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Research Paper

In which natural environments are people happiest? Large-scale experience sampling in the Netherlands

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ABSTRACT

Previous studies have shown that people feel happier in more natural environments than in predominantly built-up environments; however, it is less clear whether the type of natural environment matters. In a large-scale experience sampling study in the Netherlands, we explored whether happiness differs by the type of natural environment experienced. We also investigated to what extent scenic beauty, peacefulness or fascinatingness are associated with momentary happiness. Smartphone apps were developed for both iOS and Android smartphones, and made freely available in both app stores. The app, named HappyHier, sent requests to fill in a short questionnaire, starting with how happy the participant feels. The requests were programmed to oversample experiences in natural environments. Location data were provided by the GPS of the smartphone, and the type of environment was determined based on a land-use map incorporated in the app. HappyHier was launched with a media campaign starting on 1st May 2016. In the following few months, over 4000 people participated, generating over 100,000 experience samples. Multi-level analyses were conducted, controlling for, among other things, being inside or outside, type of activity, type of company and weather conditions. The participants generally felt happier in natural environments, especially at the coast and in areas with low-lying natural vegetation, such as heathlands. Whether the environment is thought to be peaceful and fascinating appears to be more important for happiness than its scenic beauty. The representativeness of the data gathered by this relatively new method was explored from several angles: people, time and location.

1. Introduction

There is mounting evidence that contact with nature has positive effects on human health and wellbeing (Houlden, Weich, de Albuquerque, Jarvis, & Rees, 2018; Twohig-Bennett & Jones, 2018); however, little is known about which type of nature, or nature experience, is most beneficial with regard to a specific health aspect (Frumkin et al., 2017). Moreover, much of the evidence is based on epidemiological studies showing only an association between access to, or the availability of, nature in the residential environment and human health and wellbeing (Van den Berg et al., 2015). Common assumptions associated with this type of finding, especially when it comes to mental health and wellbeing, are that easy access leads to more contact with nature, contact with nature has a positive short-term effect, and the accumulation of these positive short-term effects results in more long-term mental health benefits (Cox et al., 2017). Regarding short-term effects, this assumption is partially supported by laboratory experiments, which often show positive effects of exposure to nature on mood, attention restoration and stress reduction (Berto, 2014). There is also some preliminary evidence of a dose–response relationship between exposure to nature and the size of health benefits. Shanahan et al. (2016) assessed the amount of exposure based on the retrospective self-reported frequency of outdoor green space visits across a year and the average duration of the visits, while Cox, Shanahan, Hudson, Fuller, and Gaston (2018) looked at the frequency with which people spent at least 10 min in their own garden during the preceding week, and the total time spent in their garden. Both observed positive associations between the exposure to nature and health benefits. Li, Deal, Zhou, Slavenas, and Sullivan (2018) looked at daily exposure to greenery and mood at the end of the day, and found that higher exposure was

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associated with a better mood.

Research into how different types of physical environment affect one's mood in daily life is still scarce, however. One way to study this is by experience sampling, i.e., having people conduct ecological momentary assessments (EMAs) of their mood. Used specifically for studying the effects of the physical environment, this method has become less cumbersome for participants following the widespread use of smartphones with GPS functionality, making it easier to conduct studies involving large numbers of people. One of the first large-scale studies using a smartphone app for experience sampling was performed by MacKerron and Mourato (2013). These authors developed the Mappiness app for iOS-based phones, and had more than 20,000 self-enrolled participants generate over a million EMAs of their mood. The main question asked was how happy one felt at that moment in time, which was considered a self-reported measure of momentary subjective wellbeing, tapping mainly into the hedonic component of happiness (MacKerron & Mourato, 2013; see also Choi, Catapano, & Choi, 2017; White, Pahl, Wheeler, Depledge, & Fleming, 2017). Happiness also has an eudaimonic component, but this component is assumed to be more temporally stable, rather than to change from moment to moment (Steptoe, 2019).

MacKerron and Mourato (2013) focused on happiness when outdoors and concluded that, in general, people felt happier in any type of natural environment than in an urban environment, but especially in marine and coastal margins. In this latter type of outdoor environment, the happiness score was about 6 points higher than in continuous urban environments, on a scale from 0 to 100. From a policy perspective, the issue of which type on natural environment is most conducive to happiness is an important one, guiding decisions on which type of nature should have improved access or be promoted for visiting as a way of enhancing mental wellbeing. This study aims to provide more insight into this matter, particularly in the Dutch context.

We set out to conduct a study similar to Mappiness, but with an emphasis on potential differences between types of nature built into its design. Furthermore, we decided not to look at the type of land use at the 'precise' GPS location, but at the dominant type of land use in the vicinity of this location. This allowed us to also examine the effect of the dominant type of land use on people who are indoors. This is of interest, since a) many people spend most of their time indoors and b) several studies have shown that even having a window view of nature is associated with health benefits (for examples, see Honold, Lakes, Beyer, & van der Meer, 2016; Dempsey, Devine, Gillespie, Lyons, & Nolan, 2018). Although living in a predominantly natural environment does not guarantee a window view of nature, it may be considered a reasonable proxy.

In addition, we explored why some types of natural environments may be more conducive to happiness than others. Recently, Seresinhe, Preis, MacKerron, and Moat (2019) concluded that happiness is greater in more scenic environments; however, scenicness was the only perceived characteristic of the environment included in their study. Theoretically, other characteristics are likely to be relevant as well. According to two dominant theories in the field, the Stress Reduction Theory (Ulrich, 1983) and the Attention Restoration Theory (Kaplan, 1995), stress reduction and recovering from mental fatigue are important pathways linking exposure to nature with mood (Berto, 2014), and by accumulation with mental health. To some extent, this has been supported by empirical studies conducted in real-world settings, showing an association between access to green space and mental health. (De Vries, van Dillen, Groenewegen, & Spreeuwenberg, 2013; Triguero-Mas et al., 2017). Therefore, it is important to know which environmental qualities are relevant for producing such effects. According to Ulrich (1983), the environment should not be threatening. In line with his Stress Reduction Theory, peacefulness or serenity is assumed to be indicative of the stress-reducing qualities of the environment (Annerstedt-van den Bosch, Östergren, Grahn, Skärbäck, & Währborg, 2015; Beute & de Kort, 2018; Kondo, Jacoby, & South, 2018; Pálsdóttir, Stigsdotter, Persson, Thorpert, & Grahn, 2018). Fascinatingness, especially of the non-demanding variety (soft fascination), is a characteristic of the environment that, according to the Attention Restoration Theory, determines its restorative capacity (Kaplan, 1995). Natural environments tend to possess this characteristic to a larger extent than do built-up environments. Therefore, besides scenic beauty we asked participants about the peacefulness and fascinatingness of the environment.

Finally, we explored three possible biases in our results: the self-selection of participants, the possible selectivity in responding to the requests to conduct an EMA, and the possibility that the locations at which EMAs were performed are not representative for other areas belonging to the same type of environment.

To summarise, our research questions are:

1. Does the type of physical environment in which one finds oneself, predominantly built-up or predominantly natural, affect how happy one feels at that moment in time?

1a. Are there differences in this respect between different types of natural environments?

1b. Does the dominant type of environment only affect one's level of happiness when one is outdoors, or also when one is indoors?

2. To what extent are the following perceived characteristics of the environment predictive of how happy one feels: scenic beauty, peacefulness and fascinatingness?

3. To what extent may the outcomes of an EMA study using a dedicated app on self-enrolled participant's smartphones be considered representative

3a. of people other than those participating in the study?

3b. of times other than when the EMAs are conducted?

3c. of locations other than where the EMAs are conducted?

2. Method

2.1. App development for iOS and Android

Taking our lead from the Mappiness app as developed by MacKerron and Mourato (2013), we used a smartphone app that was specifically designed for the purpose of experience sampling. Our app was based on the Mappiness app, but contained some changes that we considered to be improvements. To increase the representativeness of the participants, we developed an app not only for the iOS platform, but also one for the Android platform. The app was called HappyHier (see Fig. 1). Because of the inherent differences in the two operating systems, it proved difficult to have exactly the same app for the two platforms. These differences, particularly in the triggering of the requests (push messages), meant that the operating system needed to be taken into account as a covariate in statistical analyses with the individual as unit of observation. In analyses with the EMA as unit of observation, a possible effect of the operating system is absorbed in an individual constant (intercept).

2.2. Oversampling natural environments

The random-time sampling in the Mappiness study meant that over 85% of the EMAs had 'indoors' as the type of location, and only about

Fig. 1. HappyHier logo.

7.5% were located outdoors. Moreover, of these outdoor EMAs, over 50% had ‘continuous urban’ as the land cover type. Given that we are interested in whether happiness differs by the type of natural environment, we decided to discard random-time sampling in favour of oversampling natural environments. To facilitate this, the app contained a national grid map of land-use types, enabling it to operate without mobile data or a WiFi connection. The map was kept simple due to technical limitations (smartphone memory).

The app checked the location of the participant at regular time intervals (Android) or checked the location when the participant changed position (iOS). When the participant was located in the land-use type ‘built-up area’, the app randomly decided whether to send a request to conduct an EMA, up to a maximum of two requests per day. In contrast, when the participant was located in a natural environment, a request would always be sent, though again with a maximum number of two requests per day. The requests were sent after a delay of 10 min The delay was introduced to prevent the sending of requests at the moment the participant enters an area with a certain type of land use, at which time their mood might perhaps be more affected by the previous type of land use experienced. Upon ignoring or completing a request, at least 50 min had to pass before a new request was sent. In total, a participant could receive up to four requests per day. Participants could also start an EMA themselves.

2.3. Privacy statement

During the installation of the app, participants were asked to give their consent regarding the privacy policy in relation to the use of the data provided for the research project. In accordance with Dutch and European law, the data collecting was reported to the Authority Personal Data under nr. M1626577. After consent was given, an initial questionnaire opened with questions on the background characteristics of the participant, such as gender, age and level of education. It was only upon completion of this initial questionnaire that the participant received requests to fill out the short EMA questionnaires on location.

2.4. EMA questionnaire

The EMA requests were introduced by the sound of a bicycle bell and a notification on the screen. When opened, the EMA questionnaire started with a single question on how happy one felt, to be answered on a scale from 0 (not at all) to 10 (completely). Given the repeated measurements taken in this study, with multiple assessments during the participant’s daily life over multiple days, the use of more extensive mood scales, was considered less appropriate. Previous research has shown single-items measures of happiness to have a good reliability and validity (Abdel-Khalek, 2006). More in general, single-item measures have proven to be useful in repeated measurement studies (De Boer et al., 2004; Macias, Gold, Öngür, Cohen, & Panch, 2015). Subsequent questions included the type of setting (indoors, outdoors, in a vehicle), type of context (at home, at work/school, elsewhere), type of activity and type of company. In contrast to MacKerron and Mourato (2013), we also asked questions on the type of activity and company when the participant indicated they were indoors. Most questions were asked only when participants had indicated they were not in a vehicle.

At the end of the EMA, when participants had indicated they were not at home or work/school, some additional questions were asked. In particular, three perceived characteristics of the environment were enquired about: the scenic beauty of the environment, its peacefulness and its fascinatingness. As before, to keep the burden for the participants as low as possible, single questions were used for each concept, rather than more elaborate scales (see Hartig, Korpela, Evans, & Gärling, 1997, for a scale for fascinatingness, for example). The ratings were given on the same 11-point scale as the happiness rating (see Figure A.1 in the supplementary data for screenshots with the exact formulation of these questions, in Dutch). Participants were asked to participate for 30 days. The app showed a counter going backwards from 30. To promote continued participation, participants could look up feedback regarding their own happiness scores (by day of the week, by type of setting). See, De Vries et al., 2017, masked for blind review) for a more detailed description of the app, including the complete questionnaires (in Dutch only).

The necessary conditions for an EMA request to be made and a response to it to be received were that the smartphone was powered on, that the sound (or at least the vibration function) was turned on, that the participant heard (or felt) the signal and was able to respond (e.g., not driving), and was willing to do so.

2.5. Recruiting participants

The apps were placed in the Google Play Store and Apple App Store. Participation depended on self-enrolment. The media campaign to recruit participants was launched on Sunday, 1st May 2016, with the study being introduced during a nature show, “Vroege Vogels” [Early Birds], on a national radio station, combined with a press release on the same day. The item was picked up by several national and regional news sites later that day. Subsequently, other efforts were made to generate attention for the study and to invite people to participate, including social media posts and radio interviews. People could join the study until 20th June 2016, at which date the app was taken out of the stores. Background information was provided on the website www.happyhier.nl.

2.6. Additional data

For the analysis regarding the type of environment, we did not use the classification of land use included in the simple map in the app itself, but rather used a more detailed land-use map with a resolution of 2.5 m, based on a national topographic map, TOP10NL (Kadaster, 2016). We looked at the dominant type of land use within 125 m of this location fix, rather than at the type of land use at the GPS location itself. This dominant type of land use was determined in two steps. First, it

Table 1
Types of land use distinguished in the analysis.

Number	Name	Description
0	Built-up area	Built-up areas plus other sealed surfaces, such as roads
1.1	Linear water	Rivers, canals
1.2	Planar water	Seas, lakes, ponds
2.1	Agricultural grassland	Meadows, excluding natural grasslands
2.2	Arable land	Land used for growing crops
3.1	Parks	Parks and recreation areas
3.2	Other recreational area	Bungalow parks, campgrounds, sports areas
4.1	Forest	All types of forest
4.2	Natural coast	Beaches, dunes
4.3	Low-lying natural vegetation	Heathlands (except in dunes), natural grasslands, and other forms of low-lying natural vegetation (i.e., not agricultural)

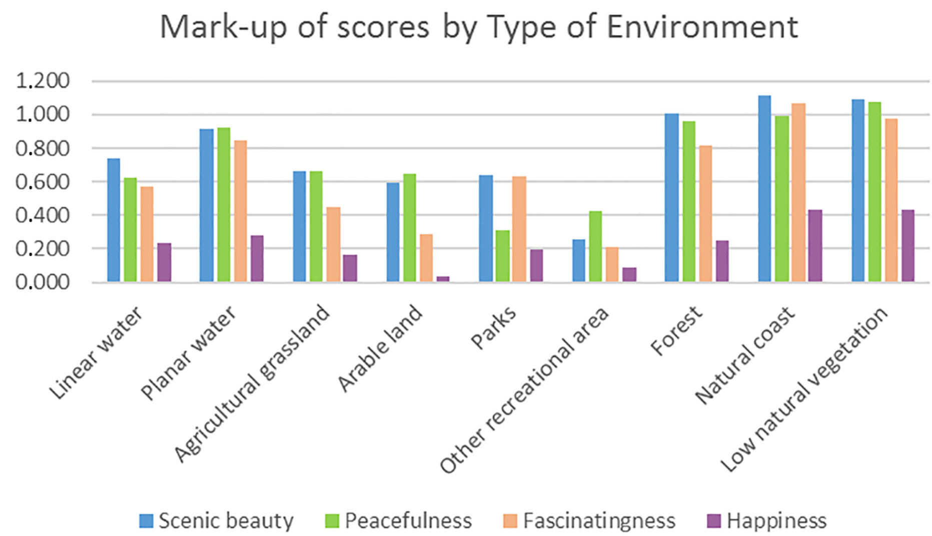

Fig. 2. Mark-up of scores for the three perceived environmental characteristics and happiness by type of environment (reference: built-up area), based on models built using only the EMAs related to the 'elsewhere' context and 'outside' setting (n = 20,932).

was determined whether the environment was predominantly built-up or natural. When predominantly natural, the dominant type of nature was determined in the second step. Table 1 shows the types of land use that were distinguished (see also Fig. 2).

Besides the detailed land-use data, we also added data on the level of traffic noise in 2012, based on a national model developed by the Dutch National Institute for Public Health and the Environment (Schreurs, Jabben, & Verheijen, 2010). The noise level was classified in six categories (see below). Finally, we added data on the weather conditions. Based on the data from the nearest weather station and the RayMan software package, we determined the physiologically equivalent temperature (PET) and classified it into five categories (see below). In addition to the PET, we also looked at rainfall in the half hour preceding the EMA, using more spatially detailed data (1 km × 1 km) provided by the Royal Netherlands Meteorological Institute (KNMI), sampled every five minutes (KNMI, 2019). With respect to rainfall, we distinguished two categories (see below).

2.7. Analyses

Only participants who provided at least one EMA were included in the analyses. Descriptive analyses of the data at the participant level were conducted using SPSS (version 25). The EMA data were analysed using a random intercept multi-level model, with EMA being the first level and participant the second. The multi-level analyses were conducted with MLwiN (version 2.32). All EMAs in which the participant was in a vehicle were excluded from the multi-level analyses. We considered that, when travelling in a vehicle, the type of environment might have changed shortly before.

First, a basic model was developed. This basic model contained the following categorical variables:

- type of context: at home (reference), at work/school, elsewhere
- type of setting: indoors (reference), outdoors (excluding in a vehicle)
- type of activity: work/school related (reference), household/administrative, personal care/care of others, passive leisure, social leisure, active leisure, other leisure
- type of company: none (reference), partner, child(ren), other
- PET: < 10 (reference), 10–15, 15–20, 20–25, greater than25°Celsius
- rain: at most 0.1 mm in the preceding half hour (reference), more than 0.1 mm
- traffic noise: ≤45 dB (reference), 46–50, 51–55, 56–60, 61–65, greater than66 dB
- day of the week: Sunday (reference), Monday, …, Saturday
- time of day: night (reference), morning (6:00–12:00), afternoon (12:00–18:00), evening (18:00–24:00)

The interaction between the type of context and the type of setting was also included in the model. Furthermore, since PET, rain, and traffic noise level are likely to be more relevant when one is outdoors, the interaction with the type of setting was also included for these three variables in the basic model. Likewise, the interaction between the type of activity and the type of setting was included in the basic model, since the actual activity is likely to differ between indoor and outdoor settings. More specifically, the types of activity offered as answers in the EMA questionnaire differed depending on whether the participant had indicated they were indoors or outdoors (see Table A.1 in the supplementary data).

Subsequently, the type of environment was added to the basic model, as well as its interaction with the type of setting (indoors/outdoors). In follow-up analyses, the main effects of several personal characteristics (gender, age, membership of nature organisation) and their interaction with the type of environment were added to the latter model one by one. This was done to explore the extent to which the sample of participants not being representative for the Dutch population may have affected the results.

3. Results

3.1. Participants

The final sample consisted of 4318 participants who conducted at least one EMA. Their background characteristics are presented in Table 2. Compared to the Dutch population as a whole, women are clearly overrepresented, as are more highly educated people. With regard to age, the middle category (30–50 years) is overrepresented at the expense of both other age categories. For other characteristics, this is difficult to assess, as population-level data are not available. However, given that Android-based phones have a larger market share (Telecompaper, 2016), people with an iOS-based smartphone seem to be overrepresented.

3.2. Emas and dominant type of land use

The participants completed a mean of 25 EMAs, for a grand total of

Table 2
Background characteristics of participants (n = 4318).

Gender	
- male	33%
- female	67%
Age category	
- under 30	27%
- 30–50	44%
- 50 and above	29%
Level of education	
- low	16%
- high (general secondary and above)	84%
Hours of paid work per week	
- up to 10 h	24%
- between 10 and 30 h	22%
- more than 30 h	54%
Participant has partner	
- no	27%
- yes	73%
Child(ren) present in household	
- no	64%
- yes	36%
Dog present in household	
- no	80%
- yes	20%
Presence of domestic garden and its greenness	
- not present	25%
- predominantly paved	21%
- about half paved, half unpaved	20%
- predominantly unpaved	35%
Car present in the household	
- no	16%
- yes	84%
In possession of recreational accommodation at fixed location (e.g., summer cottage)	
- no	85%
- yes	15%
Member of nature organisation (e.g., WWF)	
- no	70%
- yes	30%
Phone platform	
- Android	44%
- iOS	57%

108,420 EMAs. The distribution was strongly skewed, however; the median number was 15 EMAs, and the mode was one EMA. More specifically, 11% of the 4318 participants filled out only one EMA. Almost 20,000 EMAs were completed while in a vehicle. Furthermore, the type of land use could not be determined in over 5000 cases, leaving 82,901 EMAs available for analysis. In 37,755 cases, the EMA could not be linked to a preceding request, indicating that the participant may have consciously started the EMA themselves. However, the lack of a preceding request can also be due to a delayed response, or to accidently starting an EMA while intending to respond to a request. Overall, for about 22% of these EMAs, the dominant type of land use was natural (see Table 3). Agricultural grassland was the most common dominant subtype of natural environment.

Table 4
Effect of the type of environment on momentary happiness: mark-up of happiness score, compared with the reference condition (n = 82,901).

Dominant type of land use within 125 m	When indoors	Additional effect on momentary happiness when outdoors	Total effect on momentary happiness when outdoors
Built-up environment	Reference	Reference	Reference
Standard error			
Significance			
Linear water	–0.012	**0.242**	**0.230**
Standard error	0.068	0.084	
Significance	0.860	0.004	< 0.001
Planar water	0.060	**0.250**	**0.310**
Standard error	0.082	0.092	
Significance	0.464	0.007	< 0.001
Agricultural grassland	**0.085**	**0.069**	**0.154**
Standard error	0.023	0.031	
Significance	0.000	0.026	< 0.001
Arable land	0.044	0.051	**0.094**
Standard error	0.043	0.054	
Significance	0.306	0.345	0.017
Parks	–0.061	**0.245**	**0.184**
Standard error	0.040	0.049	
Significance	0.127	< 0.001	< 0.001
Other recreational area	**0.066**	0.046	**0.113**
Standard error	0.033	0.041	
Significance	0.046	0.262	< 0.001
Forest	**0.126**	**0.133**	**0.259**
Standard error	0.040	0.048	
Significance	0.002	0.006	< 0.001
Natural coast	**0.384**	0.056	**0.440**
Standard error	0.190	0.197	
Significance	0.043	0.776	< 0.001
Low-lying natural vegetation	–0.037	**0.473**	**0.436**
Standard error	0.097	0.106	
Significance	0.703	< 0.001	< 0.001

Bold: significant at p = 0.05. Total effect tested by means of joint Chi-square test.

3.3. Effects on happiness

The multi-level analyses for momentary happiness showed a significant improvement when the type of environment and its interaction with the type of setting (indoors/outdoors) were added to the basic model: χ^2 (18) = 257; p < 0.001. When outdoors, people reported feeling happier in all subtypes of natural environment than in built-up environments (Table 4). In some subtypes of predominantly natural environment, people felt happier than in a predominantly built-up environment even when indoors. This is especially the case for natural coasts; in this type of natural environment participants reported feeling equally happy, regardless of whether they were indoors or outdoors. When outdoors in natural coasts or environments dominated by low-

Table 3
Percentage of EMAs by dominant type of land use and phone platform.

Dominant type of land use within 125 m	Android(n = 35,119)	iOS(n = 47,782)	Total(n = 82,901)
Built-up	78.7%	77.9%	78.3%
Natural	21.3%	22.1%	21.7%
- Linear water	0.9%	0.9%	0.9%
- Planar water	0.9%	0.9%	0.9%
- Agricultural grassland	7.2%	7.0%	7.1%
- Arable land	2.0%	2.1%	2.1%
- Parks	2.7%	2.7%	2.7%
- Other recreational area	3.8%	4.0%	3.9%
- Forest	2.6%	3.1%	2.9%
- Natural coast	0.4%	0.6%	0.5%
- Low-lying natural vegetation	0.8%	0.7%	0.7%

lying natural vegetation, participants showed the greatest level of happiness. Participants in arable land reported the smallest difference in happiness relative to the built-up-environment, although it was still a significant increase. For the complete multi-level model, see Appendix 1 (supplementary data).

In general, people felt happier when they were outdoors relative to when they were indoors: B = 0.315 (SE = 0.036; $p < 0.001$). The unstandardized regression parameters, or happiness mark-ups, are additive; for example, being outdoors in a forest environment is associated with a (0.315 + 0.259 = 0.574) higher happiness score than being indoors in a built-up environment (keeping other factors in the model constant).

To check whether it matters if the participant clearly responded to a request or might have self-initiated the EMA, an additional analysis was performed. In an extended model, whether or not a preceding request was identified and its interaction with the type of environment were added as predictors. None of these additional parameters were significant. Moreover, the parameter for the type of environment and its interaction with the type of setting (indoors/outdoors) remained virtually the same (see Appendix 1 in the supplementary data for the complete model).

To assess the robustness of the model, an additional analysis was performed, including only those participants who supplied at least five EMAs. The happiness mark-ups for the type of environment were highly similar to those of the model without this selection. The largest difference was an increase of 0.014 in the mark-up for parks when outdoors (see Appendix 1 in the supplementary data for the complete model).

3.4. Characteristics of environment associated with happiness

To gain insight into what makes an environment conducive to happiness, an analysis was performed in which the type of environment was replaced by the three subjective ratings of the environment: scenic beauty, peacefulness and fascinatingness (all 0–10 scales). Only the 20,932 EMAs that pertained to the type of context 'elsewhere' and the type of setting 'outdoors' were included in this analysis. The intercorrelations between the three ratings were 0.76 at the maximum. Given the large number of EMAs, this was not considered problematic for multi-collinearity. A new basic model was formulated, leaving out the type of context and type of setting, as well as their interactions with other factors. Simultaneously adding the three perceived characteristics clearly improved the model: χ^2 (3) = 2816; $p < 0.001$. The results showed that all three ratings had predictive value, but peacefulness and fascinatingness were more important than scenic beauty (Table 5).

As a follow-up, the effect of the type of environment on the three perceived environment characteristics was analysed for the same selection of EMAs: elsewhere and outdoors. The same model as above was used, but now with one of the perceived characteristics as a dependent variable and the type of environment as an extra predictor. The same analysis was also performed for happiness. The results show that the mark-ups for the perceived environmental characteristics were substantially larger than those for happiness (Fig. 2; supplementary data Table A.2). Natural coasts and low-lying natural vegetation environments scored highest for all three perceived characteristics. Forests scored somewhat lower than natural coasts, particularly for fascinatingness. Although arable land had a similar mark-up for scenic beauty as parks, the latter had a higher mark-up for happiness, in line with arable land being less fascinating. The mark-up for happiness for arable land was no longer significant for this selection of EMAs.

Table 5
Effect of the perceived characteristics of the environment on momentary happiness (together in one model): mark-up of ratings (parameter) when elsewhere and outdoors (n = 20,932).

Perceived characteristic	Parameter value
Scenic beauty	**0.029**
Standard error	0.007
Significance	< 0.001
Peacefulness	**0.121**
Standard error	0.005
Significance	< 0.001
Fascinatingness	**0.114**
Standard error	0.005
Significance	< 0.001

Bold: significant at p = 0.05.

3.5. Representativeness of outcomes

Participants in the HappyHier study were not representative of the Dutch population. More highly educated people, and to a lesser extent women, were overrepresented; however, if these characteristics do not affect how people respond, the outcomes may still be representative. This was tested by looking at the interaction of these two characteristics with the type of environment. We found that, overall, women felt slightly less happy than men: –0.072 (SE = 0.029). Other than that, gender only interacted with agricultural grassland: women felt less happy in this type of environment than men: –0.076 (SE = 0.036). The level of education of the participants had no main effect on happiness, but there were two significant interactions. The more highly educated people felt less happy in parks (–0.168; SE = 0.078) and especially in natural coastal environments (–0.480; SE = 0.205) than the underrepresented lower-educated participants. As a third individual-level characteristic, the effect of being a member of a nature organisation was investigated. Overall, members felt slightly happier than non-members: 0.106 (SE = 0.029); however, they felt less happy than non-members in environments dominated by planar water (–0.279; SE = 0.083) and natural coasts (–0.247; SE = 0.104).

Besides the issue of the representativeness of participants for the Dutch population, there is the issue of whether the EMA requests being responded to were representative for other points in time. We investigated whether the chance that a request was responded to was dependent on the type of environment the person was in when the request was made. Only requests with a known type of environment were included in this analysis. Obviously, EMAs that were not linked to a preceding request were excluded as well. Requests that were made in a built-up environment showed the highest response percentage (23.4%), while requests sent in natural coasts showed the lowest response percentage (16.7%). Thus, participants seemed less inclined to respond in a happy environment than in a less happy environment.

A third issue regarding the representativeness of the outcomes is the extent to which the locations in which EMAs were performed are representative of other places with the same dominant type of environment. We specifically looked at the EMAs conducted in predominantly natural environments (see Fig. 3), revealing somewhat of a concentration of EMAs undertaken just outside built-up areas, along the coastline and in some well-known forests and national parks (especially along their edges).

A more quantitative assessment of the distribution of EMAs was made by looking at the density of EMAs in each type of environment. The highest densities were observed for built-up areas, followed by parks and other recreational areas. The lowest EMA densities were observed for planar water and arable land (Table 6). The two types of land use that were most conducive to happiness did not have very high densities of EMAs, although the density for natural coasts was still almost three times as high as that for low-lying natural vegetation.

To explore the spatial distribution of EMAs over the total (non-contiguous) area with a certain type of land use, a coefficient of variation (CV) was calculated for the number of EMAs per type of land use (standard deviation divided by mean). For each raster cell of 5 × 5 km, the number of EMAs was calculated. Subsequently, the CV was calculated for each type of land use. All raster cells containing the particular

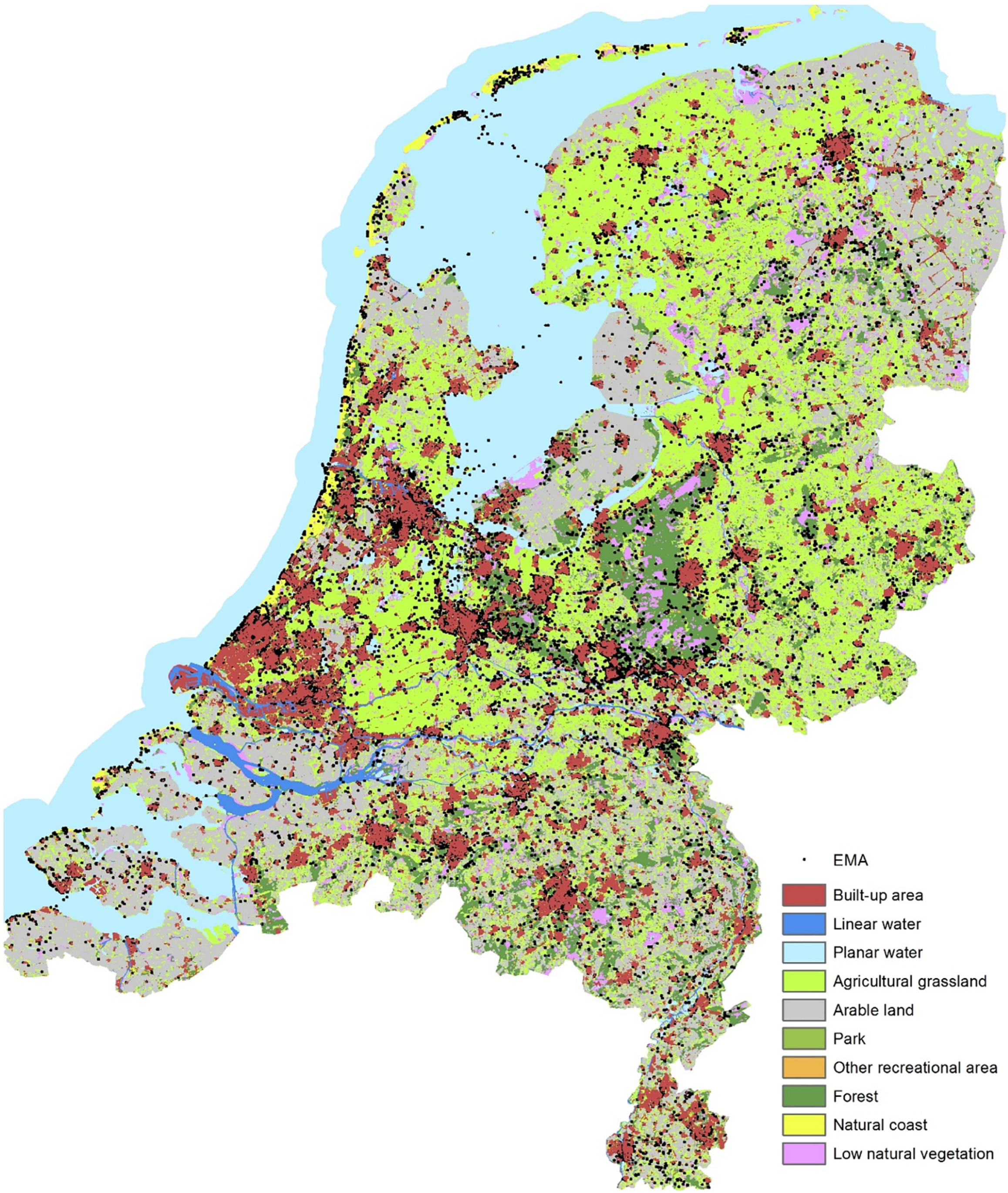

Fig. 3. Map of EMAs conducted in predominantly natural environments.

dominant type of land use were included in this calculation. Since its maximum value depends on the number of units of observation (here, raster cells), the CV is presented as the percentage of this maximum value (Abdi, 2010). The lower the CV percentage, the more equally distributed the EMAs are over the area with a certain dominant type of land use. Built-up area had the lowest CV percentage and linear water the highest percentage (Table 6). The latter percentage is less reliable, since there are likely to be many raster cells, which are rather large, in which linear water is the dominant type of land use in only a small part of the cell. Consequently, many of the EMAs in the cell may actually be located in another type of dominant land use within that cell. Next to linear water, forests and low-lying natural vegetation had the highest CV values, indicating a more uneven distribution of the EMAs in these two types of land use.

4. Discussion

Our findings about the effect of the type of environment on momentary happiness are largely in line with those of MacKerron and Mourato (2013), who conducted their study in the UK. We found that people generally felt happier in natural environments than in predominantly built-up environments, especially at natural coasts. Environments dominated by low-lying natural vegetation did equally well. However, this type of land use does not correspond to one of the types distinguished by MacKerron and Mourato (2013). Therefore, a direct comparison is not possible for this type. Our results are also in line with

Table 6
Density of EMAs by dominant type of land use and coefficient of variation (CV).

Dominant type of land use within 125 m	Total area (km^2 NL)	Number of EMAs	Density per 25 km^2 *	Density per raster cell **	Standard deviation (raster cells)	CV (% of max. value)
Built-up	4583	65,968	360	230	493	5.4
Linear water	707	725	26	57	792	47.4
Planar water #	8188	782	2	9	62	17.4
Agricultural grassland	12,861	5922	12	17	92	13.2
Arable land	9907	1747	4	6	29	12.5
Parks	362	2312	160	99	415	12.8
Other recreational area	618	3288	133	135	790	15.4
Forest	3579	2381	17	19	190	26.5
Natural coast	342	539	39	41	80	16.3
Low-lying natural vegetation	1848	627	9	14	141	25.7

: only a small part of the North Sea is taken into account (see map in Fig. 2)
* : based on total area in the Netherlands (NL)
** : calculated over all raster cells in which a certain dominant land use type is present, in which case all EMAs within that cell are taken into account.

more recent studies making use of a smartphone app for experience sampling. Mennis, Mason, and Ambrus (2018) found that, when away from home, greener urban environments were associated with less self-reported momentary stress than less green urban environments. Bakolis et al. (2018) found that exposure to natural features was positively associated with momentary subjective wellbeing. Beute and de Kort (2018) looked at people with varying levels of depressive symptoms and concluded that exposure to nature was positively associated with affect, and to a lesser extent negatively with self-reported stress levels. Moreover, the positive association tended to be stronger for those with more depressive symptoms.

To appreciate the size of the differences in happiness between the types of environment, we compared them to those associated with some of the other factors in the analysis (see the second model in Appendix 1). Being outside at a natural coast was associated with a 0.44 higher score on the 0–10 happiness scale than being outside in a built-up environment. The presence of one's partner was associated with a 0.22 higher score compared with being alone. Similarly, spending time outside in a temperature of over 25 °C (PET) was associated with a 0.19 higher score than a temperature below 10 °C (PET). In this respect, the type of environment outperforms both the type of company and the weather condition; however, the largest differences were observed for the type of activity. When indoors, active leisure was associated with a 0.75 higher happiness score than a work- or study-related activity. Finally, the mark-up for natural coasts has the same order of magnitude as that observed by MacKerron and Mourato (2013) for marine and coastal margins, which was 6.02 on a scale from 0 to 100. Translating the 0.44 that we observed on our scale to their scale results in a parameter value of 4.40.

A novel result of the present study is that some types of environment are associated with happiness even when the participant was indoors. This was specifically the case for natural coasts. This is potentially highly relevant, since people generally spend much more time indoors than outdoors. The effect may depend on whether one is able to see the coast or sea when inside. Dempsey et al. (2018) showed that having a sea view at home is more strongly linked to wellbeing than the distance to the coast. Honold et al. (2016) observed that people with a varied green view from their living room window had a lower level of the stress hormone cortisol. Note that in our study, we had no data about whether people were actually able to see the coast and/or sea while indoors.

Seresinhe et al. (2019) concluded that people are happier in more scenic environments; however, scenicness was the only perceived characteristic of the environment they examined. Based on our results, scenic beauty may not be the most important characteristic when it comes to happiness. Taking into account all three characteristics simultaneously, peacefulness and fascinatingness both had more predictive value for happiness than scenic beauty; in other words, given a certain level of peacefulness and fascinatingness, how happy one feels does not depend strongly on how beautiful one finds the environment. This result fits quite well with theoretical notions on why spending time in natural environments is beneficial to human wellbeing. Neither the Stress Reduction Theory proposed by Ulrich (1983) nor the Attention Restoration Theory proposed by Kaplan (1995) explicitly mention scenic beauty as a key characteristic of beneficial or restorative environments. Note, however, that scenicness affects how attractive a location is as a place to visit, and may thereby influence its level of visitation, especially during leisure time; therefore, it may help by increasing the amount of exposure.

4.1. Representativeness of outcomes

The sample was not representative of the Dutch population in terms of the level of education and gender; however, these factors had a relatively small influence on the outcomes with regard to the type of environment. The main bias was that the happiness mark-up for natural coasts was underestimated, since the underrepresented group of people with lower levels of education felt happier in this type of environment. Being a member of a nature organisation, an individual-level characteristic that may have affected one's willingness to participate in this nature-related study, also had limited influence on the outcomes with regard to the type of environment. This implies that also the sample not being representative in this respect (which could not be assessed), would not strongly affect the representativeness of the outcomes. However, it remains possible that our sample may not be representative in other respects, for example with regard to ethnic background, which could limit the generalizability of the outcomes of the present study.

The representativeness of the EMAs for other moments in time is hard to assess, since it is unknown how the participants felt during the times they were not responding to a request. However, in general the response rates were higher when participants were in a built-up environment at the time of the request. At the same time, this is the type of environment in which they felt less happy on average; therefore, people do not seem to be more likely to respond to EMA requests at times when they feel happier. Other factors may be more important. First of all, there is the issue of being aware of the request and being able to respond to it. If the sound of the smartphone is turned off, or very low, the request is likely to go unnoticed. Also, when a participant receives a request while driving a car, they may not be able to or even legally allowed to respond to a request. Another issue is that one may be very involved in an activity and not willing to pause to fill out an EMA. Especially given the self-enrolment used here, participants may feel at liberty to ignore a request, and are perhaps more likely to respond at times when they have nothing better to do and/or are engaged in an activity that can easily be interrupted for a moment.

The representativeness of the locations where EMAs were conducted for other locations with the same type of land use is an issue that deserves more attention. Peri-urban areas close to large cities appear to have received more visits than other parts. Undoubtedly this is due to their proximity to the homes of many people, but it may partly also be due to the geo-sampling procedure, since it will often have been the first predominantly natural environment that people encountered when leaving the built-up area, triggering a request. In general, these *peri*-urban areas are not the most attractive parts of the countryside in terms of scenic beauty (De Vries, Lankhorst, & Buijs, 2007). Furthermore, the proximity of the city and the high level of visitation may negatively affect the peacefulness of these areas. Both may have negatively affected the happiness mark-ups for the predominantly natural environments that we observed.

A related issue is that some types of land use, such as arable land, may be less accessible to the general public. People could potentially feel happy when visiting areas belonging to such types, but they may not be permitted to do so, or not be able to do so because of a lack of infrastructure. A similar argument can be made for large water surfaces, which require special equipment (e.g., a boat) to access large parts of it. The relevance of the issue of accessibility with regard to generalising from the locations where EMAs took place to the land-use category as a whole depends on whether one is interested in the ability of a certain type of environment to affect emotional wellbeing (potency), or in the actual contribution of a specific area with a certain type of land use to, for example, gross national happiness (Sim & Diener, 2018).

4.2. Strengths and limitations

One of the strengths of the present study is that of the EMAs in general. The mood assessments took place in the actual environment of interest, and therefore have a high ecological validity. Since they were instantaneous, they did not suffer from recall bias. Furthermore, in this study, the type of environment was determined independently of the participant, precluding possible biases in reporting on the type of environment associated with one's mood state. Also, the geo-based sampling strategy hard-wired in the apps worked well, in that a substantial proportion of the EMAs (22%) were conducted in predominantly natural environments. A third strength is that we managed to attract a substantial number of people to participate in the study. We expect that this will become harder to do in the future, because of an increasing competition for attention between all kinds of new apps.

One limitation is that, due to the self-enrolment process, the participants were not representative of the Dutch population. We identified a clear overrepresentation of women and more highly educated people, but this had only a limited effect on the outcomes of the study, as described above. People who were not fluent in Dutch are also less likely to have participated, as the app was only available in Dutch. Also, people without an Android or Apple smartphone (or other iOS device) were not able to participate at all. The representativeness of the EMAs for other moments in time and for other locations with the same type of land use have been discussed above.

A final limitation is that the study is cross-sectional and does not permit strong conclusions on the causality of the observed associations. For example, people who are happier in general may be more likely to go outdoors and find themselves in a predominantly natural environment, or may even be inclined to look for such an environment. The converse could also be true: people who are unhappy may try to go to one of their favourite places to become happy again. Korpela and Ylen (2007) showed that Finnish adults with health problems more often identify a natural environment as one of their favourite places and reported larger emotional benefits from visiting such places than those without such problems. Visiting a favourite place may be instrumental in emotional self-regulation (see also Korpela et al., 2018).

4.3. Future research

This study adds to the evidence base that contact with nature is instrumental in linking access to nature with mental wellbeing, and provides information which type of nature may be most beneficial. However, it remains somewhat uncertain to what extent spatial planning and land management can increase happiness because of reversed causality issues: happy people may be more inclined to go outdoors. It would strengthen the argument if mood could be shown to actually improve and/or stress reduced when one walks from a built-up environment into a natural one, and vice versa. Non-obtrusive ambulant and continuous monitoring of physiological mood and stress indicators could provide a way forward; however, preliminary studies in this direction have not yet provided clear results (Aspinall, Mavros, Coyne, & Roe, 2015; Neale et al., 2019).

It is important to note that we looked at the dominant type of land use in the vicinity of the location of the participant when conducting the EMA. For an environment to be defined as predominantly natural, all types of natural environment taken together should comprise at least 50% of this environment. The specific type of natural environment that dominated this area could easily comprise < 50% of the total environment, however. Presumably, the dominant type of nature within a predominantly natural environment was not the only type of nature present in all cases. Many different combinations of types of natural land use may occur, in different ratios, which may prove to be relevant. For example, it is already known that, in general, diversity contributes to the attractiveness of a landscape (see e.g., Tieskens, Van Zanten, Schulp, & Verburg, 2018). Further research is needed to address the issue of the effect of specific mixtures of types of natural land use in the environment on happiness, compared with environments in which only one type of land use is present. Moreover, perhaps the environment does not have to be dominated by natural features for those features to have a beneficial effect. Walking through a tree-lined street within the built-up area might already have a positive impact (De Vries et al., 2013; Taylor, Wheeler, White, Economou, & Osborne, 2015). This type of natural feature is not taken into account in our land-use based typology of environments.

5. Conclusions

Much of the research on nature and health focuses on public green spaces within built-up areas, such as urban parks; however, our study clearly shows that this is not the type of natural environment in which people feel most happy. When outdoors, participants felt most happy in environments dominated by natural coasts and low-lying natural vegetation, followed by forests. Consequently, facilitating and promoting visits to such more natural areas outside the city should be considered as a means to the mental wellbeing of the population. Urban parks may nevertheless be important; Kondo et al. (2019) found evidence indicating the positive effect of exposure to a natural outdoor environment on mood wears off after just 10 min, suggesting that repeated exposure is needed to establish a more permanent effect on human wellbeing. As we mentioned in our introduction, there is preliminary evidence that a dose–response relationship between the amount of exposure to nature and the size of health benefits does exist. Distance is an important determinant for visitation, and thereby exposure during leisure time. And for many people, urban parks are the closest type of natural environment available. The relevance of the amount of exposure ties in with the importance of finding an impact of the predominant type of environment when one is indoors, given that this is where most people spend most of their time. Also indoors, natural coasts led to the highest happiness mark-ups. Unfortunately, it is not realistic to aim for providing every dwelling (or workplace) with a window view of a natural coastline; however, forests had the second highest impact on happiness when indoors. Moreover, as mentioned above, other studies suggest that even a couple of trees already make a difference. A final remark regarding urban parks is that they scored particularly low on peacefulness, which we found to be more important for happiness than scenic beauty. Thus, improving the peacefulness of parks might be a more effective strategy for enhancing citizens' happiness than their beautification. At minimum, people should feel safe for the environment to be experienced as peaceful (see also McKinney & VerBerkmoes, 2020). Overcrowding may be another issue to look into, as this is likely to affect the peacefulness of the environment in a negative way. Moreover, the ongoing densification of cities may exacerbate this issue.

CRediT authorship contribution statement

Sjerp De Vries: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **Wim Nieuwenhuizen:** Conceptualization, Methodology, Investigation, Writing - review & editing, Project administration. **Hans Farjon:** Conceptualization, Methodology, Investigation, Writing - review & editing, Supervision. **Arjen Van Hinsberg:** Conceptualization, Methodology, Writing - review & editing, Supervision. **Joep Dirkx:** Conceptualization, Writing - review & editing, Funding acquisition.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.landurbplan.2020.103972.

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