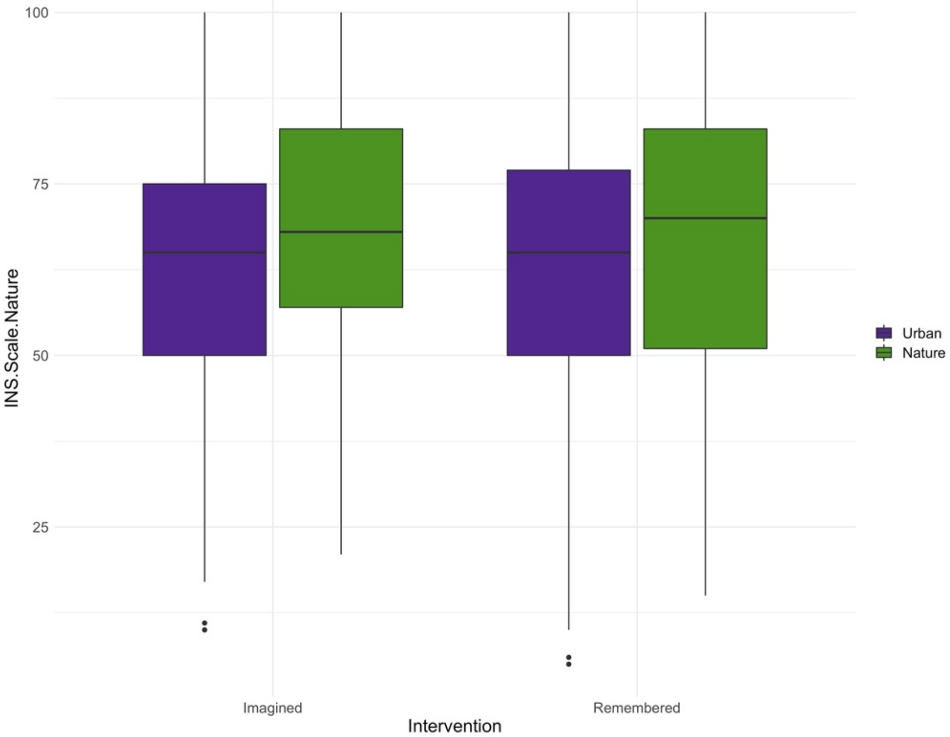
R code for Manipulation on Nature Connectedness – Covariate Contact

```
glmNC_P <- glm(INS.Scale.Nature ~ Nature.Urban.Weekly.Contact + Intervention*Moment, family=poisson, da
ta = my_experiment)
summary(glmNC_P)
```

```
Call:
glm(formula = INS.Scale.Nature ~ Nature.Urban.Weekly.Contact +
    Intervention * Moment, family = poisson, data = my_experiment)

Deviance Residuals:
   Min      1Q  Median      3Q     Max
-8.485  -1.513   0.355   1.665   5.144

Coefficients:
                                      Estimate Std. Error z value Pr(>|z|)
(Intercept)                          3.9399636  0.0122503 321.623   <2e-16 ***
Nature.Urban.Weekly.Contact          0.0042152  0.0001913  22.029   <2e-16 ***
InterventionRemembered               0.0057095  0.0132924   0.430    0.668
MomentNature                         0.1157958  0.0129609   8.934   <2e-16 ***
InterventionRemembered:MomentNature -0.0217902  0.0183205  -1.189    0.234
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 5383.7  on 739  degrees of freedom
Residual deviance: 4775.3  on 735  degrees of freedom
AIC: 9182

Number of Fisher Scoring iterations: 4
```

Figure M2

Boxplot showing Nature Connectedness (y-axis) by Intervention Type (x-axis) and Content



Appendix M – Effects of Mental Imagery on Connectedness Cont…

Figure M3

R code for Manipulation on Nature Connectedness – Covariate Contact

```
#URBAN
glmUC_G <- glm(INS.Scale.Urban ~ Nature.Urban.Weekly.Contact + Intervention*Moment, family=poisson, data = my_exp
eriment)
summary(glmUC_G)
```

```
Call:
glm(formula = INS.Scale.Urban ~ Nature.Urban.Weekly.Contact +
    Intervention * Moment, family = poisson, data = my_experiment)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-10.9394   -2.1628    0.0379    2.2190    7.9436

Coefficients:
                                      Estimate Std. Error z value Pr(>|z|)
(Intercept)                          4.2324404  0.0125178 338.113  < 2e-16 ***
Nature.Urban.Weekly.Contact         -0.0047225  0.0002183 -21.631  < 2e-16 ***
InterventionRemembered               0.0258205  0.0136380   1.893   0.0583 .
MomentNature                        -0.0700043  0.0139385  -5.022  5.1e-07 ***
InterventionRemembered:MomentNature -0.0258903  0.0196832  -1.315   0.1884
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 8113.0  on 739  degrees of freedom
Residual deviance: 7564.8  on 735  degrees of freedom
AIC: 11810

Number of Fisher Scoring iterations: 4
```

Figure M4

Boxplot showing Urban Connectedness (y-axis) by Intervention Type (x-axis) and Content