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# A LONE WALK IN A PARK: THE NON-SOCIAL EFFECT OF URBAN GREENERY ON LONELINESS



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**A Lone Walk in a Park:**  
**the Non-social Effect of Urban Greenery on Loneliness**

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## Abstract

**Background:** Green areas have been shown to reduce loneliness in urban citizens, however, the mechanism behind the relationship has not been widely investigated. In the present study two possible mechanisms are distinguished: (i) social — green areas providing opportunities for social contacts; and (ii) non-social — green areas in themselves alleviating loneliness through such possible means as solace, reminders of social connections and anthropomorphisation of nature. Anthropomorphisation of nature was theorised to be amplified by pro-environmental attitudes. The main objective of the study was to assess the likelihood of both mechanisms with particular emphasis on the non-social mechanism.

**Methods:** A 57-item questionnaire based on validated instruments including scales of loneliness, social isolation, positive affect and environmental attitudes was administered to the residents of Groningen, the Netherlands. The number of respondents who finished the questionnaire was 43. The spatial data were analysed with QGIS (distance to the nearest point and amount of points within an area) and statistical data with SPSS (Kendall's  $\tau$  and ordered logit regression).

**Results:** The data showed support for the social mechanism, however, not the non-social mechanism. Pro-environmental attitudes were not shown to have an amplifying effect on the non-social path.

**Conclusion:** Although, the study found support for the existence of the social mechanism but not the non-social mechanism, the efforts to study it do not need to be abandoned yet. It is possible, that the present study did not have enough power to uncover the small effect due to the low number of respondents. The framework of the study and suggestions for adjustments could be utilised in future research.

*Keywords:* green areas, street greenery, gardens, loneliness, social isolation.

**Table of contents**

Abstract .....2

1. Introduction .....5

2. Literature review .....9

    2.1. Loneliness .....9

    2.2. Green areas .....13

    2.3. Linking loneliness to green areas .....14

    2.4. Social mechanism .....15

    2.5. Non-social mechanism .....17

    2.6. Street greenery and gardens .....22

3. Conceptual model .....23

4. Methodology .....24

    4.1. Participants .....24

    4.2. Setting .....27

    4.3. Materials .....28

    4.4. Ethical considerations .....35

    4.5. Directed Acyclical Graphs .....36

5. Results .....38

    5.1. Tests of reliability of the scales .....38

    5.2. Normality of data distribution .....39

    5.3. Test results .....43

6. Discussion .....48

    6.1. The main findings .....50

6.2. Causality .....	57
6.3. Limitations of the study.....	58
6.4. Suggestions for future research.....	59
7. Conclusion .....	60
References.....	62
Appendix A: The questionnaire.....	69
Appendix B: Screenshots of the questionnaire.....	76

## **A Lone Walk in a Park: the Non-social Effect of Urban Greenery on Loneliness**

### **1. Introduction**

In 1845 – 1847 Henry David Thoreau spent two years, two months and two days living alone in a small cabin in the woods near the Walden Pond, Massachusetts (Thoreau, 1854). The closest village, Concord, was an hour-walk away. Thoreau reports being perfectly satisfied with his solitary arrangement and insists he has been no more lonely than the natural elements that surrounded him.

I have never felt lonesome, or in the least oppressed by a sense of solitude, but once, and that was a few weeks after I came to the woods, when, for an hour, I doubted if the near neighborhood of man was not essential to a serene and healthy life. To be alone was something unpleasant. But I was at the same time conscious of a slight insanity in my mood, and seemed to foresee my recovery. In the midst of a gentle rain while these thoughts prevailed, I was suddenly sensible of such sweet and beneficent society in Nature, in the very pattering of the drops, and in every sound and sight around my house, an infinite and unaccountable friendliness all at once like an atmosphere sustaining me, as made the fancied advantages of human neighborhood insignificant, and I have never thought of them since. Every little pine needle expanded and swelled with sympathy and befriended me. I was so distinctly made aware of the presence of something kindred to me, even in scenes which we are accustomed to call wild and dreary, and also that the nearest of blood to me and humanest was not a person nor a villager, that I thought no place could ever be strange to me again (pp. 114-115, Thoreau, 1854).

Thoreau was a transcendentalist. His reports of living in a company of nature might be inspiring, but could hardly be considered a piece of empirical evidence to draw

any generalisations. Yet, his book which I cited above, “Walden; or, Life in the Woods” (1854), has resonated with many people in the near two-hundred years it has existed. Was he onto something?

It is not a new discovery that people tend to like nature and enjoy various experiences it provides (Eisenberger et al., 2010). As much as there exists a lot of empirical evidence for this, just so much nature has been praised in literature and folklore in different cultures at different times. However, apart from mere hedonistic enjoyment, visiting green areas or living in green environments has been repeatedly shown to improve one’s well-being and mental health (Birch, Rishbeth & Payne, 2020; Nutsford, Pearson & Kingham, 2013; van den Berg, Hartig & Staats, 2007; van den Berg et al. 2019). In other words, at the present times, it is rather clear that greenery in the surroundings can affect human mental states. The mental state of interest in the present paper is not an enjoyable one but still undeniable common — loneliness.

In the body of literature, there already exists evidence to suggest that green areas are, to some extent, able to decrease one’s loneliness (Astell-Burt et al, 2021; Beucker et al, 2021; Lyu & Forsyth, 2021, p. 6, 9; Maas et al., 2009). Studies on this topic usually suggest the following explanation: green areas such as parks, nature reserves, community gardens, etc., provide opportunities for social contacts (planned or unplanned), which then alleviate loneliness (Astell-Burt et al, 2021; Beucker et al, 2021; Neal et al., 2015). Yet, without such social meetings, would the relationship between green areas and loneliness hold true? Thoreau’s account, for example, suggested that such encounters are not absolutely necessary and just the company of nature is what is sufficient.

As we always want to improve our cities and improve people’s lives within them, it is worth our attention to see what lies behind the environment-loneliness relationship — particularly considering that feeling lonely can significantly decrease the quality of life (Astell-Burt et al., 2021; Coyle & Dugan, 2012; Santini et al., 2020). Scharf and de Jong Gierveld (2008) and Beuker et al. (2021) have shown that the rates of loneliness are unevenly spatially distributed and can vary greatly depending on the environment one lives in. The purpose of this paper is to shed more light on the mechanisms behind the effect of green areas on loneliness in urban citizens.

Groningen, a city in the north of the Netherlands, was chosen as the research site. In the context of the Netherlands, population-wise it is an average-sized city (estimated at approximately 235 000 residents as of April of 2022; CBS, 2022a). The city has a rather concentrated spatial layout which does not allow for the inclusion of a lot of greenery in the neighbourhoods. This is particularly true for the city centre, which was historically enclosed by a wall and physically divided from the countryside and nature. However, the city is not as large area-wise (197,96 km<sup>2</sup>; CBS, 2022b) and many residents can access the green areas lying outside of the city. Additionally, there are a few green areas scattered within the city, which promises a variety of cases with higher and lower access to green areas. Of course, as it is just one city, it cannot be claimed that it is perfectly representative of all urban environments in Europe or even in the Netherlands. However, it can nevertheless provide valuable information even if generalisable to only similar urban contexts.

### ***1.1 Research questions***

The main research question of this paper is the following:



*To what extent does access to green areas (parks, forests, gardens or street greenery) in one's immediate neighbourhood decrease loneliness through the non-social mechanisms in the residents of Groningen?*

To better understand the non-social mechanism, also the following sub-questions would be studied:

*To what extent does access to green areas (parks, forests, gardens or street greenery) in one's immediate neighbourhood decrease loneliness through the non-social mechanisms in the residents of Groningen?*

*To what extent does access to green areas ((parks, forests, gardens or street greenery) in one's immediate neighbourhood decrease loneliness through the social mechanisms in the residents of Groningen?*

*Do personal environmental attitudes influence the relationships described in the previous sub-questions?*

The structure of the paper is the following. First, I would cover the main theories on the topic in the body of literature: loneliness, social isolation and their relationship with green areas. I would suggest a division of the effect of green areas on loneliness into two paths: social and non-social, and discuss the possible effect of environmental attitudes on the non-social path. I would follow the literature review by the conceptual model which would unite the discussed theories. In the methods section, I would describe the questionnaire which was made to gather the needed data. It would be followed by the results of the analyses and the discussion of the results, which would put them in the context of the findings of other studies. The validity of the findings and limitations of the study would be

likewise discussed. The appendices of the present paper include the questionnaire and the screenshots depicting how the questionnaire was presented to the respondents.

## **2. Literature review**

In this literature review, I would first discuss the key concepts needed to develop the conceptual model: loneliness, social isolation and green areas, and outline why it is relevant to study loneliness in general and in this context in particular. I will shortly cover studies which investigate the relationships between these concepts and other minor related concepts such as solace, anthropomorphisation of nature and environmental attitudes.

### **2.1. Loneliness**

Loneliness, essentially, is a concept which describes a deficit. Aristotle described humans as social animals, and his argument was hardly argued against in over two millennia since (Aristotle, Jowett & Davis, 1920; Epley, Waytz, & Cacioppo, 2007). It is fully acknowledged that social experiences are a universal human need (at least so for neurotypical people), which, being unfulfilled, can lead to significant discomfort or even suffering in more extreme cases (Epley, Waytz, & Cacioppo, 2007).

To be more precise, loneliness can be defined as a discrepancy between the minimal desired amount of social contacts and the actual amount of social contacts (Beuker et al., 2021). Of course, this relationship is not the same for everyone — some have high social needs and others could be perfectly content being largely isolated from society. These are individual differences in needs and they have been largely addressed in the literature (Beuker et al., 2021). However, the effect of the environment on this relationship was hardly studied as widely (ibid.).

Regarding the definition of loneliness, I would like to stress that loneliness does not refer to the lack of social contacts exclusively, and it is important to realise that the level of individual need is a crucial factor in understanding what loneliness is. Therefore, it is an important distinction to draw between loneliness and social isolation (Beuker et al., 2021). These are related concepts, but in the present study, they are not interchangeable. Loneliness refers to an unfulfilled need, mental discomfort interpreted as a lack of social interactions. Social isolation, on the other hand, refers to the lack of social contacts, that is, regardless of what subjective experiences it provokes in a person. In other words, the former refers to subjective experiences and the latter to objective factors in one's life. Although they have been shown to overlap, the correlation is not high enough to fully equate them (Coyle & Dugan, 2012), and therefore, they need to be regarded as separate concepts.

Several types of loneliness are distinguished in the literature: transient loneliness, situational loneliness and chronic loneliness (d'Hombres, Barjaková, & Schnepf, 2021, p. 5, 6). Transient loneliness refers to occasional feelings of loneliness and is more akin to being an emotion rather than a state. Situational loneliness is related to the feelings brought about by particular events or situations. Chronic loneliness is related to the feelings of lack of fulfilling social contacts — the feelings which stretch over prolonged periods of time. The latter one has the most consequences and is the most detrimental to overall human well-being. Furthermore, assessing the effect of green areas on situational loneliness is rather difficult on the practical level. Sampling people who are visiting a green area would present a bias as those are more likely to be people who enjoy spending time in nature and frequent that particular green area. On the other hand, sampling people outside of green areas and asking them to go to a green area with the purpose of filling a questionnaire would

likely lead to difficulties with gathering enough responses. In the present paper, I focus specifically on chronic loneliness and further on refer to it just as ‘loneliness’.

Another common classification of loneliness divides it into social and emotional loneliness (d'Hombres, Barjaková, & Schnepf, 2021, p. 5, 6). Emotional loneliness refers to the lack of intimate attachments in one’s relationships (Cramer & Barry, 1999; d'Hombres, Barjaková, & Schnepf, 2021). Social loneliness refers to unsatisfactory or unfulfilling contacts with the broader social network. D'Hombres, Barjaková, & Schnepf (2021) suggest that emotional loneliness would commonly lead to feelings of anxiety and isolation, while social loneliness leads to feelings of marginality and aimlessness. However, in the studies of loneliness emotional and social loneliness are not often distinguished and according to Russel et al., the authors of the University of California, Los Angeles (UCLA) Loneliness Scale, one of the most commonly used scales to assess loneliness, they share a “common core of experiences” (1984, p. 1320). As the main effect that the present study investigates — the non-social effect of greenery on loneliness — is not yet established in the body of literature, it would be wise not yet to delve into the distinction between these two types of loneliness. In the present study, I would follow the trend of many studies and the argument of Russel et al. (ibid.) and treat ‘loneliness’ as an umbrella concept for the two subtypes.

### ***2.1.1. Relevance to study loneliness***

Is loneliness actually so important to strive to contribute to this discussion at all? Loneliness is not an isolated phenomenon — besides the negative experience in itself, loneliness can lead to various consequences. It can affect not only mental health but also physical health. In adults, Astell-Burt et al. (2021), Beuker et al. (2021), Santini et al. (2020) and Coyle and Dugan (2012) list such possible consequences as: higher risks of anxiety, de-

pression and suicide, stroke, heart disease, increased body weight, dementia (including faster progression of Alzheimer's disease), inflammation, hypertension, diminished immunity, sleep disturbances and premature death. Feelings of loneliness activate the hypothalamic-pituitary-adrenal axis — an element of the neuroendocrine system which coordinates how an organism responds to stress. This is a possible explanation of how loneliness can affect all the various bodily systems (Coyle and Dugan, 2012). In children and adolescents, loneliness can additionally have a negative effect on emotions, behaviour and cognition (Beuker et al., 2021). The consequences of loneliness are increasingly acknowledged outside of the academia as well. In the United Kingdom, for example, there already exist policies which aim to reduce loneliness among the population (Astell-Burt et al., 2021).

From 8 to 23% of adults in various Global North countries (Japan, the United States and European countries) report frequent feelings of loneliness (Beutel et al., 2017; DiJulio et al., 2018; D'Hombres, Barjaková, & Schnepf, 2021). It seems clear that such a widespread issue should be deserving of attention. As mentioned before, the traditional approach is to address it on an individual basis (Beuker et al., 2021). However, contextual factors are being increasingly acknowledged to be important. Beuker et al. (2021), Astell-Burt et al. (2021) and Vaughan (n.d.) suggest that the surroundings or broader environmental factors (e.g., urban context, neighbourhood characteristics) should be considered among the factors of influence as well. As a result, Beuker et al. (2021) call for research that investigates such factors. Lyu & Forsyth (2021) and Astell-Burt et al. (2021) call for research on how green areas in particular might affect the feelings of loneliness and the mechanism behind it. Therefore, there arises the relevance to study the relationship between loneliness and green areas in the context of spatial planning. Green areas could be

seen as a public good provided for the residents and, as there is a variety of options of how it could be implemented or executed, it is important to better understand the mechanism to be able to make more informed design or governance choices.

## **2.2. Green areas**

Nature has always played a significant role in human history — from surviving it, to taming it, to fleeing from it to the cities, to trying to bring it back to urban environments. Nowadays, if one travels to a new city and, feeling like spending some time in the shade of the trees, searches the Internet for the nearest park — not doubting that such exists — it is unlikely one would be disappointed. Densely built medieval cities with vast gardens enclosed on the properties of the rich are now mere city centres surrounded by the variety which often includes public green space. Parks and community gardens or, if one wills to venture further, forest and nature reserves are options available to many.

Overall, the presence of green areas near humans has been shown to be beneficial for many elements of well-being. Visits to parks, forests and other green areas have been shown to reduce stress, mental fatigue and be overall beneficial to mental health (van den Berg, Hartig & Staats, 2007; van den Berg et al. 2019). In a similar way, access (that is, short, walkable distance) to green areas has been shown to be negatively correlated with mood disorders (e.g., anxiety) within urban environments (Nutsford, Pearson & Kingham, 2013). Among young people, the experiences green areas provide were shown to be related to mood improvements and higher degrees of happiness (Birch, Rishbeth & Payne, 2020). Overall, there is a significant body of literature that is showing the benefits of green areas for mental and physical health (van den Berg et al. 2019). As a consequence, there have

been calls from researchers to better include green areas in city planning in part to specifically address these issues (Harries, n.d.).

### **2.3. Linking loneliness to green areas**

In fact, the relationship between green areas and loneliness has been studied and documented before. These studies tend to show that loneliness is negatively correlated to access or visits to green areas (Astell-Burt et al, 2021, p. 7, 8, 9; Beucker et al., 2021, p. 5, 6; Lyu & Forsyth, 2021, p. 6, 9; Maas et al., 2009, p. 8). Beucker et al. (2021) in their study have investigated how accessibility to public parks affects loneliness. They found that there is indeed a negative relationship between the two. It has been shown both on an individual and regional level; that is, there are differences in loneliness among individuals within the same region and also between regions. Maas et al. (2009) similarly found that those with more green areas in their living environments reported feeling less lonely. Lyu and Forsyth (2021) conducted a literature review, exploring the same relationship in older adults. They likewise found that older adults are likely to feel less lonely if they visit green areas frequently. Astell-Burt et al. (2021) had somewhat differing results investigating the same topic. Their longitudinal study shows that the preventive effect of green areas on loneliness was only present in particular circumstances — 1600 meters from home — at shorter distances the relationship was weaker. It might be a somewhat counterintuitive conclusion, considering that other studies show that accessibility to green areas is a positive factor. However, Astell-Burt et al. (2021) suggest that it might be possible that those who live far away from green areas might invest in gardens or backyards more often than other groups, therefore leading to an additional positive effect from their gardens as well. Furthermore, in the discussed study they distinguished such effects on loneliness as a relief from loneliness

and prevention of loneliness — the effect of green areas was found only on the latter, prevention. However, they also suggested, although not investigated, that cutting access to green areas might have an even stronger effect on loneliness.

Overall, there is evidence to conclude that green areas do have an effect on loneliness in one way or the other. This is beginning to be acknowledged by planners and policymakers as well. In the UK, for example, green areas have been included in the category of “third spaces,” which are expected to assist in confronting loneliness among the UK population (Astell-Burt et al., 2021).

Looking behind the relationship between the green areas and loneliness, Astell-Burt et al. (2021, p. 8) suggest two mechanisms — social opportunities which such green areas as parks might provide, and solace. As mentioned before, the majority of literature focuses on the first — the social mechanism. Yet, DiJulio et al. (2018, p. 2), d'Hombres, Barjaková and Schnepf (2021, p. 3) and Coyle and Dugan (2012) have shown that social isolation or social contacts are not the only contextual factor which is related to loneliness, which gives a basis to inquiry into the non-social mechanism as well.

#### **2.4. Social mechanism**

Before delving into the discussion of the non-social mechanism which is the central topic of the present paper, it would be relevant to discuss the social mechanism to be able to compare the two. As mentioned before, some types of green areas can provide opportunities for social interactions both with strangers and family and friends. Neal et al. (2015) held interviews which indicated that while visiting urban parks people often feel they might meet someone they are acquainted with. They also found that people report that urban parks are places where they often meet, intentionally or not, their family members



and interact as families with other families. Similarly, Lai et al. (2021, p.8) have shown that proximity to green areas is related to lower rates of social isolation, which is directly related to the number of social contacts. Regarding the quality of such social contacts, some people feel a better connection with their family and friends when on an outing in nature compared to more urbanised environments (Birch, Rishbeth & Payne, 2020, p. 7). There is a multitude of similar studies which have found that green areas in the vicinity of one's living place facilitate social contacts (Arnberger & Eder, 2012; van den Berg et al. 2019, p. 3; Jennings, & Bamkole, 2018; Kaźmierczak, 2012; Kuo et al., 1998; Maas et al., 2009).

However, it has also been shown that the effect of green areas on social interactions is dependent on circumstances — for example only longer, but not so much shorter, visits to urban parks provide significant benefit (Kaźmierczak, 2012). The presence of greenery like trees and lawns in common spaces was shown to be likely to prolong the visits to those places (Coley, Sullivan, & Kuo, 1997; Kuo et al., 1998). Furthermore, unsurprisingly, greater accessibility promoted more frequent visits (Kuo et al., 1998). On the other hand, visits to green areas which were deemed unpleasant, unwelcoming, anxiety-provoking, deserted or overgrown with greenery were shown to be less frequent (Neal et al., 2015). In other words, green areas in urban spaces tend to provide opportunities for social interactions, but not every such area is the same in this regard.

It is also possible that not all meetings in green areas provide the same effect. For, example, Maas et al. (2009; p. 10) have found some evidence that loneliness was unrelated to social contacts with neighbours in green areas. Regardless, the presence of the social mechanism could be said to be well documented overall. Yet, it remains interesting to in-

investigate whether it is the only mechanism behind the relationship or if there is another mechanism that works alongside it (Astall-Burt et al., 2021).

## 2.5. Non-social mechanism

Astell-Burt et al. (2021) have suggested that sometimes people can ‘lean on green’ when it comes to dealing with loneliness. Birch, Rishbeth and Payne (2020) described how some tend to seek green areas when socialisation with humans (in the desired amounts) is not a possibility. As described before, green areas have been shown to be good for many elements of mental well-being (e.g., mood). These are non-social but have been shown to be themselves linked with loneliness (Astall-Burt 2021, p.1-2). There are several theories as to how the non-social mechanism could work: solace, reminders of social connections and anthropomorphisation of nature. It is also possible — and likely — that it is a combination of them that underpins the non-social mechanism. Therefore, first, I would like to introduce these theories.

### 2.5.1. *Solace*

As was defined before, loneliness can be described as the result of a disparity between the actual amount of social interactions and the desired amount of social interactions. It is possible that green areas could have an effect on either of these two elements. The solace theory concerns the latter — the desired amount of socialisation.

It has been suggested by Astall-Burt et al. (2021) that green areas could provide solace. Such positive feelings might distract or diminish the feelings of social need. Green areas might improve general well-being, as has been described in Section 2.2, which might make other unfulfilled needs not so detrimental.

For some, nature is reported to serve as an escape from problematic socialisation (e.g., social rejection) which might be enforcing the feelings of loneliness (Birch, Rishbeth & Payne, 2020; Astell-Burt et al. 2021, p. 8). A relief from the negative feelings that come from it could be also understood as solace, even though, in this case, it does bear a direct relationship to socialisation. Nevertheless, in whatever ways solace might originate, it is one possible mechanism to consider.

### ***2.5.2. Reminders of social connections***

Although a sense of escape is a common and often welcomed feeling in the visitors to green areas, Birch, Rishbeth and Payne (2020) suggest that being in nature might facilitate strengthening the existing social connections. Various studies have also shown that green areas might evoke attachments to places, which might reduce loneliness by increasing the sense of belonging (Astell-Burt et al., 2021, p. 3; Rishbeth & Powell, 2013), by evoking pleasant social memories or associations (Astell-Burt et al., 2021, p. 8; Sobel, 1990) and by increasing the feelings of attachment to one’s neighbourhood and, accordingly, the sense of community (Prezza et al., 2001). This effect might be affecting the perception of the amount of actual social interactions, decreasing the need for socialisation and thus minimising the discrepancy which is the cause of loneliness.

### ***2.5.3. Anthropomorphisation of nature***

According to this theory, visiting green areas might affect the perception of the amount of social interactions without such interactions with humans — embodying essentially the “more than human world” (Astell-Burt 2021, p.1-2; Birch, Rishbeth & Payne 2020). Of course, it will be an overstatement to say that “socialisation” with a green area is equivalent to socialisation with a human, however, in the end, it is up to one’s own inter-

pretation of what they feel a social interaction is. Pets, for example, have been shown to alleviate loneliness. Therefore, even if the company that nature provides would not be equal to socialisation with humans, it could decrease the need for such socialisation (Zaslloff, 1994).

In the interviews held by Birch, Rishbeth and Payne (2020, p. 7), some interviewees expressed that spending time in nature often led them to have a better connection with human but also non-human elements of their surroundings. They found that such connection with the natural world was reported in various environments — green areas (being in, but also views of), street greenery and house plants. One interviewee from the same study when asked what a particular natural place would say if it could speak, described it as if it were a social entity: “[This nature place would] just like give me a hug basically, like ‘here’s a hug’, this is a gift from me to you and like these are all of the resources that you’ll ever need” (Birch, Rishbeth & Payne, 2020, p.1). Other interviewees often prescribed nature anthropomorphising features even when not prompted. For example, some were expressing gratitude to nature, which might or might not be a sign that it was seen as something more than an inanimate object. One interviewee expressed a belief that trees are able to suffer, which is also a feature of an animate object. Yet another interviewee described nature as if it could possess agency: “nature doesn’t judge you” (Birch, Rishbeth & Payne, 2020, p. 6).

Such attitudes and beliefs can be summarised as anthropomorphism — the tendency to perceive behaviours or features of non-human entities as if they possessed human characteristics (Epley, Waytz, & Cacioppo, 2007, p. 1). When so needed social contacts are not enough, it is natural to be seeking these social contacts, even in untypical places. It has

been shown that two non-human beings — pets and religious entities — are the most commonly anthropomorphised when human social contacts seem lacking (Epley, Waytz, & Cacioppo, 2007, p. 12). In some cases, even essentially “lifeless” objects such as gadgets have also been shown to be anthropomorphised (Epley et al, 2008). Although nature or greenery could be instinctively categorised as less animate than animals and gods, it is arguably no less animate than gadgets. In fact, anthropomorphising nature is a common phenomenon in various circumstances. An obvious example is referring to the natural world as “Mother Nature” or “Mother Earth” (Tam, Lee & Chao, 2013). A study by Tam, Lee and Chao (2013) provides a look at whether anthropomorphisation of nature is more than a turn of phrase and whether it does, in fact, affect people’s behaviour. They found that this kind of anthropomorphism leads to greater feelings of connection to nature. Mayer et al. (2009; cited in Tam, Lee & Chao, 2013) suggest that connection with nature can, to some extent, meet the need for social connection. Astell-Burt et al. (2021, p. 8) suggest that this phenomenon might occur in people with particular personality characteristics such as introversion or in people with higher nature-relatedness.

Given the findings of the studies mentioned above, it would be fair to conclude that there is a possibility that living within an accessible distance to a green area, with lush street greenery around or with a garden might (partly) decrease the need to socialise with humans. It must also be disclaimed that there is a chance of a reverse relationship — that lonely people could be attracted to green areas, which would cause them to visit these green areas more often or, possibly, to even move closer to them. For more discussion on this point see Section 6.2.

Although outlining these three theories was important for the understanding of how exactly the non-social mechanism might work, in the present study, I would not be deeply investigating which of these theories is likely to be true, as the first step is to identify whether the non-social mechanism is present at all.

#### *2.5.4. Environmental attitudes as a moderating variable*

As mentioned before, there might be a plentitude of moderating variables that affect the relationship between green areas and loneliness. Environmental attitudes could be one of them as they are directly linked to the last discussed theory of non-social mechanism — anthropomorphisation of nature.

A hard division between the natural world and humanity is a rather recent one in the Western culture. Such tradition could be roughly traced to the rise of Enlightenment and particularly to Rene Descartes (Blum, 2021). Descartes is famous for developing the idea of dualism, dividing the essence of ‘human’ into body and soul. This, by extension, entailed the division between the broader physical world — nature — and humans (as represented by human souls). As this view was becoming commonplace, the natural world was accordingly being perceived (and treated, as can be seen in the example of careless industrialisation; Varkey, 1984, p. 83) as less-than-equal. This process is more of a characteristic of human culture rather than an essential human disposition.

Of course, even nowadays, not everyone perceives the natural world the same way. It is possible that the reverse look at nature — as a subject rather than an object — might be related to deriving company from nature. Astell-Burt et al. (2021) similarly suggest that environmental attitudes might shape the nature-loneliness relationship in such a way.

Coming back to the study by Tam, Lee and Chao (2013), some of their results show that anthropomorphisation of and connectedness to nature are correlated with conservational behaviour. Similarly, Birch, Rishbeth and Payne (2020) found that connection to nature is often expressed not as something gained *from* nature, but also as something provided *for* nature — a direct suggestion for conservational behaviour. For this reason, it appears worth investigating whether environmental attitudes would, among other factors, mediate the relationship between green areas and loneliness. It has to be noted that environmental attitudes and conservational behaviour are differing concepts, however, they are directly related. Schultz (2001) found that those who held pro-environmental attitudes were more likely to engage in conservational behaviour. Therefore, in the present study, the factor of environmental attitudes would stand as a proxy for the tendency to anthropomorphise nature.

## **2.6. Street greenery and gardens**

Although it is the green areas that are the central topic of this study, it has been suggested (e.g., see Astell-Burt et al., 2021) that other greenery in one’s environment such as gardens and street greenery might have a similar effect. Nutsford, Pearson and Kingham (2013) and van den Berg et al. (2019) found that such greenery — just like green areas — is also beneficial for human mental health. There are many distinctions between green areas and gardens or street greenery, however, the three theories discussed in Sections 2.5.1. to 2.5.3. — solace, reminders of social connections and anthropomorphisation of nature might, to a greater and lesser extent, apply to gardens and street greenery as well.

### 3. Conceptual model

To sum up all the theories above, I suggest the following conceptual model (see Figure 1). Green areas (be it forests, parks, street greenery or garden greenery) could provide a possible relief from loneliness. Loneliness is the effect of disparity between the amount of desired social activity and the actual amount of social activity. The link form green areas and loneliness lies in two paths. Path one is social: green areas provide places for socialisation or other social interactions. These social interactions affect the factor of the actual amount of social activity (represented by social isolation). This affects the disparity between it and desired or needed amount of social contacts, which finally affects loneliness.

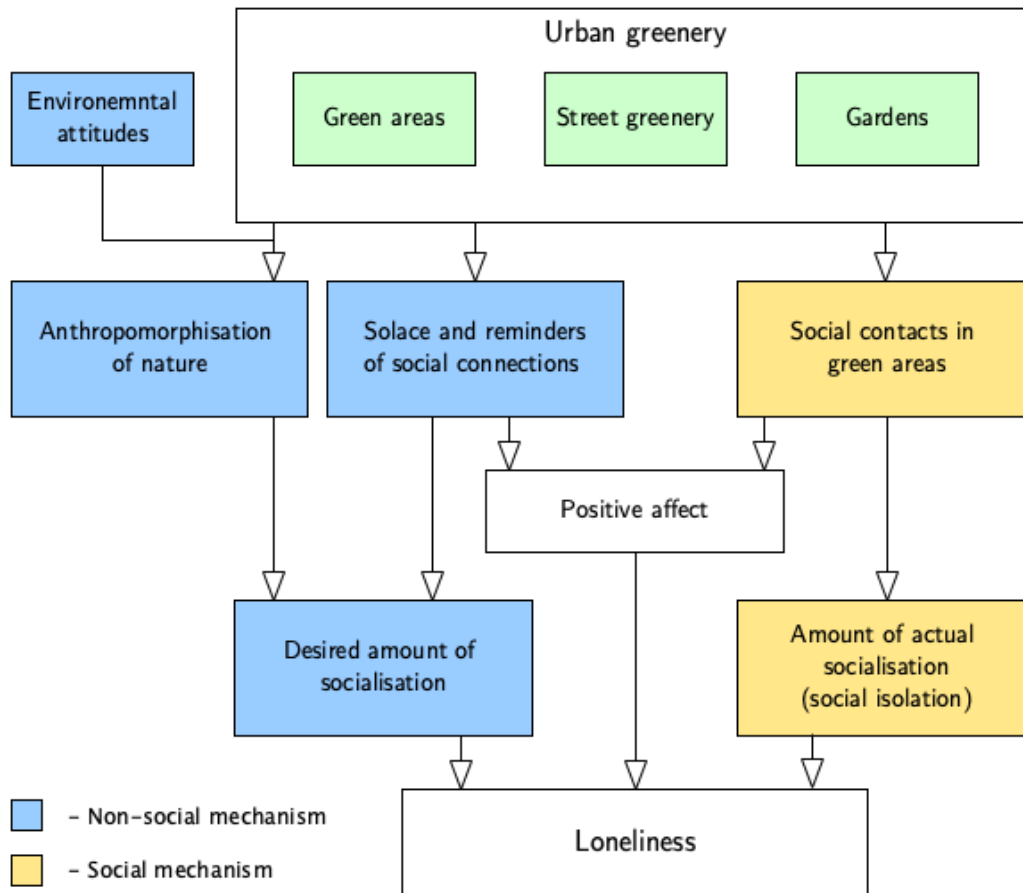


Figure 1. Conceptual model.



Path two is non-social and is the main focus of the present study. Green areas (as well as gardens and street greenery) (i) provide solace, which affects the desired amount of social contacts. Green areas also (ii) might serve as reminders of social connections, strengthening the perception of social ties and decreasing the need in socialisation. Finally, (iii) some people could anthropomorphise nature — in this case spending time in nature might in turn decrease the need in human socialisation. As people with pro-environmental attitudes are more likely to anthropomorphise nature, the last factor of the non-social path (anthropomorphisation of nature) could be particularly relevant for them.

Positive affect has been included in the model as it can be an intermediary in the relationship between urban greenery and loneliness. It could potentially be a part of both paths — as the effect of solace of the non-social path and as the effect of pleasant socialisation of the social path.

## 4. Methodology

### 4.1. Participants

The number of participants who finished the questionnaire was 43. Twenty participants (47%) were female. Fifteen (35%) were aged between 18 and 24, twenty-four (56%) between 25 and 44 and four (9%) between 45 and 64.

#### *4.1.1. Recruiting participants*

The questionnaire was distributed via two methods. The first one was a distribution of printed QR codes and a shortened link to the questionnaire (see Appendix A). This approach was particularly relevant for the area north of the Sterrebos, which was meant to be a set for a quasi-experiment (see Section 4.2.). However, as the number of responses from this area was not sufficient, these responses were treated as all the other responses.

Approximately 170 flyers with the QR code were distributed via mailboxes in this area.

The response rate was rather low (under 10%) so approximately 120 more follow-up flyers were distributed to the same households, however, it did not improve the response rate to any significant degree.

At the same time, the same method was also used to recruit more participants from other areas as well. Originally, it was planned to choose five random areas of Groningen (randomised with QGIS; QGIS Development Team, 2022) and distribute approximately 150 flyers in each. However, after spreading 160 flyers in one area which yielded only one response, this method was abandoned.

It is difficult to exactly specify what the total response rate was as there was no indication of where the respondent came from apart from the date and time of submitting the questionnaire. An approximation could be made, however: the response rate from the flyers was about 5%.

There could be multiple reasons particular to this study which could have caused a lower response rate. First of all, not every household could be sampled as in the Netherlands the majority of mailboxes have stickers on them which indicate that it is not allowed to put unaddressed mail into that particular mailbox. Those people who have no sticker typically receive a lot of advertisements and other unaddressed mail. Among them, a flyer with a QR code could appear as another advertisement or be thrown out right away with other junk mail.

Second of all — particularly relevant to older generations — possibly, not everyone who received a flyer with the QR code knew how to scan in or thought it too bothersome.

The flyers also included a shortened link, but although it was only 12 characters in length, it is unlikely many bother with typing it in manually.

Finally, in the flyers, it was indicated that the study was carried out by a student, which could make the study appear unimportant. For the lack of budget, the flyers were also printed on a black and white printer on A6 paper, which might be considered not very professional.

As for the rest of the respondents, most of them came through various means via social networks and social media. This led to a major part of the participants being students and under 25 years old.

Out of the 150 respondents who started filling the questionnaire, only 43 (that is, 29 %) finished it. The participants were given space at the end of the questionnaire to leave a comment or a question. Some have indicated that the questionnaire was long and had repetitive questions (the repetitive questions could not be eliminated as they were a part of the existing validated scales). It is possible, that this led some of the participants to drop out.

During the data collection, there also occurred two problems with the platform — Maptionnaire (maptionnaire.com). The first published version of it included a map which was too detailed and therefore too heavy to load on some phones. This led to the questionnaire reloading after the first map question (regarding the location of the most frequently visited green area). The answer to the second map question (regarding the residence location) was essential to draw meaningful data from the responses, which, if unanswered rendered the respondent data unusable to answer the main reattach question.

The second problem arose from the design of the page for smartphones: after the first map question, it was not immediately intuitive how to return from the map back to the questionnaire to continue onto the next map question — it does not happen automatically and it might appear that it was the end of the questionnaire (see Appendix B). The platform allowed no option to execute the shift between the map questions in another way.

## 4.2. Setting

Groningen, a city in the north of the Netherlands, was the place where the study was conducted. Groningen is a medium-sized city of approximately 235 000 residents (as of April of 2022) and an area of 197.96 km<sup>2</sup> (CBS, 2022a; CBS, 2022b). The whole municipality of Groningen, including Ten Boer and Haren, which were previously separate municipalities, was included in the study. Including the whole municipality provided a variety of data from urban and suburban residents.

Of particular interest were the neighbourhoods surrounding Sterrebos, a small forest within the city. Due to a road construction nearby — the renewed Southern Ring Road — part of the neighbourhoods lost access to the Sterrebos when the pass over the railroad which they could utilise before was removed. At the time of the suited, to access the forest, residents of those neighbourhoods needed to cross the railroad at another location, increasing the distance to the forest by over 1 km. Such circumstances happened to provide a suitable setting for a quasi-experiment. All the residents in these neighbourhoods come from the same part of town, making them more comparable to each other. In this way, two groups should have emerged — one that lost close access to Sterrebos and one that preserved it. Such comparison would allow to investigate what effect removing access to a green area would have. However, due to the low number of participants that could be re-

cruited from that area, such a comparison could not be carried out within the present study. Nevertheless, such an approach could be taken as a design or inspiration for future research on the topic.

### **4.3. Materials**

The data for the present paper was collected with a 57-item questionnaire on the Maptionnaire platform ([maptionnaire.com](https://maptionnaire.com)), which allows for the collection of geographical information alongside other types of questions. The questionnaire consisted of questions to assess such variables as: general demographic information, loneliness, positive affect, social isolation, environmental attitudes, approximate geographic location of one's most frequently visited green area, one's current living place and one's previous living place. For the variables of loneliness, positive affect, social isolation and environmental attitudes, the questionnaire utilises existing verified scales which would be described in more detail below.

Although the relationship of interest could be assessed using qualitative methods as well, the utilisation of validated scales that distinguish loneliness from social isolation is expected to be better able to capture the difference between the social and non-social paths. Presenting the questions in a form of a questionnaire instead of an interview could potentially limit the effect of social desirability or an inclination to reply in a way that fulfils the researcher's hypothesis as it is easier to hide the purpose of the study in a questionnaire. Finally, a questionnaire also allows for a higher number of respondents, which allows for better generalisability of the findings. Particularly for the first reason, the present study utilised quantitative methods to test the hypotheses.

#### **4.3.1. *Validity and reliability criteria***

The scales described below were assessed by various approaches for their validity and reliability. The approaches of how validity can be assessed are the following: construct validity, content validity and criterion validity (Middleton, 2019). Construct validity describes how the scale adheres to the existing theory or knowledge of the concept. Content validity describes how well the scale addresses all the elements of the concept in question. Criterion validity describes how the scale corresponds to other existing scales which aim to measure the same concept.

Accordingly, there are two relevant approaches to assessing the reliability of a scale: test-retest reliability and internal consistency (ibid.). Test-retest reliability assesses whether the responses to the scale stay consistent across time. Internal consistency assesses whether all the parts of the scale measure the same underlying concept; it can be assessed with Cronbach's alpha. Additionally to the analyses by the creators or reviewers of the scales described below, the present paper contains a section which analyses the internal consistency (Cronbach's alpha) of the used scales using the data gathered in the present study (see Section 5.2.).

#### **4.3.2. *Loneliness***

As mentioned in the literature review above (Section 2.1.), two types of loneliness are generally distinguished: social loneliness and emotional loneliness (Cramer & Barry, 1999; Elphinstone, 2018). The distinction is made because the concept of 'loneliness' can refer to different states or circumstances. Social loneliness refers to the perception of one's experience of their overall social network, while emotional loneliness refers to intimate relationships and attachments (or lack thereof; e.g., with a romantic partner or a family mem-

ber). There exist various scales which assess one of these, both of these separately or both of these together (Cramer & Barry, 1999). Since there is a significant overlap between the two and as many studies that similarly investigate the effect of environmental factors on loneliness do, for the purpose of the present study, I would not divide the variable of loneliness into social loneliness and emotional loneliness (*ibid.*, p 499). One scale which would serve this purpose is the University of California, Los Angeles (UCLA) Loneliness Scale (Russel, 1996). It is one of the most commonly used measures to assess loneliness via self-report (Cramer & Barry, 1999). The scale has been shown on different social groups to be sufficiently reliable on test-retest reliability (equal to 0.73) and internal consistency (with Cronbach's alpha ranging from 0.89 to 0.94 in different samples; Russel, 1996). Construct validity, criterion validity and convergent validity (a subtype of construct validity) have also been shown to be sufficient (Russel, 1996; Elphinstone, 2018). Overall, it is a widely recognised measure of loneliness, which makes it suitable to include in the present questionnaire (Cramer & Barry, 1999; Elphinstone, 2018).

The latest revised version of the scale consists of 20 items (Russel, 1996). For the purposes of the present study, considering the other scales and inventories which are also included in the questionnaire, a shorter version of the scale would be preferable. There exist many short versions of the UCLA scale. Elphinstone (2018) has conducted a comparison of the six most-used short versions showing that the ten-item version developed by Russel (1996) provided the best fit to the original scale. This shortened measure showed similar internal consistency (with Cronbach's alpha equal to 0.89) and convergent validity to the original full scale (Elphinstone, 2018). Therefore, this version promised to be a sufficient substitute for the full version of the scale.

The answer options to any of the ten questions were “Never” (score 1), “Rarely” (score 2), “Sometimes” (score 3) and “Always” (score 4); the scoring of some questions was reversed. The scores of the individual responses were summed together, with higher total scores signifying a higher degree of loneliness.

#### **4.3.3. Positive affect**

There is a need to measure positive or negative affect as there is a weak to moderate correlation between them and loneliness when the above-described measure for loneliness, UCLA Loneliness Scale, is utilised (Elphinstone, 2018). To exclude the effect of positive or negative affect on the level of loneliness, a corresponding scale was also included in the present questionnaire. There is a moderate negative correlation between positive and negative affect, and, therefore, with the intention of keeping the questionnaire short, only the positive affect scale was included in the questionnaire (Joshani, 2017).

Joshani (2017) has shown that both the full 12-item version and the shortened ten-item version of the negative and positive affect scale of Mroczek and Kolarz (1998) to have sufficient criterion validity and internal consistency (with Cronbach’s alpha equal to 0.895 for the shortened version). Shortening the scale did not affect the degree of correlation between positive affect and negative affect (Joshani, 2017, p. 236). That is, the strength of the correlation was similar to that of the original scale. Therefore, the shortened version of the positive affect scale was included in the questionnaire for this study.

The answer options to any of the questions were “Never” (score 1), “Rarely” (score 2), “Sometimes” (score 3), “Often” (score 4) and “All the time” (score 5). The scores of the individual responses were summed together, with higher total scores signifying a higher degree of positive affect.



#### **4.3.4. *Environmental attitudes***

To measure the environmental attitudes, Milfont and Duckitt's (2010) environmental attitudes inventory was added to the questionnaire. Milfont and Duckitt (2010) showed that the inventory had sufficient construct validity (with relation to ecological behaviour) and test-retest reliability (for sub-scales ranging from 0.62 to 0.90 with the mean of 0.83) and internal reliability (with Cronbach's alpha for sub-scales ranging from 0.72 to 0.89 with the mean of 0.84) and is relatively free of the effect of social desirability. The full environmental attitudes inventory consists of twelve scales, which could be analysed individually or as two higher-order factors — preservation and utilisation. The full inventory consists of 120 questions, ten per scale, however, Milfont and Duckitt (2010) also presented a shortened version of 24 questions, two per scale. As was the case with the two previously discussed scales, the shorter version was preferable to limit the length of the questionnaire. In the end, only the data from the seven questions which addressed the preservation factor were used in the analysis, as utilisation came to be irrelevant for the relationships that were of interest to the present study.

The answer options were on a five-point Likert scale ranging from “Strongly disagree” (scored as -2) to “Strongly agree” (scored as 2). Each scale included one question with reversed scoring. The scores of the individual responses were summed together, with higher total scores signifying a higher degree of positive environmental attitudes.

#### **4.3.5. *Social isolation***

As mentioned in Section 2.1., it is important to distinguish between the feelings of loneliness and the objective fact of social isolation. Cornwell and Waite (2009) have developed a scale that precisely measures social isolation separately from the feelings it evokes.

The scale has shown to have sufficient content validity, construct validity and internal consistency (with Cronbach's alpha equal to 0.73). The scale has been commonly employed before in other research on social isolation (e.g., Coyle and Dugan, 2012; Santini et al., 2020).

The scores are calculated by standardising the score for each item ( $M = 0$ ,  $SD = 1$ ) and then summing the individual standardised responses. Higher scores signify higher levels of social isolation.

#### ***4.3.6. Accessibility to green areas***

In this part of the questionnaire, participants were asked to self-report their approximate residence location, previous residence location and the location of a green area which they visit the most frequently. They were offered a map of Groningen divided into 500 by 500-meter squares and asked to indicate in which of them the place in question was located. Such a 500 by 500-meter division allowed to avoid collecting personally identifiable information and at the same time was precise enough to meaningfully assess accessibility to green areas.

The geographical question about the location of the most frequently visited green area included follow-up questions: how frequently the participant visits it, how many people the participant typically encounters there, what is the chance that the participant will strike up a conversation with someone and finally how satisfied the participant is with the green area. The question about the location of one's current residence was followed by questions concerning the presence or absence of a garden and if present, how green it is. To control for the novelty effect, the questionnaire also asks about the location of the previous residence location, the state of the garden and the satisfaction with the green areas there.

#### *4.3.7. Extra variables*

To test the conceptual model, some variables needed to be computed from the gathered data. The variable of the amount of street greenery (represented by trees) in the vicinity of one's residence was calculated using QGIS (QGIS Development Team, 2022). The respondents indicated in which 500 by 500 meter grid cell in Groningen they lived. Using this data and the data from Groningen Open Data (2022) which included the locations of every tree in the city, a new variable was calculated which indicated how many trees were located in the chosen 500 by 500 grid cell. As the exact location of the residence place was unknown, the computed variable is supposed to give an approximation of the number of trees within a 250-meter radius of one's residence. Figure 11 depicts the locations of the trees in Groningen and the approximate residence locations of the respondents.

The variable of the distance to the most frequently visited green area was also calculated using QGIS (QGIS Development Team, 2022). As was the case with the previous variable, the precise residence location was unknown, only the 500 by 500 meter grid cell. The distance was calculated from the centre of the grid cell to the centre of the cell where the green area (or the entrance to it, in case the green area is larger than one square) was located. Such an approach takes away from precision, however, it keeps the respondents' data more private. The error could not be larger than 707 meters, which could be covered in 8,5 minutes by foot. However, given the random spatial distribution of the respondents, the expected mean error should be nearing 0. The distance was calculated along the network, rather than as a direct distance between the two points. This choice is particularly relevant for green areas outside of the city, as the route to them might not be very straightforward (e.g., because of highways or canals).

One of the variables of interest was a presence or absence of a garden. Rather than using it as a binary variable, it was combined with the variable of the amount of greenery in the garden, as just the presence or absence of a garden does not in all cases represent whether there are actually plants growing in it. No greenery in the garden (or a few potted plants only) was assigned the same value as having no garden at all as in such case the presence of a garden does not increase the amount of greenery in one's surroundings.

Cumulative greenery is a variable which aims to assess the combination of the variables of the distance to the most frequently visited green area, the amount of trees in the vicinity of one's residence and the amount of greenery in one's garden (if present). The scores of the three variables were first standardised and then summed up (with the distance to the most frequently visited green area multiplied by -1, as high scores for this variable were hypothesised to have a negative effect on loneliness).

The variable of unplanned social encounters in a green area was computed by adding the score of the amount of people encountered (seen) in the most frequently visited green area and the score of the likelihood of talking to someone encountered there.

#### **4.4. Ethical considerations**

No personally identifiable information was collected in the present study. The residence location asked was only approximate — the participants were asked only to indicate 500 by 500 meter grid cell in which they live. As for background demographic information (age and gender), the participants were given an option of “Would rather not tell”. For those participants who chose to reply to these questions, it would still be not possible to identify them based on these two variables and the participant's approximate residence location. No minors under 18 were given an option to participate in the study. A study with

such a setup did not require the approval of the Research Ethics Committee of the Faculty of Spatial Sciences of the university of Groningen.

As the first question of the questionnaire, the participants were presented with a consent question, the conditions for which were: (i) the participant is over 18 years old, (ii) the participant currently lives in Groningen, (iii) the participant has read the consent form, (iv) the participant agrees to their responses being recorded and used for the study.

At the end of the questionnaire, the participants were provided with the contact information of the researcher and given an option to leave a comment. By either means, they had an option to ask for their data not to be included in the study.

#### 4.5. Directed Acyclical Graphs

The design of the study required controlling for some variables to be able to determine the separate effect of the non-social path. Unjustified controlling for assumed confounders might introduce bias (Greenland, Pearl & Robins, 1999). Therefore, to understand the possible causal relationship, I utilised the Directed Acyclical Graphs (DAGs) as described by Greenland, Pearl and Robins (1999) to identify which variables could present as confounders and which could not.

A DAG is a schematic depiction of the variables of interest and their connections which represent the relationship in inquiry (ibid.). In the graph, the variables become nodes and the connections between them are referred to as edges or arrows. Two nodes may be connected by a path — an unbroken series of arrows and intermediary nodes. The path is called directed when it can be followed through a series of single-headed arrows following the direction they point at, that is moving from the tail to the head of the arrow only. Any directed path shows a causal relationship. It is possible that there are several di-

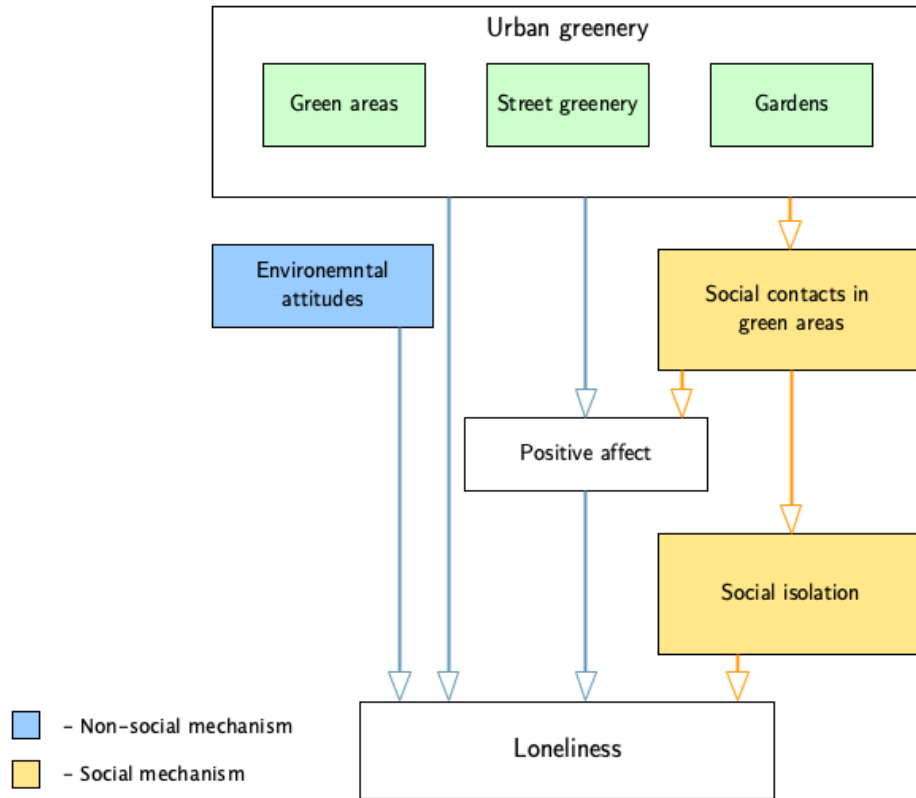


Figure 2. Directed Acyclical Graph (DAG) illustrating the analysed relationships.

rected paths that connect two nodes. Another type of path to note is a path which goes through the common ancestor.

If only one of the paths is of interest for a particular study, the other path(s) (that is, the other directed paths or the paths through common ancestors) become a confounder and are referred to as a backdoor path. This scenario applies to the present study as well. In Figure 2 two paths — the social path and the non-social path — can be seen. As it is the non-social path which is the central topic of the present study, the social path needs to be blocked to eliminate its effect. To block a backdoor path, it is sufficient to control for any variable (any node) of the path (ibid.). Social isolation presented to be a convenient variable to control in the analysis of the non-social path.

Instinctively, the variable of positive affect might appear to be a confounder as well. It is related to loneliness and might affect how the respondents fill the questionnaire (Elphinstone, 2018). It can be seen that positive affect is included in the model as a part of both social and non-social paths. In the case of the social path, no further action needs to be taken as it was already being blocked by controlling for social isolation. Positive affect might be also playing a role in the non-social path, however, this effect does not arise as a problem as any element of the non-social path is relevant. Therefore, there was no justification to control for positive affect.

## 5. Results

### 5.1. Tests of reliability of the scales

Although the reliability of the four used scales (i.e., loneliness scale, positive affect scale, social isolation scale and environmental attitudes scale) was already assessed by other researchers or their creators (Cornwell and Waite, 2009; Elphinstone, 2018; Joshanloo, 2017; Milfont and Duckitt, 2010; Russel, 1996), in the present study I also assessed the Cronbach's alpha for the internal reliability of the scales. The UCLA Loneliness Scale (10-item version; of Russel, 1996) showed Cronbach's alpha to be 0,850 (N = 73; participants who filled this section of the questionnaire but did not finish the full questionnaire were also included in this measurement), which could be considered good internal reliability according to Glen (n.d.). The Chronbach's alpha of the positive affect scale (of Mroczek & Kolarz, 1998) was 0,674 (N = 71), which could be considered of questionable reliability (Glen, n.d.). However, as other studies (Joshanloo, 2017) did show it to be reliable and since it is not used to answer the main research question, in the context of this study, it could be regarded as acceptable. The social isolation scale (of Cornwell & Waite, 2009)

showed Cronbach’s alpha (based on standardised items) of 0,713 (N = 56), which could be considered acceptable (Glen, n.d.). The environmental attitudes scale’s (of Milfont and Duckitt’s, 2010) Cronbach’s alpha was 0,712 (n = 63), which could also be considered an acceptable value (Glen, n.d.). See Table 1 for a summary of Cronbach’s alpha of the scales. Based on these results, further analysis could be carried out with the data from these four questionnaires.

## 5.2. Normality of data distribution

Normality tests (Kolmogorov-Smirnov and Shapiro-Wilk) have shown that none of the variables of interest was normally distributed (see Table 2). For the following variables — distance to the most frequently visited green area, amount of street greenery (represented by the number of trees) in the vicinity of one’s residence, amount of greenery in one’s garden (if present), the cumulative amount of greenery, environmental attitudes, unplanned social interactions in green areas — both test have shown significant deviation from the normal distribution. For the variables of loneliness, social isolation and positive affect one of the tests — but not both — has shown a significant deviation from the normal distribution.

Nevertheless, it is generally advised to use normality tests along with visual inspection of graphical representation of data (Ghasemi & Zahediasl, 2012). Figures 3-10 show

*Table 1.* Reliability of the scales

Scale	Author	Cronbach’s alpha	N
Loneliness	Russel, 1996	,850	73
Positive affect	Mroczek & Kolarz, 1998	,674	71
Social isolation	Cornwell & Waite, 2009	,713	56
Environmental attitudes	Milfont and Duckitt’s, 2010	,712	63



the histograms of the variables listed above. The variables of loneliness and social isolation (which were shown to significantly differ from normal distribution by the Shapiro-Wilk test, but not by the Kolmogorov-Smirnov test) are both visibly skewed (see Figures 3 and 5), which further suggests that they are not fit for tests which assume a normal distribution. The variable of positive affect was shown to differ from normal distribution only by the Kolmogorov-Smirnov test, but not Shapiro-Wilk. Although the Shapiro-Wilk test is said to be preferable to the Kolmogorov-Smirnov test, the histogram nevertheless appears somewhat right-skewed (ibid.). Ghasemi and Zahediasl, (2012) suggest that sometimes if the sample size is over 30-40 respondents, parametric tests still could be used. Therefore, such borderline case as the variable of positive affect in the present study technically could be analysed with parametric tests. However, as it appears to be the only variable fit for parametric tests, it renders parametric tests inapplicable nevertheless

### *5.2.1. Choosing the tests*

As described in the previous section, the distribution of data for almost all of the variables is significantly different from the normal distribution. Taking into account the non-normal distribution and the nature of data (continuous and ordinal), a non-parametric correlation would be considered a fitting test. Newson (2002) argues that among the two most used non-parametric correlation tests, Kendall's  $\tau$  is preferred to Spearman's  $\rho$ , therefore, Kendall's  $\tau$  would be utilised for further analyses. Interpretation of Kendall's  $\tau$  is slightly different from a more widely used Pearson's  $r$  correlation. The interpretation guidelines provided by Botsch (2011) are the following:

- less than + or - 0.10: very weak
- + or -0.10 to 0.19: weak

Table 2. Tests of Normality

	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Loneliness	,129	43	,071	,906**	43	,002
Social isolation	,111	43	,200 <sup>†</sup>	,945*	43	,038
Environmental attitudes	,136*	43	,045	,947*	43	,046
Positive affect	,148*	43	,019	,953	43	,077
Distance to a green area	,149*	43	,017	,914**	43	,003
Street greenery (trees)	,237**	43	,000	,860**	43	,000
Garden greenery	,419**	43	,000	,628**	43	,000
Cumulative greenery	,118	43	,148	,946	43	,042
Unplanned social encounters in a green area	,208**	43	,000	,937*	43	,021

Note. †. This is a lower bound of the true significance

\*. Correlation is significant at the 0.05 level.

\*\*. Correlation is significant at the 0.01 level.

a. Lilliefors Significance Correction

- + or - 0.20 to 0.29: moderate
- + or - 0.30 or above: strong

All the correlations drawn in this analysis are one-tailed, as the direction of the effect was included in the hypothesis. Tests were computed using IBM SPSS Statistics 26 (IBM Corp., 2019).

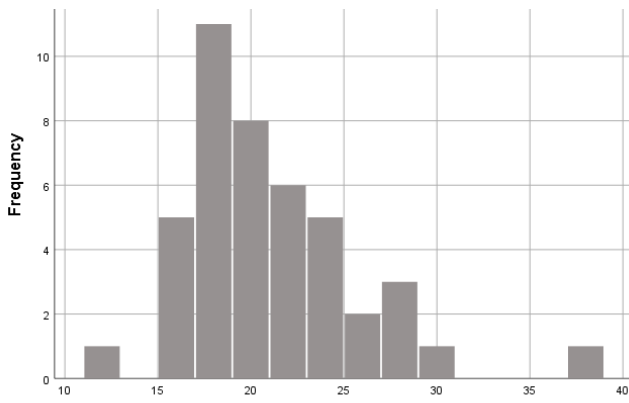


Figure 3. Histogram: Loneliness.

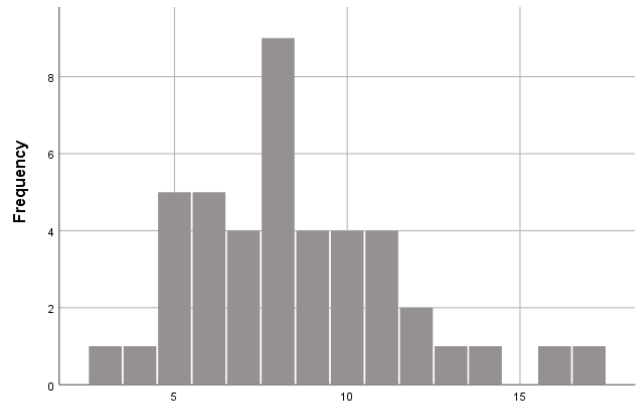


Figure 4. Histogram: Positive affect.

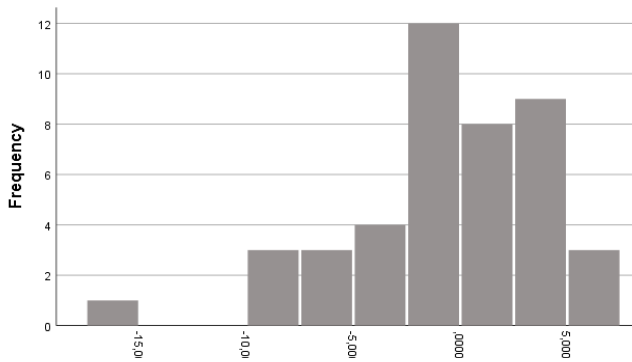


Figure 5. Histogram: Social isolation.

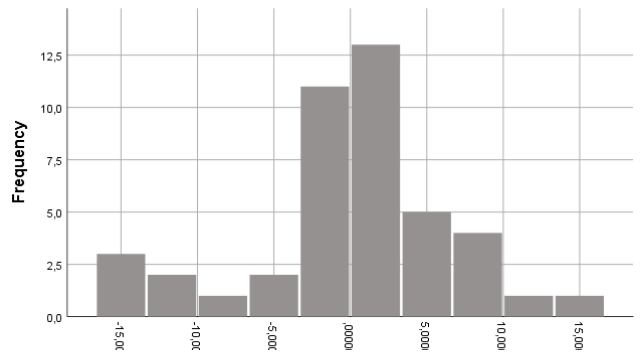


Figure 6. Histogram: Environmental attitudes.

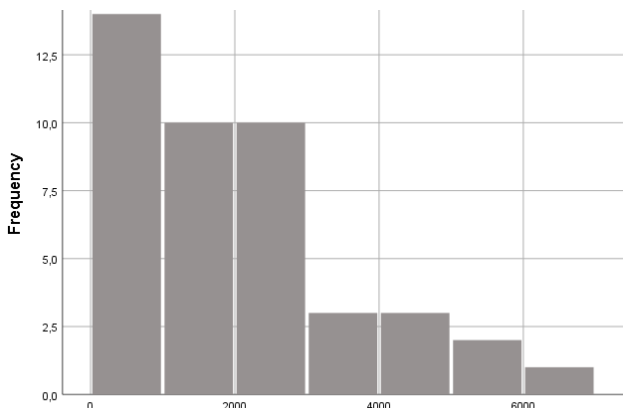


Figure 7. Histogram: Distance to a green area.

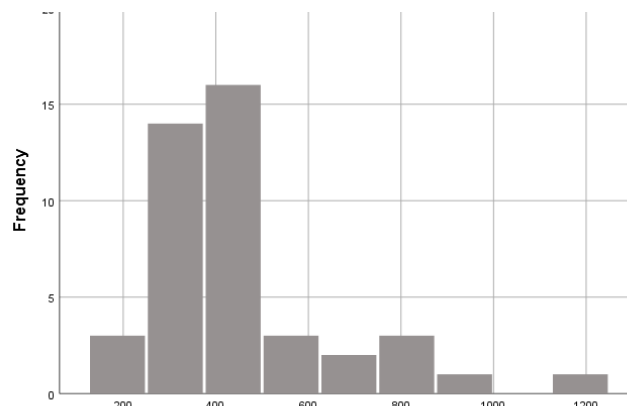


Figure 8. Histogram: Street greenery.

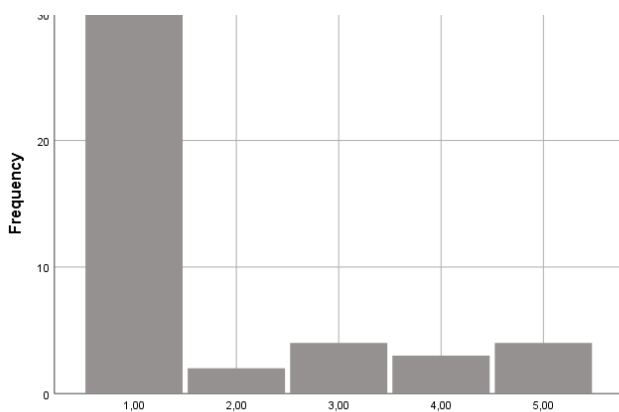


Figure 9. Histogram: Garden greenery.

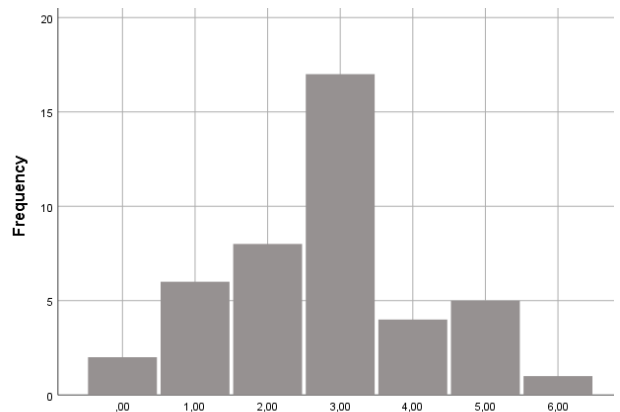


Figure 10. Histogram: Unplanned social encounters in green areas.

### 5.3. Test results

#### 5.3.1. *The effects of background characteristics*

The results showed no difference between female and male participants on the variables of loneliness and social isolation, suggesting that interaction is unlikely (see Table 3). The same was true concerning the variable of age as well. There seem to be no differences in loneliness between age groups. It must be noted that the oldest group 45-64 contained only four participants and thus could not be compared to younger participants with the tests described below. Differences between two other groups are also unlikely as these two groups (18-24 and 25-44) lead comparable social lives (e.g. are more likely to be employed or study and be socially active). For these reasons, age and gender were not taken into account in the further analysis.

As mentioned before, not all the participants who started the questionnaire finished it. Those that quit the questionnaire (however, fully completed the first section, the UCLA Loneliness scale) did not differ significantly from those who finished the questionnaire ( $t = -1,108$ ,  $\alpha = 0,272$ ) on the variable of loneliness according to an independent samples t-test.

#### 5.3.2. *The overall effect of greenery on loneliness*

First, it would be relevant to look at the effect of green areas on loneliness overall, that is, without dividing it into the social and non-social paths. See Table 4 for Kendall's  $\tau$  correlations between loneliness and all the hypothesised independent variables. Looking at the results, it appears that there is no significant correlation between loneliness and the distance to the most frequently visited green area ( $\tau = ,130$ ,  $p = ,117$ ), amount of trees in the vicinity of one's residence ( $\tau = -,034$ ,  $p = ,380$ ) or the amount of greenery in one's gar-

den (if present;  $\tau = -.135$ ,  $p = .140$ ). The correlation between loneliness and cumulative effect of greenery was not significant under  $\alpha = .05$ , however was significant under  $\alpha = .10$  ( $\tau = -.168$ ,  $p = .062$ ). The strength of the correlation, however, is moderate. The most compelling relationship of significant (at  $\alpha = .05$ ) moderate magnitude was between loneliness and the visit frequently to the most often visited green area ( $\tau = -.281$ ,  $p = .010$ ).

The positive affect scale is expected to assess the current mood of the respondents and also the general mood they experienced in the past 30 days (Joshnloo, 2017). This time period could allow for the influence of greenery on it as well. The correlations between positive affect and distance to the most frequently visited green area ( $\tau = -.071$ ,  $p = .260$ ), garden greenery ( $\tau = -.015$ ,  $p = .353$ ) or cumulative greenery ( $\tau = .002$ ,  $p = .453$ ) were not significant. The effect of street greenery ( $\tau = -.170$ ,  $p = .064$ ) would appear significant at  $\alpha = .10$ , however, it is in the opposite direction to the hypothesised and, since it is the one-tailed significance that is reported, this effect cannot be considered significant. Only the relationship between positive affect and the visit frequently to the most often visited green area ( $\tau = .207$ ,  $p = .034$ ) was significant (at  $\alpha = .05$ ) and of moderate strength.

*Table 3.* Hypothesis Test Summary

Null Hypothesis	Test	Sig.	Decision
The distribution of Loneliness is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	,114	Retain the null hypothesis.
The distribution of Social isolation is the same across categories of Gender.	Independent-Samples Mann-Whitney U Test	,865	Retain the null hypothesis.
The distribution of Loneliness is the same across categories of Age.	Independent-Samples Kruskal-Wallis Test	,411	Retain the null hypothesis.
The distribution of Social isolation is the same across categories of Age.	Independent-Samples Kruskal-Wallis Test	,774	Retain the null hypothesis.

*Note.* Asymptotic significances are displayed. The significance level is .050.

As for the relationship between loneliness and positive affect, it would be logical to hypothesise that loneliness leads to decreased positive affect, however, the correlation shows the opposite ( $\tau = ,207, p = ,034$ ). As the significant value is one-tailed, any conclusion as to the presence of the effect could be driven only if it is in the hypothesised direction. As, in this case, it is not, it cannot be concluded from this test that loneliness is positively associated with positive affect.

The data also shows that there is a relationship between distance to a green area and visit frequency to that green area — the shorter the distance, the higher the visit frequency ( $\tau = -,350, p = ,001$ ). The correlation is of strong magnitude and is significant at  $\alpha = ,05$  (see Table 5).

**5.3.3. Non-social mechanism**

The non-social path was a particular interest of the present paper. To isolate the effect of the non-social path from the social path, partial Kendall’s  $\tau$  correlation with con-

Table 4. Correlations<sup>a</sup>: Kendall's  $\tau$

		Distance to a green area	Street greenery (trees)	Garden greenery	Cumulative greenery	Green area visit frequency	Lone liness	Positive affect
	$\tau$	,130	-,034	-,135	-,168 <sup>†</sup>	-,281**	1,000	,207*
Loneliness	Sig. (1-tailed)	,117	,380	,140	,062	,010	.	,034
	$\tau$	-,071	-,170 <sup>†</sup>	-,015	,002	,207*	,207*	1,000
Positive affect	Sig. (1-tailed)	,260	,064	,453	,492	,034	,034	.

Note. <sup>†</sup>. Correlation is significant at the 0.10 level (1-tailed).

\*. Correlation is significant at the 0.05 level (1-tailed).

\*\*. Correlation is significant at the 0.01 level (1-tailed).

a. Listwise N = 43

trolling for the variable of social isolation was applied. The effect of distance to the most frequently visited green area ( $\tau = ,071, p = ,327$ ), street greenery (represented by trees;  $\tau = ,084, p = ,298$ ), garden greenery ( $\tau = -,033, p = ,417$ ), cumulative greenery ( $\tau = -,038, p = ,406$ ) and visit frequently to the most frequently visited green area ( $\tau = -,167, p = ,146$ ) on loneliness were not significant (see Table 6).

One of the hypotheses was that the participants with higher environmental values (i.e., preservation) would be more likely to be susceptible to the effect of greenery on loneliness through the non-social path as they are assumed to be more likely to anthropomorphise nature. As the sample size was rather low to carry the analysis only on those participants who scored the highest on the environmental attitudes (EA) scale, the next best option was to create interaction variables between EA scores and the distance to the most frequently visited green area, street greenery (represented by trees), garden greenery, cumulative greenery and visit frequency to the most frequently visited green area. To analyse the effect of the interaction variables, ordered logit regression was utilised.

As can be seen in Table 7 the effects of the distance to the most frequently visited green area by EA ( $p = ,511$ ), street greenery by EA ( $p = ,080$ ), garden greenery by EA ( $p = ,350$ ) and cumulative greenery by EA ( $p = ,130$ ) on loneliness were all not significant at

Table 5. Correlations: Kendall's  $\tau$

		Distance to a green area
	$\tau$	-,350**
Green area visit frequency	Sig. (1-tailed)	,001
	N	43

\*\* . Correlation is significant at the 0.01 level (1-tailed).

$\alpha = 0,05$ . Street greenery by EA could be considered significant under  $\alpha = 0,10$ , however the coefficient estimate is nearing zero meaning that the effect size is negligible.

To analyse these interactions, the regression had to include the main factors as well. These factors were already analysed with Kendall’s  $\tau$  correlation above and the regression showed similar outcomes. The relationships between loneliness and distance to the most frequently visited green area ( $p = ,499$ ), garden greenery ( $p = ,355$ ) or cumulative greenery ( $p = ,518$ ) were not significant. The relationship between loneliness and street greenery was significant ( $p = ,038$ ), however, the estimated coefficient was approaching zero making it, therefore, insignificant.

**5.3.4. Social mechanism**

Although the social path was not the main focus of the paper, given the relevance to the topic, the collected data also allowed to assess this path. First, Kendall’s  $\tau$  correlation was utilised to assess whether there is a relationship between social isolation and loneliness, as it is the key assumption of the social path. Table 8 shows that there is indeed a significant correlation between the two and it is of strong magnitude.

As for the effect of greenery on social isolation, which is the other key factor to the social path, the data showed the following results: street greenery (represented by trees;  $\tau$

Table 6. Correlations: Partial Kendall's  $\tau$

		Distance to a green area	Street greenery (trees)	Garden greenery	Cumulative greenery	Green area visit frequency
	$\tau$	,071	,084	-,033	-,038	-,167
Loneliness†	Sig. (1-tailed)	,327	,298	,417	,406	,146
	df	40	40	40	40	40

Note. †. Controlled for Social isolation.



= -,244,  $p = ,011$ ) and garden greenery ( $\tau = -,241, p = ,023$ ) both show a significant correlation (at  $\alpha = ,05$ ) of moderate magnitude. Correlation with the distance to the most frequently visited green area ( $\tau = ,153, p = ,074$ ) is not significant at  $\alpha = ,05$ , but is at  $\alpha = ,10$  and is of weak magnitude. The cumulative greenery is strongly correlated with social isolation ( $\tau = -,309, p = ,002$ ) and significant at  $\alpha = ,05$ . The correlation between social isolation and the amount of accidental meetings in the most frequently visited green area was not significant ( $\tau = -,101, p = ,189$ ). However, the visit frequency to the most frequently visited green area was strongly and significantly (at  $\alpha = ,05$ ) correlated to social isolation ( $\tau = -,317, p = ,003$ ; see Table 9).

### 6. Discussion

In the body of literature on the topic, there is a somewhat established link between green areas and loneliness (Astell-Burt et al, 2021; Beucker et al, 2021; Lyu & Forsyth, 2021, p. 6, 9; Maas et al., 2009). As described in the literature review section, many studies explain this relationship as green areas providing extra opportunities to socialise and inter-

Table 7. Ordinal regression: Parameter estimates

	Estimate	Std. Error	Wald	Df	Sig.
EA	-,173	,243	,506	1	,477
Social isolation	-,465	,116	15,962	1	,000
Distance to the green area	,000	,000	,458	1	,499
Distance to the green area by EA	-149,754	227,628	,433	1	,511
Street greenery (trees)	,004	,002	4,320	1	,038
Street greenery (trees) by EA	,000	,000	3,067	1	,080
Garden greenery	-,514	,555	,857	1	,355
Garden greenery by EA	,104	,112	,875	1	,350
Cumulative greenery	,689	1,066	,417	1	,518
Cumulative greenery by EA	-,309	,204	2,292	1	,130

Table 8. Correlations: Kendall’s  $\tau$

		Social isolation
	$\tau$	,439**
Loneliness	Sig. (1-tailed)	,000
	N	43

Note. \*\*. Correlation is significant at the 0.01 level (1-tailed).

act with strangers and friends and family alike (Astell-Burt et al, 2021; Beucker et al, 2021; Neal et al., 2015). According to this theory, the green areas per se are not the cause of decreased loneliness but just provide the setting which facilitates socialisation. In this paper, I describe this mechanism as the social path. The main subjective of the present study was, however, not to test this mechanism, but its counterpart — the non-social path. The non-social path’s mechanism could be theorised through the following three aspects: (i) pleasant social memories which attending green areas might invoke, (ii) solace (or, deriving pleasant feelings from being in nature) and (iii) anthropomorphisation of nature which might allow to derive company from spending time in nature. The last one, anthropomorphisation of nature, could be particularly relevant to people who hold high environ-

Table 9. Correlations<sup>a</sup>: Kendall’s  $\tau$

		Distance to a green area	Street greenery (trees)	Garden greenery	Cumulative greenery	Green area visit frequency	Unplanned social encounters in a green area
Social	$\tau$	,153 <sup>†</sup>	-,244*	-,241*	-,309**	-,317**	-,101
isolation	Sig. (1-tailed)	,074	,011	,023	,002	,003	,189

Note. <sup>†</sup>. Correlation is significant at the 0.10 level (1-tailed).

\*. Correlation is significant at the 0.05 level (1-tailed).

\*\*. Correlation is significant at the 0.01 level (1-tailed).

a. Listwise N = 43

mental attitudes, as possession of such attitudes has been shown to be related to a higher tendency to anthropomorphise nature (Birch, Rishbeth & Payne, 2020; Tam, Lee & Chao, 2013).

The two paths are related to the two factors from which the feelings of loneliness originate. Loneliness has been defined as a discrepancy between the amount of desired socialisation and the amount of actual socialisation (Beuker et al., 2021). The non-social path could only be connected to the concept of the desired amount of socialisation as it, by definition, does not involve social interactions. Accordingly, the social path is related to the amount of actual socialisation. See Figure 1 for the full conceptual model which illustrates the relationships described here.

I would start the discussion section with a summary of the main findings and then put them in the context of other existing studies — with the exception of the non-social path as to my best knowledge, no research on this effect in particular was conducted before. I would follow it with the discussion of the possible limitations of the study: low number of respondents, the fitness of the measures and approaches used. I will finish this section with suggestions for future research on the topic.

## **6.1. The main findings**

### ***6.1.1. The overall relationship between greenery and loneliness***

For some of the assessed indicators of greenery, there was an association with loneliness, however, not for all of them. The high scores on all three physical indicators of greenery together (distance to the most frequently visited green area, the amount of trees in the vicinity of one's residence place (approximately within 250 meters) and greenery in one's garden) were associated with decreased loneliness. The same variables separately,

however, did not show a significant association with loneliness. Yet, concerning the variable of distance to the most frequently visited green area, although there was no significant effect of the distance itself, there was an effect of visit frequency, which could be considered a more direct factor, as living near a green area does not guarantee frequent visits. However, the data has also shown that there is a strong relationship between the distance to a green area and the visit frequently. Therefore, it is possible that there is in fact an association between the distance to the most frequently visited green area and loneliness but the present study did not have enough power due to a low number of respondents to uncover it (see Section 6.3. for the discussion of the power of the study).

Overall, this relationship between greenery and loneliness has found support to some extent in many studies (Ateell-Burt et al, 2021, p. 7, 8, 9; Beucker et al., 2021, p. 5, 6; Lyu & Forsyth, 2021, p. 6, 9; Maas et al., 2009, p. 8), and although the lukewarm findings of the present study have shown limited support, they nevertheless could hardly dispute them.

### ***6.1.2. Social mechanism***

The key assumption of the social path is that it alleviates loneliness through extra opportunities for social interactions in green areas, gardens or other urban environments which possess high amounts of greenery. The most direct way to assess this path is to look at the variable of social isolation, which is assumed to be a precursor to loneliness. Confirming the findings of the many similar studies which assess loneliness through this lens, the present study found a relationship between the amount of greenery in one's environment and social isolation. The collected data showed significant relationships between social isolation and distance to the most frequently visited green area, street greenery in the

vicinity of one's residence and garden greenery (however, in the case of distance to the most frequently visited green area, the relationship is significant only at  $\alpha = ,10$ , but not at  $\alpha = ,05$ ). The strength of the relationship for these three variables is moderate. However, it must be noted that in the case of the variable of the garden greenery, the direction of the relationship might come from both directions: those who live in larger families are more likely to live in a larger apartment or house which includes a garden — in this case it might be the presence of a higher number of housemates that would lead to lower social isolation (the social isolation scale included a question about the number of network members living in the household). As was the case with the overall relationship between greenery and loneliness, the frequency of visits to the most frequently visited green area appeared to be more relevant than the distance — it was also of strong magnitude.

The data showed the effect of the highest magnitude in the case of the combination of high values of all three of the physical indicators of greenery (represented by the variable of the cumulative greenery). This shows that those living close to a green area, with more than the average amount of trees in the neighbourhood and with a garden full of greenery are less likely to be lonely. Overall, the findings of the positive effect of greenery on social isolation go in line with many studies: Arnberger & Eder, 2012; van den Berg et al. 2019, p. 3; Jennings, & Bamkole, 2018; Kaźmierczak, 2012; Kuo et al., 1998; Lai et al., 2021, p.8; Maas et al., 2009.

Now, what is the nature of the social interactions which the social path presumably facilitates? The questionnaire of the present study also included a measure for unplanned social meetings (e.g., just seeing people in the green area or engaging in a conversation with them), as it is often suggested that those might be (partly) responsible for the

socialisation opportunities that green areas provide. However, the data of the present study has shown that it is not the case — there was no significant association between unplanned social meetings and social isolation. This finding goes somewhat in line with Maas et al. (2009) who showed that more greenery in the environment does not lead to more encounters with neighbours. Kaźmierczak (2013) and Jennings and Bamkole (2018) also highlight the importance of planned social activities (e.g., a walk with a friend, a family picnic) in green areas. Interviewees in Kaźmierczak’s (2013) study also suggested the importance of seeing other members of their community in the parks, however, it is not clear whether in isolation from the planned social activities this could influence social isolation.

Overall, from the gathered data and the findings of other studies, it appears that these are planned social meetings in green areas rather than accidental interactions that provide social support, at least so to a greater magnitude.

### ***6.1.3. Non-social mechanism***

As can be seen from the results section, overall, many of the hypotheses of the non-social path should be given a negative answer. The data showed nonsignificant relationships between greenery and loneliness when the social path is controlled for (via the variable of social isolation). This could be said about all the analysed variables: distance to the most frequently visited green area, street greenery in the vicinity of one’s residence and garden greenery. The variables of frequency of visits to the most frequently visited green area and the cumulative greenery, which have shown the strongest effect on loneliness compared to the other variables, were not significantly correlated to loneliness either when the relationship was controlled for the social path.

One of the hypotheses of the present paper suggested that high environmental attitudes might enhance the strength of the relationship as those with high environmental attitudes are more likely to anthropomorphise nature and thus derive some ‘socialisation’ from being in nature’s presence. However, the variables which were computed as interactions between environmental attitudes and the variable of greenery did not show any significant relationship to loneliness. This suggests that the hypothesis of ‘socialisation’ with anthropomorphised nature is not a likely mediator in the relationship between greenery and social isolation.

There is little in the body of literature that has provided empirical evidence for the likelihood of the non-social path. Maas et al. (2009, p. 10) have shown that in their study it was not the social contacts that were responsible for the link between green areas and loneliness, which suggests that there should be some non-social effect. Maas et al. (2009) suggest that it is the attachment to the place and community that green areas facilitate, which in turn relieves loneliness.

On the example of one study, it is difficult to say if these findings are generalisable or particular to the context in which Maas et al. (2009) carried out their study. The same could be said, of course, about the results of this study. It is possible that Groningen either did not have enough variability in the amount of distance to green areas or street greenery or that there is a ceiling effect. Groningen is not a large city area-wise (197,96 km<sup>2</sup>; CBS, 2022b) and essentially most able-bodied people could reach the outskirts of the city and the green areas situated there by cycling for about 20 minutes (or less, if the starting point is further from the city centre). Cycling infrastructure is very developed in Groningen and cycling as a method of transportation is widespread (Pucher & Buehler, 2008). Therefore,



*Figure 11.* Approximate residence locations of the respondents (red) and locations of trees (green) in Groningen.

many would likely find a 20-minute cycling trip reasonable, particularly considering that most of the participants (40 out of 44) were 44 years old or younger. It is possible, that at this level of accessibility even more accessible green areas would not make a significant difference when it comes to the effect on loneliness, therefore, creating a ceiling effect.

Regarding the amount of street greenery, it is not clear whether it would face the same issues of a lack of variability or a ceiling effect. There were a few participants who lived in the city centre, which does not have as much street greenery. However, the majority of other respondents lived in areas which tend to have more street greenery. See Figure 11 for the locations of every tree in Groningen and the approximate locations of residence places of the respondents. The figure shows that there are very few locations with indeed small amounts of trees.



Another possible explanation of why the effect of the social path did not significantly contribute to the overall relationship between greenery and loneliness could be that the non-social path was working in the opposite direction of that hypothesised. Although green areas in urban environments are often viewed favourably, in some circumstances visiting them or passing by can be anxiety-provoking and make one uncomfortable— particularly often it is reported by women (Hengehold, 2011). Overgrown green areas with few or no other people in them might seem like places with a higher likelihood of criminal activity. Hengehold (2011) discusses that such negative feelings could come both from the feelings of anxiety and loneliness — “of being abandoned by everything and everybody” (p.48) whose presence could serve as a protection.

Now, it is relevant to discuss if it could be so in the case of Groningen and if it could have influenced the results of the analysis of the non-social path. Generally, the crime level in Groningen is considered very low (Numbeo, 2022) and the safety of walking alone during daylight and night are very low and low accordingly. The chances of being robbed, mugged, attacked or assaulted are low or very low and the level of associated anxieties is also low (ibid.). The green areas in the city are well taken care of and the parks are rarely fully deserted. The street greenery is also taken care of and could hardly be called overgrown. There is no data that could show if greenery in Groningen is actually anxiety-provoking, but it seems unlikely given the well-taken care state of it.

#### ***6.1.4. Positive affect***

As can be seen in the conceptual model, positive affect could be considered as a part of both the social and non-social path. However, the data showed that the relationship between positive affect and loneliness to be in the opposite direction of the one hypothe-

sised (which renders it non-significant as it was a one-tailed test). This finding would also be not in line with the studies which investigated the relationship between the two (Elphinstone, 2018).

The relationship between loneliness and positive affect could be a complicated one, as the relationship could be cyclical — negative feelings of loneliness could also be diminishing positive affect. Taking this into account, it could be said that the findings in the present study indicate no support for including positive affect in the model neither in the social path nor in the non-social path. Moreover, considering the possible cyclical relationship, including positive affect in the model does not seem to aid the explanation of the effect of green areas on loneliness.

## 6.2. Causality

On one hand, the DAG approach described by Greenland, Pearl and Robins (1999) is utilised to assess causal relationships and conclusions drawn based on them suggest to be causal, however, the observational nature of the present study cannot fully suggest a causal relationship. It is also possible, although difficult to investigate, that there is after all an element of cyclicity in the relationship between green areas and loneliness. Less lonely people might be more driven to visit green areas than more lonely people. Nevertheless, even if so, it would likely affect only the variable of the visit frequency to the green area, but not the variables of distance to the green area, street greenery or garden. If there is a cyclical relationship with these three variables, it would imply that less lonely people move into areas which have such features, which is, for obvious reasons, difficult on the practical level and therefore less likely. Therefore, with the other three indicators of the physical environment (distance to the most frequently visited green area, street greenery and garden

greenery), the analysis should be reasonably informative with regard to causality. It must be also noted, that a truly experimental setting, in this case, would be impossible in practice. Therefore, quasi-experimental and observational studies are the next best options and would need to be regarded as valid enough to uncover the effect.

### **6.3. Limitations of the study**

Unlike the studies carried out by Astell-Burt et al. (2021), Beucker et al, (2021), Lyu and Forsyth (2021, p. 6, 9) and Maas et al. (2009), the present study did not find any significant relationship between green areas and loneliness. There could be several possible factors that influenced it. First of all, it is likely that the present study lacked the power to uncover the weak effects due to the low number of participants. Studies with a low number of participants might be able to uncover an effect if it is large enough, which it is unlikely to be for the present topic. Considering that there is a multitude of more direct factors influencing loneliness (e.g., personal social relations), it is to be expected that the relationship would not be strong. The lack of power is a likely explanation as the data showed a significant relationship between greenery and social isolation and social isolation and loneliness, therefore, providing indirect evidence for the social path.

A second possible explanation comes from the appropriateness of the scales used in the questionnaire. Although the UCLA Loneliness Scale is one of the most widely used scales to measure loneliness (Cramer & Barry, 1999) and has been utilised by studies which aim to assess the effect of green areas (e.g., Maas et al., 2009), it might after all not be the most suitable measure for the purpose of separating the social and non-social paths. Some of the questions used appeared to be more factual and centred around relationships with other people rather than feelings (e.g., “How often do you feel that there are people you

can talk to?"; Russel, 1996, p. 23), which could have lead to an overlap with the scale of social isolation, which would distort the effect. However, many other widely used loneliness scales also seem to occasionally include questions about social relations and not only about feelings (e.g., Social and Emotional Loneliness Scale for Adults, also known as SELSA; DiTommaso & Spinner, 1993). Probably the ideal case for a study which aims to assess the social and non-social paths separately would be to develop a specialised scale which assesses feelings only and does not include questions regarding social relations.

Finally, for the majority of people, the place where they live is not the only place where or around where they spend a significant amount of time. As the majority of the respondents in the present study were 44 years old or younger, they are more likely to be spending a significant amount of time at their study place or workplace — ideally, the urban environments where these places are situated should also be taken into account. It is important to highlight that it is not only the place that matters but also the routes that people use to get to their daily destinations, particularly if they tend to travel at least a part of the distance by foot or cycling (which are both possible and typical of the residents of Groningen). This could be taken as a suggestion for a future research on the topic of loneliness and urban surroundings, which takes us to the next section.

#### **6.4. Suggestions for future research**

First of all, there is a need to repeat the investigation of the non-social path with more participants than in the present study. As mentioned before, if there is an effect, it is rather small and the present study possibly lacked the power to uncover it. Ideally, a quasi-experimental study design similar to that of the Sterreboos case would be better suited for establishing casual connections (see Section 4.2.).

Secondly, as social isolation was taken as an indicator of the actual amount of social interactions, a similar variable could ideally be developed for the desired amount of social interactions. If the effect of green areas on loneliness is indeed small, such a variable would allow to break up the non-social path into two parts, making the effect more direct and thus easier to uncover.

## 7. Conclusion

In the present study, I aimed to investigate the effect of access to green areas on loneliness. I suggested a division of the effect into two paths — social and non-social. The social path was hypothesised to come from the social opportunities green areas in urban environments could provide. The non-social path was hypothesised to affect loneliness without relying on socialisation opportunities and instead relying on solace, reminders of social connections and anthropomorphisation of nature.

The data showed no significant relationship between loneliness and green areas, street greenery or gardens. However, it is likely that the study lacked the power to uncover the small effect size of the relationship due to the low number of respondents. Yet, when investigating the elements of the relationship, that data has provided support to the social path: there was a significant relationship between greenery in urban environments and social isolation. That is, having access to urban greenery is associated with more social contacts and/or broader social networks.

As for the non-social path, the data has shown no support to confirm this theory. Environmental attitudes did not appear to have an influence on the relationships in the non-social path either. However, it still would be relevant to repeat the investigation with a larger number of participants, since if there is an effect, it likely is small.

The main contributions of the present study to the research field are the following:

(i) the framework providing the division of the effect of urban greenery on loneliness into the social and non-social paths; (ii) additional evidence to the social path theory; (iii) the present study could be treated as a pilot study for further investigation of the non-social path.

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## Appendix A: The questionnaire

### *General*

Your age:

Answer options: "18-24"/"25-44"/"45-64"/"65 or more"/"Would rather not tell".

Your gender:

Answer options: "Female"/"Male"/"Non-binary"/"Would rather not tell".

### *Loneliness (Russel, 1996)*

1. How often do you feel that you lack companionship?
2. How often do you feel that you have a lot in common with people around you?
3. How often do you feel close to people?
4. How often do you feel left out?
5. How often do you feel that no one really knows you well?
6. How often do you feel isolated from others?
7. How often do you feel that there are people who really understand you?
8. How often do you feel that people are around you but not with you?
9. How often do you feel that there are people you can talk to?
10. How often do you feel that there are people you can turn to?

Answer options: "Never"/"Rarely"/"Sometimes"/"Often"

### *Positive affect (Mroczek and Kolarz, 1998)*

1. How much did you feel in good spirits during the past 30 days?
2. How much did you feel extremely happy during the past 30 days?

3. How much did you feel calm and peaceful during the past 30 days?

4. How much did you feel satisfied during the past 30 days?

5. How much did you feel full of life during the past 30 days?

Answer options: “Never”/“Rarely”/“Sometimes”/“Often”/“All the time”

*Environmental attitudes inventory (Milfont and Duckitt’s, 2010)*

Scale 01. Enjoyment of nature

1. I really like going on trips into the countryside, for example to forests or fields.

2. I think spending time in nature is boring.

Scale 02. Support for interventionist conservation policies

3. Governments should control the rate at which raw materials are used to ensure that they last as long as possible.

4. I am opposed to governments controlling and regulating the way raw materials are used in order to try and make them last longer.

Scale 03. Environmental movement activism

5. I would like to join and actively participate in an environmentalist group.

6. I would NOT get involved in an environmentalist organisation.

Scale 04. Conservation motivated by anthropocentric concern

7. One of the most important reasons to keep lakes and rivers clean is so that people have a place to enjoy water sports.

8. We need to keep rivers and lakes clean in order to protect the environment, and NOT as places for people to enjoy water sports.

Scale 05. Confidence in science and technology

- 9. Modern science will NOT be able to solve our environmental problems.
- 10. Modern science will solve our environmental problems.

Scale 06. Environmental threat

- 11. Humans are severely abusing the environment.
- 12. I do not believe that the environment has been severely abused by humans.

Scale 07. Altering nature

- 13. I'd prefer a garden that is wild and natural to a well groomed and ordered one.
- 14. I'd much prefer a garden that is well groomed and ordered to a wild and natural one.

Scale 08. Personal conservation behaviour

- 15. I am NOT the kind of person who makes efforts to conserve natural resources.
- 16. Whenever possible, I try to save natural resources.

Scale 09. Human dominance over nature

- 17. Human beings were created or evolved to dominate the rest of nature.
- 18. I DO NOT believe humans were created or evolved to dominate the rest of nature.

Scale 10. Human utilisation of nature

- 19. Protecting peoples' jobs is more important than protecting the environment.
- 20. Protecting the environment is more important than protecting peoples' jobs.

Scale 11. Ecocentric concern

- 21. It makes me sad to see forests cleared for agriculture.
- 22. It does NOT make me sad to see natural environments destroyed.

Scale 12. Support for population growth policies

- 23. Families should be encouraged to limit themselves to two children or fewer.



24. A married couple should have as many children as they wish, as long as they can adequately provide for them.

Answer options: “Strongly agree”/“Somewhat agree”/“Neutral”/“Somewhat disagree”/“Strongly disagree”

***Social isolation (Cornwell, 2009)***

Social network size: With how much individuals can you discuss important matters?

Answer options: “0”/“1”/“2”/“3”/“4”/“5”/“6 or more”.

Which types of relationships do you have in your social network?

Answer options: “Spouse”/“Family member”/“Friend”/“Coworker”/“Other”.

On average, how often do you interact with members in your social network?

Answer options: a slider from “Never” to “Everyday”.

How many members of your social network live in your household?

Answer options: a slider from “None” to “All”.

How many friends would you say you have?

Answer options: “none”/“1”/“2–3”/“4–9”/“10–20”/“More than 20”.

How often do you attend meetings of an organised group?

Answer options: “Daily”/“Several times”/“1 time per week”/“1 or 2 times per month”/“Several times per year”/“1 to 2 times per year”/“Less than 1 time per year”.

How often do you socialise with family or friends?

Answer options: “Daily”/“Several times”/“1 time per week”/“1 or 2 times per month”/“Several times per year”/“1 to 2 times per year”/“Less than 1 time per year”. How often do you volunteer somewhere?

Answer options: “Daily”/“Several times”/“1 time per week”/“1 or 2 times per month”/“Several times per year”/“1 to 2 times per year”/“Less than 1 time per year”.

Scoring: The responses to each individual questions were standardised and then summed together into a single score for each participant.

### *Green areas*

Think of a green area (e.g., a park, a forest, a nature reserve, etc.) which you visit the most frequently. Click the square on the map where this green area is:

1. How often do you visit this area?

Answer options: “Daily”/“Several times”/“1 time per week”/“1 or 2 times per month”/“Several times per year”/“1 to 2 times per year”/“Less than 1 time per year”.

not every week/once or twice a week/3-5 times a week/almost every day]

2. When you are in this green area, how many people do you typically see on your walk?

Answer options: “No one”/“Few”/“Some”/“A lot”.

3. When you are in this green area, how likely is it that you will start a conversation with someone you encountered there?

Answer options: “Very likely”/“Somewhat likely”/“Neutral”/“Somewhat not likely”/“Not likely”.

4. How satisfied are you with this green area?

Answer options: “Satisfied”/“Somewhat satisfied”/“Neutral”/“Somewhat dissatisfied”/“Dissatisfied”.

***Residence place***

Click on the square on the map where you currently live:

1. If you have a garden, how much greenery do you have there?

Answer options: “No greenery or a few potted plants”/“Less than half of the garden is green”/“Half of the garden”/“More than half of the garden”/“All garden is green”/“I don’t have a garden”.

2. In the past 6 months, did you modify you garden to have more or less greenery?

Answer options: “Yes, more greenery”/“No, it stayed the same”/“Yes, less greenery”/“I don’t have a garden”.

3. How many years have you lived here?

***Previous residence place***

Click on the square on the map where your previous residence location was:

1. How much were you satisfied with green areas at your previous residence location?

Answer options: “Very satisfied”/“Somewhat satisfied”/“Neutral”/“Somewhat dissatisfied”/“Very dissatisfied”.

2. If you had a garden at your previous residence place, how much greenery did you have in that garden?

Answer options: “No greenery or a few potted plants”/“Less than half of the garden is green”/“Half of the garden”/“More than half of the garden”/“All garden is green”/“I don’t have a garden”.

*Outro*

Some people feel uncomfortable answering personal questions, and so we ask you to indicate whether you have answered the questions truthfully, to ensure that we have representative data for the study.

Answer options: “Yes”/“No”.

Appendix B: Screenshots of the questionnaire

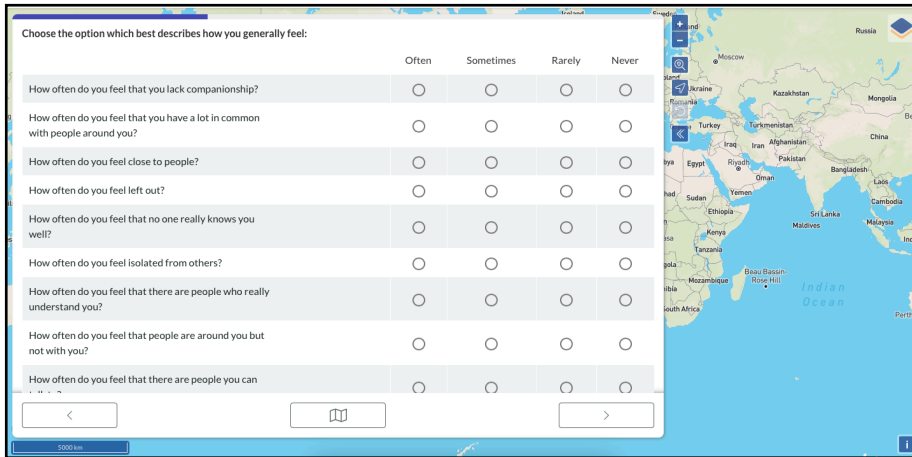


Figure 1. Display of the UCLA Loneliness scale as a part of the questionnaire. The other multiple-choice questions were presented in the same way.

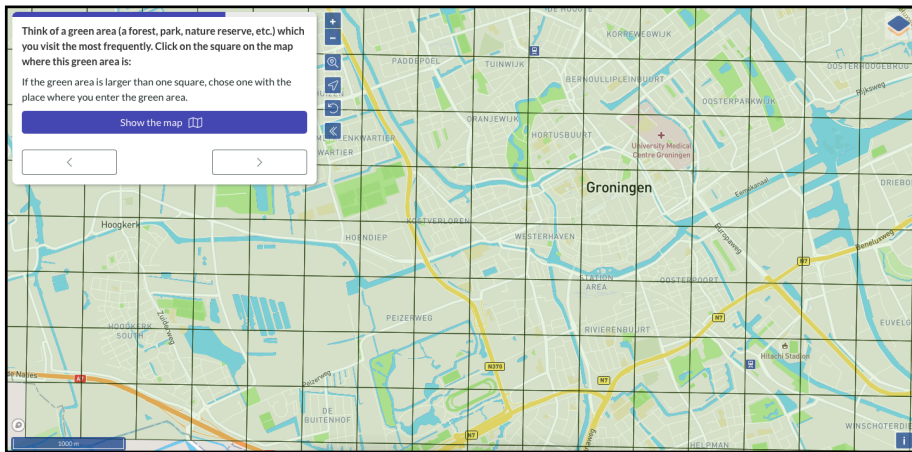


Figure 2. Display of a map question as a part of the questionnaire. The other map questions were presented in the same way.

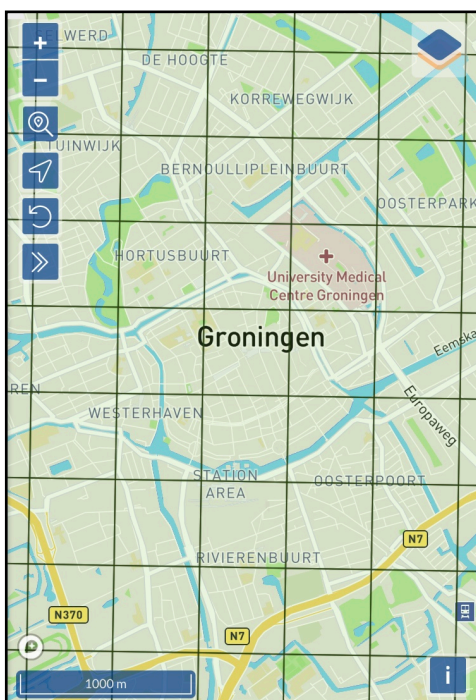


Figure 3. Display of a map question on a smartphone. After choose one grid cell and answering pop-up questions, the questionnaire does not automatically continue to the next question. To return back to the questionnaire, the arrow on the left needs to be clicked, which might not be intuitive.