Building Intimate Connections

The influence of the built environment on the loneliness of young adults

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Award date:
2023

Department of The Built Environment

Building Intimate Connections: The influence of the built environment on the loneliness of young adults

by

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MSC THESIS

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Graduation

Program:	Architecture, Building and Planning
Date of defense:	July 4, 2023
Student ID:	1256874
Study load (ECTS):	45
Track:	Urban Systems and Real Estate

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Abstract

Loneliness amongst young adults has become a significant problem of the past few years. Loneliness has negative effects on an individual, both physical and mental. It can lead to feelings of not belonging, emptiness, sadness, and fear. In severe cases it can lead to depression, alcoholism, and increased mortality risk. It is therefore not only a problem on a personal scale but also on a society level. Loneliness can be categorized into 'emotional versus social loneliness' and 'state versus trait loneliness'. Herein, emotional loneliness refers to the lack of intimate relationships, whereas social loneliness pertains to the lack of a broad and diverse social network. State loneliness is a temporary feeling caused by situational factors, whilst trait loneliness is a general feeling of loneliness. The research aims to explore the influence of social and physical environment factors on the emotional state loneliness of young adults, aged 18-25. Herein, the role of the activity setting in the built environment is of interest. The activity setting refers to the environment in which a certain activity takes place. Both the social and physical environment is addressed.

The relationship between a person's loneliness and the built environment is a complex issue, influenced by multiple layers of characteristics. Therefore, a social-ecological model has been introduced. It consists out of five layers: individual, household, social environment, physical environment, and external factors. Each of these layers contain multiple variables that could influence the feeling of emotional loneliness. The individual layer includes personal factors like age, gender, and personality traits. The household layer considers socio-demographic variables and household composition. The social environment layer examines the influence of friends, social media, the sense of community, the activity type, and the company a person is in. The physical environment layer includes factors like green spaces, facilities, aesthetics, and transportation. The external layer comprises influences that are present, but are out of a person's influence, such as the weather. The study focuses on the momentary experience of emotional loneliness of individuals and its relationship to the social environment, physical environment, and external factors. Additionally, the model will be controlled for the 'baseline' characteristics such as the individual, household, and social environments layer.

The aim of the research is to get insight in the momentary emotional loneliness of young adults. To measure the feeling of loneliness, several measurement scales are considered, but the 'de Jong Gierveld' scale is selected, due to its distinction of social and emotional loneliness. Both loneliness types will be measured during the research, as they influence on another.
For the gathering of momentary data, the experience sampling method (ESM) is used. EMS is a longitudinal study method that gathers real-time data. This can, for example, be done by prompting the participants on an application on their phone. The participants each were requested to fill in an 8-minute baseline survey covering the personal characteristics,

followed by short 2-minute momentary surveys, twice a day for the course of a week. The gathered data will be clustered on 'id' as one participant fills in the momentary survey at multiple moments. To process the clustered data, the mixed effects regression model (MRM) is used.

The surveys were distributed mainly through student networks and social media, targeting individuals between the ages of 18 and 25. A total of 43 participants completed the surveys, resulting in 393 data points. In the collected data it stood out that most of the participants were male, part- or full-time students, most of which in higher education. For the momentary experiences, most of the activities included studying, relaxing, social gatherings, working and eating, primarily executed alone or with friends. The locational factors were generally rated high, except from smell, diversity in activities, natural elements, and cleanliness, all of which had more varying scores.

After the basic data preparation, bivariate analyses were conducted to control for the assumption necessary for the execution of an MRM. Additionally, the relationships between the independent variables and the dependent variables were checked within each social-ecological layer. Due to high correlation, two variables were removed from the dataset. In the significance check some variables were deemed insignificant, however because these are necessary either as control variable or variable of interest, they remain in the model.

The gathered data has an intra-class correlation (ICC) of 0.53, suggesting that the use of a mixed model due to clustering is beneficial. As per the survey design, the clustering variable is 'id'. By following a top-down method, the 'optimal model' with two random variables and an R-value of 0.519 is obtained.

The aim of the thesis was to identify the built environment characteristics that influence the emotional state loneliness among young adults during their daily activities. The research questions focused both on the respondent-level variables and activity setting variables.

For the respondent-level variables, personality traits and trait loneliness had significant effect on the loneliness scores. Socio-ecological variables, study time, education level and partner status were seen as significant. Having a partner increased loneliness in individual. This is in contrast with literature, as in various sources this is stated to decrease loneliness. The type of house and household composition also influenced loneliness, with living in an apartment/studio increasing loneliness, whilst living alone or with your partner had the opposite effect. Social media use was important, with most of the social media types increasing loneliness. TikTok, interestingly, seemed to decrease it.

Activity settings were derived from the social environment, the physical environment, and contextual factors. For the social environment, being alone increased loneliness, whilst the

influence of activities was inconclusive. The physical environment variables ‘accessibility’ and ‘atmosphere’ were found to be influential on emotional loneliness. The type of location (e.g. home, on the road) and transport type (e.g. walking, car) also influenced loneliness. Weekends were associated with lower loneliness levels, while weather variables did not show significant results.

Even though the study does have its limitations in both time and facilities, the study provides first insight in the built environment factors that influence the emotional state loneliness of young adults. Create intimate connections by increasing accessibility and atmosphere of the locations.

1.

Introduction

noun

an occasion when something is put into use or brought to a place for the first time

1. Introduction

Loneliness, or the feeling of being alone, is often thought to be a result of introversion, depression, or a lack in social skills. However, loneliness can inhabit anyone, since it is the individual feeling of someone who perceives him- or herself to be socially isolated (Cacioppo & Cacioppo, 2018). Loneliness has been stigmatized and ignored for quite some time and it now becoming a public health problem. In loneliness two distinct 'categories' of loneliness are defined: emotional versus social loneliness and state versus trait loneliness. In emotional versus social loneliness, the focus is on the type of intimate relationships a person has. The problem in emotional loneliness is lack of good quality intimate relations, whereas for social loneliness the problem is the lack of a wider network of relations (de Jong Gierveld & van Tilburg, 2006). In state versus trait loneliness, the duration of the feeling of loneliness is viewed. State loneliness is the temporal feeling of loneliness experienced in a daily setting. This can be caused by a situation, such as a bad day or painful situation, as well as other situational effects, such as environment and the weather. Trait loneliness is where the loneliness is long-term and general (van Roekel et al., 2018).

Loneliness affects a person's health, both physically and mental, and could in the long-term affect someone's quality of life. The feeling of loneliness can cause feelings of not belonging, uselessness, emptiness, sadness, and fear. These mental complaints can be accompanied by physical issues (Een tegen Eenzaamheid, 2023). In severe cases, the effects of loneliness are associated with depression, alcoholism, child abuse and a heightened mortality risk (West et al., 1986). The heightened risk of mortality is especially increased for young- and middle-aged adults (Lara et al., 2020).

According to research done by CBS, the group of 15-to-25-year old's, tend to suffer from loneliness most out of all the groups in the Netherlands (CBS, 2022). This number has been rapidly increasing since 2019. It is important to note that youth suffer mostly from emotional loneliness; the craving of a more intimate connection with some-one (Weiss, 1973). Young people who suffer from loneliness often, have a three times higher chance of getting depressed at a later age, with these symptoms lasting for years (Loades et al., 2020).

Since the highest loneliness rates used to be in the 60+ age category (CBS, 2022), very little research was done on what influences loneliness on young persons (Scharf & Jong Gierveld, 2008). If research on the loneliness of young people was conducted, this was mainly on the loneliness of young children and adolescents (aged 10-19). The knowledge on the loneliness of young adults (aged 18 – 25) is still very limited (Fardghassemi & Joffe, 2021; van Roekel et al., 2015). Moreover, when youth and loneliness are researched, the focus is on those being in high risk of the effects on loneliness (f.e. with previous health concerns), not those who report to experience loneliness themselves (Eccles & Qualter, 2021).

In research on human development, it is important to focus not only on the laboratory settings, but also take the daily factors that influence an individual into account. In Bronfenbrenner's 1979 research he faced a similar problem, stating: "One needs to discover empirically how situations are perceived by the people who participate in them." (Bronfenbrenner, 1979). To map all the factors that might influence a person's behaviour or experiences, he proposed an ecological system composed of six main layers: individual, microsystem, mesosystem, exosystem, macrosystem and chronosystem. This socio-ecological approach of breaking down the influential factors is already used in other research regarding mental well-being and loneliness and widely used in general research regarding physical activity and health (Kousoulis & Goldie, 2021).

Earlier research has shown that both the social and physical environment has influence on the mental well-being of inhabitants (Hsueh et al., 2022; Lyu & Forsyth, 2022; Marquez et al., 2022; Scharf & Jong Gierveld, 2008). The focus of this research will be on which social and physical environment factors influence the feeling of loneliness. The other systems, however, need to be tested for the control variables. An adaptation of Bronfenbrenner's model will be used to gain insight in the influence of the control variables.

Loneliness can be influenced by the performance of activities (Lyu & Forsyth, 2022). Partaking in a diverse number of activities in a person's environment can help reduce loneliness (Chipuer, 2001). Experiencing loneliness does not affect the number of activities a person participates in. However, it does influence the amount and type of reward one gets from these activities (Queen et al., 2014).

1.1 Problem definition

1.1.1 Knowledge Gap

In current literature regarding the loneliness of young adults in the built environment, there are still some literature gaps to be found. Firstly, most of the current research that is available is focussed on the elderly population. This can be explained when looking at the numbers of loneliness over the years. There is a need for research on this subject, as both the current numbers (CBS, 2022) and previous research mention that isolation is one of the larger risks for this age group (Kousoulis & Goldie, 2021). Whenever loneliness is researched for a younger group of people, the adolescents, aged 10 to 19, is the subject. Little research is done on the relationship between adolescents and the built environment. Both groups of the population tend to have different needs and need to be treated differently.

The second problem is the 'type' of loneliness that is researched. as young adults tend to suffer mostly from emotional loneliness (CBS, 2022), this is the main focus for this paper. As a result of the large number of research done on the elderly population, social loneliness is the primary researched type of loneliness. Additionally, a lot of the time the type of

loneliness researched is not defined at all, which makes for a rather ambiguous source of information.

Thirdly, most research focusses on long-term or trait loneliness rather than state loneliness. There is little knowledge regarding the influence of built environment on state loneliness (van Roekel et al., 2015, 2018). Since this is ill defined, the proposed interventions of different research might not apply on short-term loneliness. Moreover, the relationship between trait and state loneliness lacks some research. To what extent does trait loneliness influence the experience of state loneliness?

The fourth problem is that there is little research on the mediating role of the experience of activities in the built environment on the feeling of loneliness. There is research that states that the experience of an activity results in a different outcome when a person is feeling lonely (Queen et al., 2014). The exact role between the experience of activities and the feeling of loneliness could be elaborated on more in depth.

And lastly, a lot of the built environment characteristics that influence the feeling of loneliness have no unambiguous answer in literature. A lot of the research has contradictory findings between different studies and there are differences in culture and background to consider. Research on the combination of the young adults age group, the feeling of loneliness, built environment characteristics and the experience of activities does not exist now.

1.1.2 Aim

The emotional loneliness of young adults is a current problem that needs immediate attention as, when unsolved, it will cause problems for society later (Center for Disease Control and Prevention, 2021). When people feel lonely at a young age, they also have an increased probability to feel lonely at later stages of their lives. Therefore, this research aims to increase the knowledge concerning the influence of built environment characteristics, both physical and social, on the state feeling of emotional loneliness on young adults. These insights can be used by planners and municipalities to implement and increase a healthy living environment for the younger group of inhabitants of both cities and rural areas. People who experience loneliness have different reactions to a certain activity setting than less lonely individuals (Queen et al., 2014). Therefore, the second objective is to find out to what extent the activity setting has an influence on the perception of the built environment characteristics on the feeling of loneliness. Knowledge on this subject can help define whether the proposed state loneliness implementations will reach the young adults.

1.1.3 Problem Statement

The problem statement of this study is the following:
"What are the built environment characteristics that influence the emotional state loneliness of young adults during their daily activities and what is the mediating role of activity settings?"

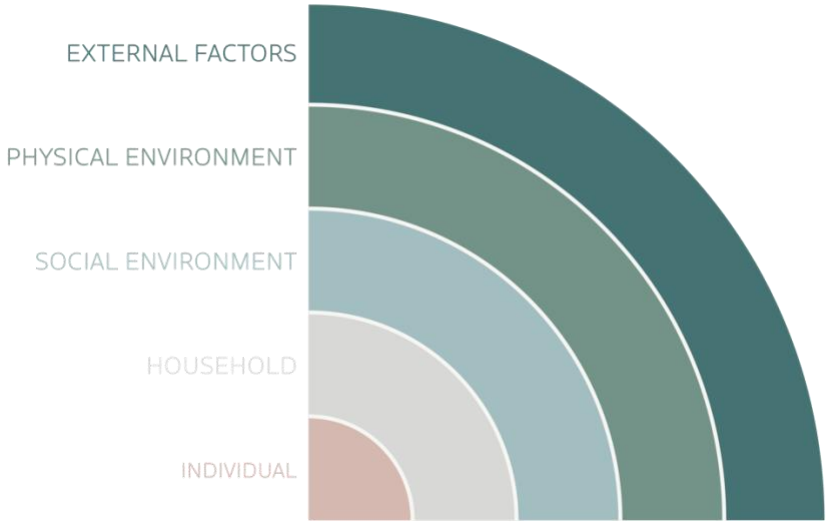


Figure 1: socio-ecological model. Adapted from McLaren and Hawes (2005) and Curtis et al. (2015)

To solve the problem as stated, an adaptation of Bronfenbrenner's socio-ecological model is introduced. As mentioned in the previous section, to gain insight in a person's feelings or experience, all layers of influence need to be considered. Each of these layers contain different variables that influence the feeling of loneliness and perhaps even each other. Even though the focus of this study is on the built environment characteristics, the other layers contain valuable information. The variables in the other layers will work as control variables.

1.1.4 Sub-questions

The socio-ecological model and the basic conceptual model show the expected influences on the feeling of loneliness. To gain insight in the depth of the problem, the research question is dissected into several sub-questions:

- What is the influence of respondent-level variables on emotional state loneliness?
- What is the influence of the activity setting on emotional state loneliness?

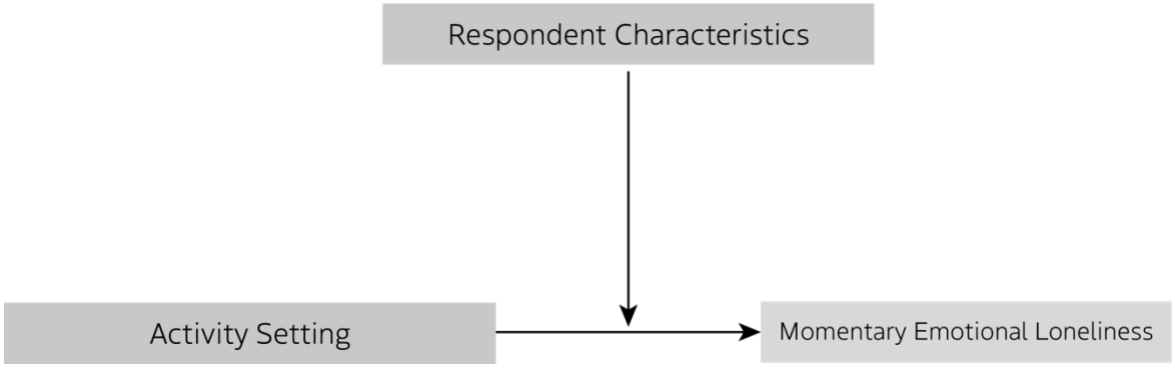


Figure 2: Basic Conceptual Model

1.2 Set-up report

The report is set-up in four different parts to answer the problem statement.

Literature study

Firstly, a literature study will be conducted. The literature study will gain insight in the current state-of-the-art theories and the previous knowledge regarding the variables and characteristics of loneliness. The knowledge of the literature study can be used for specifying the variables, which can be used further in the background theory and set-up for the research. This will be discussed in chapters 2 and 3.

Research: Operationalisation

The second step is preparing the background theory regarding the research. It entails the research behind the chosen methods and the preparation of the research prior to conduction. This step provides information for the implementation of the research. The research operationalisation can be found in chapter 4.

Research: Methodology

In the third step, research implementation, the data will be gathered and analysed according to the previously researched theories. As the data focusses on the momentary experiences of a person, Experience Sampling Method is used. The processed data will gain insight in the weight of the several variables and their influence on the feeling of loneliness of young adults. The results following the research will be supplied. The research methodology and implementation can be found in chapters 5 through 7.

Conclusion

The last step will provide the conclusions regarding the main problem statement. There will be stated what addition this research brings to the current knowledge on the subject and what action could be taken accordingly. Potential follow-up research will be discussed. The result, conclusion and discussion will be discussed in chapters 8 and 9.

2.

Literature Study

noun

all the information relating to a subject,
especially information written by experts

2. Literature Study

In the literature study insight is given in the current knowledge around the three main topics of the research: loneliness, young adults, and activity settings. The mutual connections between the topic will be studied and discussed.

2.1 Loneliness

To understand to what extent which built environment characteristics have an influence on the feeling of loneliness in young adults, it must be understood what entails loneliness. In the past, social connections, be that of a family or tribe, could secure the safety and likelihood of procreation and the survival in unexpected and potential hostile environments (Hawkley & Cacioppo, 2010). As a result, the human species are a very socially focused species, being able to form empathetic connections with people as well as story characters and animals. Social exclusion affects a person's day to day life, whether it stems from the lack of social activities surrounding them or the energy to join in.

Loneliness has been a subject of interest for quite some time. Sociologist Weiss started to describe loneliness as: "A situation experienced by the individual as one where there is an unpleasant or inadmissible lack of (quality of) certain relationships. This includes situations, in which the number of existing relationships is smaller than is considered desirable or admissible, as well as situations where the intimacy one whished for has not been realized." (Weiss, 1973). He defined two different types of loneliness: emotional loneliness and social loneliness.

Figure 3: Social versus Emotional Loneliness

Emotional loneliness focusses on 'the feeling of missing an intimate relationship', whereas social loneliness entails 'the missing of a wider social network'. (de Jong Gierveld & van Tilburg, 2006). Social loneliness is what is commonly thought of when thinking about loneliness. The stereotypical 'lonely elderly person' is most of the time socially lonely (CBS, 2022). Social loneliness can root from a limited transport range, because of which friends are harder to visit, or the loss of friends and relatives (Center for Disease Control and Prevention, 2021).

Emotional loneliness, on the other hand, tends to be more problematic for the younger generations, specifically young adults (CBS, 2022). Emotional loneliness can stem from loss from a close personal relationship, like a break-up, or from moving into a new social circle where there are no deep social connections yet. Generally, emotional loneliness is identified by "intense feelings of emptiness, abandonment, and forlornness" (de Jong Gierveld & van Tilburg, 2006). Even though the concept of emotional loneliness has been around since the

social provisions' theory of Weiss (1973), only few papers define emotional loneliness in their research (de Jong Gierveld & van Tilburg, 2006; Domènech-Abella et al., 2020; van Roekel et al., 2015). Most of the papers do point out that there is some form of emotional experience that influences the feeling of loneliness (Fardghassemi & Joffe, 2021; Queen et al., 2014). The emotional experiences are part of a person's experience of that moment, or momentary experiences. In research on momentary experiences, attention is given on both the affective (emotion) and the cognitive (satisfaction) components (Zhao et al., 2022). Zhao defines momentary experience as "a short-term perception that covers a wide range of subjective meanings such as moods, emotions and feelings of individuals". The emotional experiences are measured using four emotions on a Likert scale; safety, annoyance, comfort and happiness. This was deemed to give adequate insight in the emotional aspect of the momentary experience.

In recent works, two different phenomena of loneliness are defined: "(1) a temporary condition brought about by significant life changes (e.g., job loss, relationship conflict) or (2) a more persistent or chronic experience, in which an individual experiences a long-lasting isolation from human contact or socialization" (Bodford, 2017). Another study describes this as state and trait loneliness.

Figure 4: State versus trait loneliness

Herein state loneliness refers to 'momentary feelings of loneliness in daily life' and trait loneliness is defined as 'a baseline measure of how lonely someone feels in general' (van Roekel et al., 2018). In the work of van Roekel et al. (2018), the trait loneliness is measured with a baseline questionnaire. To evaluate the effect of the state loneliness, experience sampling methods were used. The combination of the two types of questionnaires provides the contrast needed to find the influence of the state loneliness. In this research it is not identified whether social or emotional loneliness is considered (van Roekel et al., 2018). This subject needs further research.

As there is very little research on state loneliness, momentary well-being is the nearest research subject. Momentary well-being is something discussed in various sources (Birenboim, 2018; Weijs-Perrée et al., 2019, 2020). In the work of Zhao et al. (2022) it is concluded that the momentary social-well-being has significant effects on the long-term social well-being. This could suggest that this might be true for short-term (state) and long-term (trait) loneliness as well. Nevertheless, well-being and loneliness cannot be seen as the same thing, and this should be researched in more detail.

The feeling of loneliness can be a self-perpetuating cycle oftentimes combined with symptoms of depression, making it more and more difficult to escape (Kenrick et al., 2014). To reduce or prevent the feeling of loneliness, the triggers of loneliness should be known. As the feeling of loneliness is the perception of social exclusion, the feeling of connectedness can help people avoid the feelings of loneliness (Chipuer, 2001). Creating the feeling that people are truly part of something can provide for the needed connection. As a prevention for loneliness, it is stated that consciousness surrounding the topic of loneliness can help finding the signs and sources of the situation (Bodford, 2017).
Concluding, loneliness can be defined by one's perception of social exclusion. This exclusion can be found in various forms: e.g., the type of loneliness (emotional/social) and the duration (state/trait).

2.2 Youth and Loneliness

During the COVID-19 lockdown, loneliness amongst young people has skyrocketed. The disruption of the lives of youth has effects in both the feeling of loneliness and the amount of people with depression (Lee et al., 2020). Despite that, the growing loneliness amongst youth was already visible before the COVID-19 epidemic (Mental Health Foundation, 2022). These numbers contradict the typical image of the lonely elderly person.

When 'youth' is researched in combination with loneliness, the research focusses oftentimes on the age group of 10-19 years (adolescents) rather than the young adults, aged 18-24 (Fardghassemi & Joffe, 2021; van Roekel et al., 2015). This is concerning, since this age group suffers most from emotional loneliness of all researched groups in the Netherlands (CBS, 2022). The lack of true intimate connections and the quality of these connections seems to be a problem for this age group (CBS, 2022; Weiss, 1973). The social isolation of this group is limited, since the amount of people surrounding them seems to be enough. There is evidence that for loneliness in young people the duration of the feeling of social exclusion is important. Long-term exposure to loneliness increases the risk of future depression most (Loades et al., 2020). Loneliness and depression are oftentimes named simultaneously; these are separate problems, however, and should be addressed as such (Bodford, 2017; Cacioppo & Cacioppo, 2018).

The feeling of loneliness in young adults is a continuation of the social exclusion and peer validation of children. Intimate relationships with friends, families and peers can reduce the feeling of loneliness in youngsters (van Roekel et al., 2018). Loneliness seems to arise mostly in the transition of the family network into the social network of their peers (Chipuer, 2001). The feeling of connectedness with their peers becomes increasingly important with age. The judgement and opinion of peers can induce loneliness in adolescents (Fardghassemi & Joffe, 2021). After a certain age, the influence and opinion of peers matter more in the terms of loneliness than the connectedness to the family (Marcoen et al., 1987).

Even though loneliness can have serious effects, spending time alone while growing up can prove beneficial as it allows for space for reflection and self-nurturing thoughts (Fardghassemi & Joffe, 2021). Spending some time separate from their peers can help develop their personal identities better.

Most of the current-day research on loneliness is focused on the older adults and the elderly of the population, as social loneliness was most visible in this age group over the years (CBS, 2022). In research there is still some discussion whereas age is a factor in the feeling of loneliness. Some research state that the feeling of loneliness is experienced similarly throughout all ages (Hawkley et al., 2022), whereas others state that with age loneliness decreases (Barreto et al., 2021). Where the feeling of loneliness itself is still up to discussion, the ground of the feeling of loneliness is known to vary over age. For elderly in the population the roots of loneliness lie in, among other things, the limitation in mobility and the declining health of both the person themselves as their surroundings (Victor et al., 2005). In youth, the feeling of loneliness seems to stem in the insecurity and acceptance of their peers and the changes they go through in identity and social network (Qualter et al., 2015). The difference in reason behind the feeling of loneliness would suggest that the research on the loneliness of elderly is not applicable for the young adults. Even though the ages cannot be compared, research showed that across cultures the feeling of loneliness is comparable (van Roekel et al., 2018). Even if correct interventions can be made in the built environment, it is important to keep in mind that there is no ‘one size fits all’ solution (Eccles & Qualter, 2021). This includes both youths as elderly people.

2.3 Activity Setting and Loneliness

The activities a person undertakes daily have a significant influence on the feeling of loneliness a person can experience. The built environment can influence the feeling of loneliness by either supporting or hindering activities (Lyu & Forsyth, 2022). Performing a high amount of (neighbourhood) activities is proven to reduce the feeling of loneliness (Chipuer, 2001). For the younger part of the population, the quality of the activities is of high importance. The presence of activities that support the learning of new skills and bringing people together socially, yield the highest effect (Eccles & Qualter, 2021). The feeling of loneliness due to the lack of activities is especially visible during the weekdays, as the lack of time and quality connections causes a problem (van Roekel et al., 2018). The activities provided by the communities should not only be accessible for everyone, but these opportunities should also be diverse and reflect the cultural context of the population (Reed & Bohr, 2021).

The setting that facilitates a certain activity is called an ‘activity setting’. Activity settings regarded as ‘the unit by which culture and community are propagated across time’ (McLaren & Hawe, 2005). Activity settings differ from physical environments as they both

connect the environment and a person's activity experience (O'Donnell et al., 1993). The feeling of loneliness influences how an activity setting is experienced. The activity setting is the same for both the people who experience loneliness and those who do not, however the positive feedback is less intense for someone who suffers from loneliness (Queen et al., 2014).

2.4 Conclusion

This chapter explores the concept of loneliness, specifically focusing on its influence on young adults and the role of the built environment. Additionally, the different categories of loneliness are identified as "social versus emotional loneliness" and "state versus trait loneliness". In this research the focus will be on emotional state loneliness. Emotional loneliness appears to be a significant issue for young adults, as it is a result of the lack of intimate connections and quality relationships. Currently, most of the research existing is focused on older adults, which might cause problems as the needs for each age group are different. Lastly the concept of activity settings is introduced as the environment that facilitate certain activities and its role in relationship to loneliness is discussed.

3.

Framework

noun

a system of rules, ideas, or beliefs
that is used to plan or decide something

3. Loneliness in a social-ecological framework

In chapter three, a quick overview of the social ecological model will be given. All the layers that influence the feeling of loneliness will be addressed and elaborated on. Out of a literature study, the variables that make up the socio-ecological layers will be researched and defined.

3.1 Social-Ecological Model: Built Environment & Loneliness

In moments of stress, loneliness or other types of heightened caution, humans are extremely aware of their surroundings (Bodford, 2017). It is therefore no surprise that the built environment is of high influence on the feeling of loneliness of its users. A positive perception of the built environment can help reduce the feeling of stress (Lyu & Forsyth, 2022). 'Built environment' refers to "places (be they neighbourhoods, towns or cities) made up of individual buildings, streets and transport infrastructure, public places, and green open spaces" (Thompson & Kent, 2017). The relationship between the built environment and loneliness is a complex one, "emerging from interrelationships among the built environment and the broader socio-cultural and economic milieu, which intersect with individual experiences, needs, values, and practices" (Bower et al., 2023b). In furtherance of breaking down this complexity, a social-ecological model is introduced.

A social-ecological model is a "framework or set of theoretical principles for under-standing the dynamic interrelations among various personal and environmental factors in health" (McLaren & Hawe, 2005). There are various frameworks that try to document the complexity of the built environment and its social influence in a comprehensive way, such as Moffatt & Kohler. In their 2008 system they compare the natural and the cultural influences over time (Moffatt & Kohler, 2008). The most used framework though is Bronfenbrenner's model (Bronfenbrenner, 1979). In his model he distinguishes five different systems that influence the individual: the microsystem, the mesosystem, the exosystem, the macrosystem, and the chronosystem. Variables within each layer might be bi-directional; they can influence each other as well as other layers. Bronfenbrenner's model is a general system looking at all factors concerning health and a person's well-being. For this research, Bronfenbrenner's model is adapted to portray the layers concerning the built environment more specifically. The proposed adaptation is based mostly on the work of Curtis et al. (2015), wherein they research the environments influence on the mobility of children. The adapted model recognizes five different layers of influence: the individual layer, the household layer, the social environment, the physical environment, and the external factors.

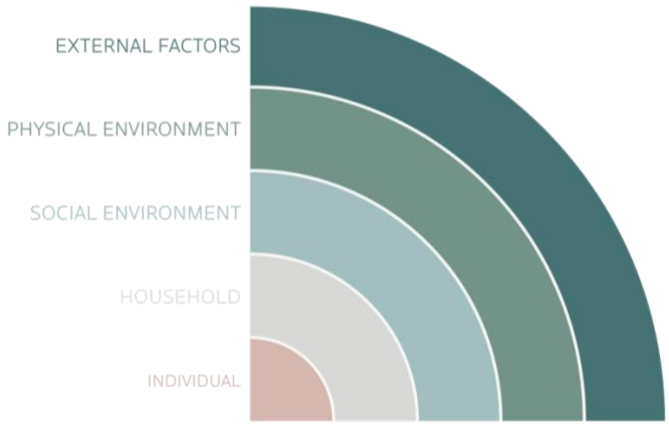


Figure 5: Social-Ecological Model. Adapted from (McLaren & Hawe, 2005) and (Curtis et al., 2015)

The model in figure 5 shows the adapted model. This model will be applied for both the respondent level and the activity setting level. The first layer is the individual layer, which directly influences a person or their setting. It contains personal factors such as age, gender, personality traits or previous familiarity with the place. These matters have been developed over age and are based on both nature and nurture.
The second layer is named household. It contains factors that directly influence individuals in their daily lives; closest contact (household members) and household characteristics (socio-economic status and living environment).
The third layer is the social environment and the fourth is the physical environment. In social environment, variables entail the sense of community one has and the influence of social media on their daily lives.
The fourth layer contains the physical environment. This entails the presence of greenery, the amount and quality of facilities nearby, the aesthetics of a location and the ease in which one can travel around, are all factors of interest.
The fifth and last layer, external factors, consists of influences that are present, but feel distant. National policies, the weather, what day of the week, and such.

In the following part of this chapter, a literature per layer of the model will be reviewed for both the respondent level and the activity setting level. This will result in a collection of variables that influence the feeling of loneliness of young adults. Important to note is that there is very little literature on the feeling of loneliness of young adults. Therefore, the majority of the variables are based on data from other age group, such as children or adults and some data stems from ‘general mental well-being’.

3.2 Respondent-level model

The respondent level of the social-ecological model dives into the personal factors that might influence the feeling of loneliness daily. These factors oftentimes do not change over time and are deemed more permanent aspects of one's persona. The physical environment layer and the external factors layers are not considered, as these both look at a larger scope.

3.2.1 Individual

Age

As mentioned in the previous section, the age range of young adults (18-25) is accompanied by a fast-changing social scene (Chipuer, 2001). Even though age is an important factor in loneliness over time (Hawkley et al., 2022), no large differences are expected within the age group young adults as most literary sources do not distinguish differences in the age group.

Gender

Even though in general women are reported to be lonelier than men (de Jong Gierveld et al., 2006), in adolescents no significant difference was found (Marcoen et al., 1987; van Roekel et al., 2015). Recent research states that men are at greater risk of feeling lonely, especially when living in an individualistic culture (Barreto et al., 2021). The research does not specify whether this applies to emotional or social loneliness is research; presumably it is a combination of the two. In research on social and emotional loneliness in elderly people, it was concluded that being male is one of the significant variables that influences social loneliness (Dahlberg & Mckee, 2014). Gender seems to have no influence on emotional loneliness, however. On fulfilling emotional needs, especially single men seem to have some difficulty over women (Reed & Bohr, 2021). Single men do not seem to be able to create emotional relationships outside of romantic relationships with their partner/spouse. Women on the other hand seem to be able to fulfil these needs through their relationships with their friends.

Personality Traits

The personality traits have been linked to how one perceives the world and the feeling of loneliness (Wang & Dong, 2018). Especially intrapersonal factors play a role in the feeling of loneliness throughout time when growing up. These factors include introversion and emotional instability for example (Fardghassemi & Joffe, 2021; Weijs-Perrée et al., 2019). However, it seems that for the feeling of a certain emotion in a moment itself, the personality characteristics are of little influence (Eid & Diener, 2004). This is confirmed in work researching the determinants of well-being and general life satisfaction (Birenboim, 2018).

Trait Loneliness

As mentioned before, trait loneliness is considered to be a continual feeling of loneliness or 'baseline' loneliness (van Roekel et al., 2018). Having a higher level of trait loneliness results

in a stronger feeling of 'wanting to be alone', but in doing so, people isolate themselves further. As a result, the levels of state loneliness increase as well (Mote et al., 2020).

3.2.2 Household

Socio-demographic variables

In contrast to the personality traits, the socio-demographic characteristics were found to be highly important in the explanation of long-term social well-being (van den Berg et al., 2016; Weijs-Perrée et al., 2019). Socio-demographic variables entail 'education, migration background and ethnicity, religious affiliation, marital status, household, employment, and income' (Leibniz Institute of the Social Sciences, 2022). For the elderly (aged 70 and above) in the Netherlands, the socio-economic and financial status had a significant effect on the feeling of loneliness (Scharf & Jong Gierveld, 2008). As an addition to the socio-demographic variables, the sense of community a person has and his/her state of health has large impact on the feeling of loneliness (Marquez et al., 2022; van den Berg et al., 2016).

Household composition

Even though there is little research on the subject, the presence and the connection an individual has with their roommates seems to have a significant effect on their mental health (Erb et al., 2014). People living with a partner see a reduction in social interaction outside of their household, however this might not influence a person's loneliness (Weijs-Perrée et al., 2015). For students, living with roommates is oftentimes part of their university experience. Men seem to be easily satisfied with whom they live, whereas women tend to have more difficulty living with others for longer periods of time (Henninger et al., 2016). Overall, living with roommates decreases the feeling of loneliness amongst students.

House type

Housing generation itself is one of the main factors of the feeling of loneliness (Hsueh et al., 2022). The lack of affordable housing can be a determinant for loneliness as well (Thompson & Kent, 2017). Especially the type of housing, such as a small apartment (En Wee et al., 2019; Morgan et al., 2021), the duration of residence, presence, and satisfaction of the facilities in the neighbourhood are of significance (van den Berg et al., 2016). In some research this was contradicted after adjusting for the socio-demographic characteristics (Kearns et al., 2015).

Density

The housing density did not influence the feeling of loneliness immediately, whereas being located on the outer skirts of the city does have a significant influence (Finlay et al., 2020). Another study found that housing density had mixed influences on loneliness (Bower et al.,

2023). The main features that influence the feeling of loneliness tend to be on household or on neighborhood scale.

3.2.3 Social environment

Friends

A strong connection with at least four different people in a young adult's network, can provide some protection against the feeling of loneliness. It is important that these connections are not all the same; diversity in connection makes for a stronger and long-lasting bond (de Jong Gierveld, 2006). In adolescents, the only real connection that was significant was the connection to their best friend. As the young adults build upon that base, this might be true for this age group as well (Chipuer, 2001).

Social Media

The passive consumption of social media has an increasing effect in the feeling of loneliness (Fardghassemi & Joffe, 2021). A study showed that the use of social media in youth was not a predictor of loneliness on its own (Marquez et al., 2022). On the other hand, face-to-face contact was proven to decrease loneliness. Online connection seems to reduce for the feeling of social loneliness. The connections made online seem to be enough for the feeling of a wide and diverse network of friends. For emotional loneliness, however, the online / internet friends are not beneficial and face-to-face contact is required. The forming of intimate connections needs time and resources, that people who make friend online seem to lack (Bodford, 2017).

Sense of community

A community is defined as a group of individual units that bond over a relationship of mutual interdepence. In humans, these relations are commonly interpersonal groups, such as a network of friends or neighbours (McLaren & Hawe, 2005). The sense of community is defined as "the bond between the various residents in a neighbourhood" (Haans, 2021). This differs from place attachment as the community forms the bond and social safety net for those within the community. People who experience little to no sense of community are at risk for social exclusion and as a result feeling lonely (Chipuer, 2001).
Socially, the feeling of belonging and the sense of community contain three different items to reduce the feeling of loneliness. They are defined as networks, norms, and trust (Kearns et al., 2015). Whenever there is shared hurt or exclusion within the community, it will reflect on a person's own emotional loneliness (Chipuer, 2001).
To some extent the physical environment can influence the feeling of community, as it is intertwined with nature bonding, place identity and place dependence (Raymond et al., 2010). The connection between the built environment of a community and their social structure is an important predictor for their feeling of social isolation and social loneliness. This is especially of importance for those individuals who have a type of disadvantage or

accessibility problems (Reed & Bohr, 2021). In most of the research on loneliness the focus is on the experience of the individual, therefore the 'community-level factors' that may have influence on the perceived feeling of loneliness are not commonly kept in mind.

3.2.4 Social-Ecological Model Overview

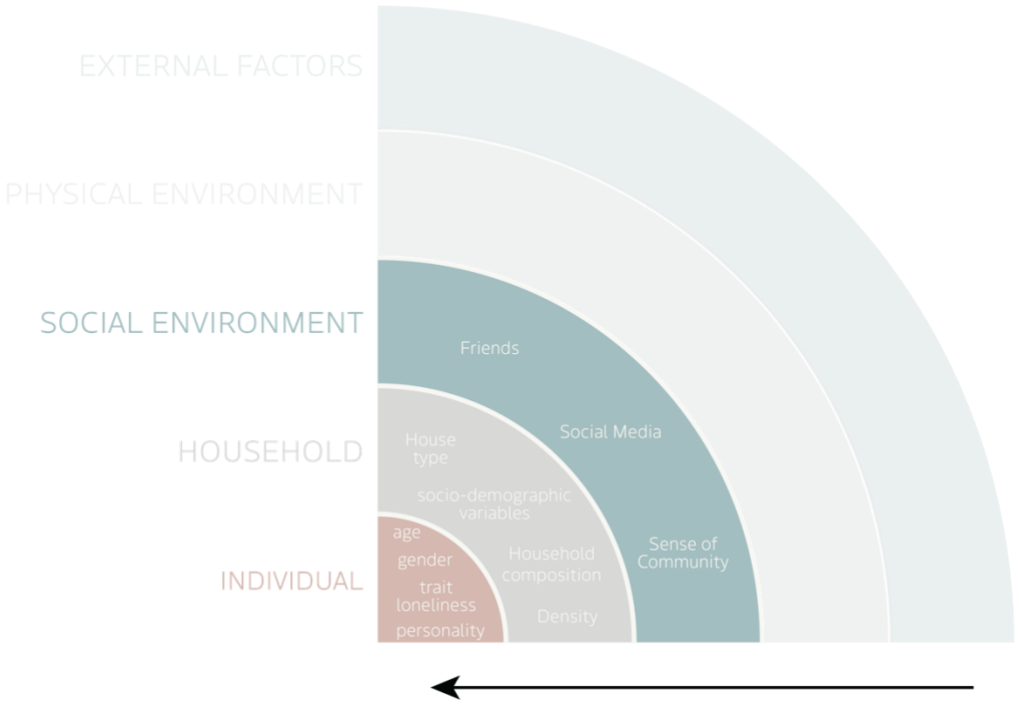


Figure 6: Social-Ecological Model Respondent Level

For the individual layer, trait loneliness seems to be of the most significant influence. Gender tends to make a difference as well, although it seems to have more influence on social loneliness than on emotional loneliness. The influence of personality traits is still in the middle, as the literature is still contradictive on the subject. It seems to have an influence on the feeling of social loneliness, but the influence on emotional loneliness is rather limited. As the target group for this research has limited age difference, no significant influence is expected from the age-variable.
For the household layer, the socio-demographic variables are deemed to be of most importance. Even though household composition has little research on the subject, it is one of the variables of interest, as there is no age group with as much variation in household composition as the young adults. House type is of importance; however, this is also correlated with the socio-demographic variables (if a household has financial problems, they are more likely to live in an apartment or smaller housing unit).
For the social environment, friends and sense of community seem to have the most influence on the emotional state loneliness. A healthy relationship with both friends and a sense of community can offer protection from isolation. Social media is an important variable for emotional loneliness, as prolonged used hinders the forming of intimate

connections. As both physical environment and external factors do not have a direct influence on the respondent-level model these remain empty.

3.3 Activity Setting-level model

The activity setting level investigates the momentary experience a person has because of several external variables. As the persons individual and household layer do not change each moment of the day, these are excluded from this model. The momentary experience will focus on the social environment, the physical environment and the external factors that influence the feeling of emotional state loneliness.

3.3.1 Social Environment

Company

In contrast to the amount and quality of friends one has, the company during the activities in a day may vary. The company surrounding the youth might have a significant influence on the loneliness. In research focussing on adolescents, it is measured that the participant felt significantly lonelier when being in the presence of their peers at school than when they were alone (van Roekel et al., 2015). Stating that “the presence of peers, especially in a forced location induces loneliness”. The type of feedback one gets from their company is also of importance to the momentary feeling of loneliness (Mote et al., 2020). Receiving feedback and rejection was related to an increase in state loneliness, whereas positive interaction was associated with less state loneliness.

Type of activity

A theory in literature stated that the type of activity a person partakes in, influences whether the experience has positive or negative effect on that person (van Roekel et al., 2015). This is possibly correlated with the company present during the activity. Having a high level of restriction in undertaking different activity types is related to higher levels of emotional loneliness (Dahlberg & Mckee, 2014).

3.3.2 Physical environment

As established in the previous chapter, the environment has an influence on a person and the feeling of loneliness. A well-perceived environment contributes significantly to "positive emotional state" (Weijs-Perrée et al., 2020). The activity of the experience might be influenced by the positive emotional state formed by the reaction on the perceived environment.

Familiarity with the environment

Previous knowledge or attachment to a place influences the momentary experience an individual has in them significantly (Birenboim, 2018). If, for example, a person had a traumatizing experience in a certain location, they are more likely to avoid the place altogether. "Place attachment" describes the bond an individual has with a meaningful setting. When positively correlated it has many benefits, increasing life satisfaction and well-being. A detachment from such an important place can have detrimental health and social

effects (Scannell & Gifford, 2017). A person's experience and relationship to the surrounding environment is strongly related to nature and their personal well-being (Raymond et al., 2010). Additionally, place attachment can create a feeling of freedom and control, which allows people to use an environment freely. This is connected to productivity, health, and general well-being (Scannell & Gifford, 2017). Therefore, it might be interesting to determine whether this will influence the feeling of loneliness as well.

Facilities

Most of the available research mentions that the presence, availability, and quality of the (community) facilities are a main determinant in the feeling of loneliness (Hsueh et al., 2022; Thompson & Kent, 2017; van den Berg et al., 2016; Weijs-Perrée et al., 2019). It is said that facilities accommodate the environments that promote social connection and therefore prevent alienation. The proximity of these facilities was especially important for those who experience loneliness with depression (Domènech-Abella et al., 2020).

Aesthetics

A field less researched is the different surrounding urban typology. The exterior characteristics could have an influence on the feeling of loneliness on youth, however this should be researched more in depth (Scharf & Jong Gierveld, 2008).

Greenery

A positive relation was found between the lowering of the level of loneliness and the presence of nature (Bower et al., 2023b; Hammoud et al., 2021). Especially the active engagement and interaction with the green spaces seem to have a positive effect (Hsueh et al., 2022). Having a natural environment present can help with attention restauration and mental health (Zijlema et al., 2017). The adding of green spaces is especially important when living in densely populated cities, as it also promotes social inclusion and reduces the feeling of overcrowding, both of which can influence the feeling of loneliness (Hammoud et al., 2021). On the exact amount of time spent in contact with nature, there is still some debate. One research states that the amount of time spent in nature is more important than the proximity (van den Berg et al., 2016). Another study states that the number of visits per week had no significant impact (van Houwelingen-Snippe et al., 2020).

Type of location

In the early 1920, biologist ecologist studied the relationship people have with their environment in a similar method as they would with other organisms. This later led to the theory about the influence of behaviour settings on human behaviour (Wicker et al., 1997). Behaviour settings is defined as "a bounded, self-regulated and ordered system composed of replaceable human and nonhuman components that interact in a synchronized fashion to carry out and ordered sequence of events called the setting program". Meaning that people

change behaviours and actions based on the environment directly surroundings. Therefore, the suitability of the type of location is of importance on the experience of that activity.

Type of transport

Good and especially safe transport within the built environment makes people more satisfied with their environment (Weijs-Perrée et al., 2020). Being satisfied with the environment has effect on the momentary well-being of a person. Since well-being is one of the most important predictors of both social as emotional loneliness, having access to safe transport might influence the feeling of loneliness (Dahlberg & Mckee, 2014). When the usability of the environment is perceived as safe, emotional loneliness tends to be lower (Domènech-Abella et al., 2020). Most of the research on loneliness focusses on the benefits of transportation on foot (Domènech-Abella et al., 2020; Lai et al., 2016; Weijs-Perrée et al., 2020). Especially for adolescents the walkability and public-transport network are important for an increased feeling of connectedness (Matthews et al., 2019). The results imply that walking itself decreases the annoyance people have with the public spaces. It can not only help with the feeling of loneliness, but it could reduce the feeling of depression in an individual as well (Kowitt et al., 2020). The transport types a person takes to reach an activity might influence their emotional state.

3.3.3 External environment

For the contextual variables there might be a connection with the feeling of loneliness, however the effect is less present than with other characteristics such as facilities or transport type (Weijs-Perrée et al., 2020). In contextual characteristics, items like air quality, noise pollution, cleanliness and even the time of day are defined. There might be a separate hierarchy between the contextual characteristics as well, as some results point to no reduction in the feeling of loneliness by for example air pollution or noise annoyance (Zijlema et al., 2017), whilst others, such as the time or day, have a larger influence on the social well-being of the participants (Weijs-Perrée et al., 2019).

Time

Loneliness can be influenced by the time of day. The human body relies on the presence of hormones, such as cortisol and melatonin, to function properly during the day. When the natural rhythm of the body is disrupted, the hormone levels change, which can result in mood-swings and increased loneliness (Legg et al., 2017). This disruption oftentimes takes place in the mornings, which is why it is called morning depression. Normally, the levels of cortisol stabilize during the day and simultaneously the increased loneliness and sadness dissipates in case of stressful events during the days, the level of cortisol might not be back to normal in the evening. The body cannot process cortisol while sleeping (Nilsson, 2006). Long-time exposure to high levels of cortisol can result in difficulties of the body to process

the hormone, with trait loneliness or possible depressions as a result. The time of the day might influence the feeling of loneliness.

Day

There is a correlation between the type of day and the type of activities that take place. Most people have a set activity pattern on weekdays, wherein mostly a higher level of loneliness takes place. In the weekends people tend to be less lonely as people can both choose their own company, as the type of activity they partake in (van Roekel et al., 2018).

Weather

Coldness is related with social exclusion. This is not only true as a figure of speech but also in practice. Cold weather can directly influence the experience of a social interaction (Zhong & Leonardelli, 2008). The physical coldness is said to make the experience of social rejection more intense. When the general temperatures are higher, it can 'compensate for the feelings of coldness after rejection'. Another factor of weather that is of importance is the amount of daylight. There is a connection between the lack of sunlight and winter depression, where people have heightened levels of loneliness and sadness during the winter months. The two factors warm weather and sunlight might be interlinked; this needs to be researched further.

3.3.4 Social-Ecological Model Overview

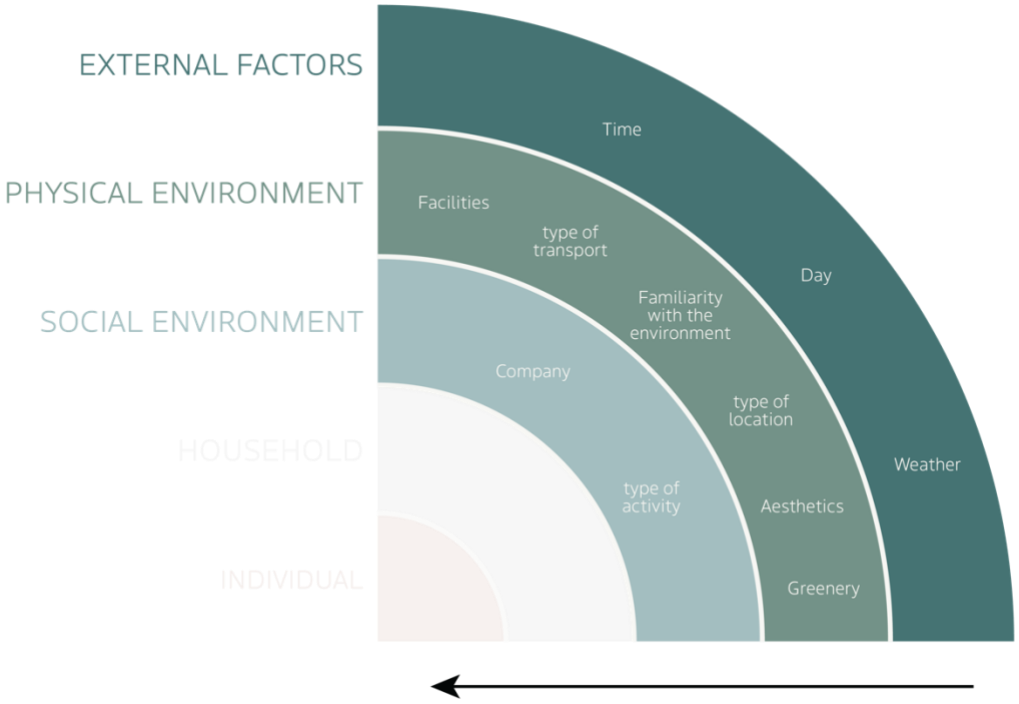


Figure 7: Social-Ecological Model Activity Setting

For the social-ecological model of the activity setting and the influence on emotional state loneliness, only three of the five proposed layers are in use. Both the individual layer and the household layer are not used in the momentary activity setting.
The social environment is composed of both the type of activity and the company a person is with. The company seems to be of more importance than the activity type. When a person is experiencing loneliness, they tend to feel lonelier participating in an activity with strangers or peers than doing the same activity alone.
For the physical environment, the type of location, perceived environment and transportation type could be of importance. The type of location should fit the activity type. The perceived environment and the transport type seem to influence the feeling of loneliness more. Furthermore, the familiarity of the environment is of importance; it might provoke earlier experienced emotions, influencing the emotional state of the individual.
The external factors can influence the activity setting as the feeling of loneliness greatly. The time of day can make some difference because of the shift in hormone levels; however, this might not be the case for everybody. The type of day influences both the activities that are undertaken as the company a person is with. The weather influences the way both activities and the companies are experienced on a social level.

3.4 Final Conceptual Model

According to literature, there are numerous factors that can influence a young adult's feeling of loneliness. These variables are divided in the separate layers of the social-ecological model.

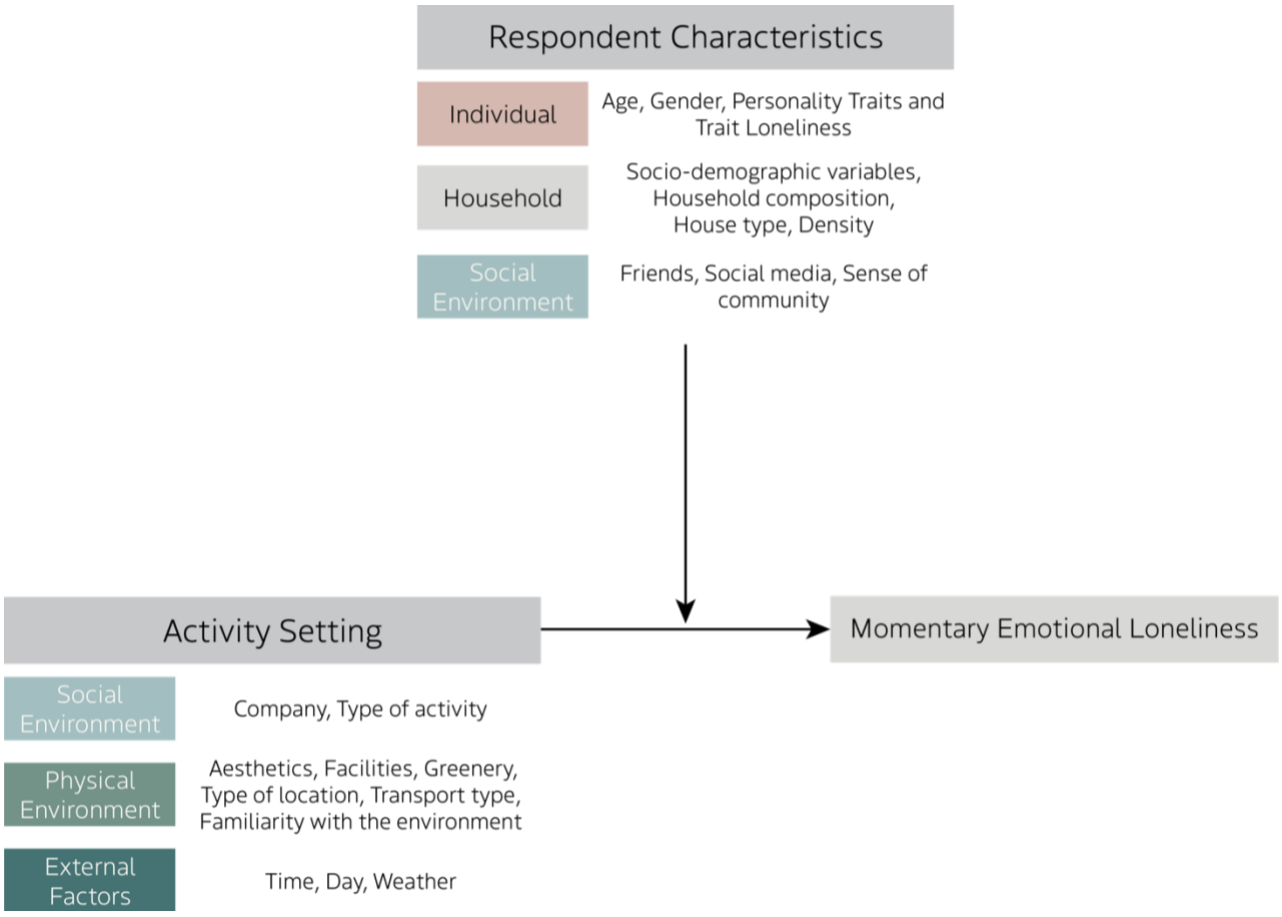


Figure 8: Conceptual model with variables in social-ecological layers

Both the social-ecological model of the respondent-level as of the activity setting are included in the conceptual model. The respondent-level focuses on the influences on the individual, whereas the activity settings focus more on the momentary influences of the daily activities a person participates in. The focus of the research is on the activity setting and the influence of the social and physical environment on the state emotional loneliness. However, the personal influences of the respondent cannot be taken out of the equation. Therefore, the respondent-level will mostly be used as control variables. The respondent-level variables can be seen as long-term variables, that do not change during the day. They might change over time, but this shift is more gradual and will most likely not chance in a week. The activity setting-level changes multiple times during a day, therefore changing the effect these variables have on the momentary feeling of emotional loneliness. Further steps will determine which of the variables are significant for the prediction of momentary emotional loneliness in young adults.

4.

Methodology

noun

a system of ways of doing, teaching,
or studying something

4. Methodology

In the methodology the results from the literature research and the social-ecological model will be used to form a set-up for the research. A literature study on the different measuring scales will be done to find out what works best for the different types of loneliness and other variables that are included in the research. Furthermore, a set-up of the questionnaire will be formulated, based on previous research. The chapter will conclude with an overview of the method of data collection.

4.1 Aim

The aim of the research is to find out which built environment variables influence the feeling of loneliness amongst young adults and in what way activity settings tend to mediate between the two. Since this is a subject not researched before, a combination of both a descriptive and exploratory research seems suitable. To gain insight in previous research on the variables which influence the feeling of loneliness for the target group, a literature study was conducted. As the aim is to test relationships between different variables, quantitative research with numeric data would be optimal.

As stated in the overview of the social ecological model, the research focuses on two aspects: the influence of the environment on the respondent level as on the activity settings level. The hypothesis is that both factors are of influence on the momentary feeling of emotional loneliness. Intending to measure the effect of these variables, it is of importance to know how to measure all the elements in the hypothesis. How is loneliness measured in the past? Is there a difference in the measuring between social and emotional loneliness? How is state loneliness measured? How can the influence of the activity setting be measured sufficiently?
When the types of measurement for the different variables are selected, the chosen data collection method will be researched and selected. After which the set-up of the questionnaire will be proposed and explained.

4.2 Research method

4.2.1 Measuring Loneliness

As loneliness has been a research subject for years, several systems have been developed as a means to establish the details of the loneliness researched. When evaluating what measurement approach is best it was stated that there was “no significant effect of the loneliness measurement used to evaluate loneliness on the success of the invention” (Eccles & Qualter, 2021). However, each of the systems is developed t0 measure different type of loneliness. The older systems might not take all types of loneliness into account as they were identified later.

The first scale developed was the UCLA (University of Carolina, Los Angeles) scale in the 1970s. It is a 20-item scale that lets the user rate their items in either “O (“I often feel this way), S (“I sometimes feel this way”), R (“I rarely feel this way”) or N (“I never feel this way”) (Russel et al., 1978). The measurement approach was revised twice, both in 1980 as in 1996, to remove the possible response bias and to add a ‘global bipolar loneliness factor’. Downside of this method is that the UCLA scale does not recognize the different types of loneliness. It only focuses on loneliness in general. This results in a one-sided view of loneliness which is not suitable for this research type.

As a response to the UCLA scale, the de Jong Gierveld scale was developed. This scale is a multi-dimensional tool that recognises overall, emotional, and social loneliness (de Jong Gierveld & van Tilburg, 2006). The original version of this scale existed of 11 different questions. To remove a bias in the phrasing of the questions, the eleven questions were divided into five positively framed questions and six negatively framed questions (de Jong Gierveld et al., 2006) Even though the scale was developed on the social and emotional loneliness, the questions have substantial overlap; it can use as a unidimensional tool. Later, a six-item scale was introduced and tested as a shorter and more user-friendly version of the 11-item scale.

In the research of van Tilburg (2021) they looked at the relation between social loneliness, emotional loneliness, and existential loneliness. The measurement system used in their research was a combination of the de Jong Gierveld (DJG) and the existential loneliness questionnaire (ELQ) To measure the different types of loneliness, five direct questions about loneliness and about 6 questions per loneliness 'type' were asked. From the results of their research, several things about the questionnaire styles were shown to be relevant. Firstly, for both the social and emotional loneliness, the highest correlation was found in the high item-factors. Meaning that a question with the five-factor scale worked best to give insight in the state of loneliness of the participants. Secondly, for measuring emotional loneliness specifically, the direct questions work well.

Another multidimensional tool that is used in loneliness research is SELSA, Social and Emotional Loneliness Scale for Adults (Pollet et al., 2018). SELSA is a 15-item scale that consist out of three different sub-sections. The sub-sections focus on family relations, romantic relations, and social relations. This tool is tested and shows to be just and valid for emotional and social loneliness (de Jong Gierveld & van Tilburg, 2006). In contrast to the de Jong Gierveld scale, the subsections of SELSA are best used separately rather than as one, which is a possibility with the DJG tool.

The research of Mote et al. (2020) tries to evaluate the influences of state and trait loneliness. In order to check the trait loneliness, they used the UCLA-LS scale and by

implementing EMA (ecological momentary assessment) they tried to assess the influence of state loneliness. The research states that there are several questions which have a high correlation with trait loneliness. Questions indicating the amount of interaction someone has with other people in general and feeling connected to others tend to be indicators of higher levels of trait loneliness. In state loneliness, on the other hand, the percentage of being alone at that time and the interactions with other people were deemed to be of more importance.

As this research takes four different types of loneliness into account, different methods should be mixed. Using a unidimensional loneliness tool, will not give the distinction between the types of loneliness necessary to answer the research question. A multi-dimensional loneliness tool is needed since the other tools do not distinguish a difference between social and emotional loneliness. As there is very little research on how to measure trait versus state loneliness, the method of Mote et al. (2020) seems the best option to adapt. To measure trait loneliness, a baseline loneliness scale should be used. However, Mote et al. use UCLA, which is a unidimensional tool that does not recognise emotional and social loneliness. Therefore, a DJG (de Jong Gierveld) or SELSA tool is more appropriate. The preference goes to the DJG tool, as in this research family and romantic relations are not researched specifically. For the research on trait loneliness, the 6-item DJG tool will be used. In research on momentary loneliness, the focus is on emotional loneliness. In the research of van Tilburg, they mention the importance of the direct questions, on a five-factor scale, when working with emotional loneliness. Additional to the direct questions, the questions that were associated with state loneliness from the research of Mote et al. (2020) will be included.

4.2.2 Experience Sampling Method

The aim of the study is to find the influence of the social and physical environment on state emotional loneliness. As state loneliness tends to differ from time to time, it is important to get a large scope of the effects different locations have on a single person. A way to research a person for a longer period with several intervals, is conducting a longitudinal study (Caruana et al., 2015). Longitudinal study methods are beneficial for examining "thoughts, feeling, physiology, and behaviour in their natural, spontaneous contexts" (Bolger & Laurenceau, 2013).

Within the field of longitudinal studies, the experience sampling method is recognised. Experience Sampling Method or ESM for short, is "an ecologically valid method that yields a comprehensive view of an individual's daily life" (Verhagen et al., 2016). The ESM stems from psychology, where the idea was that studying people in their natural space was more insightful in understanding what drives daily behaviour (Csikszentmihalyi & Larson, 2014). Self-reported diary techniques were proven to be a reliable source for investigating a

person's live. In combination with the increase of new technology and a newfound interest in subjective experience, the Experience Sampling Method was developed over time. By implementing "near real-time online surveys" and other new technologies, the research on momentary experiences is said to be more effective than ever (Birenboim, 2018).

Currently, most ESM studies are conducted by using an application on a smartphone. Prompts are sent to the participant at one or multiple times a day to fill in the questionnaire (Mote et al., 2020). Even though there is a lot of flexibility and insightfulness with this method, there are some downsides. For example, there can still be some struggle with internal validity of the gathered data (Birenboim, 2018).

4.2.3 Data processing types

When using a type of longitudinal study, there are several types of statistical testing that are commonly used. The univariate (ANOVA) and multivariate (MANOVA) analyses are used the most (Caruana et al., 2015). Both analysis methods have the assumption that there is a normal distribution amongst the participants and that the research length is equal.
Other types are mixed effect regression model (MRM) and generalised estimating equation (GEE).

Both ANOVA (Analysis of Variance) and MANOVA (Multivariate ANOVA) fall under linear models (Gibbons et al., 2010). ANOVA, or Analysis of Variance, is used to compare different groups to one dependent attribute, assuming that the variables are equal in time. MANOVA is similar as ANOVA but can include the attributes across time. A disadvantage of this method is that it looks at the data as a whole and does not consider the individual cluster. In this case, both ANOVA and MANOVA are not preferred as there are problems with the assumptions. All data must be normally distributed and complete, additionally these methods do not support "analysis of covariates that change over time". (Columbia School of Public Health, n.d.)

Other types are Mixed effect logistic Regression Model (MRM) and Generalised Estimating Equation (GEE).

The MRM is used when data is clustered or when it contains both fixed and random effect (UCLA: Statistical Consulting Group, 2021). Advantages of the MRM are that they are relatively robust. Irregularity or missing data are less of a problem than in other models. Disadvantages are that these types of models are mode difficult to compute (Gibbons et al., 2010).

The GEE and was said to be thought of "as an extension of generalized linear models (GLM) to longitudinal data" (Columbia School of Public Health, n.d.). GEE models apply an average

response instead of a person-specific system. The GEE models are easy to work with, however, there is some difficulty with missing data. When data is missing, GEE will fill it in randomly, instead of related to the found measurements. This might influence the final data (Gibbons et al., 2010).

The largest difference between GEE and MRM is that “mixed-effects models are full-likelihood methods and GEE models are partial-likelihood methods” (Gibbons et al., 2010). Even though the partial-likelihood methods are easier in use, it assumes a complete dataset, which in research concerning people is not realistic. Additionally, since GEE looks at averages instead of personal clusters, there is no understanding of the person-specific effects. An understanding in these person-specific effects could give more insight in specifics for the different sub-groups.

For this research type, MRM is the preferred model for processing of the obtained data, which is in line with the methodology of similar research, such as Mote et al., (2020), Verhagen et al., (2016) and Birenboim, (2018). MRM is available in multiple statistical analysis packages, such as R and SPSS (Verhagen et al., 2016).

4.3 MRM Method

The method theory is included to provide a basic understanding of the mixed models or MRM used in this research. As mixed models themselves are complex, this explanation has been simplified.

Linear Regressions

To understand the working of the mixed models, it is important to understand a standard linear regression, as a mixed model stems from linear regressions throughout different clusters. A basic linear regression starts as follows:

$$y = \beta \cdot X + \varepsilon \qquad (1)$$

In which:
y = the outcome variable or vector
X = the independent variable
β = the parameter to be determined
ε = the error term

In linear regression it is assumed that the error term is normally distributed as follows.

$$\varepsilon \sim N\,(0, \sigma) \qquad (2)$$

In which:
ε = the error term
σ = standard deviation
As the linear regression assumes that it is normally distributed, the mean is 0 in this equation.

In a dataset with an independent error term, a linear regression could have applied (VPPK, 2017). However, when collecting data from the same person over several points in time, there will be dependence in the data. Therefore, the model is not valid for this dataset. To solve that problem, the mixed models were created. By filtering the data per 'cluster', the error term is individual once again. This allows for the performing of separate linear regressions.

Random Effects

In linear regression, it is assumed that the data are random variables, however the parameters are fixed effects (UCLA: Statistical Consulting Group, n.d.). There are different layers in a mixed model. The first or highest layer, is the total data layer. The second level is a lower level, looking at the clusters specific. In mixed models at the lower level, the data regards different clusters with random regression coefficients, therefore these are not fixed and are a random variable themselves. This results in the following formula:

$$\beta \sim N(\mu, \sigma) \qquad (3)$$

In which:

β = regression coefficient
μ = the mean
σ = standard deviation

In the random effects, it is assumed that the regression coefficient is random on the second level, the lower level, however on the higher level the 'total' is fixed.

Theory of Linear Mixed Models

The basic theory of MRM assumes that there is a linear regression per 'cluster' in the data. In this example, the outcome variable of person i in cluster j. As this is the 'overview' equation this is the first, or higher level, of the mixed model.

$$y_{ij} = \beta_{0j} + \beta_{1j} \cdot X_i + \varepsilon_{ij} \qquad (4)$$

In which
y_{ij} = the outcome variable per person i in cluster j
β_{0j} = intercept parameter
β_{1j} = slope parameter
X_i = independent variable for person i
ε_{ij} = error term per person i in cluster j

Per cluster of data, the linear regression contains an intercept and a slope. Mixed models can contain both fixed and random effects. In which a fixed effect is a parameter that is set or unvarying (UCLA: Statistical Consulting Group, n.d.). There is a possibility of fixing both the intercept and the slope, if it makes sense in that dataset, but commonly both are allowed to vary per cluster. In this example, it is assumed that both the intercept and the slope are random. For the intercept parameter, this would result in equation 5. As these changes vary on a cluster-level, these are denoted on the 'lower level' of the total model.

$$\beta_{0j} = \gamma_{00} + u_{0j} \qquad (5)$$

In which:
β_{0j} = the intercept parameter of cluster j
γ_{00} = the total intercept
u_{0j}= cluster j's deviation from the total intercept

If the data would not have been clustered, the total intercept would have a different value and be biased. Therefore, by calculating per cluster what the intercept is and then deriving the average of these intercepts, is the 'total intercept' or γ_{00}. One of the benefits of using MRM is the attention to the individual clusters that it provides, therefore the deviation from the total intercept is considered in this equation. As in this example it is assumed that both the intercept and the slopes are random, the same can be done for the slopes, seen in equation 6.

$$\beta_{1j} = \gamma_{10} + u_{1j} \qquad (6)$$

In which:
β_{1j} = the slope parameter of cluster j
γ_{10} = the total slope
u_{1j} = cluster j's deviation from the total slope

The slope parameter and the clusters deviation from the total slope are shown in equation 5. The principle is similar as for the intercepts; however, these are specifically linked to the independent variable used in the equation. An overview of the equations 4, 5 and 6 with their coherent levels would look as follows:

L1: $y_{ij} = \beta_{0j} + \beta_{1j} \cdot X1_i + \beta_{2j} \cdot X2_i + \varepsilon_{ij}$
L2: $\beta_{0j} = \gamma_{00} + u_{0j}$
L2: $\beta_{1j} = \gamma_{10} + u_{1j}$
L2: $\beta_{2j} = \gamma_{20} + u_{2j}$

When combining all the levels 2 into the level 1, the total mixed model equation can be derived.

$$y_{ij} = (\gamma_{00} + u_{0j}) + (\gamma_{10} + u_{1j}) \cdot X1_i + (\gamma_{20} + u_{2j}) \cdot X2_i + \varepsilon_{ij} \quad (7)$$

In which
y_{ij} = the outcome variable per person i in cluster j
γ_{00}= the total intercept
u_{0j} = cluster j's deviation from the total intercept
γ_{10} = the total slope
u_{1j} = cluster j's deviation from the total slope
X_i = independent variable from person I
ε_{ij} = error term per person i in cluster j

4.4 Attributes

In the current model, the independent attributes are separated into two different categories, as defined in the basic conceptual model.

The respondent-level attributes are identified in three different layers. For the individual layer, age and gender will be requested. The household layer will investigate the socio-demographic variables, household composition and living situation. The Social environment contains the network of friends, social media use and the sense of community.

The activity setting is equally divided into three layers. The first being social environment, which looks at the momentary company and activity type. The physical environment contains a person's direct environment with their type of location and location attributes. Lastly the external factors are viewed, in which weather and type of day are considered.

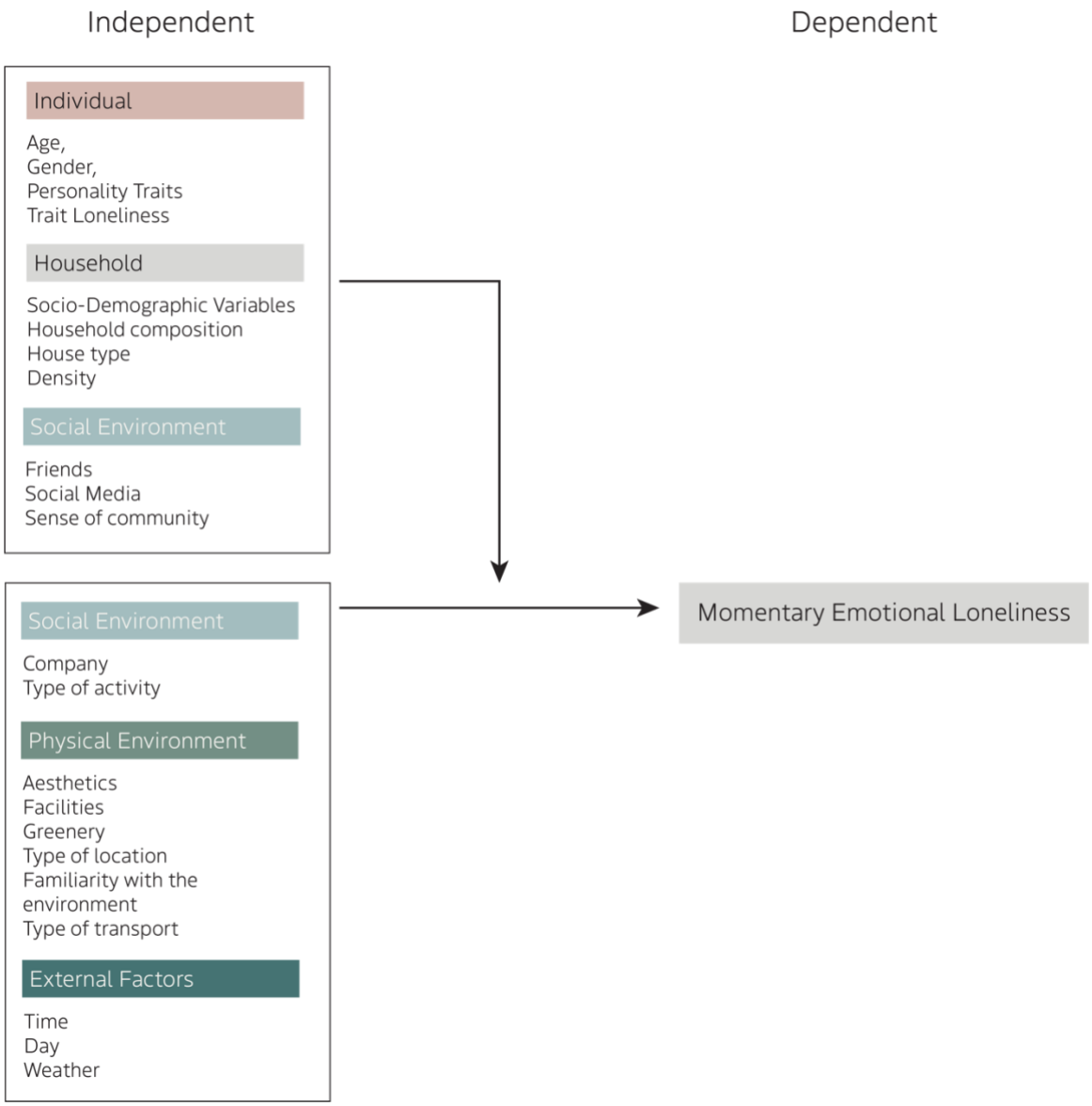


Figure 9: Basic conceptual model depicting the independent and dependent attributes.

4.5 Operationalisation

The operationalisation of attributes is the process of determining how these variables can be measured. It is important to define this in advance as it values the reliability of the produced results (McLeod, 2019).

4.5.1 Independent: Baseline survey

For the questionnaire presented to the participants, first a baseline survey will be given. This will give insight in the effect of a person's general well-being as an effect on the loneliness in the built environment. The survey will give insight in the respondent-layer variables according to the social-ecological model from the last chapter. It contains personal statistics as age and personality traits, socio-demographical information, household composition and social media use.

Individual layer

The individual layer is part of the baseline questionnaire. It will start with asking people for their ***age*** and ***gender***. Since the focus group of this study is young adults, the responded age are screener questions, on whether a person can participate in the survey. *Personality traits* that are related to feelings of loneliness are neuroticism and extraversion, two of the 'big five' of personality traits (Wang & Dong, 2018). To get insight in the level of both neuroticism and extraversion a participant has, three questions oftentimes used in the mini IPIP test are asked (Donnellan et al., 2006). This can lead to either a low or high level of both personality traits. For both traits, higher levels are associated with high levels of the feeling of loneliness. The 5-item Likert scale is used to answer the questions. As discussed in the previous chapter, for ***trait loneliness*** the 6-item De Jong Gierveld scale will be included. Since this research was made for long-term loneliness rather than short-term loneliness, it is suitable to use for trait loneliness. For the scoring, both emotional and social loneliness are used, as trait loneliness on itself does not distinguish the two.

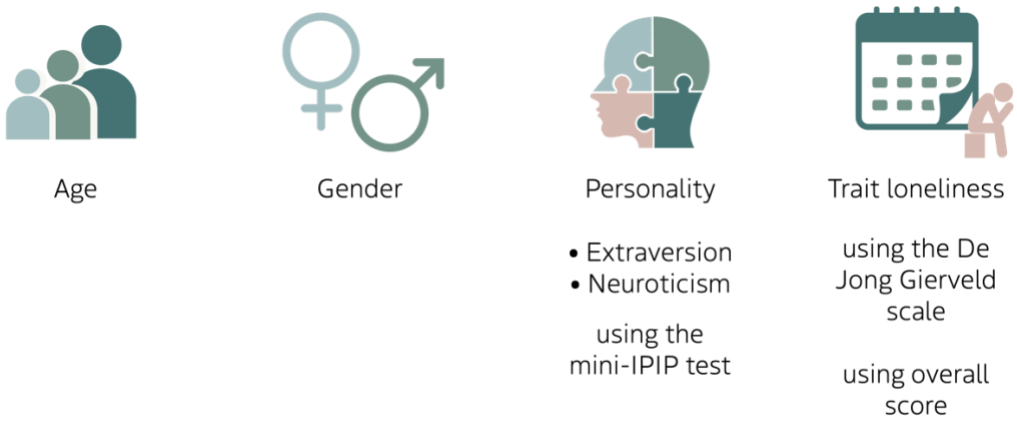


Figure 10: Individual operationalisation

Household layer

The second layer of variables is the household layer, which is part of the baseline questionnaire. All participants will be asked to provide *socio-demographic* information. This exists out of the study and work time, the achieved level of education, nationality, and partner status. The time a person spends in a day on study and work are divided in parttime (Douwes, 2020) and fulltime hours (Indeed, 2022). Achieved level of education is of importance as lower educated people tend to suffer more from loneliness than their higher educated peers (Informatie Volksgezondheid en Zorg, 2023). Partner status investigates the romantic relationships a person has, as this decreases the feeling of emotional loneliness, especially amongst men (Reed & Bohr, 2021).

For *household composition*, both the type of relation with the participants household members and the number of members. Household relations can be living with parents/family, living with friends, living with acquaintances, or living on one's own. Additionally, the *house type* of a person is requested. This question contains answers as row house, apartment/studio, student room (shared facilities), or a (semi-)detached house. Lastly, the *urban density* needs to be considered. Even though some research suggests that there is no difference between rural and urban area (Finlay et al., 2020), this should be used as a control variable.

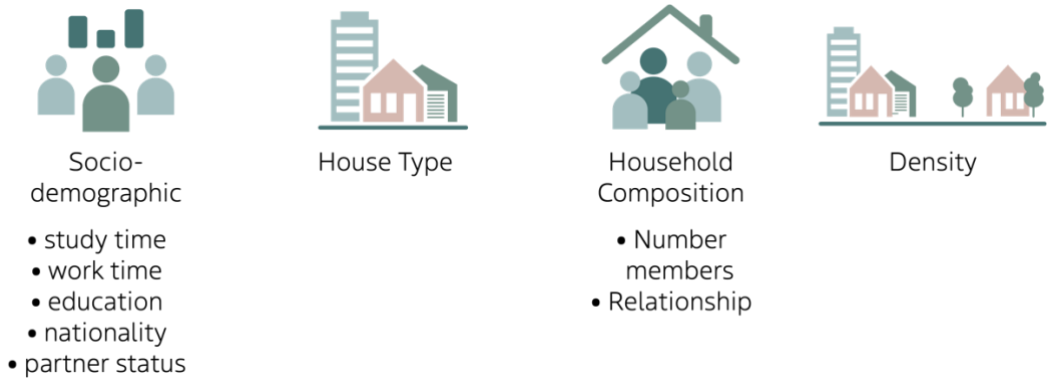


Figure 11: Household operationalisation

Social environment

For the baseline questionnaire, the first attribute is *friends*. For friends the social loneliness part of the De Jong Gierveld scale is of interest. Therein, the trust and bond one has for their friend group is tested. Secondly, the participants are requested to give insight in their *social media* use. The types of social media used will be asked and the total amount of time spent using these applications. Common social media applications as WhatsApp, Facebook and Instagram are among the examples, and since the focus group are young adults, applications as TikTok and BeReal are added, as these are popular amongst the younger crowd. Lastly the *sense of community* is tested. Commonly the sense of community is split up into four different categories, namely: support, safety, activity, and friendships within the neighbourhood (Chipuer et al., 1999). The subjective feeling of support, both social and

emotional, is deemed most important of these interactions (Reed & Bohr, 2021). The participants will be asked to comment on the following statements:

- Everybody is willing to help each other in my neighborhood.
- There are fights in my neighborhood.
- There is not much to do in my neighborhood.
- When I want, I can find someone to talk to in my neighborhood.

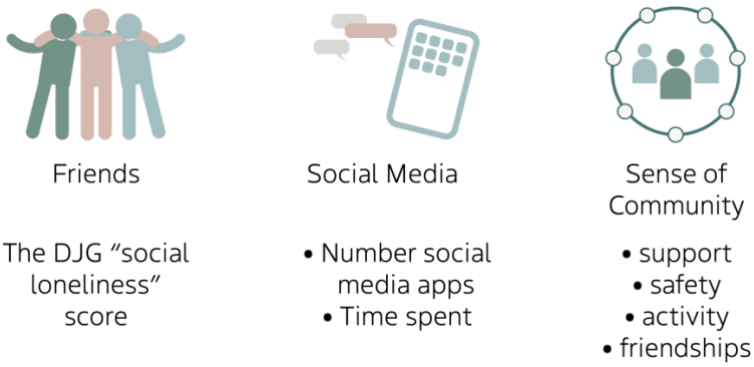


Figure 12: Social Environment operationalisation

Concluding, the previous chapter. The independent attributes of the baseline survey are as follows:

Individual	Household	Social Environment
Age	study time	social loneliness
Gender	work time	type of social media used
neuroticism	education	amount time spent
extraversion	nationality	community support
trait loneliness	partner	community safety
	living environment	community activity
	living situation	community friendships
	household members	
	house type	

4.5.2 Independent: Momentary Survey

The momentary survey is the survey that is used in the experience sampling method. It is a shorter questionnaire, about two minutes, which will be asked to be filled in 1 to 2 times a day at different times. In the momentary survey, the focus is on the outer three layers of the social-ecological model: the social and physical environment and the external factors. The participants are asked to describe their activity setting and their momentary feeling of loneliness.

Social environment

For the momentary questionnaire, the ***type of activity*** a participant is joining is, is asked. Activity types can differ from studying, sporting, working, eating, relaxing, having a social gathering, chores, or other various activities. These activities are loosely based on the work of Birenboim (2018). Secondly the ***company*** a person is with is requested. The options the person is presented with vary from friends, family, peer/co-workers, strangers, being alone or with another type of relationship.

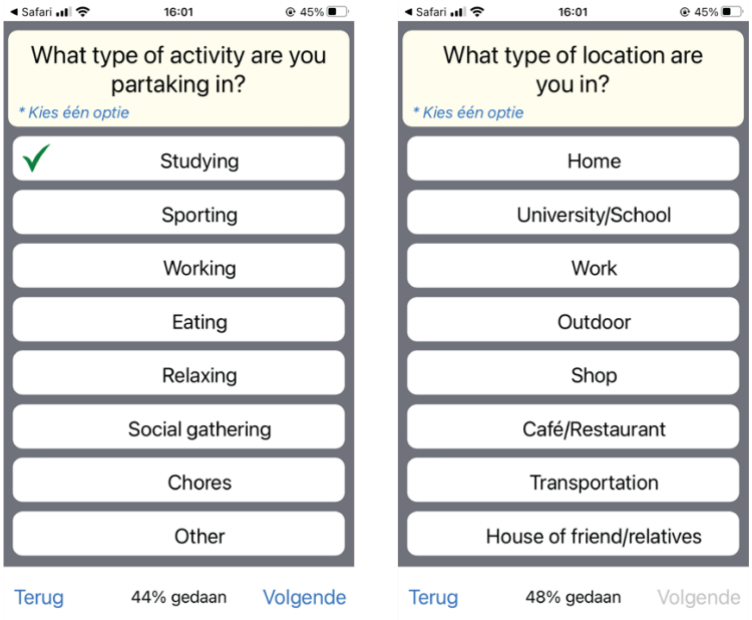


Figure 13: Example PIEL-survey question

Figure 14: Social Environment operationalisation

Physical Environment

The physical environment is divided into aesthetics, greenery, type of location, familiarity with the location and transport type. The *type of location* a participant, is based on the research of Birenboim (2018). The participant is asked to choose out of the following locations: home, university/school, work, open space, shop, café/restaurant, transportation, house of a friend or relative, culture or sports venue or another venue. For the *familiarity with the environment*, the participant will be asked whether they are familiar with the environment on a five-item scale. The *transport type* refers to the way the participant got the location. This can be on foot, by bike, public transport, by car or another method.
For the *aesthetics and greenery*, an adjusted version of Weijs-Perrée et al. (2019) is used. This includes a list of factors, such as: aesthetic quality, atmosphere, smell accessibility, traffic safety, natural elements, noise, cleanliness, and the maintenance of the space. In this version, both the diversity in activities of that location and social safety are added.

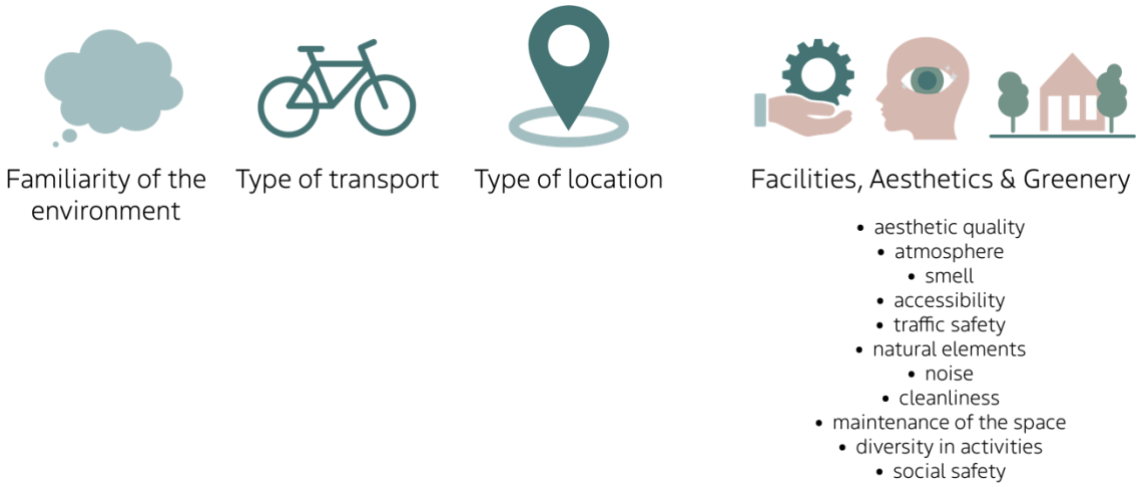


Figure 15: Physical Environment operationalisation

Contextual Factors

For the contextual factors layer, both *time* and *day* will be automatically collected by the chosen software. For *weather*, most of the information can be collected by the KNMI database. From this source, the temperature and the cloud cover will be used, as both are supported in literature.

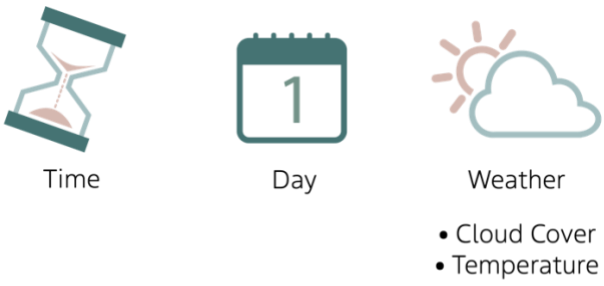


Figure 16: Contextual Factors Operationalisation

Combination of the previous layers result in the following list of independent attributes.

Social Environment	Physical environment	Contextual Factors
company	type of location	time
type of activity	familiarity with location	temperature
	transport	Cloud cover
	aesthetic quality	
	atmosphere	
	smell	
	accessibility	
	diversity in activities	
	social safety	
	traffic safety	
	natural elements	
	noise	
	cleanliness	

4.5.3 Dependent

Momentary Emotional Loneliness

For the dependent attributes, only the momentary emotional loneliness needs to be evaluated. For the momentary survey, firstly the daily mood will be examined. To select the type of emotions a person is going through in that moment; the model of basic emotions is used (Gu et al., 2019). This model identifies four basic emotions on the arousal and hedonic parameters: fear, anger, sadness, and joy. The levels of comfort and relaxation are added as well to gain further insight of the persons state of mind.

Emotional state loneliness is measured by using the emotional loneliness questions from the 6-item De Jong Gierveld scale. These questions have been adjusted to fit the 'present time'. As with the previous DJG tool, all answers are given on a 5-item Likert scale. The statements the participants must answer are the following:

- I experience a sense of emptiness.
- I miss having people around me.
- I feel rejected.

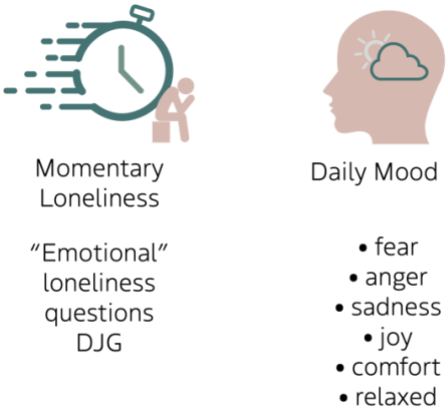


Figure 17: Momentary loneliness operationalisation

This results in the following list of dependent attributes.

Emotional Momentary Loneliness
daily mood
emotional state
loneliness

4.6 Conclusion

In this chapter, the methodology was described. To measure the type of loneliness researched, the De Jong Gierveld scale is used. The DJG scale covers both levels of social and emotional loneliness. Even though it makes no distinction between state or trait loneliness, it is deemed the best suitable for this research purpose. For the research type, Experience Sampling Method, using PIELsurvey is chosen. Experience sampling method allows for real-time reactions and feelings in an actual setting, which could provide for more realistic data. To analyse the data, MRM, or mixed models, are used. This will be done in R. Furthermore, all the independent and dependent variables were reviewed for measurability in the survey. For the respondent-level variables, the baseline survey was set up. This one-time 10-minute survey provides insight in a person's background. The individual, household and social environment layer are used in this survey.

The second survey is the momentary survey. This two-minute survey will take place twice a day at different times throughout the week. The survey are prompted twice at varying times between 9:00 o'clock in the morning and 22:00 o'clock at night. The momentary survey contains the social environment, physical environment, and external factors. The complete survey questions and survey code can be found in appendices A, B and C.

The following chapter will explain the data collection, data description and the processing of the obtained data.

5.

Data

noun

information, especially facts or numbers,
collected to be examined and considered
and used to help decision-making,
or information in an electronic form that can be
stored and used by a computer

5. Data

This chapter contains the collection, description and first processing steps of the research data. Firstly, the steps for collection will be explained. Afterwards, the data sample gathered will be described. This is divided in two different parts: part one is about the basic characteristics and the second part about the perceived levels of loneliness and its comparison to the national numbers. Lastly, the steps taken in R to come to the most reliable model are explained.

5.1 Data collection

The data is collected by implementing the experience sampling method for a week-long survey in the PIEL-survey application. The surveys have been filled in between April and May 2023. The distribution for the surveys was mainly throughout student networks and social media. As the target group is between the ages of 18 and 25, other people were excluded from the project. After reading the consent form and the instructions, participants were required to download the PIEL-survey application and import the survey file. The survey-file would, when activated, run automatically, and prompt the participant twice a day for a week. The momentary surveys would take approximately 1 to 2 minutes to complete. For each of the surveys, a period of an hour was set for the participants to open the survey. Upon finishing the survey, the participants were requested to send their results to the researcher. A total of 43 participants completed the week of surveys, resulting in 393 different data points. A description of the data set will be given in the next chapter and a complete overview can be found in appendix D.

5.2 Sample description

This section gives insight in the gathered data. The data is divided into the five different social-ecological layers. Lastly, the levels of loneliness in the sample will be compared to the national levels of loneliness, to check the significance.

5.2.1 Baseline

Individual Layer

The dataset of 43 participants can be analysed according to the baseline information the participants provided at the start of the survey. The ‘set’ age range for young adults was 18 to 25 years of age. Within the participant sample this distribution was equally distributed, except for 18- and 25-year-olds, both of which had no participants. The lack of 18-year-old participants may be due to the participants who started their studies at the beginning of the year, have turned 19 by the time this research was conducted.

Most of the participants were male. As the research was conducted in and around the city of Eindhoven, this is reasonable as it mirrors the general population of the city.

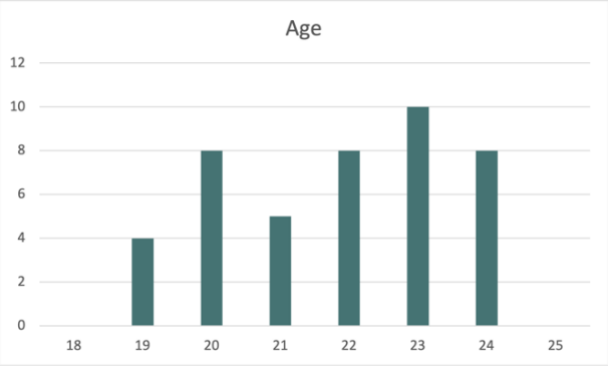


Figure 18: Age distribution participants

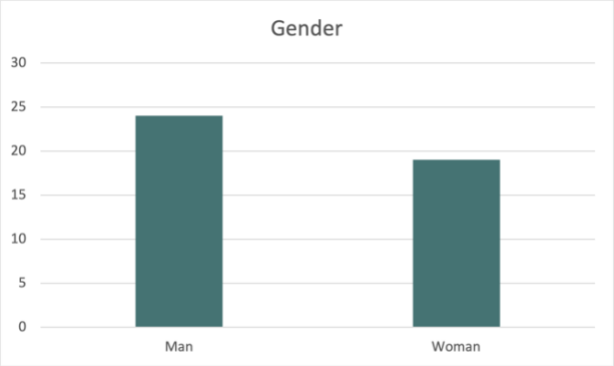


Figure 19: Gender distribution participants

In addition to a participants' age and gender, their personality type was tested. Both the neuroticism and extraversion were of interest. The levels of neuroticism were equally divided; however, it is slightly on the higher side. The extraversion levels are rather high, with one exemption. High levels could be explained because most of the participants stated to be socially active and are in the age range where a person values social contact most.

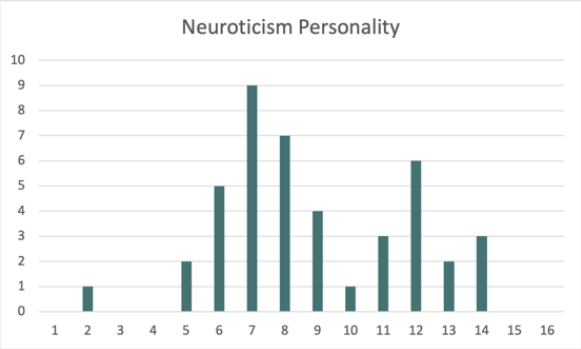


Figure 20: Neuroticism levels participants

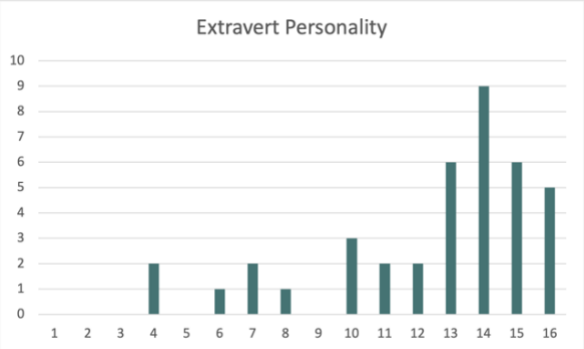


Figure 21: Extravert levels participants

The trait loneliness numbers gathered in the baseline survey are divided in social and emotional trait loneliness scores. The national scores are measured in the UCLA system, whereas the score in this research were measured in De Jong Gierveld (CBS, 2022). In the national system, the obtained scores were divided in three categories: 'not lonely', 'slightly lonely' and 'severely lonely'. When comparing the overall loneliness scores to the national number in the same age category, there is a significantly higher amount of 'slightly lonely' score. In the 'severely lonely' category, however, there is nationally a larger number of people. On social and emotional loneliness, there are only numbers for the severely lonely category. Even though this dataset does not contain numbers as high as the national sample, there is a similarity in which type of loneliness scores higher. Both national and in the dataset, social loneliness has a larger amount of people with high scores compared to emotional loneliness.

Trait Loneliness		N in sample	% in sample	% in NL
Overall Loneliness				
	Not lonely (1-4)	4	9.3%	55%
	Slightly lonely (5-16)	38	88.4%	33.60%
	Severely lonely (17-24)	1	2.3%	11.40%
Social Loneliness				
	Not lonely (1-2)	0	0.0%	N.A.
	Slightly lonely (3-8)	41	95.3%	N.A.
	Severely lonely (9-12)	2	4.7%	10.10%
Emotional Loneliness				
	Not lonely (1-2)	7	16.3%	N.A.
	Slightly lonely (3-8)	36	83.7%	N.A.
	Severely lonely (9-12)	0	0.0%	8.20%

Table 1: Trait emotional and social loneliness: dataset and national numbers

In comparison to the national numbers, the data sample does not showcase the same numbers as the national sample. However, this is to be expected as the sample size is small, and the data shows a bias towards high-educated students in and around the city of Eindhoven. Nevertheless, as the participants in the dataset do showcase varying levels of the feeling of loneliness, the sample will be used to find out more of the relation between the environmental factors on their daily emotional loneliness.

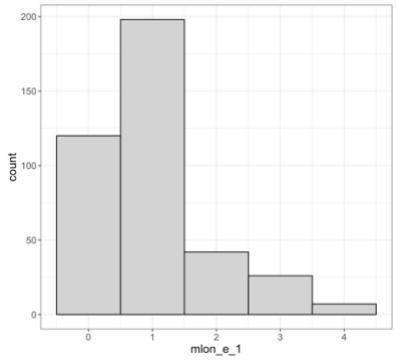


Figure 22: momentary emotional loneliness question 1

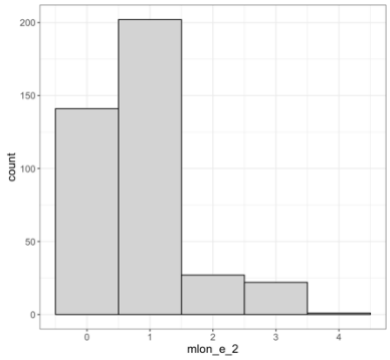


Figure 23: momentary emotional loneliness question 2

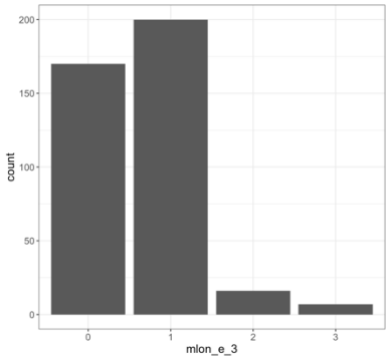


Figure 24: momentary emotional loneliness question 3

For the dependent variable momentary emotional loneliness measured, most of the values are low in loneliness, as can be seen in Figures 22-24. The distribution of loneliness scores is similar in all three of the questions. When executing a Cronbach's alpha test, this resulted in a value of 0.7088646. As the value is over the 0.7 value, this suggests a good internal consistency reliability.

Household Layer

Within the household layer, the socio-demographic factors, number of household members, house type, living situation and the living environment are considered. In the socio-demographic factors described in table 1, it stands out that most of the participants are part- or full-time students. Only four of the 43 do not study at the time of filling in the survey. For work time, almost a quarter does not work. Combining the study and work time, this would implicate that some of the participate work overtime, with more than 40 hours in both their study and work time. The reason for high work time levels in combination with high study time levels could be explained by the current Dutch education system changing. At the moment of completing this survey, there is an upcoming switch in financial support for the students, changing from a loan-based system to a grants-based system. It is plausible that some of the participants work next to their study to compensate for this transition. Completed education levels are mostly composed out of secondary education and university degree levels. This could be explained by the fact that the survey is primary executed in the city of Eindhoven, where a lot of people under the 25-year-of-age are still working on their HBO or university level bachelor. Therefore, the amount of secondary education is high. This could have influence on the results as people with a lower education seemed to be lonelier according to literature research.

Socio-demographic factors		N in sample	% in sample
Study time			
	0 hours	4	9.3%
	0-24 hours	13	30.2%
	25-40 hours	22	51.2%
	40+ hours	4	9.3%
Work time			
	0 hours	11	25.6%
	0-24 hours	23	53.5%
	25-40 hours	4	9.3%
	40+ hours	5	11.6%
Education			
	Secondary education	19	44.2%
	MBO	1	2.3%
	HBO	2	4.7%
	University degree	21	48.8%
	Other	0	0.0%
Ethnical background			
	Native Dutch	43	100.0%
	Western foreign	0	0.0%
	Non-Western foreign	0	0.0%
Partner			
	Yes	15	34.9%

	No	28	65.1%

Table 2: Sample description: Socio-demographic variables

On ethnical background, all the participants were native Dutch. Because it is unanimous, this variable was removed from the dataset. The amount of people with a partner was about 35%. It is difficult to derive conclusions on this number based on the national amount of partner in this age group, as it varies a large amount per age. Commonly, the older the people in the Netherlands get, their chances of having a partner increase. Considering that there are no 25-year-olds in this dataset, this number could be accurate.

Most of the participants are living in a student room with shared facilities or in an apartment or studio. Considering that most of the participants said to be students, this could be explained. No participants are living in a semi-detached or detached home, therefore these will be removed from the dataset, as these will not provide results when performing the analysis. For the living environment, most participants are living in the Urban Central or Suburban area. No participants said to live in village central or rural areas. As most of the research has been conducted in the city of Eindhoven, this number could be explained. The city of Eindhoven is an urban-focused city with several sub-urban areas.

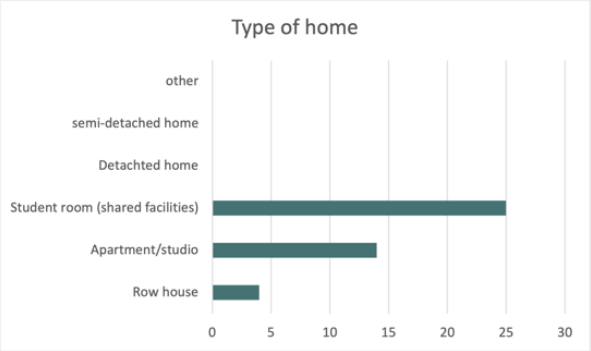


Figure 25: Type of home participants

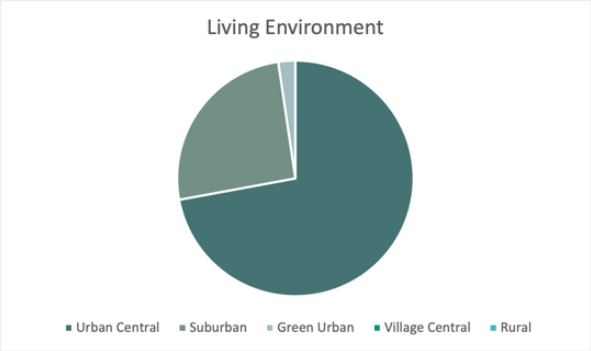


Figure 26: Living environments participants

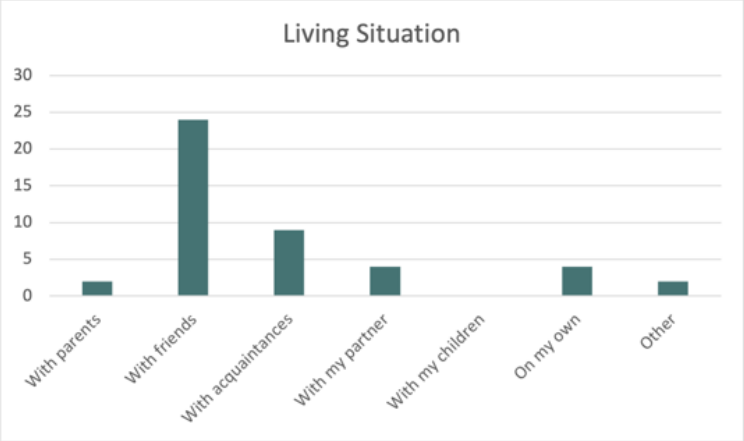


Figure 27: Living situation participants

For the living situations, the participants primarily live either with their friends or acquaintances. Very few people still live with their parents and no people live with their children. As there are no measurements in this value, 'living with my children' will be removed from the dataset. The high number of living with friends and/or acquaintances can be explained, as most of the participants as students. It is more common for student housing to have shared facilities with either friends or acquaintances. Surprisingly, the number of people living on their own is rather low. Currently, due to the new housing regulations in the city of Eindhoven, a lot of the old student houses have been transformed into studios or one-person apartment. Therefore, a low number of participants living alone is surprising. This is reflected in the household member numbers accordingly. These numbers are the amount of people living with you, excluding yourself. Therefore, the number zero represents the people living alone.

Household members	N in sample	% in sample
0	4	9.3%
1	5	11.6%
2	6	14.0%
3	5	11.6%
4	5	11.6%

5	5	11.6%
6	5	11.6%
7	5	11.6%
8	1	2.3%
9	1	2.3%
15	1	2.3%

Table 3: Sample description: Total number of household members

Social Layer

The social layer consists out of social media applications, the time spent and the sense of community. For the used social media applications by the participants, there is a clear preference for the four most-used applications. WhatsApp, Snapchat, Instagram, and YouTube seem to be used by almost all the participants. WhatsApp has a 100% user rate, which can be explained as it is the primary message source currently available. Interestingly, TikTok does not seem to be popular amongst the participants. This could be explained by the age gap. Most of the people participating might be 'too old' for intense TikTok use. Another interesting feat is the level of LinkedIn users. The amount of the LinkedIn users is explicable, as it is primarily targeted for people who are focusing on their careers. As the participants are either already working or finishing up their studies, LinkedIn might become of more importance.

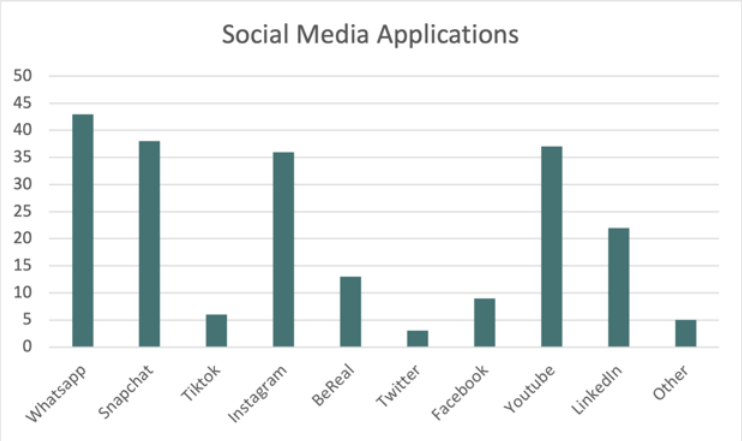


Figure 28: Social Media applications used by the participants.

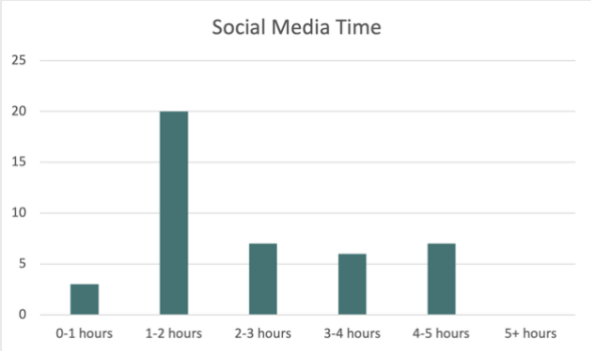


Figure 29: Social Media Time use participants

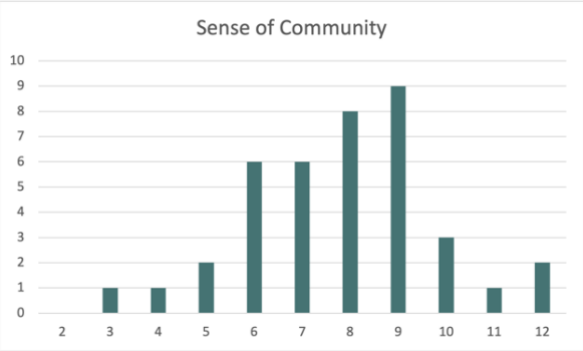


Figure 30: Sense of Community of participants

The time spent on social media is mostly somewhere between the 1 to 2 hours a day. It is important to note that this only includes social media time itself and not screen time. The average use in the Netherlands for the participant's age groups is between the 147-161 minutes per day, which translates to approximately 2 to 3 hours per day social media use (van Ooijen, 2023). Therefore, most of the participants tend to score lower than the national average. An explanation could be that the participants lead busy lives, which could be true if the study and work time are considered, or the participants are not aware about the number of hours spent on social media, as it is tends to be difficult to admit.
For the sense of community, the higher the score, the better the sense of community for that person. Overall, the number of high-level sense of community levels is skewed to the high side. Most of the participants feel safe and supported in their community. However, there are exceptions to the rule.

5.2.2 Momentary Experiences

The momentary data describes the data gathered by the momentary surveys. These exist out of the 393 different data inputs. As this is a large number, all data is described in percentages, instead of total numbers.

Social Layer

The social layer consists out of the activity types and the company. The types of activity mostly recorded are studying, relaxing and social gathering. As the data were collected once in the morning and once in the afternoon/evening, this could figure. Next, working and eating are mostly mentioned. The number of people recorded sporting is low. This might be explained because the time spend sporting is lower than the duration of either studying or social gatherings. It would seem more likely that the prompts happen during one of the earlier mentioned activities. For the company, most activities were done either alone or with friends. Interestingly, even though very few participants stated to live with their parents, being in the company of family scores over the 10%. Almost none of the activities were done in the presence of strangers or other types of company.

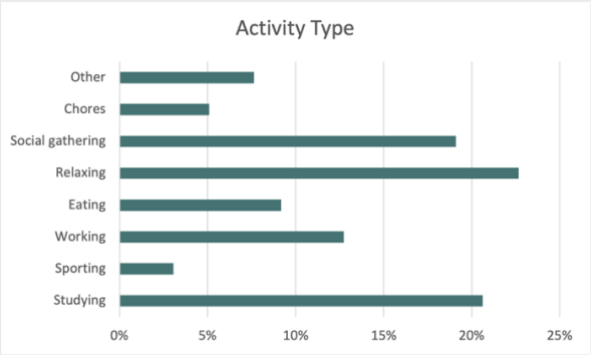


Figure 31: Types of activities

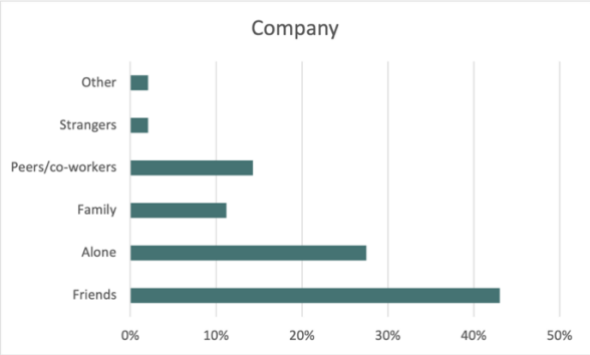


Figure 32: Types of company

Physical Layer

Within the physical layer, the location type, transportation type, familiarity with the location and the location attributes were measured. For the location type, most of the momentary surveys were filled in at home, followed closely by university/school. As most of the participants were said to be students, this is a realistic number. Interesting is the number of the 'outdoors' type, as it cannot immediately be explained when looking at the activities or the types of company.

For the transportation type more than half transfer by bike. This is a high number, however, considering that this age group mostly does not have the financial means for a car, and it is common in the Netherlands to ride a bike, this amount seems plausible.

Physical layer		N in sample	% in sample
Location Type			
	Home	156	39.7%
	University/School	84	21.4%
	Work	31	7.9%
	Outdoors	22	5.6%
	Shop	7	1.8%
	Café/Restaurant	28	7.1%
	Transportation	14	3.6%
	House of a friend/relative	31	7.9%
	Culture/Sports venue	12	3.1%
	Other	8	2.0%
Transport Type			
	By bike	219	55.7%
	By foot	21	5.3%
	By public transport	21	5.3%
	By car	30	7.6%
	I was already on location	101	25.7%
	Other	1	0.3%

Table 4: Sample description: Location and Transport type

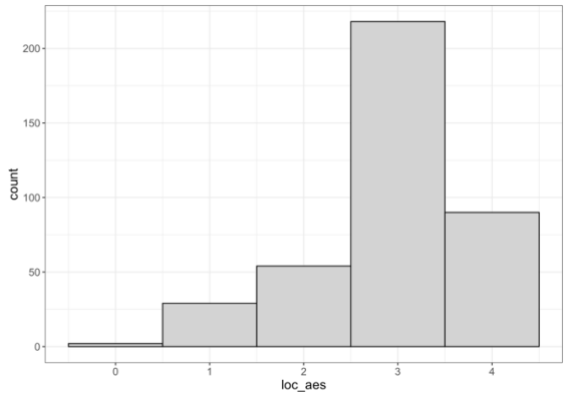


Figure 33: Location Aesthetics score

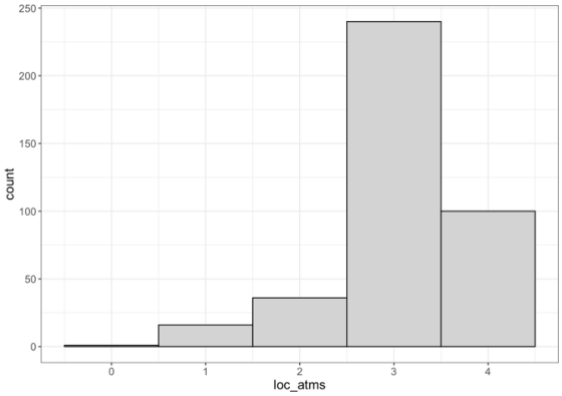


Figure 34: Location Atmosphere score

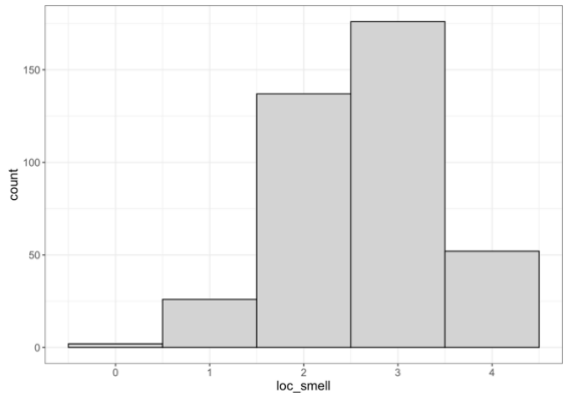


Figure 35: Location Smell score

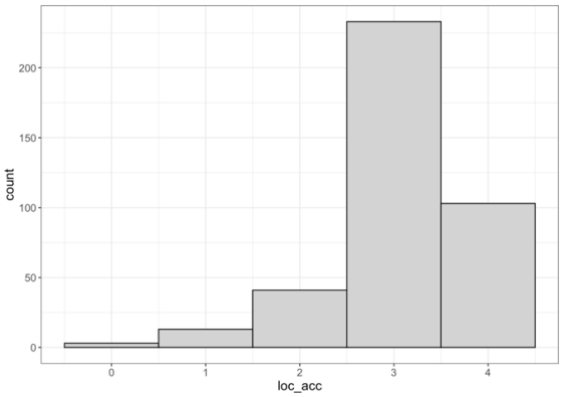


Figure 36: Location Accessibility score

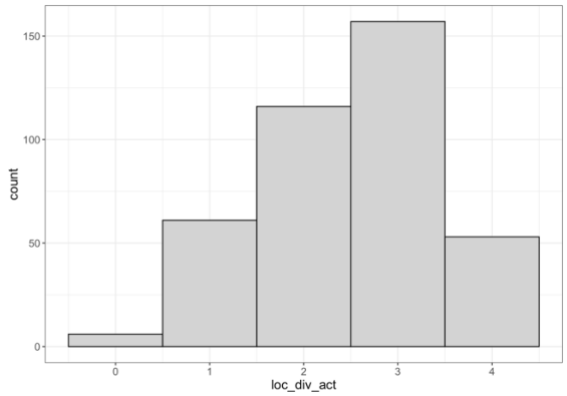


Figure 37: Location diversity in activities score

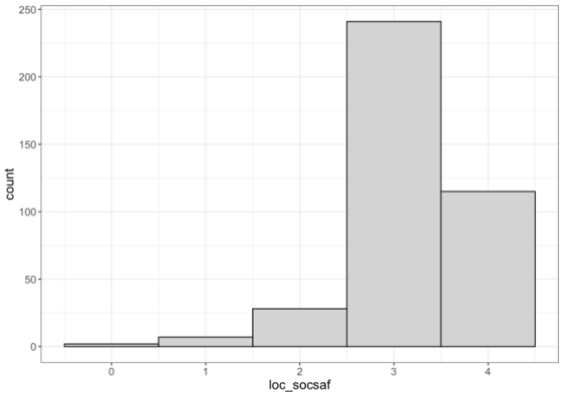


Figure 38: Location Social Safety score

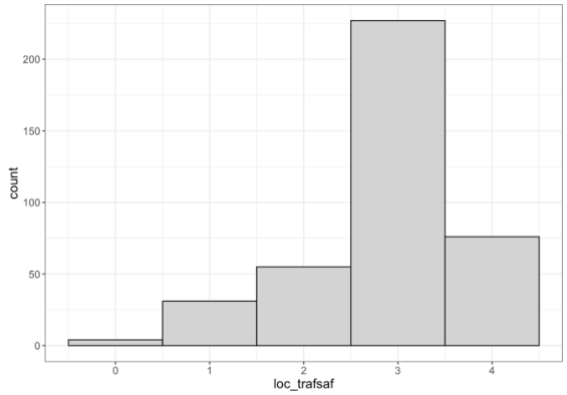


Figure 39: Location Traffic Safety score

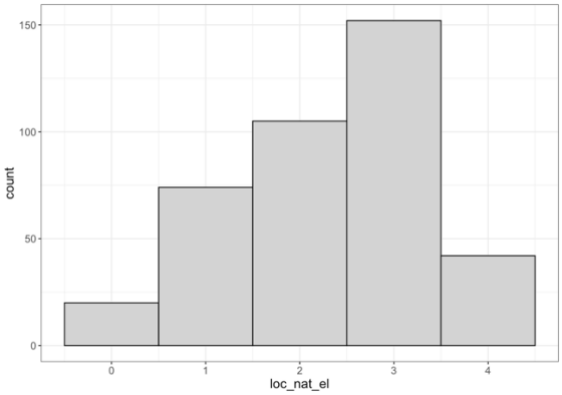


Figure 40: Location Natural Elements score

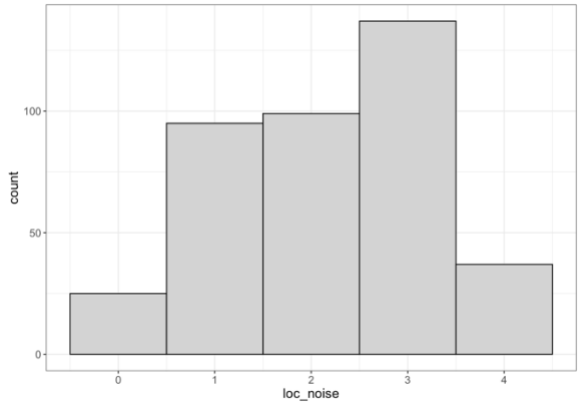


Figure 41: Location lack of noise score

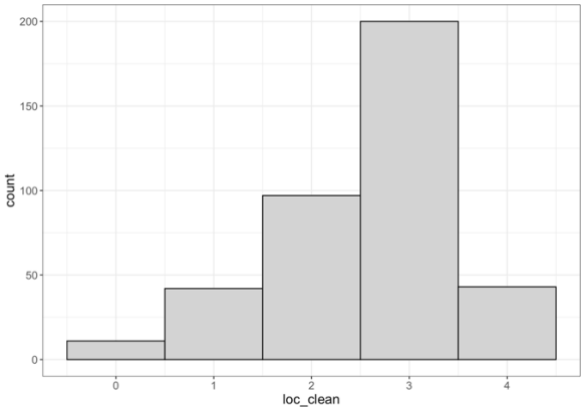


Figure 42: Location Cleanliness score

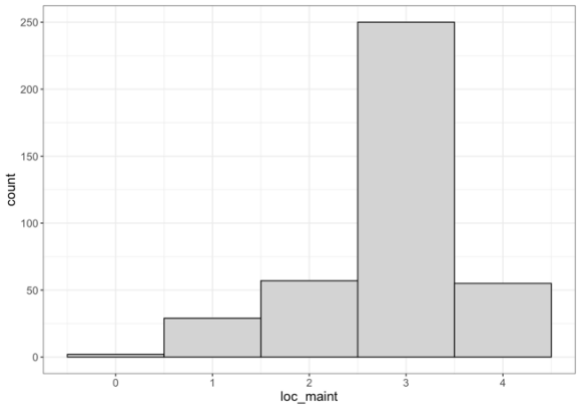


Figure 43: Location maintenance score

For the location scores, the higher the number, the better the location was rated by the users. Most of the locations attributes were rated quite good, with a distribution scored to the right side. There were a handful of location attributes that scored lower than most. Smell, diversity in activities, natural elements, the lack of noise and to some extent the cleanliness of locations were rated worse than the other attributes. Lower smell scores could be explained by the type of location one is in. For example, a participant might not like the smell of beer, but when in a café, this might be unavoidable. The cleanliness scores could have a similar explanation. The lack of diversity in activities in a location could be problematic, as it was stated as one of the attributes linked with loneliness in literature. Natural elements are rated lower than most attributes as well. This could be explained by the fact that most of the participants said to be in a sub-urban to urban environment. There is a possibility that this reduces the amount and quality of the natural elements surrounding them. Additionally, most people stated to be indoors when filling in the surveys, the natural elements might have been limited there as well.

For the location familiarity, most of the data samples scored very high on this. This could be explained by the number of times participants were at home or at university/school when they filled in the surveys, as these locations are bound to be familiar to the participants.

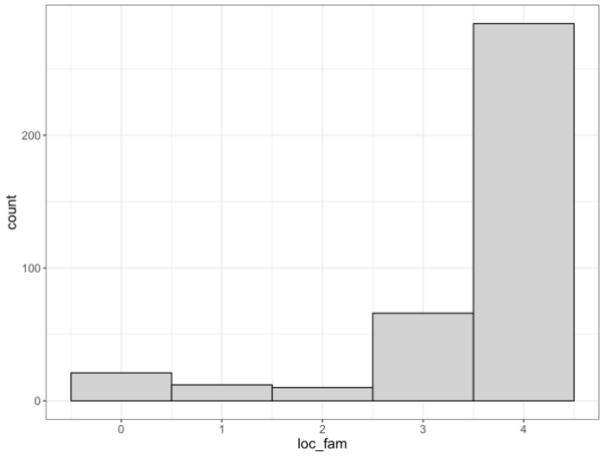


Figure 44: Location familiarity score

External Factors

For the external factors, the time, day, and weather circumstances were measured. The times were automatically prompted at different times between 9:00 o'clock in the morning and 10:00 o'clock in the evening. For the type of day, as the survey ran for 7 days, the weekend day to weekday ratio was 2:5. For the weather conditions, the KMNI was consoled.

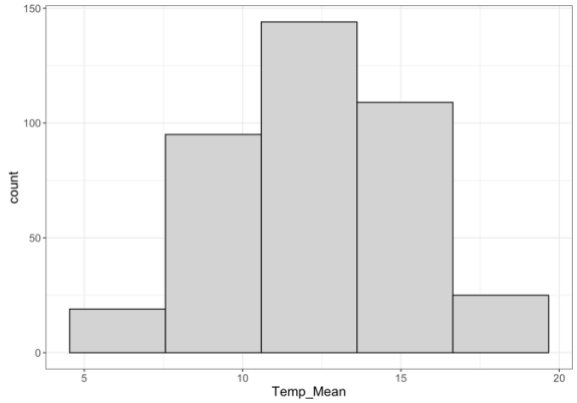


Figure 45: Mean temperatures during data collection

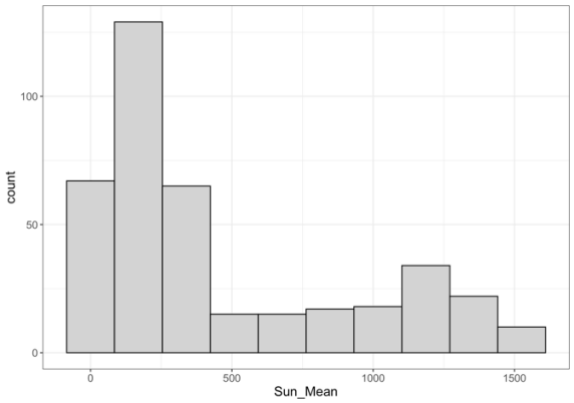


Figure 46: Mean Sun exposure during data collection

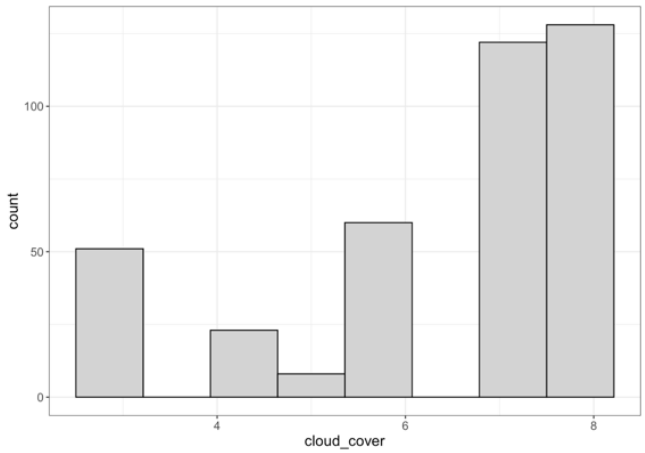


Figure 47: Cloud cover levels during data collection

The average temperatures during the day varied between 5 and 20 degrees. As the survey ran for prolonged periods of time, some participants filled it in with bad weather during the entirety of the survey. The sun exposure is both the sun hours and the strength of the sun on that day. Overall, the sun exposure during the data collection period was low. For the cloud cover, the calculation is in parts of 8. With an 8/8 score, the sky is overcast and with 0/8, it is completely free of clouds. Most of the days measured the sky was partly or completely overcast.

Additional to the previously mentioned variables, the daily mood was measured. Further description of the experienced mood of the participants can be found in Appendix D.

5.3 Data preparation

As the research consists out of two separate parts, the gathered data does accordingly. There are two different datasets: the baseline dataset and the momentary dataset.

5.3.1 The baseline dataset

In the baseline dataset, several variables, both ordinal and nominal, needed to be dummy coded to be used in the mixed model. Dummy coding was used to transform these variables. The variables include: 'gender', 'study time', 'work time', education', 'partner', 'living environment', 'household situation', 'house type', 'social media apps' and 'social media time'. For each of the variables a separate variable was created consisting only out of ones and zeros. As coding all the variables would lead to multicollinearity, the last of the variables is coded solely with zeros, as shown in table 5.

Example dummy coding			
Variable	*Coding*		
1	1	0	0
2	0	1	0
3	0	0	1
4	0	0	0

Table 5: Example dummy coding of the nominal variables

After the dummy coding, some variables had null data. As these would have no effect in the mixed model, these have been removed from the dataset, such as: 'village central', 'rural', 'household situation 5' (with my children), house types 'detached', 'semi-detached' and 'other'. As loneliness and friendship scores are directly correlated, the 'friendship' score is removed as well. As Ethnic background is the same over all participants, this variable is removed from the data.

5.3.2 The momentary dataset

For the momentary dataset, the first step was the changing of the location and the loneliness scores. By using the PIEL survey application, the first question results in the score '1' and the last a '5'. Intuitively, when researching levels of loneliness, the inclination could be to look for high numbers to represent high levels of loneliness, however in the way the data is represented, this is not the case. Therefore, by reformatting these scores, a higher loneliness score is now linked to a high number. Similarly, for the locations, a 'good' location score is associated with a high number. This is changed accordingly.

When interpreting the results, the momentary emotional loneliness is measured in three different questions. For the total momentary emotional loneliness score, these questions are combined to make it one variable to work with in the mixed model.

The 'company', 'activity type', 'location type' and 'transport type' variables are, as described in the previous chapter, all nominal variables. To use these variables in the mixed models, dummies are created. This is performed in the same method as in the baseline questionnaire.

Lastly, the weather factors were added to the dataset. The KMNI database provides information surrounding the weather situations per weather station in the Netherlands per day. As most of the research was executed in and around the city of Eindhoven and the participants did not share their locations, the weather station of the city Eindhoven was chosen for the weather factors. The weather station does not provide temperatures or cloud cover values per hour. Only daily means are available.
Three different variables are retrieved from the KMNI database: cloud coverage, mean temperature, and mean sun strength. The cloud coverage is calculated in parts of 8. Herein is 8 out of 8 a fully clouded sky and 1 out of 8 is cloudless. The mean temperature of the day is the average temperature it reached that day. The sun mean exists out of two different scores: the amount of sun hours a day and the sun strength. The sun mean is the amount of sun strength, per sun hours in a day, over the course of 24 hours. The data sets were combined by creating an excel query, overlapping on the date.
In a similar manner, all dates were assigned whether it was a weekend day or a weekday.

To create the full dataset, the momentary and baseline dataset were matched per id number. This results in varying momentary results, with the same baseline variables per id.

5.4 Conclusion

In the data chapter, both the data collection process and the data description are discussed. The data collection process gives insight in the context in which the research is conducted, and the amount of people participated in the study. In the data description, the data

gathered by means of the experience sampling method is analysed and discussed on finding and irregularities. All the findings are analysed according to their socio-ecological layer. Additionally, the overall loneliness scores retrieved during the study are compared to the national numbers. Lastly, the data processing was presented, and the steps taken were elaborated on.

6.

Bivariate Analysis

noun

the act of studying or examining something in detail, in order to discover or understand more about it, or your opinion and judgment after doing this

6. Bivariate Analysis

In the bivariate analyses, the relationships between the independent variables and the dependent variable are discussed per social-ecological layer. The aim of the bivariate analysis is to find out whether a significant relationship exists between each of the variables and state loneliness. Additionally, the assumptions that the data need to meet to conduct a linear mixed effect model are stated and checked.

6.1 Introduction bivariate analysis

A bivariate analysis is defined as "the analysis of two variables to determine relationships between them" (Sandilands, 2014). The relation between two different variables can be interesting for varying reasons. It can be interesting to check whether the data produced meets the assumptions used in the data processing type and whether there is a significant relationship between the independent and dependent variables.

For processing the data using MRM, there are several assumptions to consider. The key assumptions are:

- A linear relationship
- Multivariate Normality
- No Multicollinearity
- Homoscedasticity

(Complete Dissertation, 2023)

A linear relationship can be checked by the visual relationship shown by creating scatterplots. Testing the multivariate normality can be done by interpreting the errors, which should be normally distributed. To control for multicollinearity a correlation of the independent variables should be executed. The magnitude of this correlation coefficient should not exceed the 0.80 value. And lastly, homoscedasticity can be checked by creating a scatterplot of the residuals in relation to the predicated values. As the multivariate normality and the homoscedasticity consider the entire model, these cannot be checked in the bivariate analysis. The linear relationship and the absence of multicollinearity can be checked. Therefore, for each of the social-ecological layers, the relationships will be checked by creating scatterplots and creating a correlation matrix of the independent variables.

Apart from checking whether the assumptions for the MRM are met, the significance of the independent variables with the dependent variables should be tested. The dependent variable tested in this research is the momentary emotional loneliness score. This variable is measured on a five-points Likert scale. As a five-point scale Likert scale can be treated as an interval data type (Wu & Leung, 2017), it falls in the continuous data category. Therefore, the bivariate analysis types used can be the Independent Sample t-test for dichotomous

data, ANOVA for nominal or ordinal data and the Pearson's Correlation for continuous data, as can be seen in table 6.

Independent Variable Level	Dependent Variable Level	Analysis
Dichotomous	Continuous	Independent Sample t-Test, Linear Regression
Nominal or Ordinal	Continuous	ANOVA
Continuous	Continuous	Linear Regression, Pearson's Correlation

Table 6: Types of bivariate analysis for a continuous/interval dependent. Retrieved from (Complete Dissertation, 2023)

Independent Sample t-test

An independent sample t-test "compares the means between two unrelated groups on the same continuous, dependent variables" (Aerd Statistics, 2018). This assumes that both the dependent variable is of a continuous data type and that the independent variable is dichotomous, meaning that it has only two values, for example 'yes' and 'no' or '1' and '0'.

One-way ANOVA

ANOVA, or analysis of variance, aims to "test if two or more groups differ from each other significantly in one or more characteristics" (Complete Dissertation, n.d.). The one-way ANOVA will be used to control the relationship of nominal or ordinal independent variables with the dependent variable.

Pearson's Correlation

The Pearson's Correlation, or the Pearson Product-Moment Correlation, is the "measure of the strength of a linear association between two variables" (Aerd Statistics, 2020). The correlation value r is a value between -1 and +1, indicating total correlation. At 0 there is no correlation between the two values. This method is used to identify the correlation between an independent and dependent variable of the continuous type, these can be either ratio or interval.

6.2 Results

For the bivariate analysis, three different tests are performed. Two to check the assumptions for MRM and the last one to check the coherence of the variables with the state loneliness. For the assumptions testing, scatterplots are made of all the independent variables' relationship with the dependent variable, these must be linear to be accepted. Secondly, an independent variables correlation matrix is made. These values can be accepted as the values are under the 0.80 of magnitude. Lastly, the significance is tested by

performing either an independent sample t-test of a person's correlation test between the independent and dependent variables. This is done for each of the social-ecological layers.

6.2.1 individual layer

For the individual layers, the independent variables are divided identified as either being of the nominal or the interval data type, as can be seen in table 7.

Individual Layer	
Variable	*Type*
Age	Interval (7 levels)
Gender	Nominal (2 levels)
P. Extraversion	Interval (20 levels)
P Neuroticism	Interval (20 levels)
Emotional loneliness	Interval (15 levels)
Social loneliness	Interval (15 levels)

Table 7: Individual Layer data types

Scatterplots

The scatterplots in figures 46 and 47 show the relationship between the dependent variable momentary emotional loneliness and the independent variables extravert personality and emotional trait loneliness.

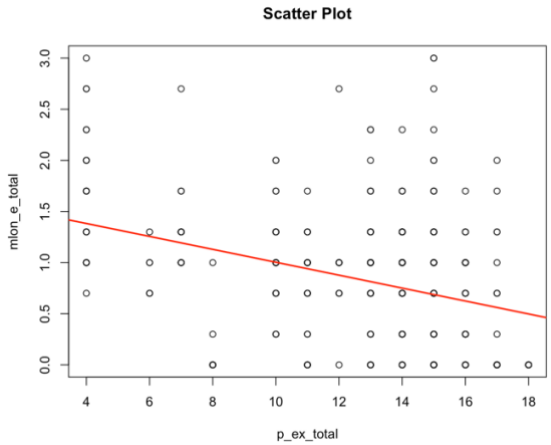


Figure 48: Scatterplot extravert personality

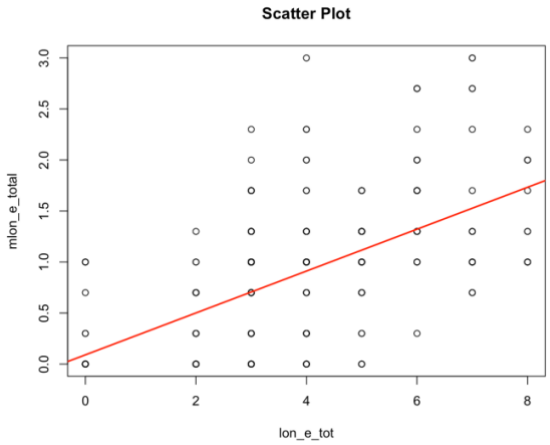


Figure 49: Scatterplot emotional trait loneliness

Both the scatterplots show a type of relationship between the variables. The extravert personality scatterplot seems to have a negative relationship with the momentary emotional loneliness, whilst emotional trait loneliness seems to have a positive relationship. Both the scatterplots are not perfect, as there are several outliers, and the data seems widespread.

The other independent variables have a linear relationship with the dependent variable as well. These scatterplots can be found in appendix E.

Correlation of independents

Table 7 contains the results of the correlation matrix of all the independent variables amongst the 'individual' layer.

	age	gender male	p_ex_total	p_neur_total	lon_e_tot	lon_s_tot
age	1					
gender male	-0.06	1				
p_ex_total	-0.05	-0.02	1			
p_neur_total	-0.02	-0.38	-0.11	1		
lon_e_tot	0.00	-0.17	-0.32	0.55	1	
lon_s_tot	0.00	-0.21	-0.08	0.27	0.55	1

Table 8: Individual layer variables; correlation of independents

The values within the model all vary between the -1 and the +1. With -1 being a perfect negative and +1 being a perfect positive relationship with the other variables. A value around the 0 could indicate little to no relationship. For the assumptions of the MRM, no values should exceed the 0.80, as otherwise multicollinearity could occur. As no values exceed this number, all variables can be accepted in the model.

Relationship with emotional state loneliness

As the gender is a dichotomous, an independent samples T-test was executed. As the t-test measures the difference between the means of the emotional state loneliness and gender (being male), the negative number suggests that the mean of male scores is lower than for females. This suggests higher levels of emotional state loneliness for women. Furthermore, the variable is significant at the 0.01 level. This means that the differences between the variables tested is statistically significant.

Table 9: Bivariate Analysis results Gender variable

Independent Samples T-test			
	t	*Sig.*	
Gender - Male	-7.74	0.00	**

**significant at the 0.05 level **significant at the 0.01 level*

The findings of table 9 are supported by table 10. The women have a higher mean than their male counterparts. A higher mean suggests a higher levels of momentary emotional loneliness. Having a lower score is preferable. There are a few more measurement points filled in by men than by women. Even though the range is similar with values between the 0 and 3. The median is clearly lower at the male measuring points than the female measuring points. This is in contrast with the findings in the literature study.

Table 10: descriptive statistics emotional state loneliness and individual variables

Momentary State Loneliness score per category			
		Mean (SD)	Median [Min, Max]
Gender			
Woman	(N=195)	0.9 (0.6)	1 [0, 3]
Man	(N=198)	0.7 (0.6)	0.7 [0, 3]
Overall	(N=393)	0.8 (0.6)	1 [0, 3]

As the other variables are treated as interval types, a Pearson's correlation test was performed. All the variables tested for in the individual layer have a p-value that suggest a statistically significant correlation. The strength of the correlations, however, varies. Both age and social trait loneliness have a weak positive correlation with emotional state loneliness. As these are positive correlations, this would suggest that the older a person is, the more likely he/she is to be lonely. Both neuroticism and emotional trait loneliness have a moderate to strong positive correlation with emotional state loneliness. Having an extravert personality is the only variable with a negative correlation. This might suggest a decrease in the feeling of loneliness when having high levels of the extravert personality type.

Table 11: Bivariate Analysis results Pearson's Correlation 'Individual'

Pearson's Correlation			
	r	*Sig.*	
Age	0.14	0.00	**
Personality extravert	-0.34	0.00	**
Personality neuroticism	0.33	0.00	**
trait emotional loneliness	0.57	0.00	**
trait social loneliness	0.26	0.00	**

**significant at the 0.05 level **significant at the 0.01 level*

6.2.2 Results household layer

For the household layer, the variables are either nominal, interval or ordinal. For the dichotomous nominal variable gender, a independent sample t-test will be executed. For the ordinal and remaining nominal level variables a one-way ANOVA will be executed. Lastly, for the interval variable 'number of household members' a Pearson's Correlation test will be performed.

Household Layer	
Variable	*Type*
Study time	Ordinal (4 levels)
Work time	Ordinal (4 levels)

Education	Nominal (5 levels)
Partner	Nominal (2 levels)
House type	Nominal (6 levels)
# of household members	Interval
Household situation	Nominal (7 levels)
Living environment	Nominal (5 levels)

Table 12: Household Layer data types

Scatterplots

The number of household members is the only interval variable of this variable layer. There seems to be a slight linear relationship, as denoted by the red line. As there is a visual support of linear relationship, the variable can be accepted for the MRM. The scatterplot can be found in appendix E.

Correlation of independents

The correlation of independents for the household layer resulted in two values above the appointed 0.80. The first correlation of independents is education level 4, university degree, and education level 1, Secondary education. This level is -0.93 and therefore exceeds the set limit. The second high correlation is between the independents house type 2, Apartment /Studio, and house type 3, student home with shared facilities (-0.87). To resolve the correlation problem, variables 'education level 4, university degree' and 'house type 3, student home with shared facilities' have been removed from the dataset for further processing. The correlation matrix of the independents for the household layer can be found in appendix F.

Relationship with emotional state loneliness

For the results of the independent samples t-test, having a partner seem to be significantly associated with the momentary emotional loneliness. As the t-value has a negative number, it suggests that the mean of 'partner – yes' is higher than for the 'no' value. This would imply that people in a relationship are lonelier than their single peers.

Table 13: Bivariate Analysis results "household" t-test

Independent Samples T-test				
		t	*Sig.*	
Partner				
	No	-11.83	0.00	**

**significant at the 0.05 level **significant at the 0.01 level*

Table 14 presents the results of the ANOVA performed between the categorical data and the independent emotional state loneliness. For the variables 'study time', 'work time', 'house type' and 'living environment' the p-value is higher than the significance level set at

0.05. This suggests that these variables are not significantly associated with emotional state loneliness. 'Education level' and 'household situation' on the other hand, seem to have a significant association with the independent variable. Within both variables there is enough variance between the categories to show significant differences.

Table 14: Bivariate Analysis results "household" ANOVA

ANOVA			
	F	*Sig.*	
Study Time	2.77	0.10	
Work Time	0.02	0.88	
Education Level	13.08	0.00	**
House Type	2.99	0.08	
Household situation	28.40	0.00	**
Living environment	1.01	0.32	

**significant at the 0.05 level **significant at the 0.01 level*

In table 15 the descriptive statistics of the relationship between emotional state loneliness and the categorical variables is shown. For partner status, the results of the t-test are supported, as the value of 'partner – yes' has a higher loneliness mean than 'partner – no'. For study time, it needs to be considered that these values do not suggest a strong significant relationship with emotional state loneliness. Considering the means of the working times, it would suggest that studying 0-24 hours makes a person the loneliest, whilst studying 40+ hours, the least lonely. For work time, the people working 24-40 hours seem to be the least lonely. For the education level, which did seem to have a significant association with emotional state loneliness, both the MBO and HBO level of education have the highest loneliness scores, whereas people who only finished secondary education have the lowest loneliness scores. Taking in consideration that this age group is still in the process of completing their studies, this is in line with the findings from the literature study, in which was claimed that lower educated individuals are lonelier than higher educated people. For house type, the apartment/studio appears to have the highest loneliness mean of the different types. For the household situation, which seemed to have a significant association with emotional state loneliness, there are three categories with a high loneliness scores; 'with parents', 'with partner' and 'on my own' all have a loneliness mean of 1. Interestingly, 'living with acquaintances' and 'living with friends' both score lower, at 0.7. Lastly for living environment, only 'urban central', 'suburban' and 'green urban' were considered. The loneliness scores between the three vary little, with urban central having a slightly lower score than the other two.

Table 15: descriptive statistics emotional state loneliness and household variables

Emotional State Loneliness score per category

		Mean (SD)	Median [Min, Max]
Partner			
Yes	(N=136)	0.9 (0.7)	1 [0, 3]
No	(N=257)	0.8 (0.6)	0.7 [0, 3]
Overall	(N=393)	0.8 (0.6)	1 [0, 3]
Study time			
0 hours	(N=36)	0.8 (0.6)	1 [0, 2]
0-24 hours	(N=120)	0.9 (0.6)	1 [0, 3]
25-40 hours	(N=199)	0.8 (0.6)	1 [0, 3]
40+ hours	(N=38)	0.5 (0.7)	0 [0, 3]
Overall	(N=393)	0.8 (0.6)	1 [0, 3]
Work time			
0 hours	(N=121)	0.8 (0.6)	1 [0, 3]
0-24 hours	(N=196)	0.8 (0.7)	1 [0, 3]
25-40 hours	(N=37)	0.7 (0.5)	0.7 [0, 2]
40+ hours	(N=39)	0.8 (0.6)	1 [0, 2]
Overall	(N=393)	0.8 (0.6)	1 [0, 3]
Education level			
Secondary education	(N=200)	0.7 (0.6)	0.7 [0, 3]
MBO	(N= 3)	1 (0.2)	1 [1, 1]
HBO	(N=12)	1 (0.5)	1 [0.7, 3]
University Degree	(N=178)	0.9 (0.6)	1 [0, 3]
Overall	(N=393)	0.8 (0.6)	1 [0, 3]
House Type			
Row house	(N=25)	0.7 (0.7)	0.7 [0, 3]
Apartment/Studio	(N=137)	0.9 (0.7)	1 [0, 3]
Student room	(N=231)	0.8 (0.5)	1 [0, 3]
Overall	(N=393)	0.8 (0.6)	1 [0, 3]
Household Situation			
With parents	(N=11)	1 (0.5)	1 [0.7, 2]
With friends	(N=218)	0.7 (0.5)	0.7 [0, 3]
With acquaintances	(N=69)	0.7 (0.6)	0.7 [0, 3]
With my partner	(N=40)	1 (0.8)	1 [0, 3]
On my own	(N=40)	1 (0.6)	1 [0.3, 3]
Other	(N=15)	0.8 (0.6)	1 [0, 2]
Overall	(N=393)	0.8 (0.6)	1 [0, 3]
Living Environment			
Urban Central	(N=304)	0.8 (0.7)	1 [0, 3]
Suburban	(N=82)	0.9 (0.5)	1 [0, 3]
Green Urban	(N= 7)	0.9 (0.3)	1 [0.3, 1]
Overall	(N=393)	0.8 (0.6)	1 [0, 3]

For the results of the Pearson's Correlation, the number of household members seems to be negatively associated with the momentary emotional loneliness. The correlation between number of household members and state loneliness is deemed significant.

Table 16: Bivariate Analysis results Pearson's Correlation "household"

Pearson's Correlation			
	r	*Sig.*	
Number hh members	-0.15	0.00	**

**significant at the 0.05 level **significant at the 0.01 level*

6.2.3 Results social environment layer

For the social environment layer, the variables data types consist out of nominal, ordinal and continuous data types. For the social media application, participants were allowed to select multiple options in answers. To process these values, dummy variables needed to be created as ANOVA does not accept multiple categories within one value. For the other nominal and ordinal variables, a one-way ANOVA was performed. Lastly, for the 'sense of community' variable a Pearson's correlation was done, as it is an interval variable type.

Social Environment	
Variable	*Type*
Social media apps	Nominal (10 levels)
Time spent on social media	Ordinal (6 levels)
Sense of community	Interval (20 levels)
Activity type	Nominal (8 levels)
Company	Nominal (6 levels)

Table 17: Social Environment Layer data types

Scatterplots

The scatterplot of the interval variable 'sense of community' shows a vague linear relationship. Therefore, this variable can be accepted in the mixed model, however it is plausible that the sense of community variable will have little effect on the momentary emotional loneliness, as the correlation seems to be little.

Correlation of independents

The correlation matrix of the independents of the social environment layer results in no correlation values over the 0.80 threshold. Therefore, all variables can be accepted in the mixed model. The correlation matrix can be found in Appendix G.

Relationship with emotional state loneliness

In the independent t-test, some of the variables came back as not significant. These are Snapchat, Instagram, and YouTube. As the type of social media application used was not specified in any of the found literature studies, the reason for their score as insignificant cannot be determined. Even though these variables are not significant, these still need to be controlled for in the model. The significance is something to keep in mind when interpreting the results, however, significance alone is in this context not enough to discard the variables from the mixed model.

Table 18: Bivariate Analysis results t-test 'social environment'

Independent Samples T-test				
		t	*Sig.*	
Social Media Apps				
	Whatsapp	5.65	0.00	**
	Snapchat	1.85	0.07	
	TikTok	20.02	0.00	**
	Instagram	0.14	0.89	
	BeReal	-13.15	0.00	**
	Twitter	-20.47	0.00	**
	Facebook	-16.33	0.00	**
	Youtube	0.55	0.58	
	LinkedIn	-9.46	0.00	**

**significant at the 0.05 level **significant at the 0.01 level*

For the other nominal variable types, an ANOVA was performed. The results of which are visible in table 19. For both 'social media time' and 'activity type' the F-value is low, implying little observed variability between the different categories. Together with a significance value over the 0.05 level, these variables do not seem significantly associated with emotional state loneliness. For the 'company' variable, the opposite is true as it has both a high F-value and meets the significance at an 0.01 level. The suggests that there is significance difference in loneliness across the different company types.

Table 19: Bivariate Analysis results ANOVA 'social environment'

ANOVA			
	F	*Sig.*	
Social Media time	2.04	0.15	
Activity Type	2.13	0.15	
Company	12.14	0.00	**

**significant at the 0.05 level **significant at the 0.01 level*

Table 20: descriptive statistics emotional state loneliness and social environment variables

Emotional State Loneliness score per category			
		Mean (SD)	Median [Min, Max]
Social Media Time			
0-1 hours	(N=31)	1 (0.6)	1 [0, 3]
1-2 hours	(N=185)	0.8 (0.6)	1 [0, 3]
2-3 hours	(N=60)	0.7 (0.6)	0.7 [0, 2]
3-4 hours	(N=56)	0.6 (0.5)	0.7 [0, 1]
4-5 hours	(N=61)	0.9 (0.8)	1 [0, 3]
Overall	(N=393)	0.8 (0.6)	1 [0, 3]
Activity Type			
Studying	(N=81)	1 (0.7)	1 [0, 3]
Sporting	(N=12)	0.6 (0.7)	0.3 [0, 2]
Working	(N=50)	0.8 (0.5)	1 [0, 2]
Eating	(N=36)	0.8 (0.7)	1 [0, 3]
Relaxing	(N=89)	0.9 (0.6)	1 [0, 3]
Social gathering	(N=75)	0.5 (0.6)	0.3 [0, 2]
Chores	(N=20)	1 (0.6)	1 [0, 3]
Other	(N=30)	1 (0.6)	1 [0, 2]
Overall	(N=393)	0.8 (0.6)	1 [0, 3]
Company			
Friends	(N=169)	0.6 (0.5)	0.7 [0, 2]
Alone	(N=108)	1 (0.7)	1 [0, 3]
Family	(N=44)	0.8 (0.6)	1 [0, 2]
Peers/co-workers	(N=56)	0.9 (0.6)	1 [0, 3]
Strangers	(N= 8)	0.7 (0.7)	0.7 [0, 2]
Other	(N= 8)	1 (0.9)	0.8 [0, 3]
Overall	(N=393)	0.8 (0.6)	1 [0, 3]
Social Media Application			
Whatsapp	(N=393)	0.8 (0.6)	1 [0, 3]
Snapchat	(N=348)	0.8 (0.6)	1 [0, 3]
TikTok	(N=42)	1 (0.8)	1 [0, 3]
Instagram	(N=324)	0.8 (0.6)	1 [0, 3]
BeReal	(N=118)	1 (0.6)	1 [0, 3]
Twitter	(N=38)	0.7 (0.5)	1 [0, 2]
Facebook	(N=79)	1 (0.6)	1 [0, 3]
Youtube	(N=330)	0.8 (0.7)	1 [0, 3]
LinkedIn	(N=171)	0.8 (0.6)	1 [0, 3]
Overall	(N=393)	0.8 (0.6)	1 [0, 3]

Table 20 explains the descriptive statistics considering the various categories within the nominal data in relation to emotional state loneliness. 'Social Media times' variable, of which the difference between categories was not deemed significant, shows high levels of loneliness with lower time spend on social media. Herein spending 0-1 hours on social media has the highest loneliness scores, whereas the loneliness scores is lowest at 3-4 hours. Results higher than this increases the loneliness score again. 'Activity type' results in high loneliness scores for the activity types 'studying', 'chores' and 'other'. As was expected, 'social gathering' resulted in the lowest means. Interestingly, relaxing has the second highest loneliness score. For 'company', which in contrast to the previous two variables, was deemed significantly associated, the 'other' and 'alone' company type resulted in the highest means. Friends resulted in the lowest mean, with a score of '0.6'. In line with the found literature, being around peers/co-workers, has a high loneliness score (0.9), exceeding both the presence of family and strangers. As for 'social media', using Twitter seemed to result in the lowest mean (0.7). 'Facebook', 'BeReal', and 'Tiktok' resulted in the highest loneliness score.

For the Pearson's Correlation in table 15, the correlation between 'sense of community' and the momentary emotional loneliness is significant. It seems to have a positive/increasing relationship with the feeling of emotional loneliness, which is in contrast with the findings in literature.

Table 21: Bivariate Analysis results Pearson's Correlation 'social environment'

Pearson's Correlation			
	r	*Sig.*	
Sense of community	0.16	0.00	**

**significant at the 0.05 level **significant at the 0.01 level*

6.2.4 Results physical environment layer

For the physical environment layer, the data types included are interval and nominal. For the nominal data types 'transport type' and 'location type' a one-way ANOVA will be performed. The remaining variables are all interval variables. A Pearson's correlation will be executed to gain insight for these variables.

Physical Environment	
Variable	*Type*
Location familiarity	Interval (5 levels)
Transport type	Nominal (6 levels)
Location type	Nominal (10 levels)
Aesthetics	Interval (5 levels)
Atmosphere	Interval (5 levels)

Smell	Interval (5 levels)
Accessibility	Interval (5 levels)
Traffic safety	Interval (5 levels)
Natural elements	Interval (5 levels)
Noise	Interval (5 levels)
Cleanliness	Interval (5 levels)
Maintenance	Interval (5 levels)
Diversity in activities	Interval (5 levels)
Social safety	Interval (5 levels)

Table 22: Physical Environment Layer data types

Scatterplots

In the scatterplots for the location, the location specific data is depicted. As the data is not entirely continuous, the scatterplot shows some space in between the measuring points. The plot of location familiarity shows some linear relationship; however, the slope of the linear regression is slightly positive. Contrastingly, the location atmosphere shows a steeper negative linear regression with the momentary emotional loneliness. The remaining scatterplots show linear relationships. These can be found in Appendix E.

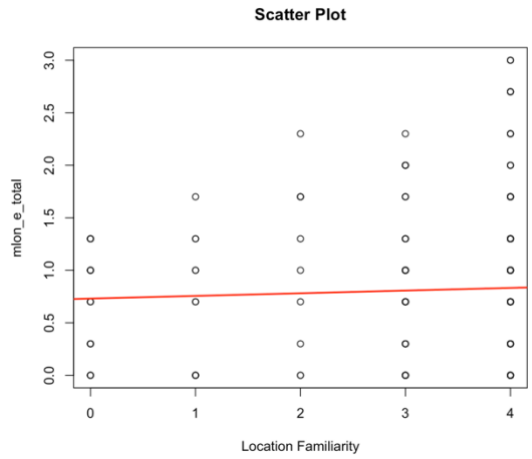


Figure 50: Scatterplot Location Familiarity

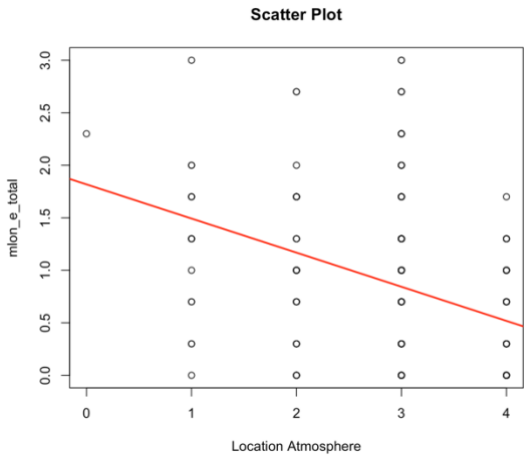


Figure 51: Scatterplot Location Atmosphere

Correlation of independents

The correlation of independent variables for the physical layer does not contain any correlations with values higher than 0.80. Therefore, all variables in this layer can be accepted and used in the mixed model. The correlation of independents matrix for the physical environment layer can be found in Appendix G.

Relationship with emotional state loneliness

The result of the ANOVA, as seen in table 23, provide insight in the variables 'transport type' and 'location type'. For the different transportation types, there seems to be no significant

difference in the mean values of the momentary emotional loneliness. It is plausible that the results for this variable were the product of chance. For 'location type' the null hypothesis can be rejected, as both the F-value is high and there seems to be a significant association at the 0.01 level.

Table 23: Bivariate Analysis results ANOVA 'physical environment'

ANOVA			
	F	*Sig.*	
Transport Type	0.60	0.44	
Location Type	14.98	0.00	**

**significant at the 0.05 level **significant at the 0.01 level*

For the categories, the descriptive statistics can be found in table 24. Herein, for 'transportation type', high levels of loneliness are associated with 'public transport', 'I was already on location' and 'other'. Surprisingly, the variable 'by car' has the lowest mean, which is in contrast with the found literature. For the 'location type', 'house of friend/relative' (0.4) and 'outdoor' (0.5) have low loneliness scores. In contrast, being 'on the road' results in the highest levels of loneliness (1).

Table 24: descriptive statistics emotional state loneliness and physical environment variables

Emotional State Loneliness score per category			
		Mean (SD)	Median [Min, Max]
Transport Type			
By bike	(N=219)	0.8 (0.7)	1 [0, 3]
By foot	(N=21)	0.8 (0.8)	0.7 [0, 3]
By public transport	(N=21)	0.9 (0.6)	1 [0, 2]
By car	(N=30)	0.6 (0.6)	0.7 [0, 2]
I was already on location	(N=101)	0.9 (0.6)	1 [0, 3]
Other	(N= 1)	1 (NA)	1 [1, 1]
Overall	(N=393)	0.8 (0.6)	1 [0, 3]
Location Type			
Home	(N=156)	0.9 (0.7)	1 [0, 3]
University/School	(N=84)	0.9 (0.6)	1 [0, 3]
Work	(N=31)	0.9 (0.5)	1 [0, 2]
Outdoor	(N=22)	0.5 (0.7)	0.3 [0, 2]
Shop	(N= 7)	0.6 (0.7)	0.3 [0, 2]
Cafe/restaurant	(N=28)	0.6 (0.5)	0.7 [0, 1]
On the road	(N=14)	1 (0.8)	1 [0, 3]
House of friend/relative	(N=31)	0.4 (0.5)	0.3 [0, 2]
Culture/sports venue	(N=12)	0.7 (0.5)	0.8 [0, 1]
Other	(N= 8)	0.8 (0.7)	1 [0, 2]
Overall	(N=393)	0.8 (0.6)	1 [0, 3]

For the Pearson's Correlation test, several variables did not test significant. This includes the variables 'location familiarity', 'location smell', 'location noise', 'location cleanliness', and 'location maintenance'. As these variables are part of the researched variables and they do pass the MRM assumptions, the variables will be included in the model. When handling the results, the insignificant variables should be handled with caution.
Apart from the insignificant variables, almost all the variables concerning the location seem to have a negative relationship with the emotional state loneliness. The location noise is an exception of this. These numbers are to be expected considering the literature research.

Table 25: Bivariate Analysis results Pearson's Correlation 'physical environment'

Pearson's Correlation			
	r	*Sig.*	
Location Familiarity	0.04	0.40	
Location Aesthetics	-0.15	0.00	**
Location Atmosphere	-0.37	0.00	**
Location Smell	-0.09	0.07	
Location Accessibiilty	-0.28	0.00	**
Location Traffic safety	-0.18	0.00	**
Location Natural elements	-0.14	0.00	**
Location Noise	0.07	0.18	
Location Cleanliness	-0.07	0.20	
Location Maintenance	-0.09	0.09	
Location diversity activities	-0.17	0.00	**
Location Social Safety	-0.29	0.00	**

**significant at the 0.05 level **significant at the 0.01 level*

6.2.5 Results external factors

In the external factors, the data used is nominal (dichotomous), interval and continuous. The 'day type' variable is dichotomous as it is either a weekend day or a weekday. Therefore, an independent t-test will be performed. For the other variables, a Pearson's correlation will be executed.

Contextual factors	
Variable	*Type*
Day type	Nominal (2 levels)
Cloud cover	Interval (8 levels)
Temperature	Continuous
Sun strength	Continuous

Table 26: Contextual Factors data types

Scatterplots

The scatterplot regarding the weather factors, show little to no correlation with the momentary feeling of loneliness. The temperature scatterplot shows a random cloud of data points, with little coherence, however, the regression line suggests a slight form of linear regression, with loneliness increases as the temperature increases. At the cloud cover scatterplot, there is a little bit more coherence, with the loneliness increasing as the cloud cover increases. The sun strength has a similar relation as the temperature scatterplot. Day type, as it is dichotomous, is always linear. It seems that the weather variables just slightly pass the assumptions of the mixed model, however the prediction is that these variables will be of little effect on the momentary emotional loneliness. The scatterplots can be found in Appendix E.

Correlation of independents

For the correlation of independents of the contextual factors, all values can be seen in table 27. As this is under the 0.80 value, the variables can be accepted to be used in the mixed model.

	weekendday	cloud_cover	Temp_Mean	Sun_Mean
weekendday	1			
cloud_cover	0.16	1		
Temp_Mean	0.30	0.20	1	
Sun_Mean	0.05	-0.58	0.22	1

Table 27: Correlation of Independent 'Contextual Factors'

Relationship with emotional state loneliness

For the day type, an independent sample t-test was conducted. The t-test results in a significant value of the weekend day, which was to be expected as it was already supported in literature concerning the loneliness of older adults.

Table 28: Bivariate Analysis results t-test 'external factors'

Independent Samples T-test				
		t	*Sig.*	
Day Type - Weekendday		-13.50	0.00	**

**significant at the 0.05 level **significant at the 0.01 level*

The result of the descriptive statistics in table 29 support the results of the t-test, as the weekdays have a higher mean than the weekend days. Higher levels of loneliness were expected during the weekdays, as this is in line with the findings from the literature study.

Table 29: descriptive statistics emotional state loneliness and external factors

Momentary State Loneliness score per category			
		Mean (SD)	Median [Min, Max]
Day Type			
Weekendday	(N=113)	0.7 (0.6)	0.7 [0, 2]
Weekday	(N=280)	0.9 (0.6)	1 [0, 3]
Overall	(N=393)	0.8 (0.6)	1 [0, 3]

For the weather variables, a Pearson's correlation test was executed. As the scatterplots suggested, the correlation value of the weather variables is only slight and there seems to be no significance. As with the previous insignificant variables, because the influence of all the layers is researched, the variables as kept in to be controlled for.

Table 30: Bivariate Analysis results Pearson's Correlation 'external factors'

Pearson's Correlation		
	r	*Sig.*
Cloud Cover	0.07	0.19
Temperature	0.05	0.34
Sun Strength	-0.03	0.55

**significant at the 0.05 level **significant at the 0.01 level*

6.3 Conclusion

In this chapter, bivariate analyses were conducted between variables from all the social-ecological layers. The analysis consisted of three different parts: two of which aimed to control whether the data was suitable to be used in MRM and the last to check the significance of the independent variables in relation to the dependent variable, emotional state loneliness. For the scatterplots, all were conducted and most of them seemed to have a linear relationship and could therefore be used in the mixed model. For the correlation matrix, two irregularities were found. The variables 'education level 4 (university degree)' and 'house type 3 (home with shared facilities)' were found to have a correlation value over 0.80 and were therefore removed from the dataset. In the significance test, some insignificant relationships between the independent and dependent variables were found, both in the social environment layer, physical environment layer and the external factors. However, as all these variables pass the MRM assumptions and the variables still need to be controlled for, the variables will be included further in the research. The results concerning these variables will be interpreted with caution.

7.

Mixed Model

noun

a simple description of a system or process that can be used in calculations or predictions of what might happen

7. Mixed Model

In this chapter, the assembling of the mixed model will be discussed. As the data contains clustered data, the MRM method is chosen to process the data. It entails the fitting of the model, the checking of the random variables and the stepwise checking and optimizing of the model. Afterwards, the parameter preparation for the model is elaborated on.

7.1 Mixed model suitability

To know how to process the data set, the ICC and design effect are checked. The ICC, or intra-class correlation, is the amount of correlation there is within clusters. How much of the correlation can be explained by the presence of clustering? In the gathered data, participants are required to fill in a survey multiple times throughout the week. Because the baseline data stays the same per participant throughout the week, there is a high likelihood of similarities between the different measuring points. The dataset provides an ICC value of 0.53, as seen in table 31. This is on the higher side and suggest that using mixed models to filter per cluster could be beneficial.

ICC	
[1]	0.5307688

Design Effect	
[1]	5.320212

Table 31: ICC and Design Effect

Secondly, the design effect is considered. The design effect describes how many times the dataset would be artificially inflated if it were to be treated as a regular linear model. Whenever the value would be around one, the data set remains the same size and could therefore be treated as a regular linear model. However, with a design effect of 5.3 the data set would lose its value and is therefore, the use of mixed models and clustering is important for the significance of the results.

For the clusters, the study design was set-up for the clusters to be the 'id' value per person. However, to check whether clustering on other variables, such as time is useful, a model comparison was executed.

Statistics model comparison

	aic	bic	Bayes factor	p
baseline_id	*597.033*	*608.955*	*19.824*	*1*
baseline_time	599.033	614.929	0.05	

R squared change	
(Intercept)	Residual

4.61E-08	-4.88E-09

Table 32: Model comparison clustering

The compared models prefer clustering on only the 'id' value, as the aic, bic and p value are tested for the model with only id as clustering value. When working with a linear mixed effect model, the aic and bic are "two terms that measure the fit of the model and the complexity of the model" (Gail et al., 2009).

7.2 Random variables

In mixed models, there might be variables in your regressions that do not follow the same slopes between within the cluster. These are called random variables. When aiming to optimise a mixed model, it is necessary to know which variables are random and which are fixed. The variables retrieved from the baseline model are fixed by default. These do not vary per id number and therefore, will not offer varying slopes within the cluster. For the variables gathered during the momentary surveys, it is necessary to check them for random variables. To do so, two different models are created, one in which the variable is fixed and one in which the variable is treated as a random variable. These models are compared both visually and statistically to determine whether the variable should be fixed or random in the final model.

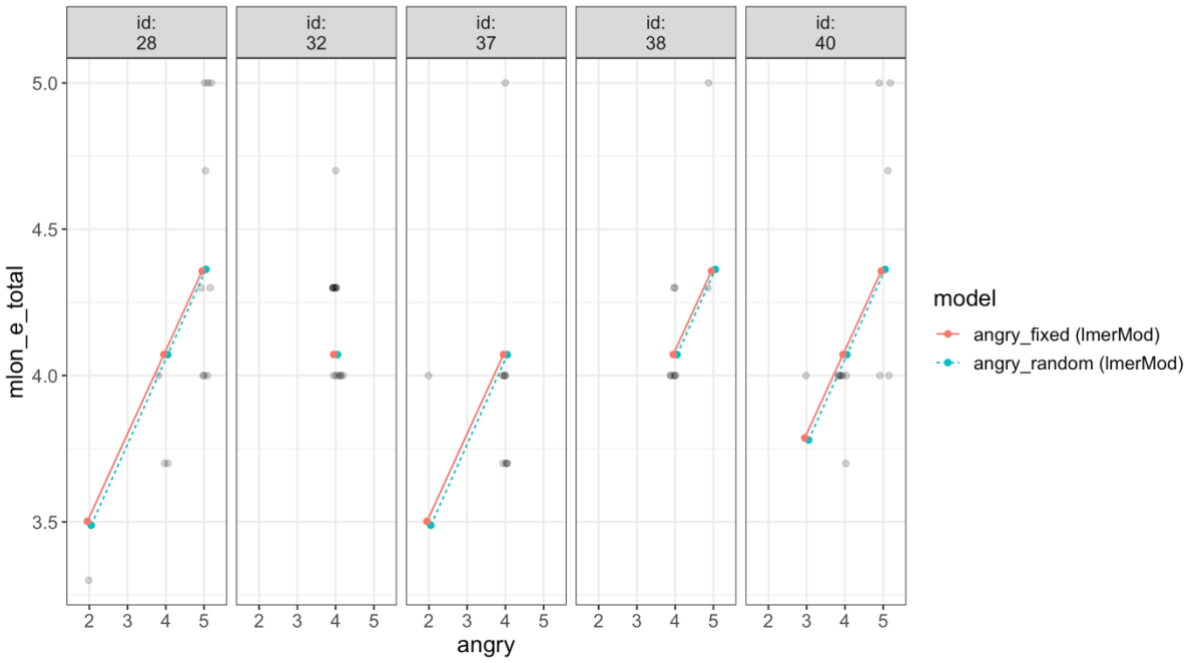


Figure 52: Fixed vs. Random effect "Angry"

In the visual comparison of the variable 'angry' over the experienced momentary emotional loneliness as both a fixed (in red) and random (in blue), five different ids are shown. If the slopes are parallel to one another, the variable tends to be fixed, whereas when they differ in slope, a variable tends to be random. In the visual representation it seems that the slopes

are almost identical to one another. This might suggest a fixed variable. To verify this statement, the statistical comparison is used.

Statistics

	aic	bic	bayes factor	p
angry_random	521.901	545.744	0.017	0.19
angry_fixed	*521.692*	*537.587*	*59.044*	

Predicted differences

0%	25%	50%	75%	100%
0.001	0.003	0.014	0.033	0.333

R squared change

(Intercept)	Residual
-2.05534704	0.04610325

Table 33: Statistical comparison "Angry": fixed or random

In the statistical comparison, there is a preference for the fixed model, as noted in cursive. The aic, bic and bayes factor prefer the fixed effect model. The comparison of the two models is done for all the momentary survey variables. These results can be found in Appendix I.

Variable	Type
Angry	Fixed
Scared	Random
sad	Indistinct
happy	Random
comfortable	Indistinct
relaxed	Fixed
loc_fam	Fixed
loc_aes	Fixed
loc_atms	Fixed
loc_smell	Fixed
loc_acc	Indistinct
loc_div_act	Fixed
loc_socsaf	Indistinct
loc_trafsaf	Fixed
loc_nat_el	Fixed
loc_noise	Indistinct
loc_clean	Indistinct
loc_maint	Indistinct

Variable	Type
act_type_1	Fixed
act_type_2	Fixed
act_type_3	Fixed
act_type_4	Fixed
act_type_5	Fixed
act_type_6	Fixed
act_type_7	Fixed
loc_type_1	Fixed
loc_type_2	Fixed
loc_type_3	Fixed
loc_type_4	Fixed
loc_type_5	Fixed
loc_type_6	Fixed
loc_type_7	Indistinct
loc_type_8	Fixed
loc_type_9	Fixed
trans_type_1	Fixed
trans_type_2	Fixed

loc_total	Fixed		trans_type_3	Fixed
company_1	Indistinct		trans_type_4	Fixed
company_2	Indistinct		weekendday	Indistinct
company_3	Fixed		cloud_cover	Indistinct
company_4	Fixed		Temp_Mean	Indistinct
company_5	Fixed		Sun_Mean	Indistinct

Table 34: Overview Random Effect check

After the first round of checks, there were still some variables with indistinct result. Herein, the visuals were unclear and the aic, bic and bayes factor also gave contrasting results. To resolve this, a reduction method was used. By using model selection, the remaining variables were stepwise compared by checking their information criteria. This resulted in a model with the highest information criteria and R-squared value.

Variable	**Type**
Scared	Random
Sad	Random
Happy	Random

Table 35: Remaining Random variables

Most of the variables that seemed indistinct with the first check, however these turned out to be mostly fixed in their behaviour. To find the results from the implementation of the random effects, the estimates are retrieved from the model.

Fixed Effects:

(Intercept)	scared	happy	sad
3.3429057	0.1073142	0.2267703	0.2083776

Random Effects:

Groups	Name	Std.Dev.	Corr		
id	(Intercept)	0.80182			
	scared	0.15939	-0.276		
	happy	0.16689	-0.607	-0.079	
	sad	0.16647	-0.661	-0.538	0.61
	Residual	0.33682			

ICC	**Design effect**
0.5307688	5.3202115

R Squared:

(Intercept)	Residual
-1.80662	0.4398132

Table 36: Estimates of the total randoms model

The estimates include both a fixed and a random effect as for each variable that is random, there is an 1st level, or 'overall', fixed effect. The ICC and Design effect levels are the same as in the previous chapter as it contains the same dataset. The R squared offers us valuable information about the goodness-to-fit level of the model. About 43.9% of the results can be explained in the current model.

In figures 55, 56, and 57, the random variables are described, controlling for all the fixed variables. The slopes of the different id's vary significantly in comparison to the fixed slope of the model. As the lines truly seem to direct in varying directions, it can be accepted that these values are random.

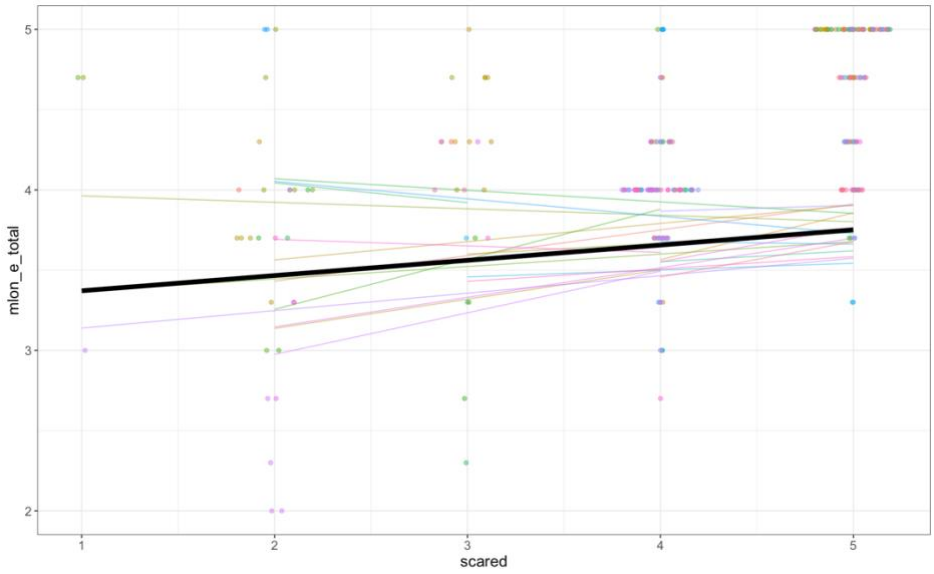


Figure 53: Random effect "Scared"

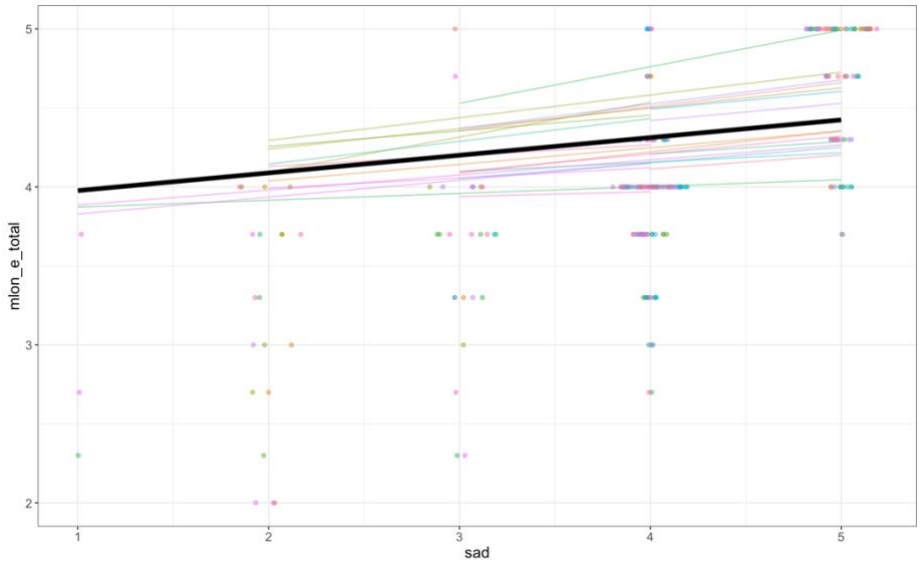


Figure 54: Random effect "Sad"

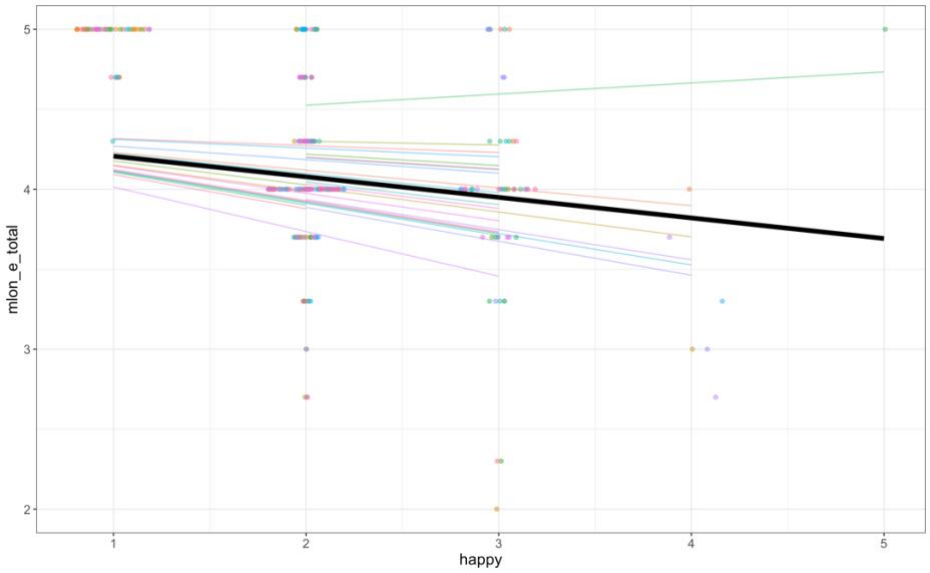


Figure 55: Random effect "Happy"

7.3 Model optimalisation and fitting

After the results of the random variables are clear, the total model can be estimated. When working with mixed models, there are two different methods of deriving the final model: the 'top-down' and the 'step-up' method (Gail et al., 2009). As the top-down method is supported most in literature, this is the chosen method. The top-down method entails the making of a full model and removing variables step by step and comparing these models on aic and bic scores and the r squared value.

In the total model, all variables are included as described in the data preparation. This results in the following model:

```
full_model_4 = lmer (mlon_e_total ~ angry + scared + sad + happy +
comfortable + relaxed + loc_fam + loc_aes + loc_atms + loc_smell +
loc_acc + loc_div_act + loc_socsaf + loc_trafsaf + loc_nat_el + loc_noise
+ loc_clean + loc_maint + company_1 + company_2 + company_3 + company_4 +
company_5 + act_type_1 + act_type_2 + act_type_3 + act_type_4 +
act_type_5 + act_type_6 + act_type_7 + loc_type_1 + loc_type_2 +
loc_type_3 + loc_type_4 + loc_type_5 + loc_type_6 + loc_type_7 +
loc_type_8 + loc_type_9 + trans_type_1 + trans_type_2 + trans_type_3 +
trans_type_4 + weekendday + cloud_cover + Temp_Mean + Sun_Mean + age +
hh_number + men + study_time_1 + study_time_2 + study_time_3 +
work_time_1 + work_time_2 + work_time_3 + educ_1 + educ_3 + partner_1 +
liv_en_1 + liv_en_2 + hh_sit_1 + hh_sit_2 + hh_sit_3 + hh_sit_4 +
hh_sit_6 + h_type_1 + h_type_2 + sm_app_2 + sm_app_3 + sm_app_4 +
sm_app_5 + sm_app_6 + sm_app_7 + sm_app_8 + sm_app_9 + sm_time_1 +
sm_time_2 + sm_time_3 + sm_time_4 + sec_total + p_ex_total +
p_neur_total_R + lon_s_tot + lon_e_tot +
(scared + happy + sad |id), data = total.v1)
```

The model states that it is a 'lmer' which is a linear mixed effects model. It is looking at dependent variable 'mlon_e_total' or the momentary emotional loneliness score in relation to the fixed effects (variables 'angry' to 'lon_e_tot') and the random effects 'scared', 'happy' and 'sad', clustered per 'id'. The data is derived from dataset total.v1.

The 'total' model has an r-squared value of 0.4903. This means that 49% of the values can be predicted by the model. This seems on the low side, however, studies performed with humans tend to have a r-squared value around the 0.5, as human behaviour is hard to predict (Frost, 2018).

In figure 58, the fitting of the 'full model' is shown. As the r-squared value predicts, the fitting of the model is not perfect. The histogram follows the expected bell-curve slightly; however, it is skewed to the right. For the independence of the residuals model, the aim is to have randomly scattered residuals. However, as this is not entirely the case, this might suggest a lack of fit in the model.

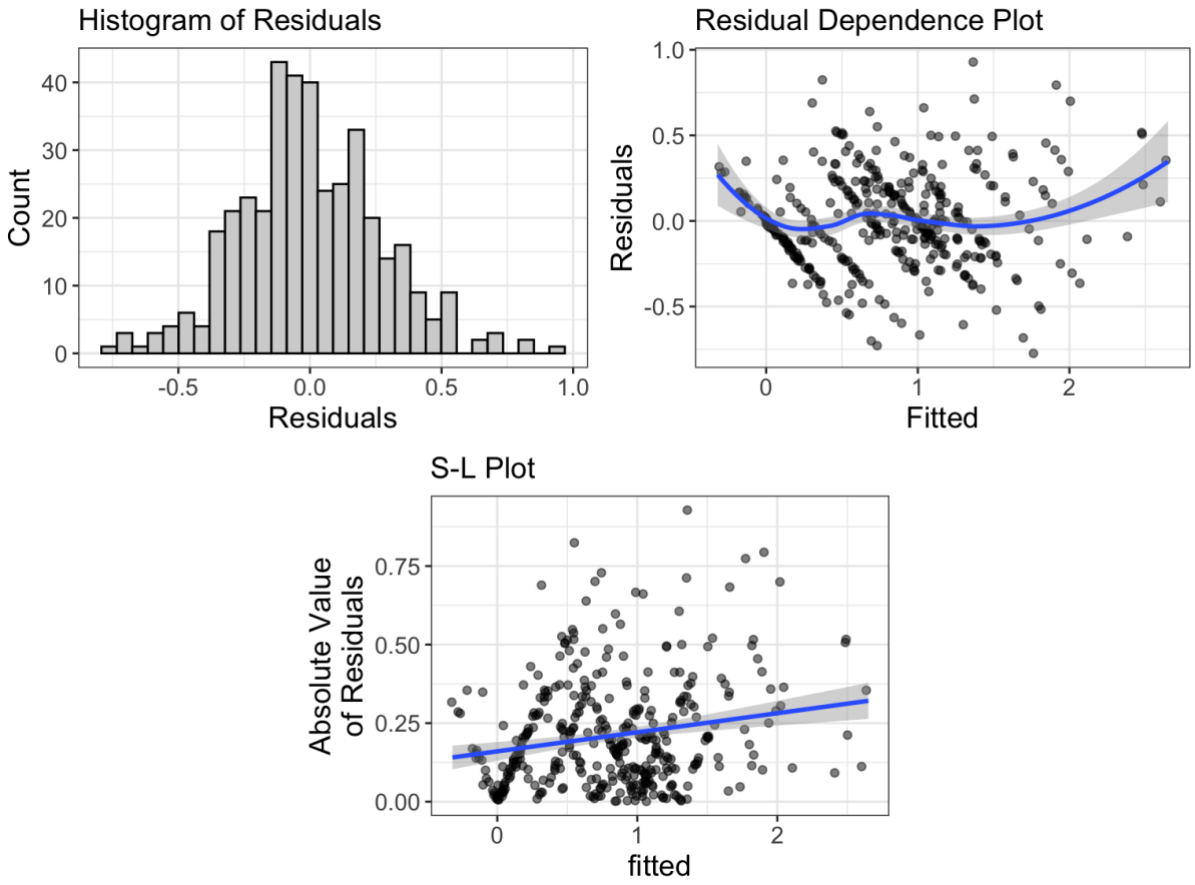


Figure 56: Fitting of the full model

To find out whether there is a better version of the model with a higher r-squared value, a new model was created by using the top-down method and removing low-significant variables stepwise. This resulted in 'full_model_8', with a total r-squared value of

0.5197, which is a slight improvement to the previous r-squared value of 0.4903. This model was also favoured over the total model by the aic, bic, and bayes factor. This is the model with the highest r-squared value that is still supported by the aic and bic.

In an aim to further investigate the effect of the emotions, the control variables, and the location attributes on the momentary feeling of emotional loneliness, three different versions of the model were made. The results of these models will be discussed in the results chapter.

7.4 Conclusion

In the mixed model chapter, all steps taken in the preparation of both the data and the model in R are described in detail. In R, it is first checked whether the dataset is suitable for making a mixed model. The cluster type used is identified as 'id', which was expected as this was the research design. Afterwards, the different random variables from the 'momentary' survey were tested and compared to derive to the three total random variables used in the full model. Lastly, the full model is talked through, and the follow-up models are described. The results of these models will be discussed in the upcoming chapter.

8.

Results

noun

the information you get from something such as a scientific experiment or medical test

8. Results

In the results chapter the findings from the earlier described models are presented. The results from the different models will be discussed and the possible effects of the removal of one or several groups of variables will be researched. Each of the models, the results will be analysed according to their appropriate layer from the social-ecological model.

8.1 Optimal model

As described in the previous chapter on the optimalisation of the mixed model, the optimal model was the model with the highest r-squared value (0.5197) and the one preferred by both the aic and bic. To attain the optimal model, variables were removed in a stepwise manner. The variables removed were the ones least significant in the previous model. The total of the variables removed were the following:

Variables	Variables
0-24 hours study time	Neuroticism personality
0-24 hours work time	Noise
Aesthetics	Outdoor
Age	Peers/co-workers
BeReal	relaxed
Café / restaurant	Relaxing
Cleanliness	Smell
Cloud cover	Social gathering
comfortable	Social Media 2-3 hours
Culture/sports venue	Social Safety
Eating	Studying
Family	Suburban
Friends	Sun Mean
Hh number	Traffic Safety
House of friend / relative	Travel By bike
LinkedIn	Travel by public transport
Living with parents	University/School
Location familiarity	Urban Central
Natural elements	Work

Table 37: Variables removed from the 'full model'

Remarkable is the amount of activity types, location attributes and location types are included in the 'insignificant' variables. A possibility could be that there was not enough difference in between the given location scores for the variable to make a significant difference on the momentary emotional loneliness score.

For all the results tables, only the significant variables were selected, as the total list of variables would be disorderly. A t-value of 1.65 is accepted as significant, as it covers approximately 90% of the confidence area. The total results of the models can be found in the Appendices K-O.

8.1.1 Individual

The individual layer contains mood, gender, a personality type, and the baseline loneliness types. Age was deemed not significant and is therefore not in the 'optimal' model.

Table 38: Significant results optimal model: individual layer

Individual	Estimate	Std. Error	t value
Mood			
angry	0.09	0.03	3.26
happy	-0.13	0.04	-3.09
sad	0.13	0.04	3.77
scared	0.09	0.04	2.37
Gender			
Male	-0.14	0.06	-2.20
Personality			
Extravert	-0.03	0.01	-2.51
Baseline loneliness			
Emotional	0.17	0.03	5.81
Social	-0.05	0.02	-2.42

For mood, only 'angry', 'happy', 'sad' and 'scared', deemed the basic emotions in literature, were significant. 'Relaxed' and 'comfortable' did not have any result. Of the basic emotions, only 'happy' has a negative influence on the feeling of loneliness, meaning that it reduced the momentary feeling of emotional loneliness for that person by 0.13. The other three emotions have an increasing effect on the feeling of momentary emotional loneliness. Especially feeling sad, increases the feeling of loneliness most. This could be explained as the feeling sad resembles feeling lonely most. The feelings 'scared' and 'angry' have a similar effect on loneliness.

For gender, being a male decreases the momentary feeling of loneliness with 0.14.

Personality seems to be of importance as well, as being extraverted has a small effect (-0.03) as well.

Both the baseline loneliness variables have a significant influence on the momentary feeling of emotional loneliness. As to be expected, higher levels of baseline emotional loneliness translate in higher levels of momentary emotional loneliness. On the other hand, high levels of social loneliness show a small decrease in momentary emotional loneliness. This is surprising but can be explained because social and emotional loneliness do not have to be correlated.

8.1.2 Household

The significant household variables are mainly socio-demographic, such as study time, work time, education level and partner status. However, house type and household composition situation have an influence as well. The density and number of household member did not seem significant in the results.

Table 39: Significant results optimal model: household layer

Household	Estimate	Std. Error	t value
Education Level			
Secondary Education	-0.27	0.06	-4.42
HBO	-0.40	0.18	-2.16
House Type			
Row house	-0.64	0.11	-5.59
Apartment/studio	0.62	0.13	4.92
Household situation			
With friends	0.43	0.12	3.56
With acquaintances	0.33	0.12	2.74
With my partner	-0.51	0.15	-3.51
On my own	-0.39	0.14	-2.75
Partner			
Yes	0.48	0.12	4.10
Study Time			
0 hours	0.22	0.12	1.80
24-40 hours	0.39	0.10	4.02
Work Time			
0 hours	-0.18	0.07	-2.49

For education level, both having completed a secondary education (-0.27) and having completed an HBO (-0.40) have decreasing effect on the level of momentary emotional loneliness. Having finished secondary education could implicate that these participants are currenty studying for a higher education degree such as HBO or a university degree.
For the house type, living in a row house has a decreasing effect on the feeling of loneliness (-0.64), whereas living in an apartment/studio increases the feeling of loneliness (+0.62). This might be caused by the lack of socialisation that is associated with living in a studio or apartment.
For the household situation, living with your partner is best at decreasing the momentary feeling of loneliness (-0.51), followed closely by living on your own (-0.39). On the other hand, both living with acquaintances (+0.33) and living with friends (+0.43) increase the feeling of emotional loneliness.

Surprisingly and in contrast to the household situation, having a partner increases the feeling of momentary emotional loneliness (+0.48).
Both not studying (+0.22) and studying full-time (+0.39) seem to increase loneliness. However, not working decreases the feeling of emotional loneliness (-0.18).

8.1.3 Social Environment

For the social environment layer, both the momentary and the baseline variables are considered. Herein, the influence of social media, both the types of applications and the times spent on these applications are covered. Furthermore, the sense of community, one type of company and one type of activity are discussed.

Table 40: Significant results optimal model: Social Environment Layer

Social Environment	Estimate	Std. Error	t value
Sense of community	0.04	0.02	2.00
Company			
Alone	0.19	0.05	3.94
Activity Type			
Sporting	0.18	0.10	1.74
Social Media Application			
Snapchat	0.45	0.13	3.55
TikTok	-0.47	0.14	-3.35
Instagram	0.28	0.09	3.16
Twitter	0.68	0.16	4.28
Facebook	0.34	0.08	4.31
Social Media Time			
0-1 hours	0.60	0.12	4.97
1-2 hours	-0.24	0.09	-2.76

Having a high-scoring sense of community has a small effect on the increase of emotional loneliness (+0.04).
For the company type, being alone increases the feeling of loneliness with +0.19. Surprisingly, sporting also increases the feeling of momentary emotional loneliness (+0.18).
For the social media influence there are a lot of varying social media applications that influence the feeling of momentary emotional loneliness. Almost all applications increase the feeling of loneliness, except for TikTok (-0.47). Instagram (+0.28), Facebook (+0.34) and Snapchat (+0.45) increase the feeling of loneliness a lot, however, Twitter increases the feeling of momentary emotional loneliness most (+0.68).
For the social media time, there seems to be a minimal number of hours one should spend on social media to be less lonely, as the 0-1 hours of social media time increases loneliness with +0.60. Contrastingly, spending about 1 to 2 hours on social media per day decreases momentary emotional loneliness (-0.24).

8.1.4 Physical Environment

For the physical environment layer, only a few location attributes, location types and transportation types are included in the optimal model. Familiarity of the location was not included in the model as it was not significant.

Table 41: Significant results optimal model: physical environment layer

Physical Environment	Estimate	Std. Error	t value
Location Attributes			
Accessibility	-0.05	0.03	-1.85
Atmosphere	-0.07	0.03	-2.03
Location Type			
Home	0.08	0.05	1.66
Transportation	0.33	0.11	3.17
Transportation Type			
By foot	-0.21	0.09	-2.41
By car	-0.14	0.08	-1.82

For the location attributes, both the accessibility of a location and the atmosphere of the location have an influence on the momentary feeling of loneliness. The atmosphere (-0.07) seems to have slightly more influence on loneliness than accessibility (-0.05). However, compared to the other variables in this category, the effect is very limited.
Being at home increases the feeling of momentary emotional loneliness slightly (+0.08), however individuals seem to feel lonelier when transporting from one location to another (+0.33).
As for the transportation types, both traveling by foot and by car decrease the feeling of loneliness. Herein the effect of travelling by foot (-0.21) is higher than by car (-0.14).

8.1.5 Contextual Factors

Lastly, for the contextual factors only the type of day reached the optimal model. The time and all three weather attributes did not have a high enough significance.

Table 42: Significant results optimal model: external factors

Contextual factors	Estimate	Std. Error	t value
weekendday	-0.08	0.04	-1.91

The difference between weekdays and weekend days have effect on the feeling of loneliness. A weekend day decreases the feeling of momentary emotional loneliness by -0.08.

8.2. Result Discussion

The result discussion considers the results found in the MRM and compares it with the found literature. This process gain insight in what relationships were unexpected and to what extent the findings of this research are in line with previously published works.

8.1.1. Respondent-level variables

The respondent-level characteristics consist out of three different layers: the individual, the household, and the social environment layer. Each of these variables were gathered in the baseline survey and the variables were controlled for in the model.

Individual

The first of the individual variables was age. As stated in the hypothesis based on the found literature, the variation of ages within the age group of young adults (18-25 years old), would not vary due to a similar state of development of the individual. As the result of the thesis conclude no significant influence on the age variable, the hypothesis on age seems to be correct. Gender seems to influence the emotional state loneliness. However, in contrast with the findings in literature, for the young adults age group, the male participants seemed to feel less lonely than their female counterparts. This difference in result could be due to a slightly male-dominant dataset, as it includes mostly high-educated male student in the technology sector and students with relatively 'high' extroversion scores. Another possible reasoning might be a generational factor. Possibly, expressing themselves emotionally towards their friends and not only their romantic partner is easier for the younger generation of men.

For the personality types, the hypothesis that an extravert personality decreases the feeling of momentary emotional loneliness seems to be correct, as it shows significant results in the model. The connection with neuroticism, which was found in literature, did not show an effect in this research. However, this might be due to little variance within the neuroticism scores.

For the trait loneliness, the hypothesis was that it influences the feeling of state loneliness, both emotional and social loneliness. Trait loneliness seems to influence momentary loneliness, as both the baseline loneliness types show a significant effect. However, it does appear 'loneliness type' linked. The emotional trait loneliness increases the emotional state loneliness. However, the social trait loneliness seems to decrease it. This suggest that social and emotional loneliness themselves can exist apart from each other, however this would require more research.

Household

The socio-demographic variables were organised into various variables: study time, work time, education level, nationality, and partner status. For study time, not studying at all resulted in higher levels of loneliness. This could be explained by the participant dataset, as

most of the participants were either students or had been students recently. Not studying at all could feel as a lifestyle change and therefore increase the feeling of loneliness. On the other hand, studying fulltime (24-40 hours) increased the feeling of loneliness as well. Therefore, it might be concluded that studying generally increases the feeling of loneliness, as being a student entails an eventful and unstable time in a person's life.
Considering work time, only 'not working' seems to show significant results, as it decreases the feeling of loneliness. This might be because the combination of both studying and working causes lack of time, lack of socialization and higher stress-levels. For the obtained education level, both having finished secondary education and having finished an HBO level of study seemed to significantly reduce the emotional state loneliness. This is somewhat in contrast with the literature findings, as the literature suggested that lower educated people would have higher levels of loneliness. However, as these participants are still in the process of obtaining further education, not all participants who selected 'secondary education' represent the low-educated population group, as they might be busy studying for an HBO or university degree. Therefore, the education level results should be considered with care. As for the nationality, the entire dataset was native Dutch and was not considered in the final model, as it would not have been significant. Partner status has contrasting results in the findings of the literature and the results from the study. In literature, having a partner decreases the feeling of loneliness, whereas in the finding having a partner seems to increase the feeling of loneliness. Possible explanations might be that this age group is still actively participating in social gatherings, such as going out, which is oftentimes limited when having a partner. This could result in feeling left out. Another explanation could be the still developing character of this age group. For a lot of people, their first 'serious' relationship falls within the young adults age category, therefore some of the relationships might not be happy and/or fulfilling ones, as these people are still trying to figure themselves out.
The house type influences the feeling of loneliness, according to the findings. As found in literature, the apartments/studios house type increases the feeling of loneliness. This could be due to the lack in financial means or the lack of social contact that is associated with living in an apartment/studio. Row houses seem to decrease this. A possible explanation might be the presence of neighbours without it being as 'packed' and mass-scale as an apartment can be. As student houses were highly correlated with the row houses, these were removed from the dataset and were not included in the mixed model. As it was highly correlated, it might have had a similar result as for row houses with the decrease of a feeling of loneliness.
The household composition seemed to be of importance, however the amount of household members did not. The relationship a person has with their household members could influence the feeling of emotional state loneliness. In line with the literature results, people living with their partner seemed less emotionally lonely. Surprisingly, living with roommates, either acquaintances or friends, seemed to have an opposite effect. A possible explanation might be that when a person lives with roommates, roommates need to be

considered. This might clash with one's personal lifestyle or preferences, which could increase loneliness. Living with a romantic partner might have a different effect because of the difference in relationship type.
The density in which a person's house was situated did not have any significant results in this research. This might be due to the little variance there was between the density types, as most participants lived either in an urban central or suburban area.

Social Environment

Social media was important for the momentary emotional loneliness score. The application types mostly increased the momentary emotional loneliness, as expected in the literature. Applications as snapchat, Facebook and Instagram, where there is very passive user engagement, increased the feeling of loneliness. Twitter scored worst. A reason might lie in the passive/argumentative nature of the social media platform. On the other hand, TikTok seemed to decrease the feeling of momentary emotional loneliness. This could be explained by a more active user-experience in contrast to the other applications.
For time spent on the social media applications, there seems to be an optimal amount around the 1-2 hours, as lower than this number there is an increase in the feeling of loneliness. This suggest that not being part of social media at all or only very little increases the feeling of loneliness. This might be linked to a fear of missing out. The effect of high number of hours spent on social media could not be found as there were probably too few participants with this behaviour pattern.
The sense of community has only a very slight negative effect. This is surprising as the literature suggest that is should decrease emotional loneliness. An explanation could be that as the young adults are still very socially active, there was no need to access and therefore find out the benefits of their community yet.

8.2.2. Activity Setting variables.

The influence of the activity setting on emotional state loneliness is derived out of the social environment, the physical environment, and contextual factors.

Social environment

The company, or especially the lack of company was important. Being alone did increase the momentary emotional loneliness, as was expected based on the findings in literature. Surprisingly, only in the full model the company type strangers became important, due to the possible overfitting of the model no conclusions can be drawn from this. The 'peers/co-worker' company type did not have a significant result in the MRM. This is surprising, considering both the findings from the literature study and the bivariate analysis. Both suggested an increase in loneliness with the presence of this company type. A possible explanation might be that the results of MRM are different due to the clustering effect.
For the activity types, few significant results were found. Only the activity 'sporting' seems to have an increasing influence on the emotional loneliness score. However, it is difficult to

draw any conclusions from this. This might suggest there is no or little relationship with the type of activity a person is partaking in and their feeling of momentary emotional loneliness.

Physical environment

A persons previous (emotional) attachment of familiarity with the environment did not provide any significant results in this model. The literature it was suggested that some cultures could have high levels of attachments with certain locations, which would emulate a feeling of togetherness. However, this was not reflected in the results. As the survey questions focus mostly on a neighbourhood sense of community and this age groups tends to move around, there might be a possibility that the sense of community has a negative effect because it is not yet supported by this community type.

The location attributes were the main research variables of this thesis, and only had few significant results: the accessibility and the atmosphere of the location. The accessibility of the facilities was expected, as higher scores of accessibility result in a more diverse and open location. In contrast to those variables, the lack of 'diversity in activities' and the lack of 'natural elements' of a location are in strong contrast with the found literature. Both seemed to be important to emotional loneliness. The diversity in activities, specifically, seemed to be important for the young adults age group. A possibility could be that all the location attributes scored relatively high, resulting in little variance to draw conclusions from.

The type of location mostly seems important when it concerns a person's home or when they are 'on the road'. Surprisingly, for a person to be at home increased the feeling of emotional loneliness. This could be explained by the exclusion of social activities or social contacts, that usually take place outside an individual's home. Additionally, taking part in traffic, resulted in higher loneliness scores. This might be relatable to the company surrounding a person when being on the road. A person is either alone or surrounded by strangers, both of which could possibly influence the feeling of emotional state loneliness. However, this is a hypothesis that needs further testing.

In the literature study, the relationship between location type and activity type was suggested as being influential on one another. However, because no other activity type than sporting was deemed significant, this hypothesis on the relationship between the two variables cannot be tested.

For transport type, the hypothesis was that communing in a way that costs physical activity, would decrease emotional loneliness. This is partially true, as transfer by foot decreases the feeling of momentary emotional loneliness. However, transfer by car does as well (to some extent). As most of the participants did not have the opportunity to travel by car, there might be a positive relation with this transport type as it offers more freedom than the participants are used to. Being on location already did not seem to have significant results, which contrasts with the bivariate analysis findings, wherein it seemed to increase loneliness. Furthermore, cycling did not provide any significant results, as it was removed from the dataset in the stepwise improving of the model.

Contextual factors

For the contextual factors, the day type is the only variable with significance. As literature suggested, the weekend days do indeed decrease the feeling of momentary emotional loneliness. A possible explanation is the freedom of activities a person must choose from in contrast to the strict working hours on weekdays.

The weather variables did not provide any significant results; therefore, no conclusions can be drawn from this. A possible explanation for the lack of weather variable significance might be that the survey was designed to last only for a week, limiting the variation between the weather variables per participant.

8.3 Different Model Comparison

To check the importance of the different components of the mixed model, various adaptations of the model were made. For the optimal model the total R-squared value was 0.5197123. Removing all the control variables retrieved from the baseline survey, resulted in a model with an R-squared value of 0.5171748. As the fitting of this model is only slightly lower than the fitting of the entire model, it might be said that the baseline information is only for a small part responsible for the influence of the prediction of the momentary emotional loneliness in relation to the built environment.

The explanation of the full comparison of all different models made can be found in Appendix J.

8.4 Conclusion

In this chapter, the results of the MRM model were discussed. From a total of 43 participants, 393 points were gathered. The results of this dataset were divided into the social-ecological layers. The individual layer stated the importance of the mood variables. Being male and being extraverted decreases the feeling of loneliness. On the other hand, having previous/baseline higher levels of emotional loneliness increases the levels of momentary emotional loneliness. For the household layer, the socio-demographic variables have significant influence. Education level, study time, work time, and whether a person has a partner all influence the feeling of loneliness. House type apartment/studio increases the loneliness levels. As does the living with roommates, whether they are friends or acquaintances. The density of the area does not seem to influence the loneliness levels. For social environment, being alone makes a person lonelier. The social media applications seem to increase loneliness except for TikTok. For the time spent on social media, there is a balance, too little time makes a person lonelier. About 1 to 2 hours a day seems to be beneficial. The physical environment, a locations accessibility and the atmosphere decrease the momentary emotional loneliness. Taking part in transport makes a person feel lonelier, however if this is by foot or by car, a person can see a decrease in loneliness. Lastly, in the

weekends, people experience a lower loneliness score. Overall, the momentary variables, in the social and physical environment and the external factors seem to have more influence on the prediction of the dependent variable than the control variables do. The results can be used in the next chapter to draw conclusions and answer the research questions.

9.

Conclusion

noun

the opinion you have after considering
all the information about something

9. Conclusion & Discussion

In the conclusion and discussion chapter, the results from the research will be discussed and compared according to the research questions and the collected information from the literature study. Then possible influencing factors on the research will be discussed. Recommendations will be given as to how include the results of this thesis in further built environment developments and suggestions for follow-up research will be given.

9.1 Conclusion

Loneliness amongst young adults is a serious problem that, if left untreated, will influence both the individual and the community. As it is known from previous research, the built environment can influence a person's experience of the feeling of loneliness. Therefore, the aim of the thesis is to find out what built environment characteristics influence the emotional state loneliness of an individual, to prevent further trait loneliness in the future. That is summarised in the problem statement:

"What are the built environment characteristics that influence the emotional state loneliness of young adults during their daily activities and what is the mediating role of activity settings?"

To answer this problem statement, two different sub questions were derived to help support and explain the complexity of the problem statement. The first question being: "*What is the influence of respondent-level variables on emotional state loneliness*?" and the second "*What is the influence of the activity setting on emotional state loneliness?*". For the conceptual model, the focus was the effect of the activity setting on the momentary emotional loneliness, controlling for the personal characteristics. To break down the complexity of the variables that influence a human, an adaptation of Bronfenbrenner's socio-ecological model was made. For respondent-level variables this included an individual, household, and social environment layer, whilst for the activity setting it was composed out of the social environment and physical environment layer and the external factors. To provide an overview of the results of the performed research steps, the conceptual model is filled out per layer in figure 57.

While working on answering the question *"What is the influence of respondent-level variables on emotional state loneliness?"*, various results were found. For the individual layer, gender, an extravert personality type and having high levels of trait loneliness had a significant influence on the emotional state loneliness. For the household variables, education level, house type, household situation, partner status, study time and work time, all provided significant results. Education level, household situation and partner status were also deemed significant in the bivariate analysis. However, it needs to be considered that the bivariate analysis does not test for clustering and that unsignificant data in this analysis

might not be correct. A surprising finding was that having a partner for this age group increases the feeling of emotional state loneliness. For the social environment of the personal characteristics, it seemed that all TikTok resulted in an increase in loneliness level. Sense of community increased the emotional state loneliness, which contrasted with the literature study findings based on the older age groups.

It can be said that the experience of loneliness is influence by a person's background. However, when comparing the model that controlled for the respondent-level variables and the one that did not, only a slight difference in the goodness-of-fit of the model could be found, preferring the model with the control variables. This indicates that, even though there are a lot of respondent-level variables that influence a person's experience of loneliness, the influence of one's background on loneliness in that specific moment might be limited. It is important that these variables are controlled for. However, if the aim is to change emotional state loneliness, the focus should be on the activity setting.

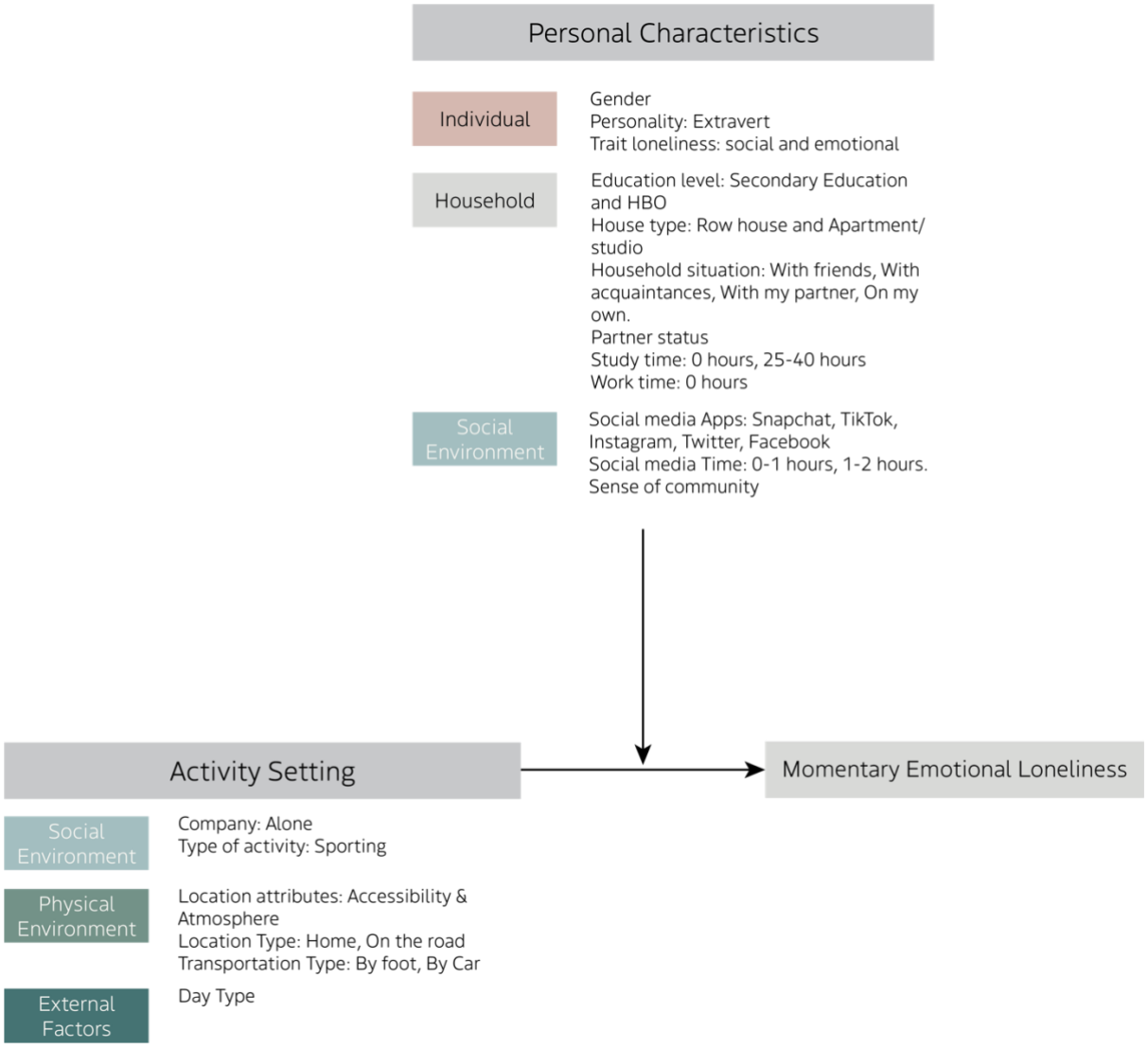


Figure 57: Overview Result in the Conceptual Model

The second sub-question was: "*What is the influence of the activity setting on emotional state loneliness?*". When looking at the significant variables that are the results of the performed MRM, the social environment layer contained both the 'company' and the 'activity type' variables. The activity 'sporting' had an increasing effect on the feeling of loneliness, which was in contrast with the hypothesis. For the physical environment, the location attributes accessibility and atmosphere were deemed significant influential on the momentary feeling of emotional loneliness. Traveling by car had an interesting effect on the reduction of the state loneliness, which contrasted with the movement-promoting hypothesis. The location type was significant in both MRM as bivariate analysis, with 'on the road' increasing the emotional state loneliness. For the external factors, the findings in literature were confirmed, with loneliness rates being lower in the weekend.
To answer the sub-question. The influence of activity setting on emotional state loneliness is significant, as almost all the identified activity setting variables provide significant results. The goodness-of-fit of the MRM model is primarily based on the activity setting variables, suggesting that the activity setting has direct influence on the emotional state loneliness.

Combining the information of the two sub questions provides insight in the information needed to answer the main research question: the main built environment characteristics that influence the emotional state loneliness of young adults are the location attributes 'accessibility' and 'atmosphere' and the location type. High scores in accessibility and atmosphere of a location significantly reduce the emotional state loneliness of young adults in a specific location. The activity setting does have a mediating role for experiencing emotional state loneliness, as both the company type and the location attributes seem to have significant influence on the loneliness score.

To conclude, the built environment directly influences the emotional state loneliness of the age group young adults, both in the physical features the built environment has, such as accessibility, atmosphere, or the location type, as the activity setting it facilitates. By using built environment feature, young adults can reduce their emotional state loneliness in and aim to create the necessary intimate connections.

9.2 Discussion

This thesis provides insight in the variables influencing momentary emotional loneliness amongst young adults in the built environment. However, due to limitation in both time and facilities, there are some remarks to make.

Firstly, the dataset is slightly biased because all the participants are from a similar sort of environment, highly educated and (relatively) social. This results in a dataset, though all

within the parameters of the research design, that does not cover the entire width of the loneliness problem in the Netherlands.

Secondly, the software used to collect the data caused problems for some of the participants, limiting the amount of data input given or even complete participation. The participants had to take various steps for the software to work. As PIEL survey was the only survey type that did not require the participants to create an account to participate, it was used. However, due to the number of steps the participants needed to take to participate and afterwards to provide the results back to the researcher, it was almost impossible to gather data from participants outside of Eindhoven or a personal social circle.

Thirdly, participants noted to have difficulty with the interpretation of certain questions in both the baseline as momentary surveys. The density type question (urban central, green urban etc.) was deemed a too difficult question, as the concepts generally seem to be too vague for participants. Furthermore, several participants had difficulty with answering the questions of the De Jong Gierveld scale as it has a lot of 'vague' words such as 'enough' or 'plenty'. Even though a person's own feeling of what these words mean, provides insight in the feeling of loneliness, it is more difficult to accurately measure how lonely they feel. Some people might rationalise too much (or too little), which changes the result of the loneliness scores.

Fourthly, the measured data contained the variable 'mood'. Even though mood was an important predictor of the emotional state loneliness for the target group, it does have a disadvantage. Mood is not entirely independent. A person's mood can be explained to some extend by the environment or the activity setting, as was discussed in the research set-up. However, in the data processing and in the MRM, mood is treated as an independent variable. In this research, there was no possibility to leave out the 'mood' variable, as it should be controlled for. However, by including it and treating it as independent, results might be altered.

Lastly, all the participants remain human. Meaning that not all of them always filled in the questionnaires, therefore the effect of time could not be taken into consideration, as was anticipated at the start of the research.

9.3 Follow-up research

The first possible follow-up research is the expansion of the research with a bigger sample and over a longer time. In this research the emotional state loneliness was measured for a small sample of participants that were not comparable with the national numbers, as the dataset did not have the same loneliness scores and the participants were not from all

varying backgrounds, education levels and cultures. Using a more diverse group of participants could give different results about the influence on the built environment.
A longer duration could be an interesting feature as well. If the research would have been executed year-round, the influence of the weather factors might have become significant. As the participants only filled in the surveys over the course of a week, there was usually little variance between the weather variables. However, with a longer duration, this might change as the influence of the different season have their effect.

Second future research could focus on the trait loneliness for this age group, rather than the state loneliness. For this research and its time limitations, research on the long-term effects was not possible. However, experiencing trait loneliness is ultimately what causes the long-term negative effects on both person and society. For an influence of trait loneliness, the scope of the research should be multiple years, rather than a few-months or one-year research. Loneliness, and the way it portrays itself, develops over time. Any effects because of long-lasting loneliness might only be visible later in life. Therefore, research on trait loneliness could provide valuable insight in the workings of trait loneliness amongst all age groups.

At last, more practical follow-up research could be out of what 'building blocks' the two significant location variables exist to apply these in practice. How are 'accessibility' and 'atmosphere' defined for the young adult age group and what attributes of these variables can be made visible in the built environment. Is there a difference for how these attributes are perceived amongst different age groups, cultures, and backgrounds. When defining these, municipalities could easily adapt these building blocks to reduce the feeling of loneliness amongst the population.

9.4 Implications

This thesis provides a first insight in what built environment characteristics are of importance for the feeling and possible prevention of emotional state loneliness amongst the age group of young adults. The conclusions suggest that implementing the built environments in a real-world setting would benefit the target group and potentially prevent further effects of loneliness in the future.
For municipalities this could imply some changes in for city planning. A reduction in the building of apartment/studios for this age group, though financially unattractive, could be effective. Additionally, creating various parts within a city or are in which there is a diversity of activities that can be reached either by bike or by foot enables this age group to use and benefit from the facilities present. Lastly, attention should go to the creating of spaces that allow for a convivial atmosphere, to provide and encourage engagement with different company and activity types.

Literature

Aerd Statistics. (2018). *Independent t-test using SPSS Statistics*. https://statistics.laerd.com/spss-tutorials/independent-t-test-using-spss-statistics.php

Aerd Statistics. (2020). *Pearson Product-Moment Correlation*. https://statistics.laerd.com/statistical-guides/pearson-correlation-coefficient-statistical-guide.php

Barreto, M., Victor, C., Hammond, C., Eccles, A., Richins, M. T., & Qualter, P. (2021). Loneliness around the world: Age, gender, and cultural differences in loneliness. *Personality and Individual Differences*, *169*. https://doi.org/10.1016/j.paid.2020.110066

Birenboim, A. (2018). The influence of urban environments on our subjective momentary experiences. *Environment and Planning B: Urban Analytics and City Science*, *45*(5), 915–932. https://doi.org/10.1177/2399808317690149

Bodford, J. E. (2017). Loneliness in Modern Life. In *Encyclopedia of Evolutionary Psychological Science* (pp. 1–16). Springer International Publishing. https://doi.org/10.1007/978-3-319-16999-6_1580-1

Bolger, N., & Laurenceau, J.-P. (2013). *Sample Chapter: Intensive Longitudinal Methods: An Introduction to Diary and Experience Sampling Research*. www.guilford.com/p/bolger

Bower, M., Kent, J., Patulny, R., Green, O., McGrath, L., Teesson, L., Jamalishahni, T., Sandison, H., & Rugel, E. (2023a). The impact of the built environment on loneliness: A systematic review and narrative synthesis. *Health & Place*, *79*, 102962. https://doi.org/10.1016/j.healthplace.2022.102962

Bower, M., Kent, J., Patulny, R., Green, O., McGrath, L., Teesson, L., Jamalishahni, T., Sandison, H., & Rugel, E. J. (2023b). *The impact of the built environment on loneliness: A systematic review and narrative synthesis Main Text*.

Bronfenbrenner, U. (1979). *The Ecology of Human Development*. Harvard University Press.

Cacioppo, J. T., & Cacioppo, S. (2018). *The growing problem of loneliness*. https://doi.org/10.1016/S0140

Caruana, E. J., Roman, M., Hernández-Sánchez, J., & Solli, P. (2015). Longitudinal studies. *Journal of Thoracic Disease*, *7*(11), E537–E540. https://doi.org/10.3978/j.issn.2072-1439.2015.10.63

CBS. (2022, September 29). *Vooral jongeren emotioneel eenzaam in 2021*. https://www.cbs.nl/nl-nl/nieuws/2022/39/vooral-jongeren-emotioneel-eenzaam-in-2021

Center for Disease Control and Prevention. (2021, April). *Loneliness and Social Isolation Linked to Serious Health Conditions*. https://www.cdc.gov/aging/publications/features/lonely-older-adults.html

Chipuer, H. M. (2001). Dyadic attachments and community connectedness: Links with youths' loneliness experiences. *Journal of Community Psychology*, *29*(4), 429–446. https://doi.org/10.1002/jcop.1027

Chipuer, H. M., Pretty, G. H., Delorey, E., Miller, M., Powers, T., Rumstein, O., Barnes, A., Cordasic, N., & Laurent, K. (1999). The neighbourhood youth inventory: Development and validation. *Journal of Community and Applied Social Psychology*, *9*(5), 355–368. https://doi.org/10.1002/(SICI)1099-1298(199909/10)9:5<355::AID-CASP511>3.0.CO;2-6

Columbia School of Public Health. (n.d.). *Repeated Measures Analysis*. Retrieved April 10, 2023, from https://www.publichealth.columbia.edu/research/population-health-methods/repeated-measures-analysis

Complete Dissertation. (n.d.). *Conduct and Interpret a One-Way ANOVA*. Retrieved June 14, 2023, from https://www.statisticssolutions.com/free-resources/directory-of-statistical-analyses/one-way-anova/

Complete Dissertation. (2023). *Assumptions of Multiple Linear regression* . https://www.statisticssolutions.com/free-resources/directory-of-statistical-analyses/assumptions-of-multiple-linear-regression/

Csikszentmihalyi, M., & Larson, R. (2014). *Flow and the Foundations of Positive Psychology*.

Dahlberg, L., & Mckee, K. J. (2014). Correlates of social and emotional loneliness in older people: Evidence from an English community study. *Aging and Mental Health*, *18*(4), 504–514. https://doi.org/10.1080/13607863.2013.856863

de Jong Gierveld, J., & van Tilburg, T. (2006). A 6-item scale for overall, emotional, and social loneliness: Confirmatory tests on survey data. *Research on Aging*, *28*(5), 582–598. https://doi.org/10.1177/0164027506289723

de Jong Gierveld, J., van Tilburg, T. G., & Dykstra, P. A. (2006). Loneliness and Social Isolation. *The Cambridge Handbook of Personal Relationships*, 485–500.

Domènech-Abella, J., Mundó, J., Leonardi, M., Chatterji, S., Tobiasz-Adamczyk, B., Koskinen, S., Ayuso-Mateos, J. L., Haro, J. M., & Olaya, B. (2020). Loneliness and depression among older European adults: The role of perceived neighborhood built environment. *Health and Place*, *62*. https://doi.org/10.1016/j.healthplace.2019.102280

Donnellan, M. B., Oswald, F. L., Baird, B. M., & Lucas, R. E. (2006). The Mini-IPIP scales: Tiny-yet-effective measures of the Big Five factors of personality. *Psychological Assessment*, *18*(2), 192–203. https://doi.org/10.1037/1040-3590.18.2.192

Douwes, I. (2020). *Wat zijn de voordelen en nadelen van parttime werken?* WeTalent. https://www.wetalent.nl/sollicitatiehulp/blog/wat-zijn-de-voordelen-en-nadelen-van-parttime-werken/

Eccles, A. M., & Qualter, P. (2021). Review: Alleviating loneliness in young people – a meta-analysis of interventions. In *Child and Adolescent Mental Health* (Vol. 26, Issue 1, pp. 17–33). Blackwell Publishing Ltd. https://doi.org/10.1111/camh.12389

Een tegen Eenzaamheid. (2023). *Over Eenzaamheid*.

Eid, M., & Diener, E. (2004). *Global judgements of subjective well-being: situational variability and long-term stability*.

En Wee, L., Tsang, Y. Y. T., Tay, S. M., Cheah, A., Puhaindran, M., Yee, J., Lee, S., Oen, K., & Koh, C. H. G. (2019). Perceived neighborhood environment and its association with health screening and exercise participation amongst low-income public rental flat residents in Singapore. *International Journal of Environmental Research and Public Health*, *16*(8). https://doi.org/10.3390/ijerph16081384

Erb, S. E., Renshaw, K. D., Short, J. L., & Pollard, J. W. (2014). The importance of college roommate relationships: A review and systemic conceptualization. In *Journal of Student Affairs Research and Practice* (Vol. 51, Issue 1, pp. 43–55). Walter de Gruyter GmbH. https://doi.org/10.1515/jsarp-2014-0004

Fardghassemi, S., & Joffe, H. (2021). Young Adults' Experience of Loneliness in London's Most Deprived Areas. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.660791

Finlay, J. M., Gaugler, J. E., & Kane, R. L. (2020). Ageing in the margins: Expectations of and struggles for “a good place to grow old” among low-income older Minnesotans. *Ageing and Society*, *40*(4), 759–783. https://doi.org/10.1017/S0144686X1800123X

Frost, J. (2018). *How High Does R-squared Need to Be?* Statistics by Jim. https://statisticsbyjim.com/regression/how-high-r-squared/#:~:text=Any%20study%20that%20attempts%20to,high%20R%2Dsquared%20should%20be.

Gail, M., Krickeberg, K., Samet, J. M., Tsiatis, A., & Wong, W. (2009). *Statistics for Biology and Health Series Editors*.

Gibbons, R. D., Hedeker, D., & Dutoit, S. (2010). Advances in analysis of longitudinal data. In *Annual Review of Clinical Psychology* (Vol. 6, pp. 79–107). https://doi.org/10.1146/annurev.clinpsy.032408.153550

Gu, S., Wang, F., Patel, N. P., Bourgeois, J. A., & Huang, J. H. (2019). A model for basic emotions using observations of behavior in Drosophila. In *Frontiers in Psychology* (Vol. 10, Issue APR). Frontiers Media S.A. https://doi.org/10.3389/fpsyg.2019.00781

Haans, A. (2021, February 17). *Environmental Psychology: The person in the environment*. Eindhoven University of Technology.

Hammoud, R., Tognin, S., Bakolis, I., Ivanova, D., Fitzpatrick, N., Burgess, L., Smythe, M., Gibbons, J., Davidson, N., & Mechelli, A. (2021). Lonely in a crowd: investigating the association between overcrowding and loneliness using smartphone technologies. *Scientific Reports*, *11*(1). https://doi.org/10.1038/s41598-021-03398-2

Hawkley, L. C., Buecker, S., Kaiser, T., & Luhmann, M. (2022). Loneliness from young adulthood to old age: Explaining age differences in loneliness. *International Journal of Behavioral Development*, *46*(1), 39–49. https://doi.org/10.1177/0165025420971048

Hawkley, L. C., & Cacioppo, J. T. (2010). Loneliness matters: A theoretical and empirical review of consequences and mechanisms. *Annals of Behavioral Medicine*, *40*(2), 218–227. https://doi.org/10.1007/s12160-010-9210-8

Henninger, W. R., Osbeck, A., Eshbaugh, E., & Madigan, C. (2016). Perceived Social Support and Roommate Status as Predictors of College Student Loneliness. *Journal of College and University Student Housing*, *42*(2), 46–59.

Hsueh, Y. C., Batchelor, R., Liebmann, M., Dhanani, A., Vaughan, L., Fett, A. K., Mann, F., & Pitman, A. (2022). A Systematic Review of Studies Describing the Effectiveness, Acceptability, and Potential Harms of Place-Based Interventions to Address Loneliness and Mental Health Problems. *International Journal of Environmental Research and Public Health*, *19*(8). https://doi.org/10.3390/ijerph19084766

Indeed. (2022, November 7). *Wat is fulltime werken?* https://nl.indeed.com/carrieregids/nieuwe-baan-beginnen/wat-is-fulltime-werken

Informatie Volksgezondheid en Zorg. (2023). *Eenzaamheid | Opleiding*. https://www.vzinfo.nl/eenzaamheid/eenzaamheid-opleiding

Kearns, A., Whitley, E., Tannahill, C., & Ellaway, A. (2015). “Lonesome town”? Is loneliness associated with the residential environment, including housing and neighborhood factors? *Journal of Community Psychology*, *43*(7), 849–867. https://doi.org/10.1002/jcop.21711

Kenrick, D. T., Neuberg, S. L., & Cialdini, R. B. (2014). *Social psychology: Goals in interaction* (6th ed.). Pearson Higher Education.

Kousoulis, A. A., & Goldie, I. (2021). A Visualization of a Socio-Ecological Model for Urban Public Mental Health Approaches. *Frontiers in Public Health*, *9*. https://doi.org/10.3389/fpubh.2021.654011

Kowitt, S. D., Aiello, A. E., Callahan, L. F., Fisher, E. B., Gottfredson, N. C., Jordan, J. M., & Muessig, K. E. (2020). Associations among neighborhood poverty, perceived neighborhood environment, and depressed mood are mediated by physical activity, perceived individual control, and loneliness. *Health and Place*, *62*. https://doi.org/10.1016/j.healthplace.2019.102278

Lai, M. M., Lein, S. Y., Lau, S. H., & Lai, M. L. (2016). Modeling Age-Friendly Environment, Active Aging, and Social Connectedness in an Emerging Asian Economy. *Journal of Aging Research*, *2016*. https://doi.org/10.1155/2016/2052380

Lara, E., Moreno-Agostino, D., Martín-María, N., Miret, M., Rico-Uribe, L. A., Olaya, B., Cabello, M., Haro, J. M., & Ayuso-Mateos, J. L. (2020). Exploring the effect of loneliness on all-cause mortality: Are there differences between older adults and younger and middle-aged adults? *Social Science and Medicine*, *258*. https://doi.org/10.1016/j.socscimed.2020.113087

Lee, C. M., Cadigan, J. M., & Rhew, I. C. (2020). Increases in Loneliness Among Young Adults During the COVID-19 Pandemic and Association With Increases in Mental Health Problems. *Journal of Adolescent Health*, *67*(5), 714–717. https://doi.org/10.1016/j.jadohealth.2020.08.009

Legg, T. J., Kerr, M., & Crooks, F. (2017, June 27). *Morning Depression: What it is and how to treat it*. Healthline. https://www.healthline.com/health/depression/morning-depression#takeaway

Leibniz Institute of the Social Sciences. (2022). *Socio-demographic variables*. https://www.gesis.org/en/gesis-survey-guidelines/instruments/survey-instruments/socio-demographic-variables

Loades, M. E., Chatburn, E., Higson-Sweeney, N., Reynolds, S., Shafran, R., Brigden, A., Linney, C., Niamh McManus, M., Borwick, C., & Crawley, E. (2020). Rapid Systematic Review: The Impact of Social Isolation and Loneliness on the Mental Health of Children and Adolescents in the Context of COVID-19. In *J Am Acad Child Adolesc Psychiatry* (Vol. 59, Issue 11). www.jaacap.org

Lyu, Y., & Forsyth, A. (2022). Planning, Aging, and Loneliness: Reviewing Evidence About Built Environment Effects. *Journal of Planning Literature*, *37*(1), 28–48. https://doi.org/10.1177/08854122211035131

Marcoen, A., Goossens, L., & Caes, P. (1987). Loneliness in Pre-Through Late Adolescence: Exploring the Contributions of a Multidimensional Approach. In *Journal of Youth and Adolescence* (Vol. 16, Issue 6).

Marquez, J., Goodfellow, C., Hardoon, D., Inchley, J., Leyland, A. H., Qualter, P., Simpson, S. A., & Long, E. (2022). Loneliness in young people: a multilevel exploration of social ecological influences and geographic variation. *Journal of Public Health*. https://doi.org/10.1093/pubmed/fdab402

Matthews, T., Odgers, C. L., Danese, A., Fisher, H. L., Newbury, J. B., Caspi, A., Moffitt, T. E., & Arseneault, L. (2019). Loneliness and Neighborhood Characteristics: A Multi-Informant, Nationally Representative Study of Young Adults. *Psychological Science*, *30*(5), 765–775. https://doi.org/10.1177/0956797619836102

McLaren, L., & Hawe, P. (2005). Ecological perspectives in health research. *Journal of Epidemiology and Community Health*, *59*(1), 6–14. https://doi.org/10.1136/jech.2003.018044

McLeod, S. (2019). *What are Independent and Dependent Variables?* SimplyPsychology.

Mental Health Foundation. (2022). *Loneliness in young people: research briefing*. https://www.mentalhealth.org.uk/our-work/public-engagement/unlock-loneliness/loneliness-young-people-research-briefing

Moffatt, S., & Kohler, N. (2008). Conceptualizing the built environment as a social-ecological system. *Building Research and Information*, *36*(3), 248–268. https://doi.org/10.1080/09613210801928131

Morgan, T., Wiles, J., Park, H. J., Moeke-Maxwell, T., Dewes, O., Black, S., Williams, L., & Gott, M. (2021). Social connectedness: What matters to older people? *Ageing and Society*, *41*(5), 1126–1144. https://doi.org/10.1017/S0144686X1900165X

Mote, J., Gonzalez, R., Kircos, C., Gard, D. E., & Fulford, D. (2020). *The relationship between state and trait loneliness and social experiences in daily life*.

Nilsson, S. (2006, October 30). *Don't Go to Bed Lonely*. ABC News. https://abcnews.go.com/Health/StressNews/story?id=2616423&page=1

O'Donnell, C. R., Tharp, R. G., & Wilson, K. (1993). Activity Settings as the Unit of Analysis: A Theoretical Basis for Community Intervention and Development. In *American Journal of Community Psychology* (Vol. 21, Issue 4).

Pollet, T. v., Saxton, T. K., & Mitchell, M. (2018). Measurement equivalence between men and women in the abbreviated Social and Emotional Loneliness Scale for Adults (SELSA). *Interpersona: An International Journal on Personal Relationships*, *12*(2), 283–292. https://doi.org/10.5964/ijpr.v12i2.316

Qualter, P., Vanhalst, J., Harris, R., van Roekel, E., Lodder, G., Bangee, M., Maes, M., & Verhagen, M. (2015). Loneliness Across the Life Span. *Perspectives on Psychological Science*, *10*(2), 250–264. https://doi.org/10.1177/1745691615568999

Queen, T. L., Stawski, R. S., Ryan, L. H., & Smith, J. (2014). Loneliness in a day: Activity engagement, time alone, and experienced emotions. *Psychology and Aging*, *29*(2), 297–305. https://doi.org/10.1037/a0036889

Raymond, C. M., Brown, G., & Weber, D. (2010). The measurement of place attachment: Personal, community, and environmental connections. *Journal of Environmental Psychology*, *30*(4), 422–434. https://doi.org/10.1016/j.jenvp.2010.08.002

Reed, S., & Bohr, J. (2021). The Influence of Local Built Environments on Social Wellbeing: a Community's Experience with Social Isolation, Social Loneliness, and Social Belonging. *International Journal of Community Well-Being*, *4*(3), 393–413. https://doi.org/10.1007/s42413-020-00091-6

Russel, D., Peplau, L. A., & Ferguson, M. L. (1978). Developing a measure of loneliness. *Journal of Personality Assessment*, *42*, 290–294.

Sandilands, D. (2014). Encyclopedia of Quality of Life and Well-Being Research. In *Encyclopedia of Quality of Life and Well-Being Research*. Springer Netherlands. https://doi.org/10.1007/978-94-007-0753-5

Scannell, L., & Gifford, R. (2017). The experienced psychological benefits of place attachment. *Journal of Environmental Psychology*, *51*, 256–269. https://doi.org/10.1016/j.jenvp.2017.04.001

Scharf, T., & Jong Gierveld, J. (2008). Loneliness in urban neighbourhoods: An Anglo-Dutch comparison. *European Journal of Ageing*, *5*(2), 103–115. https://doi.org/10.1007/s10433-008-0080-x

Thompson, S. M., & Kent, J. L. (2017). Human Health and a Sustainable Built Environment. In *Encyclopedia of Sustainable Technologies* (pp. 71–80). Elsevier. https://doi.org/10.1016/B978-0-12-409548-9.10178-2

UCLA: Statistical Consulting Group. (n.d.). *Introduction to linear mixed models*. Retrieved April 11, 2023, from https://stats.oarc.ucla.edu/other/mult-pkg/introduction-to-linear-mixed-models/

UCLA: Statistical Consulting Group. (2021). *Mixed Effects Logistic Regression | R Data analysis examples*. https://stats.oarc.ucla.edu/r/dae/mixed-effects-logistic-regression/

van den Berg, P., Kemperman, A., de Kleijn, B., & Borgers, A. (2016). Ageing and loneliness: The role of mobility and the built environment. *Travel Behaviour and Society*, *5*, 48–55. https://doi.org/10.1016/j.tbs.2015.03.001

van Houwelingen-Snippe, J., van Rompay, T. J. L., & Allouch, S. ben. (2020). Feeling connected after experiencing digital nature: A survey study. *International Journal of Environmental Research and Public Health*, *17*(18), 1–16. https://doi.org/10.3390/ijerph17186879

van Ooijen, B. (2023, February 7). *Social media cijfers 2023 in Nederland: (dagelijks) gebruik en leeftijden*. Afix. https://www.afix.nl/social-media-cijfers/#:~:text=In%202023%20gebruiken%2014%2C1,gemiddeld%2098%20minuten%20per%20dag.

van Roekel, E., Scholte, R. H. J., Engels, R. C. M. E., Goossens, L., & Verhagen, M. (2015). Loneliness in the Daily Lives of Adolescents: An Experience Sampling Study Examining the Effects of Social Contexts. *Journal of Early Adolescence*, *35*(7), 905–930. https://doi.org/10.1177/0272431614547049

van Roekel, E., Verhagen, M., Engels, R. C. M. E., Scholte, R. H. J., Cacioppo, S., & Cacioppo, J. T. (2018). Trait and State Levels of Loneliness in Early and Late Adolescents: Examining the Differential Reactivity Hypothesis. *Journal of Clinical Child and Adolescent Psychology*, *47*(6), 888–899. https://doi.org/10.1080/15374416.2016.1146993

van Tilburg, T. G. (2021). Social, Emotional, and Existential Loneliness: A Test of the Multidimensional Concept. *Gerontologist*, *61*(7), E335–E344. https://doi.org/10.1093/geront/gnaa082

Verhagen, S. J. W., Hasmi, L., Drukker, M., van Os, J., & E G Delespaul, P. A. (2016). *Use of the experience sampling method in the context of clinical trials*. http://www.psymate.eu

Victor, C. R., Scambler, S. J., Bowling, A., & Bond, J. (2005). The prevalence of, and risk factors for, loneliness in later life: A survey of older people in Great Britain. *Ageing and Society*, *25*(3), 357–375. https://doi.org/10.1017/S0144686X04003332

VPPK. (2017). *Onderzoeksmethoden II: introductie multilevel analyse*.

Wang, B., & Dong, X. (2018). The Association Between Personality and Loneliness: Findings From a Community-Dwelling Chinese Aging Population. *Gerontology and Geriatric Medicine*, *4*, 233372141877818. https://doi.org/10.1177/2333721418778181

Weijs-Perrée, M., Dane, G., & van den Berg, P. (2020). Analyzing the relationships between citizens' emotions and their momentary satisfaction in urban public spaces. *Sustainability (Switzerland)*, *12*(19). https://doi.org/10.3390/SU12197921

Weijs-Perrée, M., Dane, G., van den Berg, P., & van Dorst, M. (2019). A multi-level path analysis of the relationships between the momentary experience characteristics, satisfaction with urban public spaces, and momentary- and long-term subjective wellbeing. *International Journal of Environmental Research and Public Health*, *16*(19). https://doi.org/10.3390/ijerph16193621

Weijs-Perrée, M., Van den Berg, P., Arentze, T., & Kemperman, A. (2015). Factors influencing social satisfaction and loneliness: A path analysis. *Journal of Transport Geography*, *45*, 24–31. https://doi.org/10.1016/j.jtrangeo.2015.04.004

Weiss, R. S. (1973). *Loneliness: The experience of emotional and social isolation*. MIT Press.

West, D. A., Kellner, R., & Moore-West, M. (1986). *The Effects of Loneliness: A Review of the Literature*.

Wicker, A. W., Altman, I., Chemers, M., Stokols, D., & Wrightsman, L. S. (1997). *An Introduction to Ecological Psychology*. Brooks/Cole publishing company.

Wu, H., & Leung, S.-O. (2017). Can Likert Scales be Treated as Interval Scales? - A Simulation Study. *Jounal of Social Service Research*, *43*(4), 527–532.

Zhao, Y., van den Berg, P. E. W., Ossokina, I. v., & Arentze, T. A. (2022). Individual Momentary Experiences of Neighborhood Public Spaces: Results of a Virtual Environment Based Stated Preference Experiment. *Sustainability (Switzerland)*, *14*(9). https://doi.org/10.3390/su14094938

Zhong, C.-B., & Leonardelli, G. J. (2008). *Cold and Lonely Does Social Exclusion Literally Feel Cold?*

Zijlema, W. L., Triguero-Mas, M., Smith, G., Cirach, M., Martinez, D., Dadvand, P., Gascon, M., Jones, M., Gidlow, C., Hurst, G., Masterson, D., Ellis, N., van den Berg, M., Maas, J., van Kamp, I., van den Hazel, P., Kruize, H., Nieuwenhuijsen, M. J., & Julvez, J. (2017). The relationship between natural outdoor environments and cognitive functioning and its mediators. *Environmental Research*, *155*, 268–275. https://doi.org/10.1016/j.envres.2017.02.017

Appendices

Appendix A: Baseline Survey Questions

Age: (open question)

Gender:
- Woman
- Man
- Other

How much time do you spend studying in a week?
- 0 hours
- 0-24 hours
- 24-40 hours
- 40+ hours

How much time do you spend working in a week?
- 0 hours
- 0-24 hours
- 24-40 hours
- 40+ hours

Education
- Secondary education
- Secondary vocational education (MBO)
- Higher professional education (HBO)
- University degree
- Other

Nationality (drop-down)
- Native Dutch background
- Western foreign background
- Non-western foreign background

Do you have a partner?
- Yes
- No

What is your living environment?
- Urban Central
- Suburban
- Green Urban
- Village Central
- Rural

What is your living situation?

- With parents
- With friends
- With acquaintances
- With my partner
- With my children
- On my own
- Other

With how many people do you live? Open question

What type of home do you have?

- Row house
- Apartment/studio
- Student room (shared facilities)
- Detached home
- Semi-detached home
- Other

What social media apps do you use? (Select all that apply)

- Whatsapp
- Snapchat
- Tiktok
- Instagram
- BeReal
- Twitter
- Facebook
- Youtube
- LinkedIn
- Other

How long do you use social media per day:

- 0-1 hours
- 1-2 hour
- 2-3 hours
- 3-4 hours
- 4-5 hours
- 5+ hours

Everybody is willing to help each other in my neighborhood.

- Strongly agree
- agree
- neither agree, nor disagree
- disagree

- strongly disagree

There are fights in my neighborhood (R)
- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

There is not much to do in my neighborhood (R)
- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

When I want I can find someone to talk to in my neighborhood
- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

I am the life of the party. (Extraversion)
- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

I have frequent mood swings. (neuroticism)
- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

I don’t talk a lot. (R) (Extraversion)
- Strongly agree
- agree
- neither agree, nor disagree

- disagree
- strongly disagree

I am relaxed most of the time. (R) (neuroticism)

- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

I talk to a lot of different people at parties. (Extraversion)

- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

I get upset easily. (neuroticism)

- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

I keep in the background. (R) (Extraversion)

- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

I seldom feel blue. (R) (neuroticism)

- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

I experience a general sense of emptiness (emotional)

- Strongly agree
- agree

- neither agree, nor disagree
- disagree
- strongly disagree

There are plenty of people I can rely on. (R) (social)

- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

There are many people I can trust completely (social) (R)

- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

There are enough people I feel close to (social) (R)

- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

I miss having people around (emotional)

- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

I often feel rejected (emotional)

- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

Appendix B: Momentary Survey Questions

How are you feeling?

Angry

- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

Scared

- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

Sad

- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

Happy

- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

Comfortable

- Strongly agree
- agree
- neither agree, nor disagree
- disagree
- strongly disagree

Relaxed

- Strongly agree

- agree
- neither agree, nor disagree
- disagree
- strongly disagree

I experience a sense of emptiness.

- Strongly disagree
- Disagree
- Neither disagree, nor agree
- Agree
- Strongly agree

I miss having people around me.

- Strongly disagree
- Disagree
- Neither disagree, nor agree
- Agree
- Strongly agree

I feel rejected.

- Strongly disagree
- Disagree
- Neither disagree, nor agree
- Agree
- Strongly agree

With what company are you?

- Friends
- Alone
- Family
- Peers / co-workers
- Strangers
- Other

What type of activity are you partaking in?

- Studying
- Sporting
- Working
- Eating
- Relaxing

- Social gathering
- Chores
- Other

What type of location are you in?

- Home
- University/School
- Work
- Outdoor
- Shop
- Café/restaurant
- Transportation
- House of friend/relatives
- Culture/sports venue
- Other

How familiar are you with this location?

- Very familiar
- Slightly familiar
- Neither familiar, nor unfamiliar
- Slightly unfamiliar
- Very unfamiliar

What mode of transport did you use to get here?

- By bike
- By foot
- By public transport
- By car
- Other

What do you think about the location you are in?
Aesthetic quality

- Very good
- good
- neither good, nor poor
- poor
- Very poor

Atmosphere

- Very good
- good

- neither good, nor poor
- poor
- Very poor

Smell
- Very good
- good
- neither good, nor poor
- poor
- Very poor

Accessibility
- Very good
- good
- neither good, nor poor
- poor
- Very poor

Diversity in activities
- Very good
- good
- neither good, nor poor
- poor
- Very poor

Social Safety
- Very good
- good
- neither good, nor poor
- poor
- Very poor

Traffic safety
- Very good
- good
- neither good, nor poor
- poor
- Very poor

Natural elements
- Very good

- good
- neither good, nor poor
- poor
- Very poor

Lack of Noise

- Very good
- good
- neither good, nor poor
- poor
- Very poor

Cleanliness

- Very good
- good
- neither good, nor poor
- poor
- Very poor

Maintenance of the space

- Very good
- good
- neither good, nor poor
- poor
- very poor

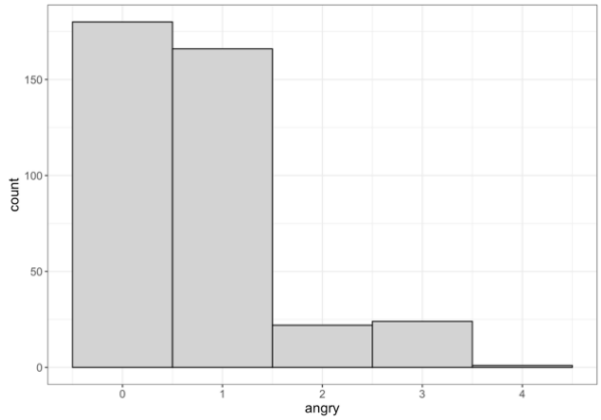
Appendix C: PIEL Survey Code

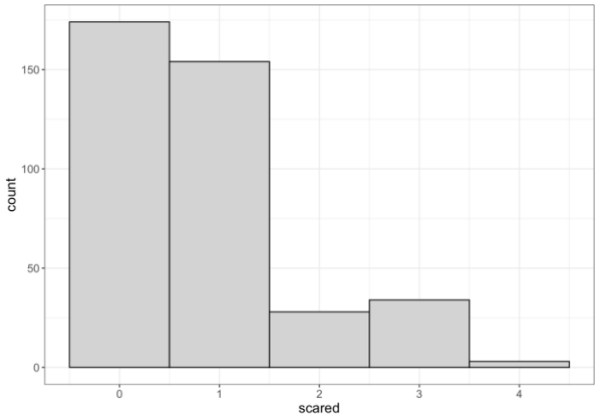
```
can-test|1
project-name|Emotional Loneliness amongst Young Adults
author|Dominique Gijsbers
author-email|d.j.h.gijsbers@student.tue.nl
subject-id|%RANDOM

%SURVEY
name|Baseline Survey
position|1
exit-message|3|Thank you for filling in the Survey.
#Below are the questions. Integers indicate the question number
1|Have you read and do you agree to the statements in the consent
form?|Yes|No
2|What is your gender? %TYPE list|Woman|Man|Other
3|How much time do you spend studying in a week? %TYPE list|0 hours|0-24
hours|24-40 hours|40+ hours
4|How much time do you spend working in a week? %TYPE list|0 hours|0-24
hours|24-40 hours|40+ hours
5|What is your highest level of attained education? %TYPE list|Secondary
education|Secondary vocation education (MBO)|Higher professional education
(HBO)|University degree|Other
6|What is your ethnical background? %TYPE list|Native Dutch
background|Western foreign background|Non-western foreign background
7|Do you have a partner? %TYPE list|Yes|No
8|What is your living environment? %TYPE list|Urban Central|Suburban|Green
Urban|Village Central|Rural
9|What is your living situation? %TYPE checkbox|With parents|With
friends|With acquaintances|With my partner|With my children|On my own|Other
10|With how many people do you live? (Excluding yourself) %TYPE text
11|What type of home do you have? %TYPE list|Row
house|Apartment/studio|student room (shared facilities)|Detached home|Semi-
detached home|Other
12|What social media apps do you use? (Select all that apply) %TYPE
checkbox|Whatsapp|Snapchat|Tiktok|Instagram|BeReal|Twitter|Facebook|Youtube
|LinkedIn|Other
13|How long do you use social media per day? %TYPE list|0-1 hours|1-2
hours|2-3 hours|3-4 hours|4-5 hours|5+ hours
14|Everybody is willing to help each other in my neighbourhood %TYPE
list|Strongly agree|Agree|Neither agree, nor disagree|Disagree|Strongly
disagree
15|There are fights in my neighbourhood. %TYPE list|Strongly
agree|Agree|Neither agree, nor disagree|Disagree|Strongly disagree
16|There is not much to do in my neighbourhood. %TYPE list|Strongly
agree|Agree|Neither agree, nor disagree|Disagree|Strongly disagree
17|When I want, I can find someone to talk to in my neighbourhood. %TYPE
list|Strongly agree|Agree|Neither agree, nor disagree|Disagree|Strongly
disagree
18|I am the life of the party. %TYPE list|Strongly agree|Agree|Neither
agree, nor disagree|Disagree|Strongly disagree
19|I have frequent mood swings. %TYPE list|Strongly agree|Agree|Neither
agree, nor disagree|Disagree|Strongly disagree
```

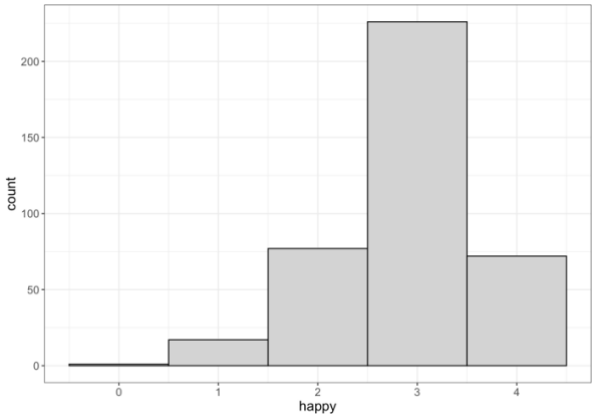
```
20|I don't talk a lot. %TYPE list|Strongly agree|Agree|Neither agree, nor
disagree|Disagree|Strongly disagree
21|I am relaxed most of the time. %TYPE list|Strongly agree|Agree|Neither
agree, nor disagree|Disagree|Strongly disagree
22|I talk to a lot of different people at parties. %TYPE list|Strongly
agree|Agree|Neither agree, nor disagree|Disagree|Strongly disagree
23|I get upset easily. %TYPE list|Strongly agree|Agree|Neither agree, nor
disagree|Disagree|Strongly disagree
24|I keep in the background. %TYPE list|Strongly agree|Agree|Neither agree,
nor disagree|Disagree|Strongly disagree
25|I seldom feel blue. %TYPE list|Strongly agree|Agree|Neither agree, nor
disagree|Disagree|Strongly disagree
26|I experience a general sense of emptiness. %TYPE list|Strongly
agree|Agree|Neither agree, nor disagree|Disagree|Strongly disagree
27|There are plenty of people I can rely on. %TYPE list|Strongly
agree|Agree|Neither agree, nor disagree|Disagree|Strongly disagree
28|There are many people I can trust completely. %TYPE list|Strongly
agree|Agree|Neither agree, nor disagree|Disagree|Strongly disagree
29|There are enough people I feel close to. %TYPE list|Strongly
agree|Agree|Neither agree, nor disagree|Disagree|Strongly disagree
30|I miss having people around. %TYPE list|Strongly agree|Agree|Neither
agree, nor disagree|Disagree|Strongly disagree
31|I often feel rejected. %TYPE list|Strongly agree|Agree|Neither agree,
nor disagree|Disagree|Strongly disagree

%SURVEY
name|Momentary Survey
run-for|7
can-run-once|0
max-duration|600
max-delay|450
run|1|1200, 2200
run|2,5|1000,1800
run|3,6|1300, 1600
run|4,7|1400, 2000
reminders|150, 300
alert-sound|004
exit-message|3|Thank you for filling in the Survey.
#Questions momentary survey
1|I feel angry today %TYPE list|Strongly agree|Agree|Neither agree, nor
disagree|Disagree|Strongly disagree
2|I feel scared today %TYPE list|Strongly agree|Agree|Neither agree, nor
disagree|Disagree|Strongly disagree
3|I feel sad today %TYPE list|Strongly agree|Agree|Neither agree, nor
disagree|Disagree|Strongly disagree
4|I feel happy today %TYPE list|Strongly agree|Agree|Neither agree, nor
disagree|Disagree|Strongly disagree
5|I feel comfortable today %TYPE list|Strongly agree|Agree|Neither agree,
nor disagree|Disagree|Strongly disagree
6|I feel relaxed today %TYPE list|Strongly agree|Agree|Neither agree, nor
disagree|Disagree|Strongly disagree
7|I experience a sense of emptiness %TYPE list|Strongly agree|Agree|Neither
agree, nor disagree|Disagree|Strongly disagree
```

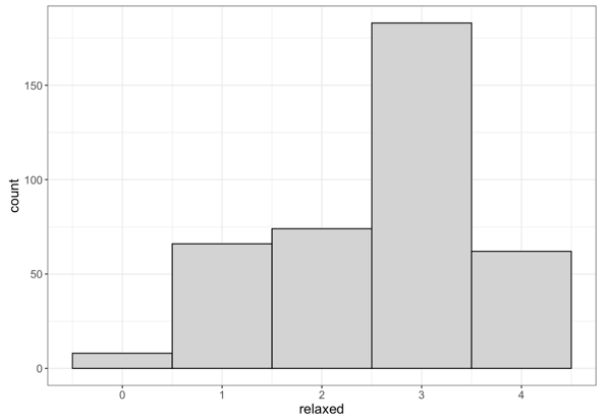
8|I miss having people around me. %TYPE list|Strongly agree|Agree|Neither agree, nor disagree|Disagree|Strongly disagree
9|I feel rejected. %TYPE list|Strongly agree|Agree|Neither agree, nor disagree|Disagree|Strongly disagree
10|With what type of company are you? %TYPE list|Friends|Alone|Family|Peers/co-workers|Strangers|Other
11|What type of activity are you partaking in? %TYPE list|Studying|Sporting|Working|Eating|Relaxing|Social gathering|Chores|Other
12|What type of location are you in? %TYPE list|Home|University/School|Work|Outdoor|Shop|Café/Restaurant|Transportation|House of friend/relatives|Culture/sports venue|Other
13|How familiar are you with this location? %TYPE list|Very familiar|Slightly familiar|Neither familiar, nor unfamiliar|Slightly unfamiliar|Very unfamiliar
14|What mode of transport did you use to get here? %TYPE list|By bike|By foot|By public transport|By car|I was already on location|Other
15|What do you think of the aesthetic quality of your location? %TYPE list|Very good|Good|Neither good, nor poor|Poor|Very poor
16|What do you think of the atmosphere of your location? %TYPE list|Very good|Good|Neither good, nor poor|Poor|Very poor
17|What do you think of the smell of your location? %TYPE list|Very good|Good|Neither good, nor poor|Poor|Very poor
18|What do you think of the accessibility of your location? %TYPE list|Very good|Good|Neither good, nor poor|Poor|Very poor
19|What do you think of the diversity of activities of your location? %TYPE list|Very good|Good|Neither good, nor poor|Poor|Very poor
20|What do you think of the social safety of your location? %TYPE list|Very good|Good|Neither good, nor poor|Poor|Very poor
21|What do you think of the traffic safety of your location? %TYPE list|Very good|Good|Neither good, nor poor|Poor|Very poor
22|What do you think of the natural elements of your location? %TYPE list|Very good|Good|Neither good, nor poor|Poor|Very poor
23|What do you think of the lack of noise of your location? %TYPE list|Very good|Good|Neither good, nor poor|Poor|Very poor
24|What do you think of the cleanliness of your location? %TYPE list|Very good|Good|Neither good, nor poor|Poor|Very poor
25|What do you think of the maintenance of the space of your location? %TYPE list|Very good|Good|Neither good, nor poor|Poor|Very poor

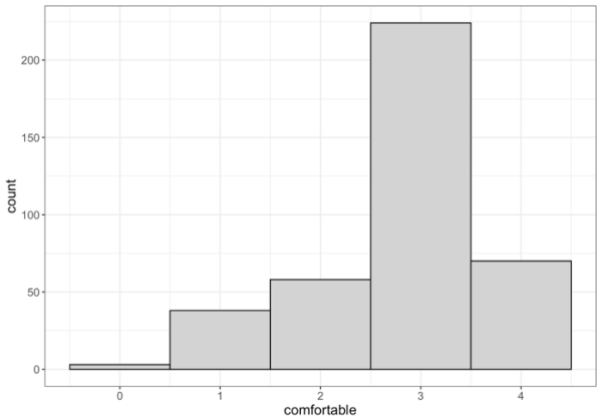
Appendix D: Sample Description Emotions





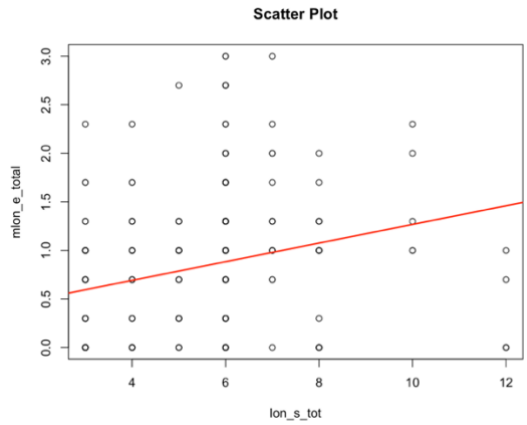


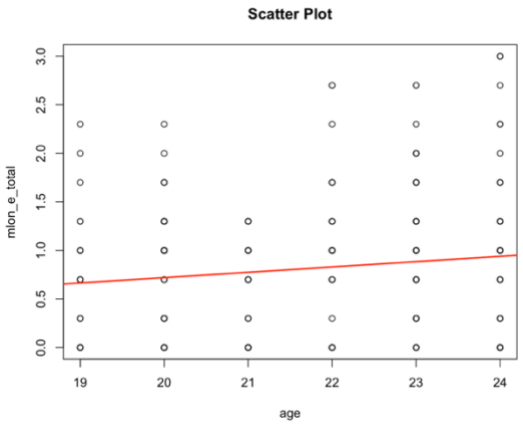


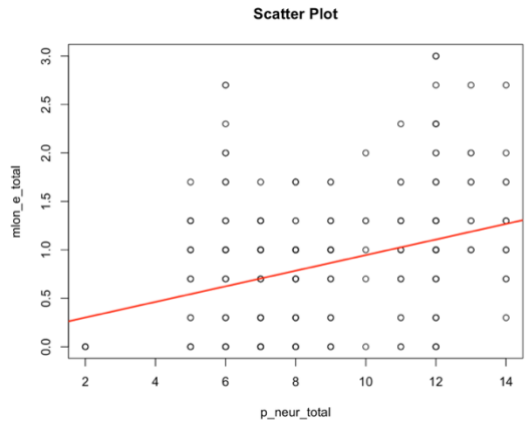


Appendix E: Bivariate Analysis Scatterplots

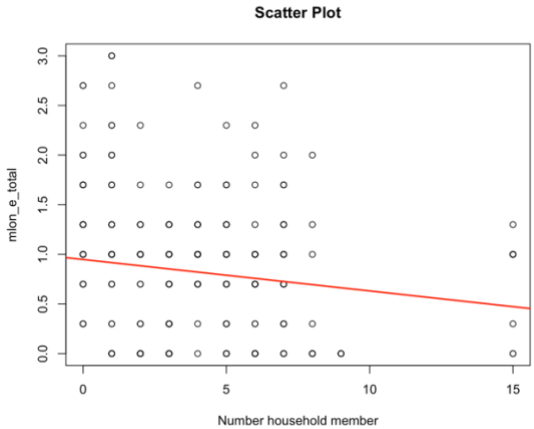
Individual Layer



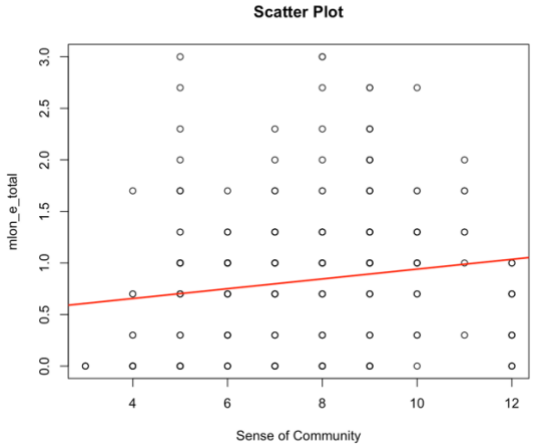




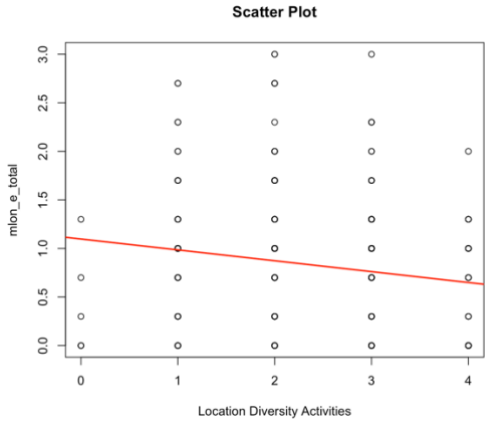
Household Layer

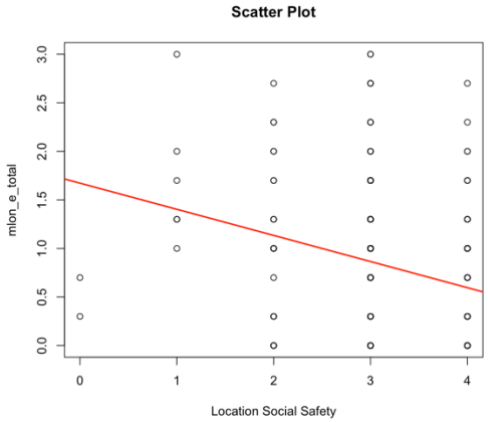


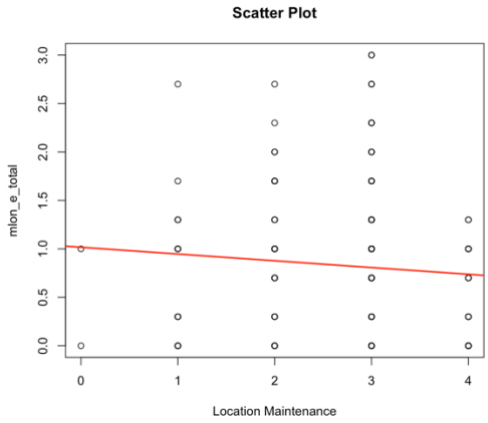
Social Environment Layer

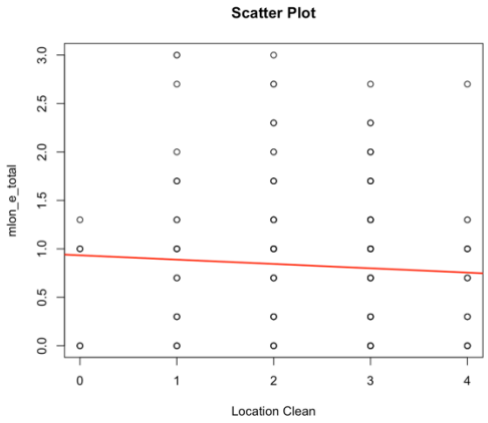


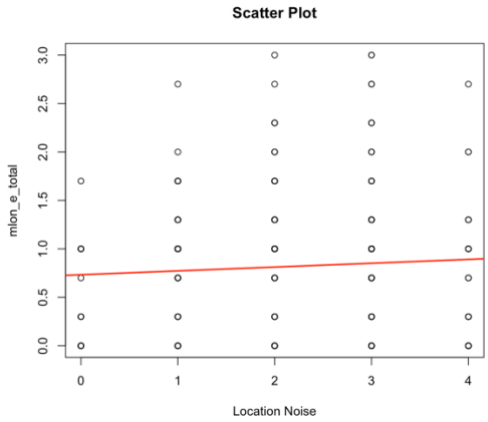
Physical Environment Layer

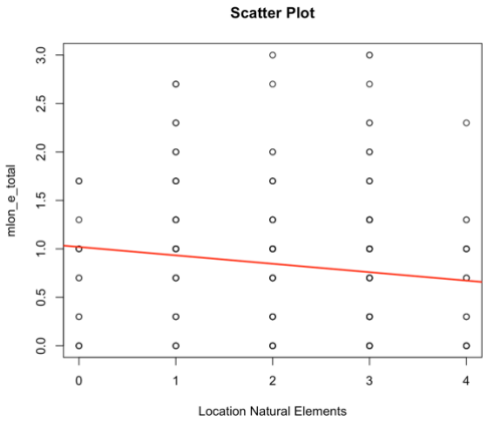


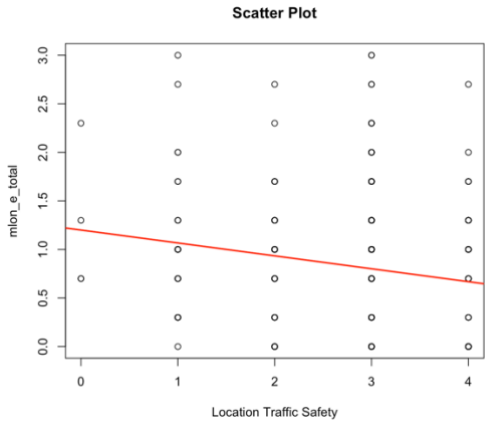


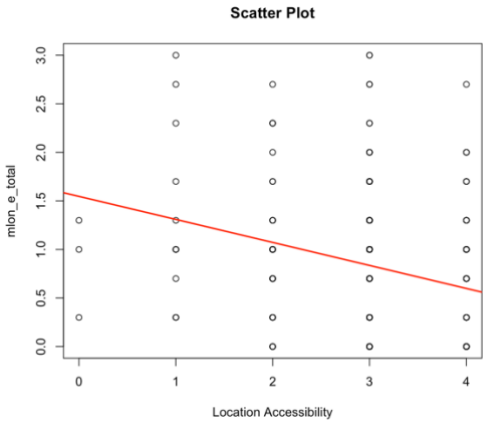


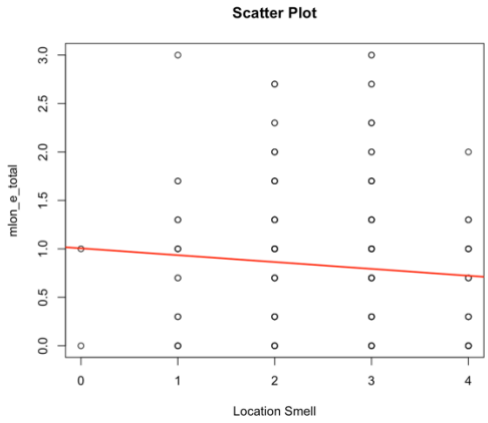


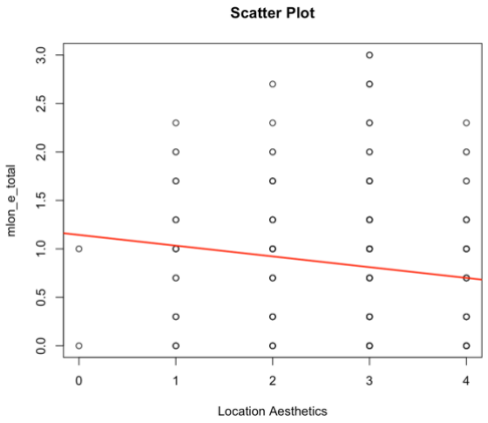

Scatter Plot
mlon_e_total
Location Noise


Scatter Plot
mlon_e_total
Location Natural Elements

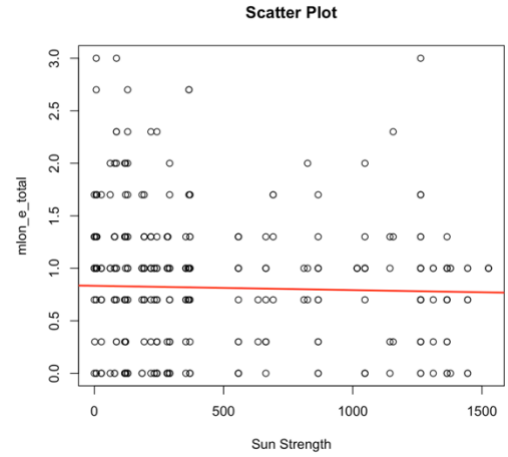

Scatter Plot
mlon_e_total
Location Traffic Safety

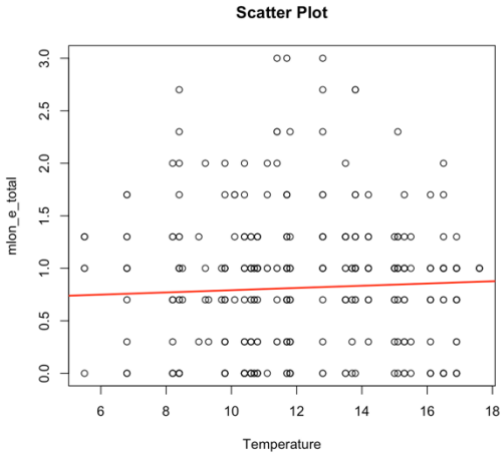

Scatter Plot
mlon_e_total
Location Accessibility

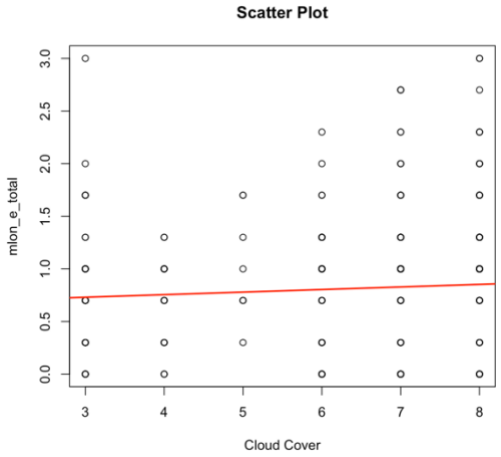

Scatter Plot
mlon_e_total
Location Smell


Scatter Plot
mlon_e_total
Location Aesthetics

External Factors







Appendix F: Correlation of Independents Household Level

	st_1	st_2	st_3	wk_1	wt_2	wt_3	e_1	e_2	e_3	e_4	part_1	ht_1	ht_2	ht_3	hh_#	hh_1	hh2	hh3	hh_4	hh_5	hh_6	liv_1	liv_2	liv_3
study_time_1	1.00																							
study_time_2	-0.21	1.00																						
study_time_3	-0.32	-0.67	1.00																					
work_time_1	-0.21	-0.18	0.42	1.00																				
work_time_2	-0.32	0.01	-0.02	-0.67	1.00																			
work_time_3	-0.10	0.49	-0.33	-0.22	-0.32	1.00																		
educ_1	0.01	0.18	-0.24	0.04	-0.10	0.12	1.00																	
educ_2	-0.03	-0.06	0.09	-0.06	-0.09	-0.03	-0.09	1.00																
educ_3	-0.06	-0.09	0.15	-0.12	0.18	-0.06	-0.18	-0.02	1.00															
educ_4	0.01	-0.14	0.17	0.01	0.05	-0.10	-0.93	-0.08	-0.16	1.00														
partner_1	-0.23	0.39	-0.35	-0.27	0.30	0.15	-0.11	-0.06	0.21	0.05	1.00													
h_type_1	0.17	-0.15	0.09	0.21	-0.24	-0.08	-0.14	-0.02	0.01	0.14	-0.19	1.00												
h_type_2	-0.10	0.16	-0.09	0.03	-0.04	0.07	-0.21	0.12	-0.13	0.24	0.06	-0.19	1.00											
h_type_3	0.02	-0.08	0.04	-0.14	0.15	-0.03	0.27	-0.10	0.12	-0.30	0.03	-0.31	-0.87	1.00										
hh_number	0.01	0.12	-0.17	0.15	-0.12	-0.01	0.37	-0.06	0.00	-0.36	-0.05	-0.02	-0.62	0.61	1.00									
hh_sit_1	-0.05	-0.11	0.17	0.09	-0.01	-0.05	0.17	-0.01	-0.03	-0.15	-0.12	0.34	-0.12	-0.05	0.05	1.00								
hh_sit_2	0.15	0.03	-0.11	0.16	-0.35	0.18	0.32	0.08	-0.17	-0.28	-0.13	0.10	-0.33	0.27	0.31	-0.04	1.00							
hh_sit_3	-0.01	-0.18	0.06	-0.19	0.28	-0.16	0.09	-0.04	0.31	-0.19	-0.02	-0.13	-0.28	0.33	0.27	-0.09	-0.44	1.00						
hh_sit_4	-0.11	0.33	-0.17	-0.04	0.07	0.06	-0.14	-0.03	-0.06	0.17	0.46	-0.09	0.46	-0.40	-0.34	-0.06	-0.39	-0.17	1.00					
hh_sit_5	-0.11	-0.08	0.20	-0.01	0.14	-0.11	-0.34	-0.03	-0.06	0.37	-0.24	-0.09	0.34	-0.28	-0.44	-0.06	-0.39	-0.17	-0.11	1.00				

hh_sit_6	-0.06	-0.13	0.20	0.15	-0.07	-0.06	-0.20	-0.02	-0.04	0.22	-0.01	-0.05	0.13	-0.10	0.06	-0.03	-0.23	-0.10	-0.07	-0.07	1.00			
liv_en_1	0.02	0.16	-0.17	0.02	-0.08	0.07	0.23	0.05	-0.33	-0.13	-0.05	-0.48	0.40	-0.14	0.00	-0.13	0.03	-0.15	0.18	0.04	0.11	1.00		
liv_en_2	-0.01	-0.14	0.13	0.01	0.04	-0.06	-0.20	-0.05	0.35	0.09	0.09	0.51	-0.38	0.11	0.06	0.14	0.02	0.18	-0.17	-0.17	-0.10	-0.95	1.00	
liv_en_3	-0.04	-0.09	0.13	-0.09	0.14	-0.04	-0.14	-0.01	-0.02	0.15	-0.10	-0.04	-0.10	0.11	-0.18	-0.02	-0.15	-0.07	-0.05	0.40	-0.03	-0.25	-0.07	1.00

Appendix G: Correlation of Independents Social Environment Level

	s_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9	st_1	st_2	st_3	st_4	st_5	sec	a_1	a_2	a_3	a_4	a_5	A_6	A_7	a_8	c_1	c_2	c_3	c_4	c_5	c_6
sm_app_2	1.00																											
sm_app_3	0.12	1.00																										
sm_app_4	0.07	0.16	1.00																									
sm_app_5	0.24	0.51	0.19	1.00																								
sm_app_6	0.12	-0.11	0.15	0.26	1.00																							
sm_app_7	-0.04	0.38	0.05	0.36	-0.16	1.00																						
sm_app_8	0.13	0.15	-0.06	-0.18	-0.14	0.01	1.00																					
sm_app_9	0.22	-0.07	-0.05	0.04	-0.29	0.08	0.01	1.00																				
sm_time_1	-0.25	-0.10	-0.34	-0.03	-0.10	-0.15	-0.08	-0.10	1.00																			
sm_time_2	-0.01	-0.33	-0.02	-0.07	-0.10	-0.12	-0.35	0.27	-0.28	1.00																		
sm_time_3	0.15	0.17	0.10	-0.06	-0.14	-0.21	0.19	0.17	-0.12	-0.40	1.00																	
sm_time_4	0.15	0.09	0.19	0.00	-0.13	0.10	0.18	-0.18	-0.12	-0.38	-0.17	1.00																
sm_time_5	-0.09	0.26	-0.01	0.18	0.48	0.38	0.19	-0.29	-0.13	-0.40	-0.18	-0.17	1.00															
sec_total	-0.44	0.16	-0.12	-0.15	-0.38	0.14	0.00	-0.14	0.34	-0.37	0.18	0.06	0.02	1.00														
act_type_1	0.04	0.05	-0.06	0.08	0.02	0.00	0.05	0.11	-0.01	0.04	0.01	-0.06	0.01	0.00	1.00													
act_type_2	0.02	-0.01	0.04	-0.08	-0.01	-0.09	0.08	-0.04	0.00	-0.02	0.05	0.01	-0.04	-0.02	-0.09	1.00												
act_type_3	0.07	-0.13	0.08	0.02	0.03	-0.13	-0.21	0.13	-0.03	0.18	-0.01	-0.05	-0.16	-0.12	-0.19	-0.07	1.00											
act_type_4	0.03	0.09	0.10	0.02	-0.07	0.08	0.09	-0.03	-0.06	-0.05	0.01	0.10	0.01	0.05	-0.16	-0.06	-0.12	1.00										
act_type_5	-0.07	0.05	-0.10	0.00	0.01	0.08	-0.03	-0.07	-0.02	-0.02	0.02	-0.08	0.10	0.01	-0.28	-0.10	-0.21	-0.17	1.00									
act_type_6	0.05	0.00	0.04	-0.08	0.02	-0.02	0.04	-0.14	0.00	-0.09	-0.01	0.10	0.04	0.03	-0.25	-0.09	-0.19	-0.15	-0.26	1.00								

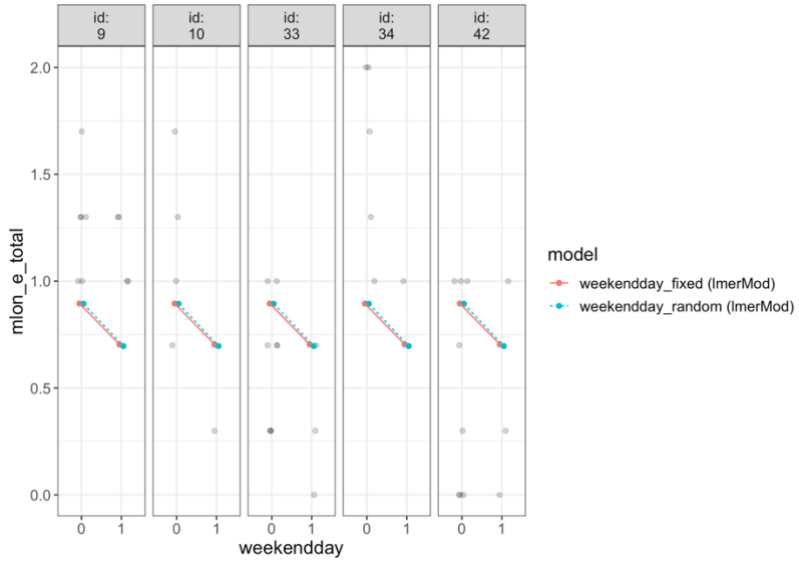
act_type_7	-0.17	-0.08	-0.08	-0.03	0.04	0.03	-0.03	-0.04	0.10	-0.03	-0.10	0.04	0.03	0.04	-0.12	-0.04	-0.09	-0.07	-0.13	-0.11	1.00							
act_type_8	-0.02	-0.01	0.03	0.02	-0.06	0.02	0.05	0.08	0.06	0.00	0.01	-0.01	-0.04	0.02	-0.15	-0.05	-0.11	-0.09	-0.16	-0.14	-0.07	1.00						
company_1	0.20	0.02	0.01	-0.10	-0.04	0.00	0.10	-0.09	-0.08	-0.11	0.12	0.12	-0.02	-0.01	0.00	0.03	-0.22	0.06	-0.13	0.40	-0.11	-0.11	1.00					
company_2	-0.23	-0.08	-0.05	0.01	-0.01	0.09	-0.01	0.00	0.07	0.01	-0.10	-0.02	0.05	0.11	0.07	0.02	-0.17	-0.08	0.23	-0.30	0.17	0.12	-0.53	1.00				
company_3	0.05	0.19	-0.05	0.10	0.02	0.00	0.07	-0.05	0.05	-0.06	0.01	-0.05	0.09	-0.04	-0.14	-0.02	-0.14	0.08	0.10	0.03	-0.01	0.11	-0.31	-0.22	1.00			
company_4	-0.04	-0.09	0.07	0.07	0.04	-0.08	-0.20	0.20	-0.01	0.17	0.01	-0.10	-0.13	-0.11	0.01	-0.07	0.67	-0.08	-0.19	-0.18	-0.06	-0.12	-0.35	-0.25	-0.14	1.00		
company_5	0.00	-0.05	0.02	-0.06	0.01	-0.07	0.01	-0.02	-0.04	0.08	-0.06	0.01	-0.01	-0.01	0.10	0.08	0.00	-0.05	-0.08	-0.07	-0.03	-0.09	-0.13	-0.09	-0.05	-0.06	1.00	
company_6	0.00	0.07	0.02	-0.02	0.01	-0.03	0.01	-0.05	-0.02	-0.03	-0.06	0.04	0.04	0.05	-0.03	-0.03	-0.06	-0.08	-0.05	-0.02	-0.05	-0.04	-0.13	-0.09	-0.05	-0.06	-0.02	1.00

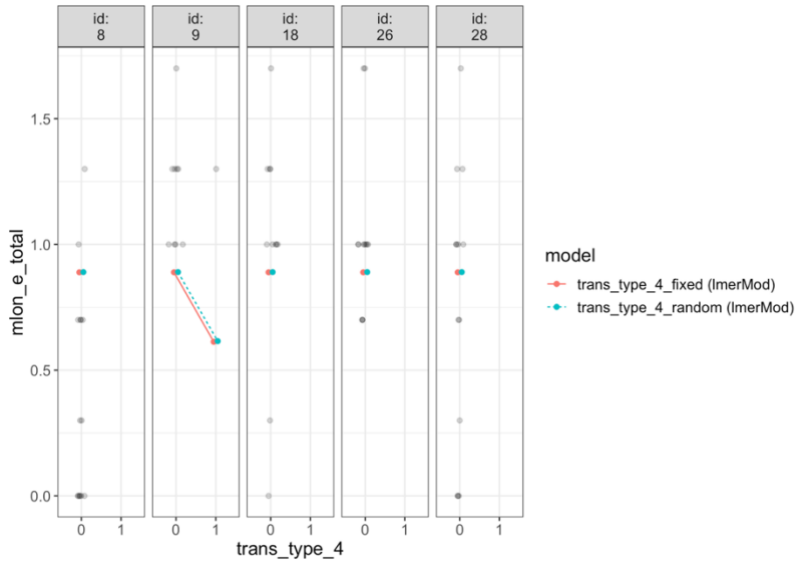
Appendix H: Correlation of Independents Physical Environment Layer

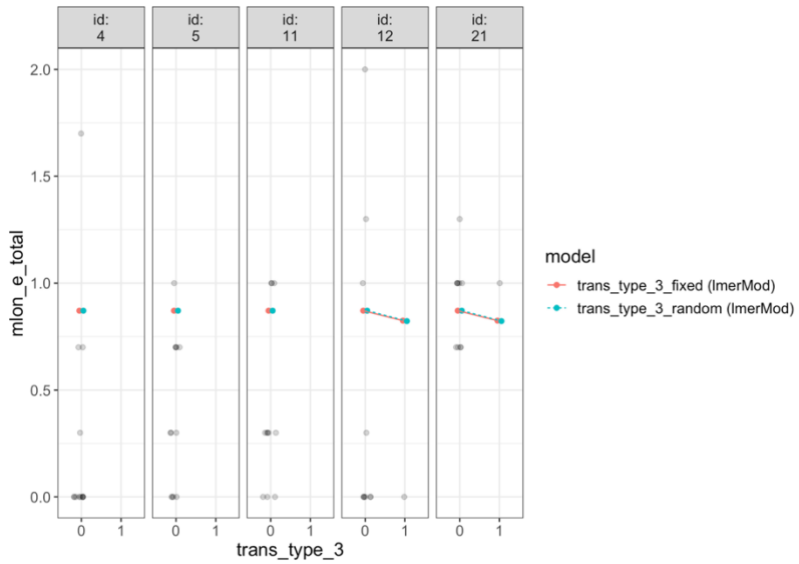
	lfa	tt1	tt2	tt3	tt4	tt5	tt6	lt1	lt2	lt3	lt4	lt5	lt6	lt7	lt8	lt9	lt10	lae	lat	ls	lac	lts	lne	lno	lcl	lma	lda	lss
loc_fam	1.00																											
trans_type_1	0.03	1.00																										
trans_type_2	-0.01	-0.27	1.00																									
trans_type_3	-0.14	-0.27	-0.06	1.00																								
trans_type_4	-0.35	-0.32	-0.07	-0.07	1.00																							
trans_type_5	0.27	-0.66	-0.14	-0.14	-0.17	1.00																						
trans_type_6	-0.17	-0.06	-0.01	-0.01	-0.01	-0.03	1.00																					
loc_type_1	0.37	-0.48	-0.08	-0.08	-0.12	0.70	-0.04	1.00																				
loc_type_2	0.12	0.41	-0.07	-0.07	-0.15	-0.31	-0.03	-0.42	1.00																			
loc_type_3	0.03	0.17	-0.07	0.06	-0.01	-0.17	-0.01	-0.24	-0.15	1.00																		
loc_type_4	-0.33	0.08	0.04	-0.01	0.06	-0.14	-0.01	-0.20	-0.13	-0.07	1.00																	
loc_type_5	-0.26	-0.03	0.05	-0.03	0.18	-0.08	-0.01	-0.11	-0.07	-0.04	-0.03	1.00																
loc_type_6	-0.24	0.07	0.07	-0.02	0.11	-0.16	-0.01	-0.22	-0.14	-0.08	-0.07	-0.04	1.00															
loc_type_7	-0.13	-0.19	0.26	0.14	0.20	-0.11	-0.01	-0.16	-0.10	-0.06	-0.05	-0.03	-0.05	1.00														
loc_type_8	0.06	0.07	-0.03	0.10	0.02	-0.13	-0.01	-0.24	-0.15	-0.09	-0.07	-0.04	-0.08	-0.06	1.00													
loc_type_9	-0.07	0.04	0.09	0.02	0.00	-0.10	-0.01	-0.14	-0.09	-0.05	-0.04	-0.02	-0.05	-0.03	-0.05	1.00												
loc_type_10	-0.32	-0.02	-0.03	0.05	0.09	-0.08	0.35	0.12	-0.08	-0.04	-0.04	-0.02	-0.04	-0.03	-0.04	-0.03	1.00											
loc_aes	0.16	-0.03	-0.11	-0.03	-0.02	0.13	-0.06	0.21	-0.10	-0.09	0.01	-0.17	-0.01	-0.05	0.13	-0.14	-0.07	1.00										
loc_atms	0.16	0.02	-0.13	0.01	-0.06	0.08	-0.01	0.15	-0.13	-0.11	0.05	-0.12	0.04	-0.21	0.19	0.00	-0.06	0.60	1.00									
loc_smell	0.15	-0.06	-0.19	-0.05	0.02	0.18	-0.10	0.29	-0.10	-0.09	0.01	-0.13	-0.06	-0.13	0.10	-0.18	-0.11	0.49	0.47	1.00								
loc_acc	0.29	0.12	-0.01	-0.22	-0.21	0.10	0.00	0.10	0.09	-0.08	-0.07	-0.01	0.01	-0.09	-0.06	-0.04	-0.09	0.20	0.35	0.21	1.00							
loc_trafsaf	0.07	0.03	-0.02	-0.08	0.02	0.02	-0.17	0.04	0.10	-0.09	-0.01	-0.09	-0.04	0.01	-0.08	0.03	0.02	0.21	0.30	0.26	0.33	1.00						
loc_nat_el	0.08	-0.04	-0.07	0.04	0.08	0.01	0.03	0.10	-0.10	-0.05	0.20	-0.15	-0.14	-0.11	0.13	0.02	-0.03	0.47	0.34	0.37	0.05	0.27	1.00					
loc_noise	0.12	-0.05	-0.10	-0.05	0.07	0.09	-0.05	0.18	0.08	-0.06	-0.18	-0.06	-0.14	-0.13	0.04	-0.05	0.03	0.18	0.09	0.24	0.00	0.20	0.31	1.00				

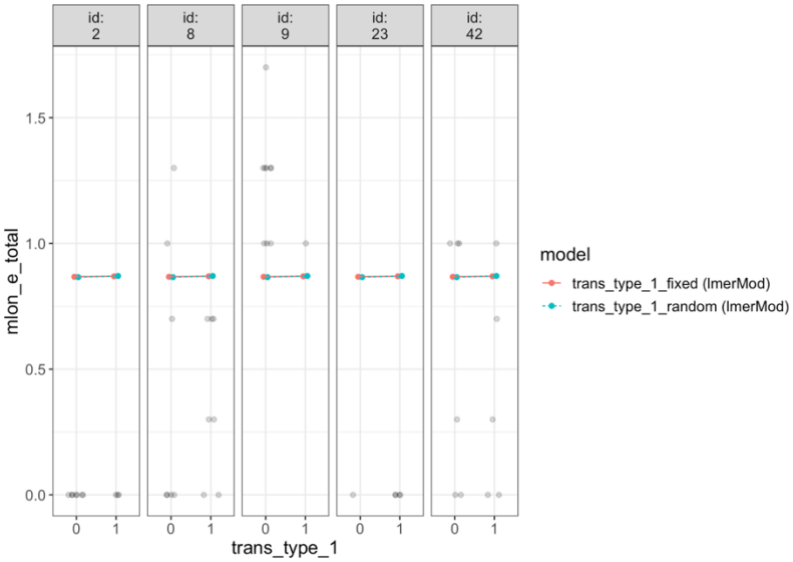
loc_clean	0.03	-0.01	-0.12	0.00	0.17	-0.02	-0.09	-0.02	0.15	0.06	-0.03	0.00	-0.11	-0.06	0.07	-0.14	-0.09	0.29	0.15	0.41	0.01	0.17	0.27	0.41	1.00			
loc_maint	0.12	-0.04	-0.08	-0.04	0.14	0.04	-0.12	0.03	0.12	0.05	0.01	-0.02	-0.11	-0.03	0.01	-0.17	-0.16	0.32	0.22	0.44	0.06	0.17	0.25	0.26	0.62	1.00		
loc_div_act	0.23	-0.08	-0.11	-0.01	-0.08	0.20	0.08	0.31	-0.18	-0.16	0.03	-0.09	0.02	-0.23	0.07	-0.01	-0.04	0.40	0.45	0.25	0.31	0.17	0.32	0.12	-0.04	0.05	1.00	
loc_socsaf	0.20	-0.06	-0.11	-0.06	0.03	0.15	-0.16	0.22	-0.09	-0.07	-0.01	-0.09	0.03	-0.15	0.07	-0.20	-0.01	0.27	0.46	0.30	0.32	0.41	0.19	0.16	0.19	0.25	0.30	1.00

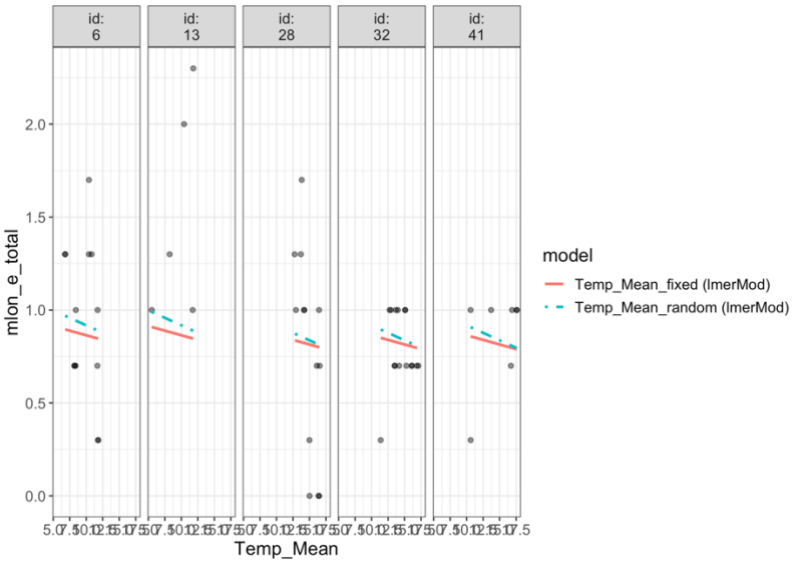
Appendix I: Random Variables Test Results

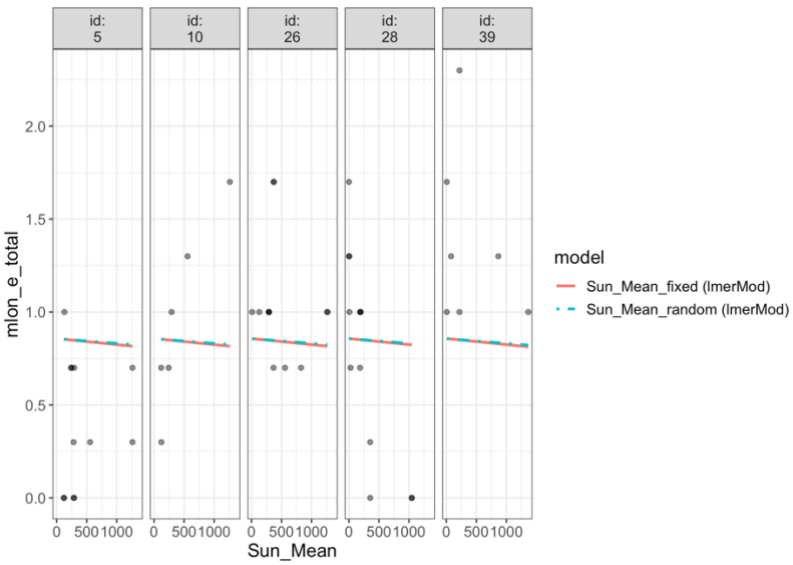


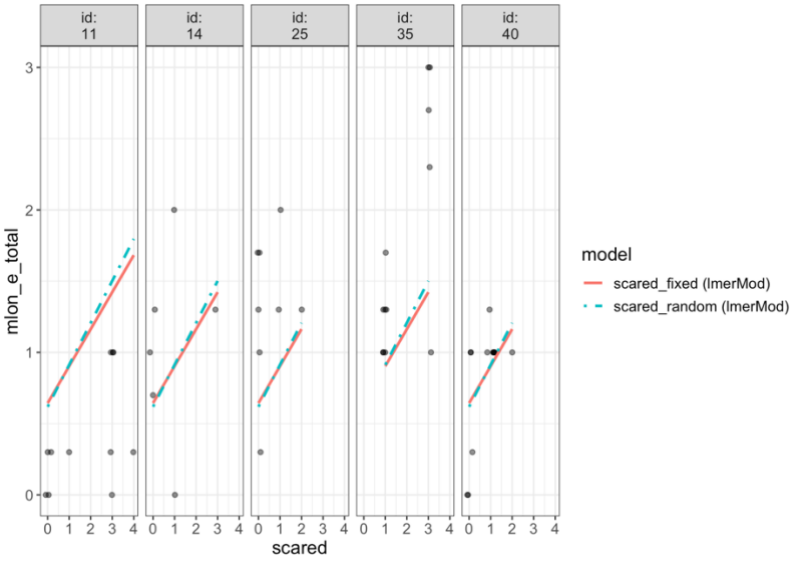


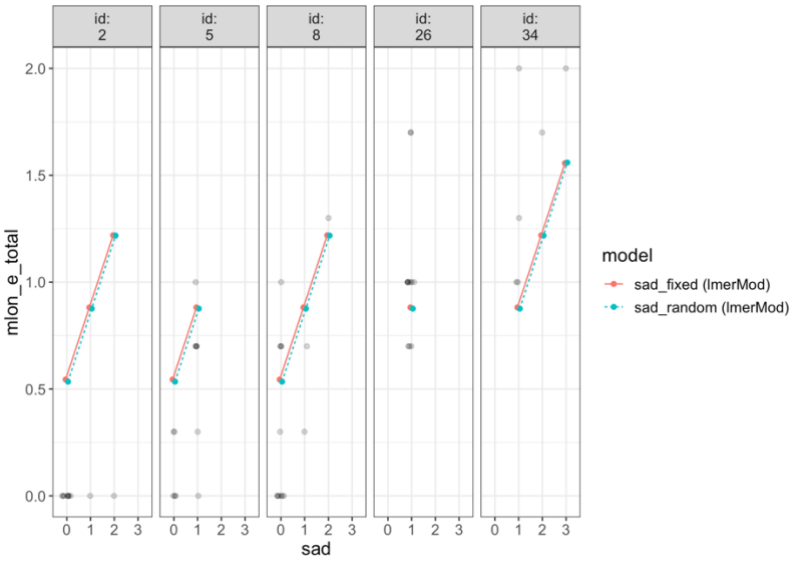



id: 2
id: 8
id: 9
id: 23
id: 42
mlon_e_total
trans_type_1
model
trans_type_1_fixed (lmerMod)
trans_type_1_random (lmerMod)


id: 6
id: 13
id: 28
id: 32
id: 41
mlon_e_total
Temp_Mean
model
Temp_Mean_fixed (lmerMod)
Temp_Mean_random (lmerMod)


id: 5
id: 10
id: 26
id: 28
id: 39
mlon_e_total
Sun_Mean
model
Sun_Mean_fixed (lmerMod)
Sun_Mean_random (lmerMod)


id: 11
id: 14
id: 25
id: 35
id: 40
mlon_e_total
scared
model
scared_fixed (lmerMod)
scared_random (lmerMod)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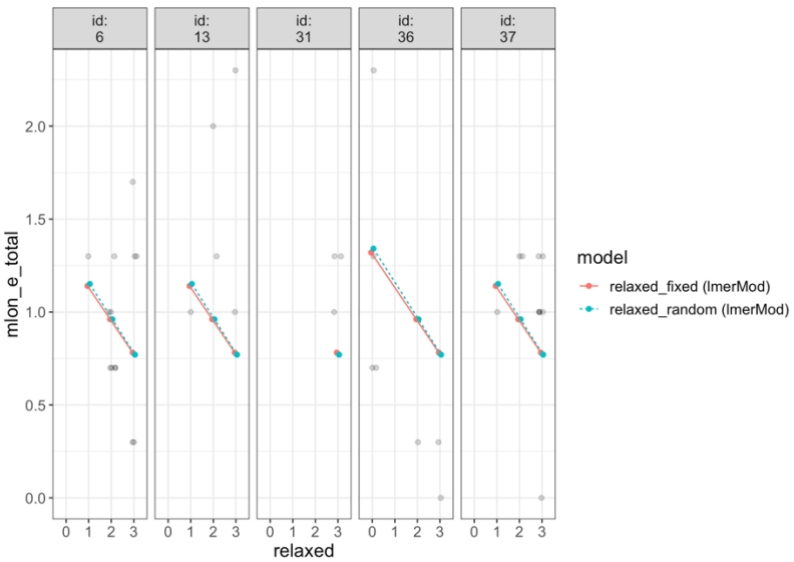
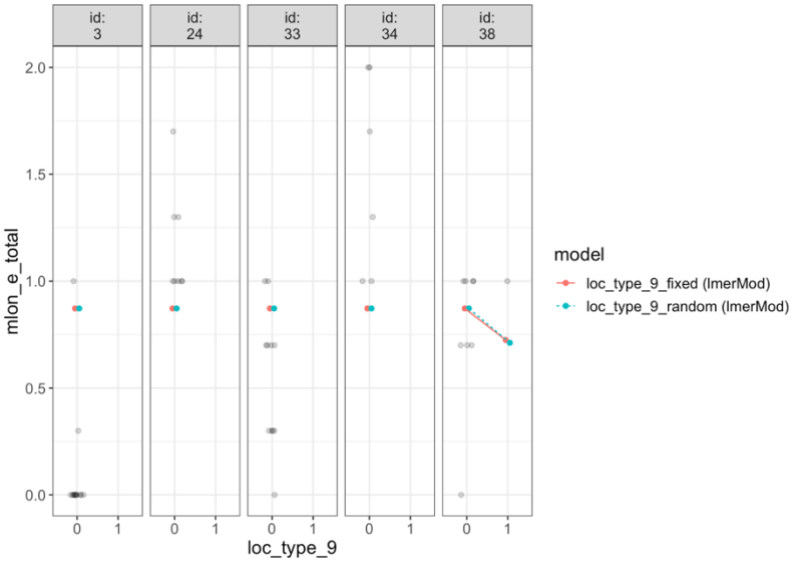
id: 5
id: 8
id: 26
id: 34
mlon_e_total
sad
model
sad_fixed (lmerMod)
sad_random (lmerMod)


id: 6
id: 13
id: 31
id: 36
id: 37
mlon_e_total
relaxed
model
relaxed_fixed (lmerMod)
relaxed_random (lmerMod)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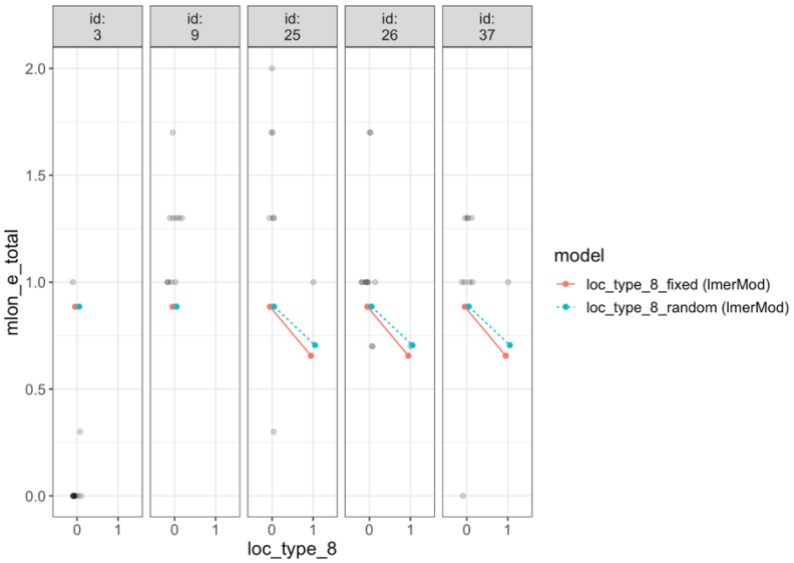
id: 24
id: 33
id: 34
id: 38
mlon_e_total
loc_type_9
model
loc_type_9_fixed (lmerMod)
loc_type_9_random (lmerMod)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id: 9
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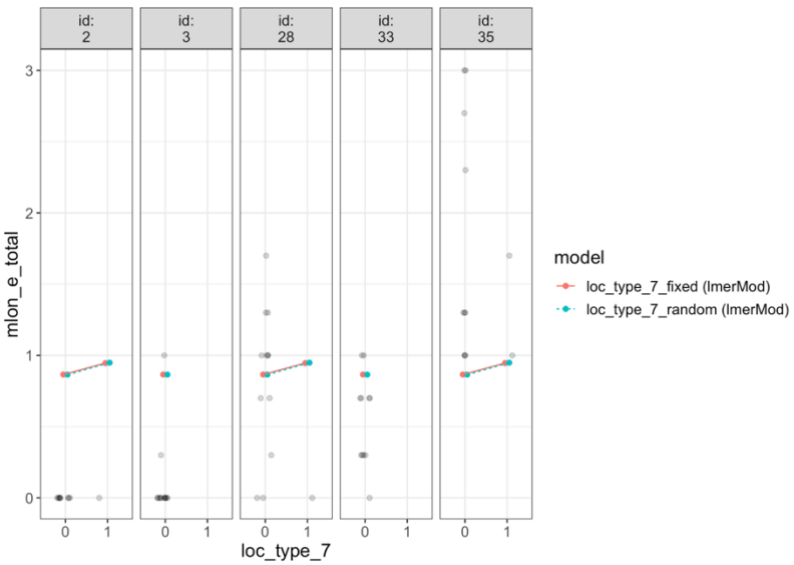
id: 26
id: 37
mlon_e_total
loc_type_8
model
loc_type_8_fixed (lmerMod)
loc_type_8_random (lmerMod)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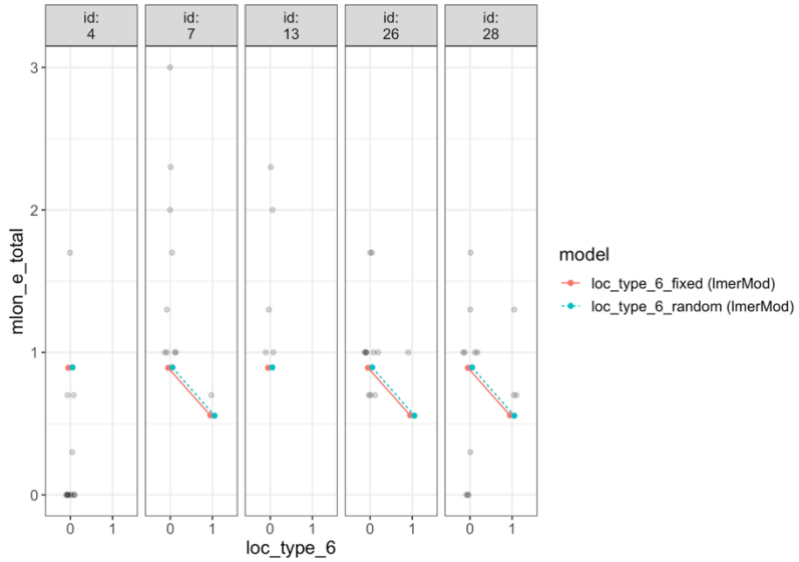
id: 3
id: 28
id: 33
id: 35
mlon_e_total
loc_type_7
model
loc_type_7_fixed (lmerMod)
loc_type_7_random (lmerMod)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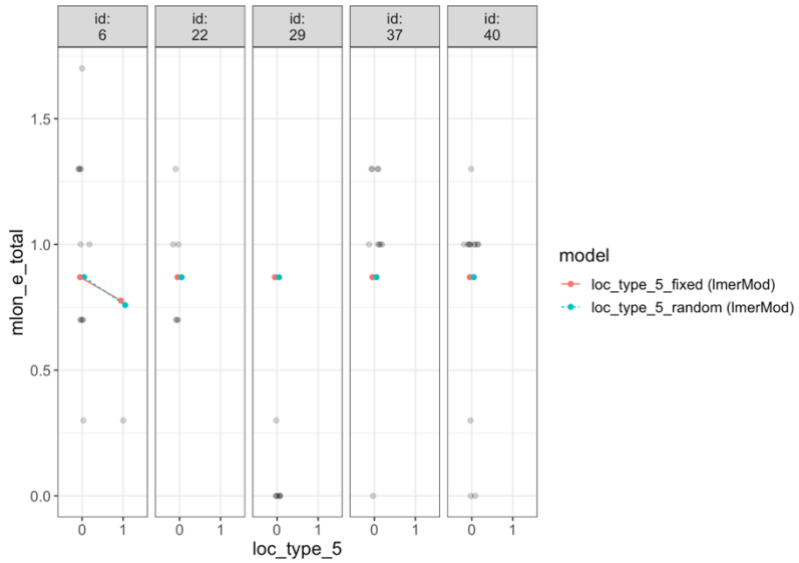
id: 7
id: 13
id: 26
id: 28
mlon_e_total
loc_type_6
model
loc_type_6_fixed (lmerMod)
loc_type_6_random (lmerMod)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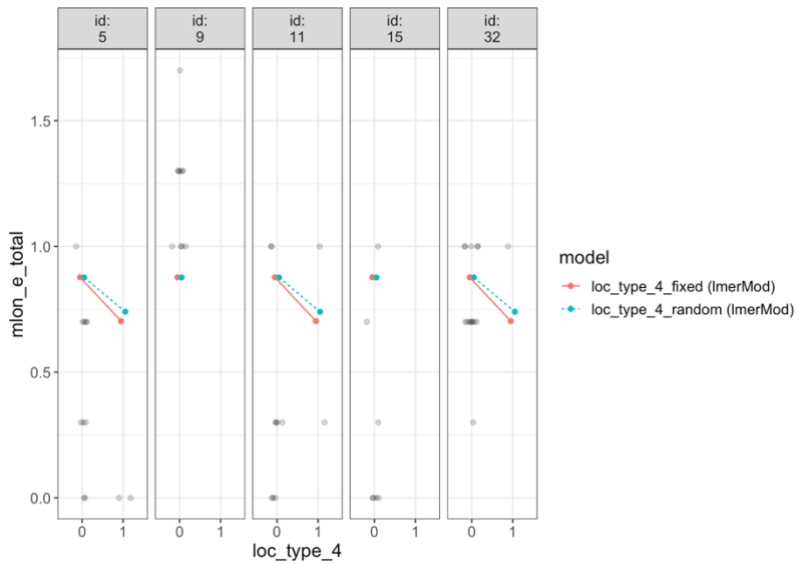
id: 29
id: 37
id: 40
mlon_e_total
loc_type_5
model
loc_type_5_fixed (lmerMod)
loc_type_5_random (lmerMod)


id: 5
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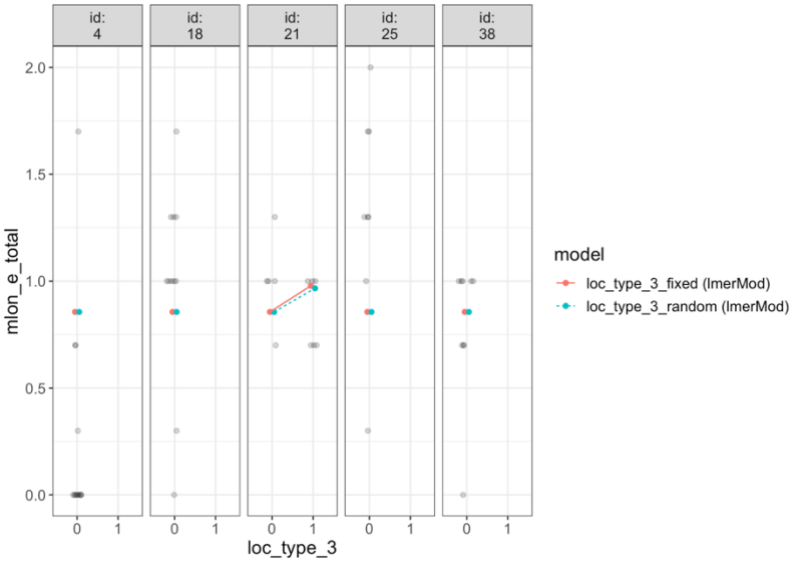
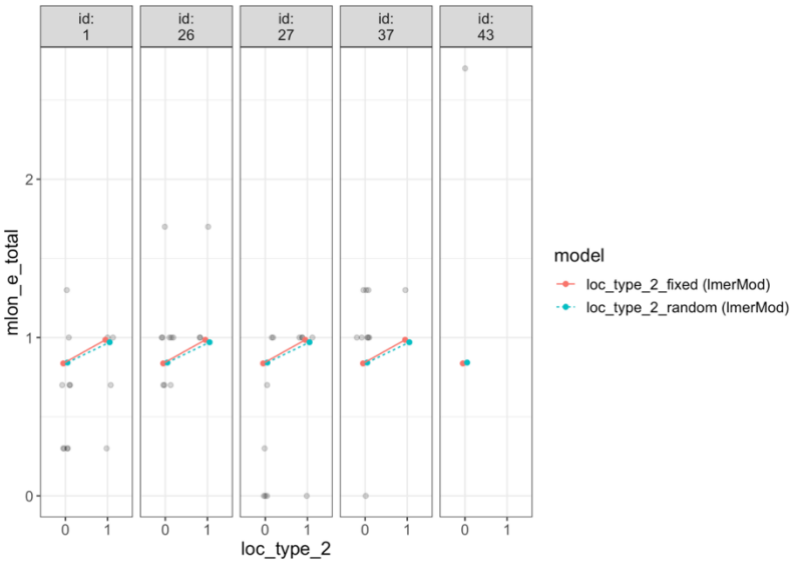
id: 11
id: 15
id: 32
mlon_e_total
loc_type_4
model
loc_type_4_fixed (lmerMod)
loc_type_4_random (lmerMod)


id: 4
id: 18
id: 21
id: 25
id: 38
mlon_e_total
loc_type_3
model
loc_type_3_fixed (lmerMod)
loc_type_3_random (lmerMod)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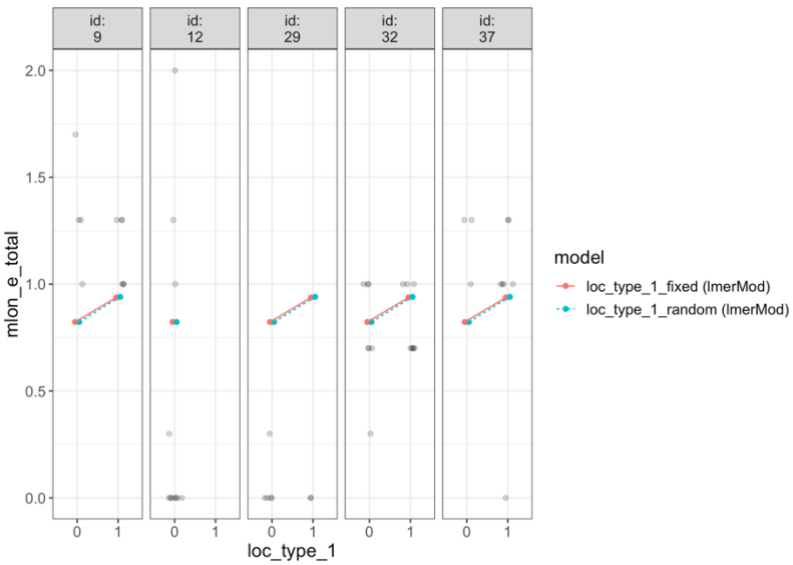
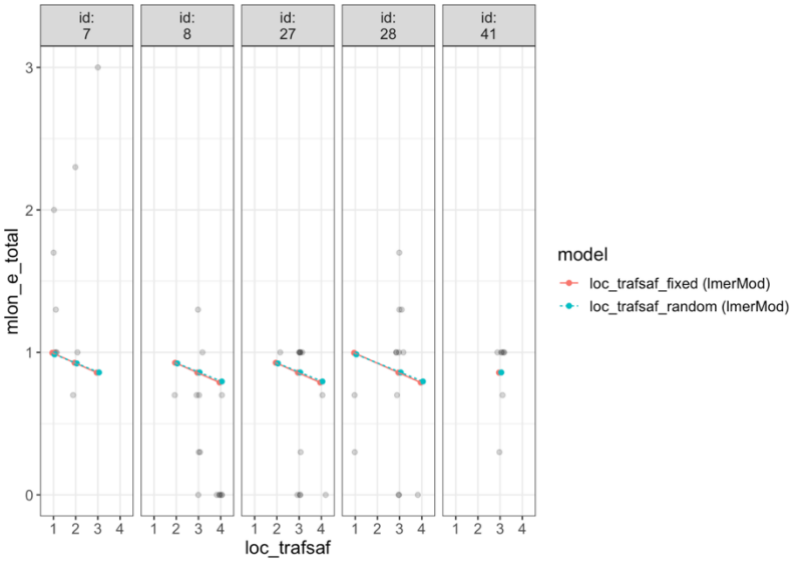
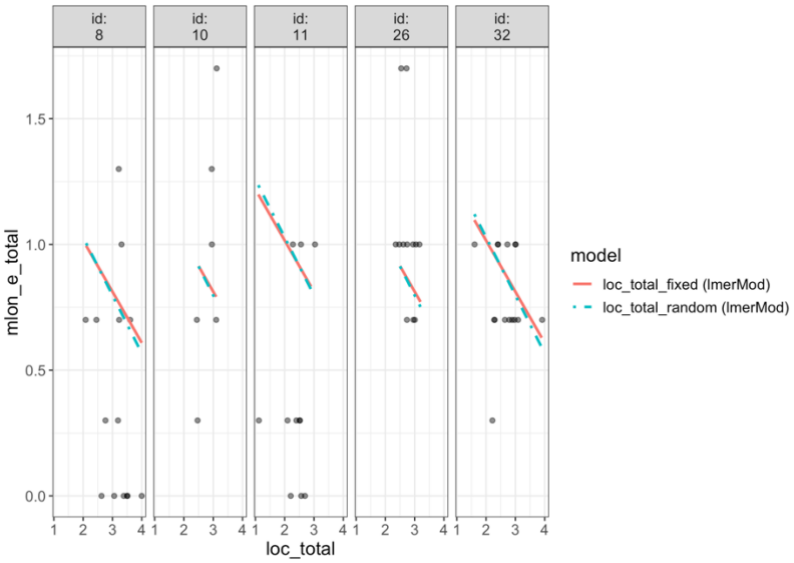
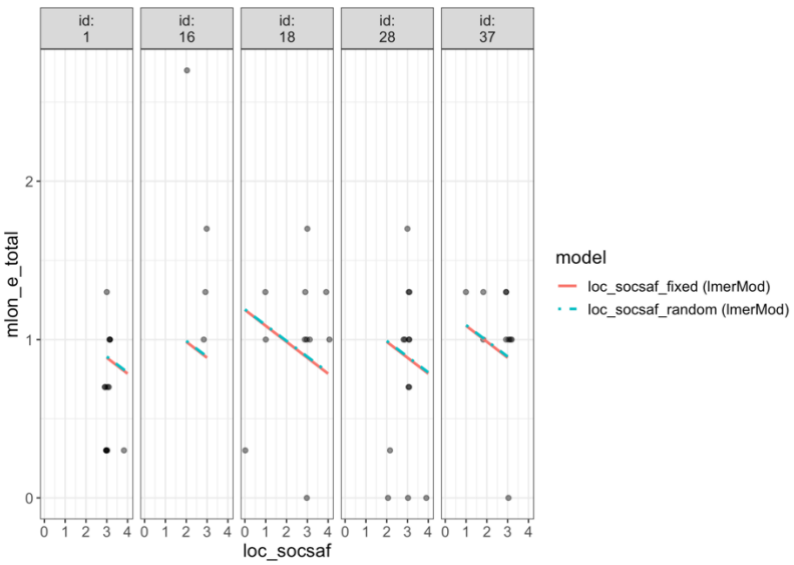
id: 26
id: 27
id: 37
id: 43
mlon_e_total
loc_type_2
model
loc_type_2_fixed (lmerMod)
loc_type_2_random (lmerMod)


id: 9
id: 12
id: 29
id: 32
id: 37
mlon_e_total
loc_type_1
model
loc_type_1_fixed (lmerMod)
loc_type_1_random (lmerMod)


id: 7
id: 8
id: 27
id: 28
id: 41
mlon_e_total
loc_trafsaf
model
loc_trafsaf_fixed (lmerMod)
loc_trafsaf_random (lmerMod)


id: 8
id: 10
id: 11
id: 26
id: 32
mlon_e_total
loc_total
model
loc_total_fixed (lmerMod)
loc_total_random (lmerMod)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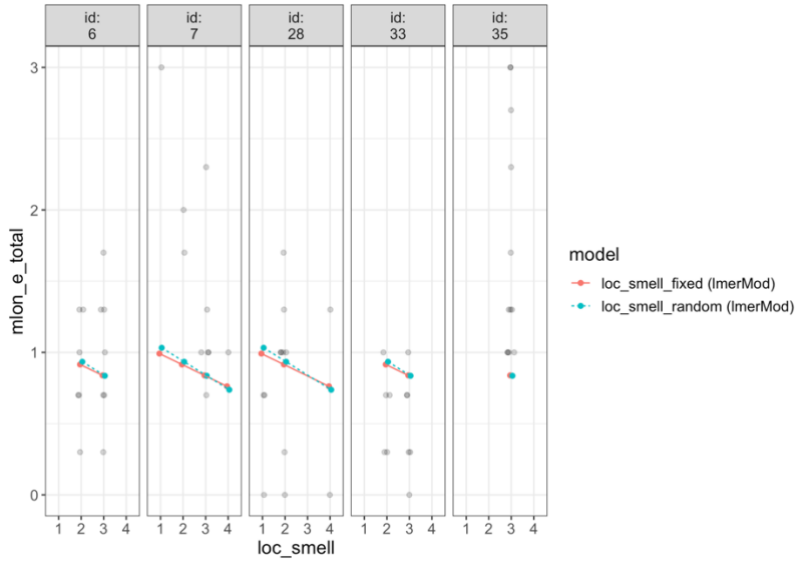
id: 16
id: 18
id: 28
id: 37
mlon_e_total
loc_socsaf
model
loc_socsaf_fixed (lmerMod)
loc_socsaf_random (lmerMod)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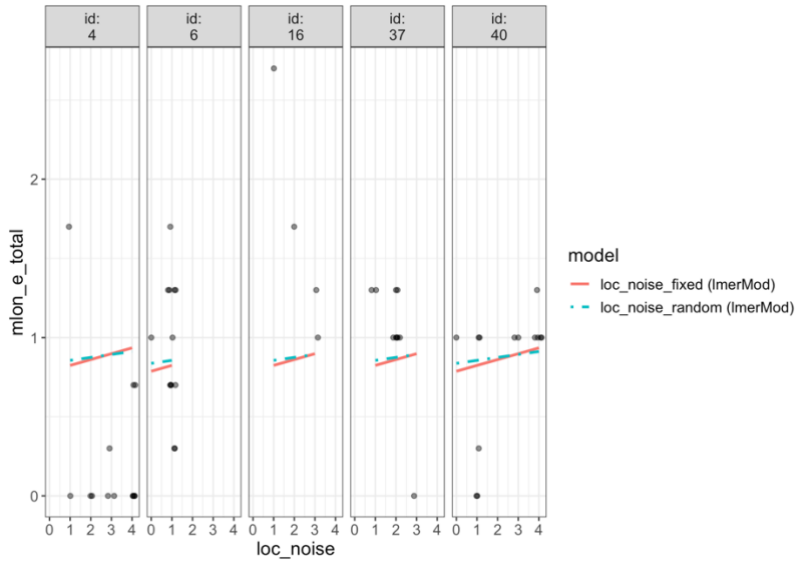
id: 33
id: 35
mlon_e_total
loc_smell
model
loc_smell_fixed (lmerMod)
loc_smell_random (lmerMod)


id: 4
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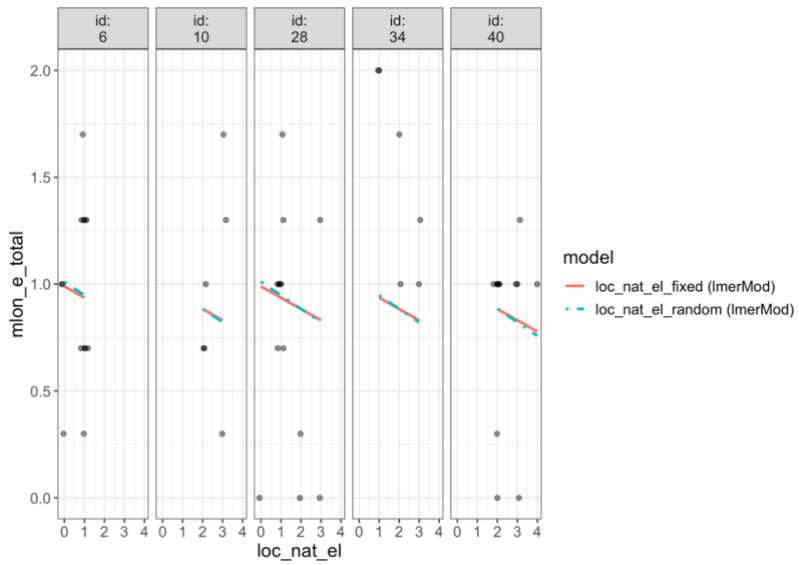
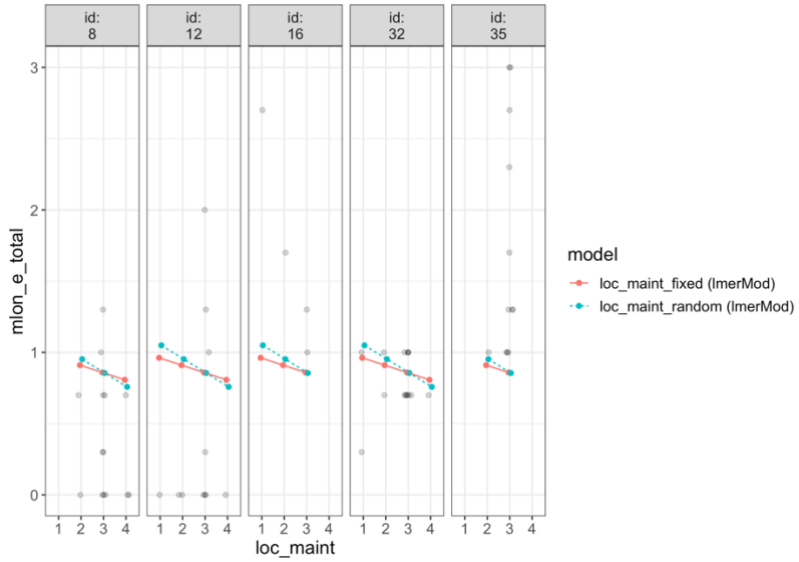
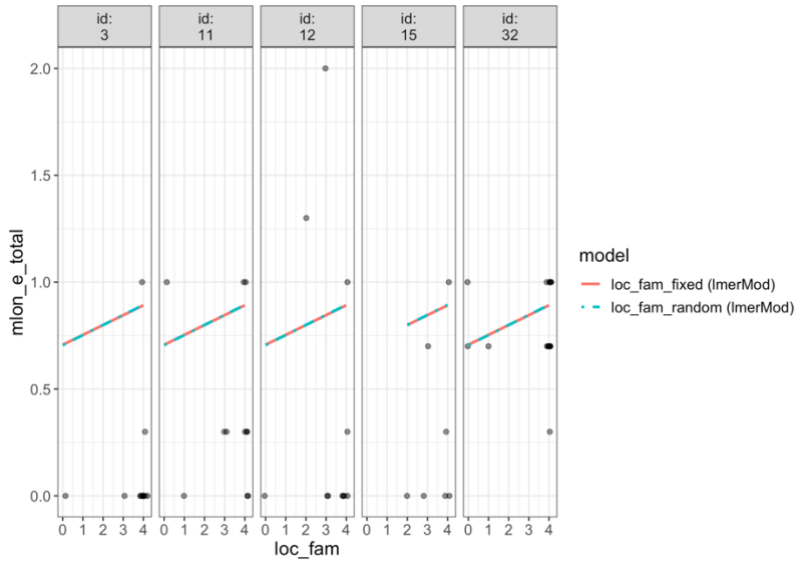
id: 16
id: 37
id: 40
mlon_e_total
loc_noise
model
loc_noise_fixed (lmerMod)
loc_noise_random (lmerMod)


id: 6
id: 10
id: 28
id: 34
id: 40
mlon_e_total
loc_nat_el
model
loc_nat_el_fixed (lmerMod)
loc_nat_el_random (lmerMod)


id: 8
id: 12
id: 16
id: 32
id: 35
mlon_e_total
loc_maint
model
loc_maint_fixed (lmerMod)
loc_maint_random (lmerMod)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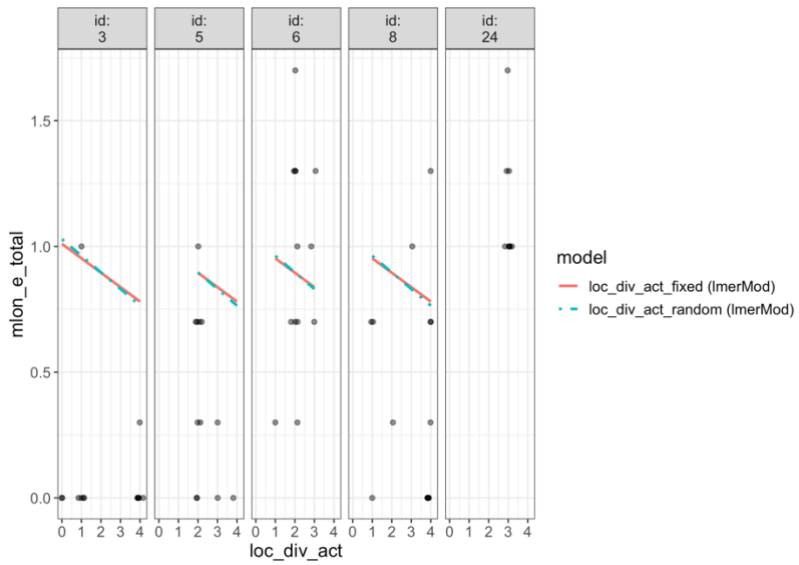
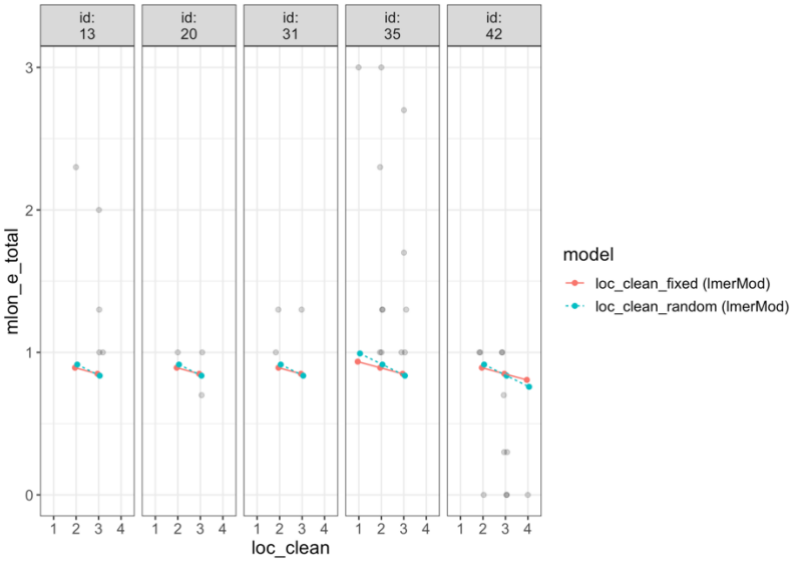
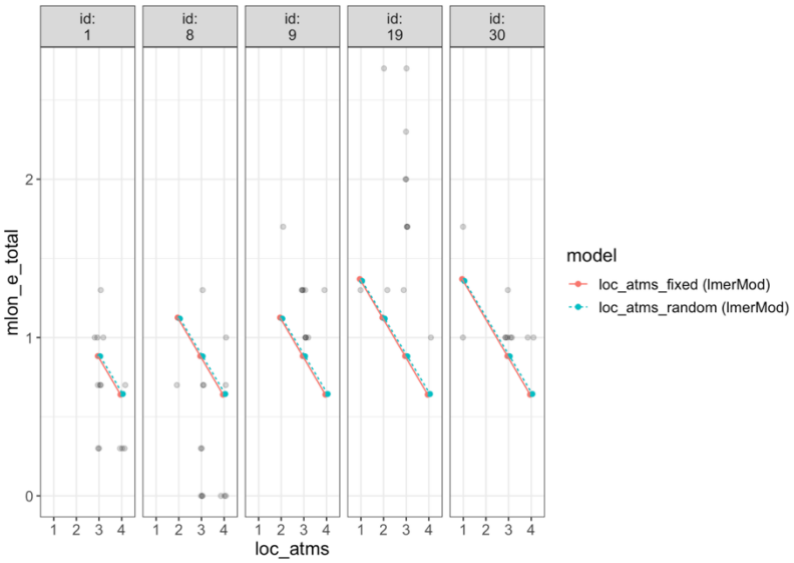
id: 12
id: 15
id: 32
mlon_e_total
loc_fam
model
loc_fam_fixed (lmerMod)
loc_fam_random (lmerMod)


id: 3
id: 5
id: 6
id: 8
id: 24
mlon_e_total
loc_div_act
model
loc_div_act_fixed (lmerMod)
loc_div_act_random (lmerMod)


id: 13
id: 20
id: 31
id: 35
id: 42
mlon_e_total
loc_clean
model
loc_clean_fixed (lmerMod)
loc_clean_random (lmerMod)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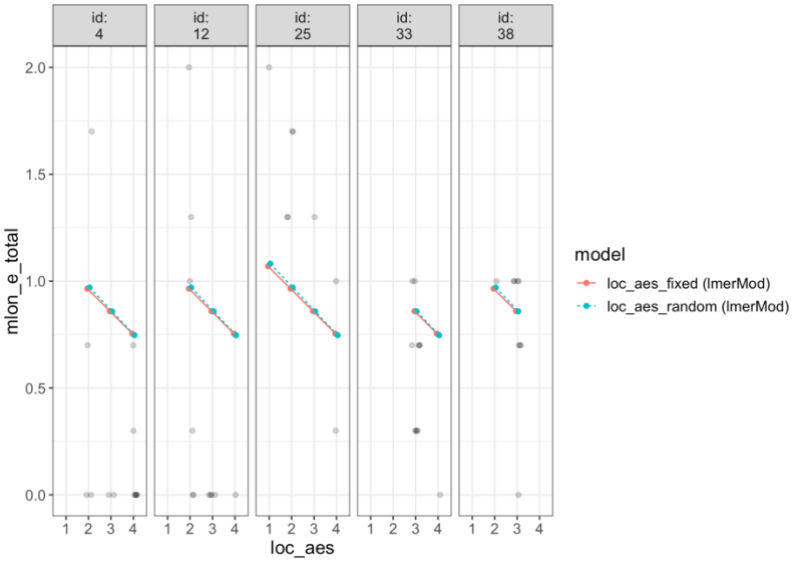
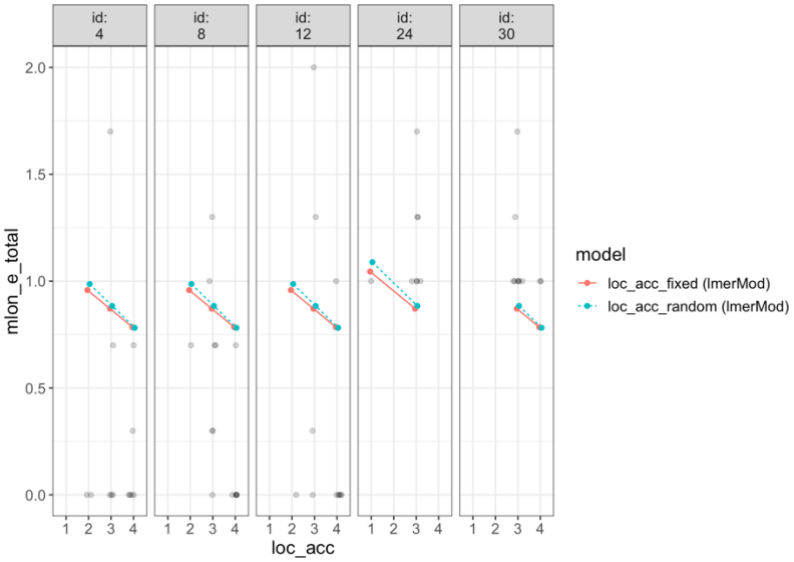
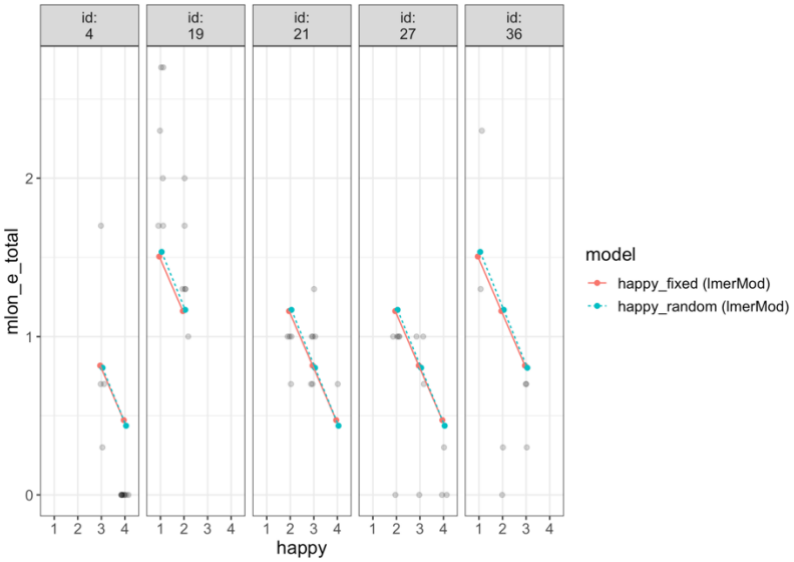
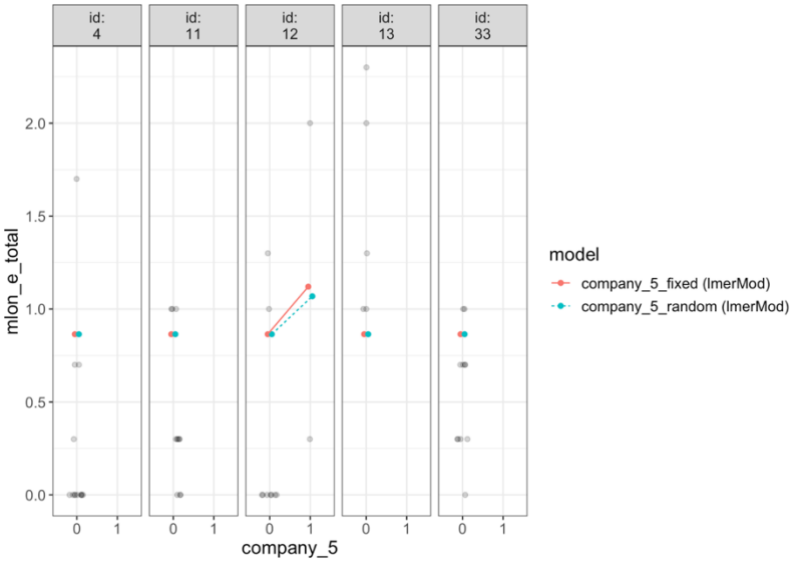
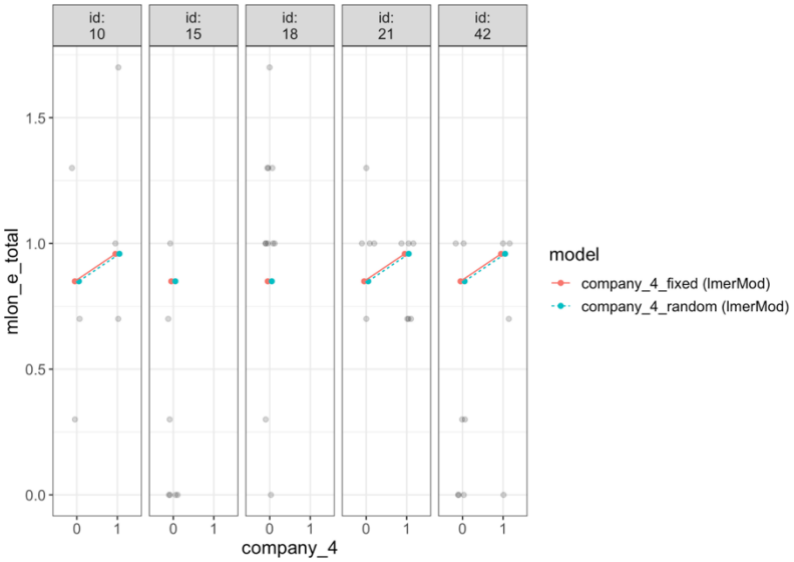
id: 30
mlon_e_total
loc_atms
model
loc_atms_fixed (lmerMod)
loc_atms_random (lmerMod)

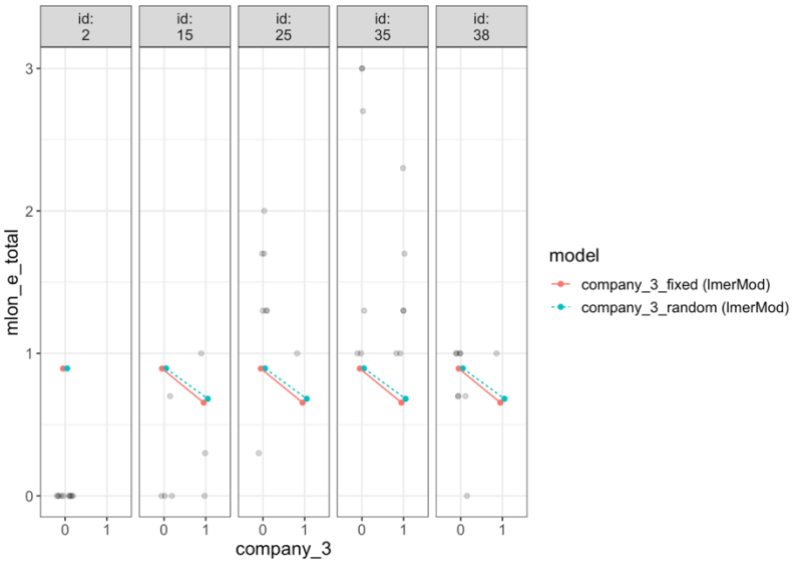

id: 4
id: 12
id: 25
id: 33
id: 38
mlon_e_total
loc_aes
model
loc_aes_fixed (lmerMod)
loc_aes_random (lmerMod)

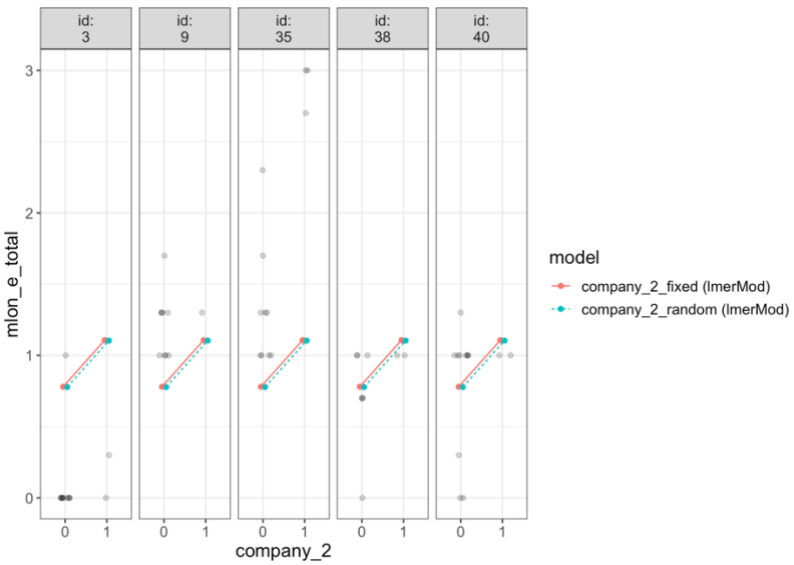

id: 4
id: 8
id: 12
id: 24
id: 30
mlon_e_total
loc_acc
model
loc_acc_fixed (lmerMod)
loc_acc_random (lmerMod)

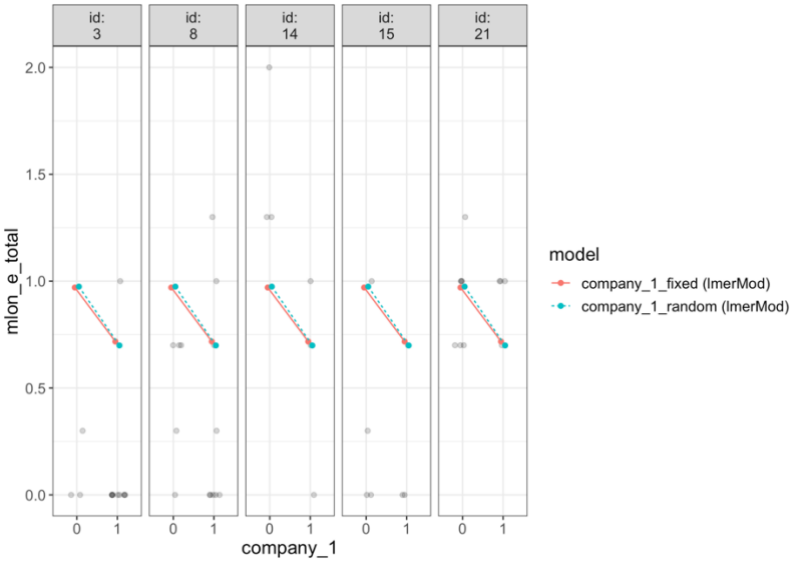

id: 4
id: 19
id: 21
id: 27
id: 36
mlon_e_total
happy
model
happy_fixed (lmerMod)
happy_random (lmerMod)


id: 4
id: 11
id: 12
id: 13
id: 33
mlon_e_total
company_5
model
company_5_fixed (lmerMod)
company_5_random (lmerMod)


id: 10
id: 15
id: 18
id: 21
id: 42
mlon_e_total
company_4
model
company_4_fixed (lmerMod)
company_4_random (lmerMod)


id: 2
id: 15
id: 25
id: 35
id: 38
mlon_e_total
company_3
model
company_3_fixed (lmerMod)
company_3_random (lmerMod)


id: 3
id: 9
id: 35
id: 38
id: 40
mlon_e_total
company_2
model
company_2_fixed (lmerMod)
company_2_random (lmerMod)


id: 3
id: 8
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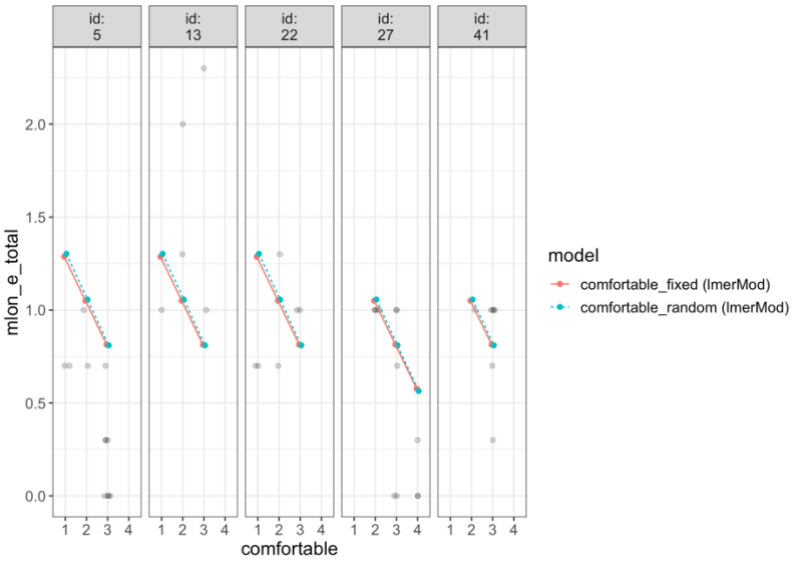
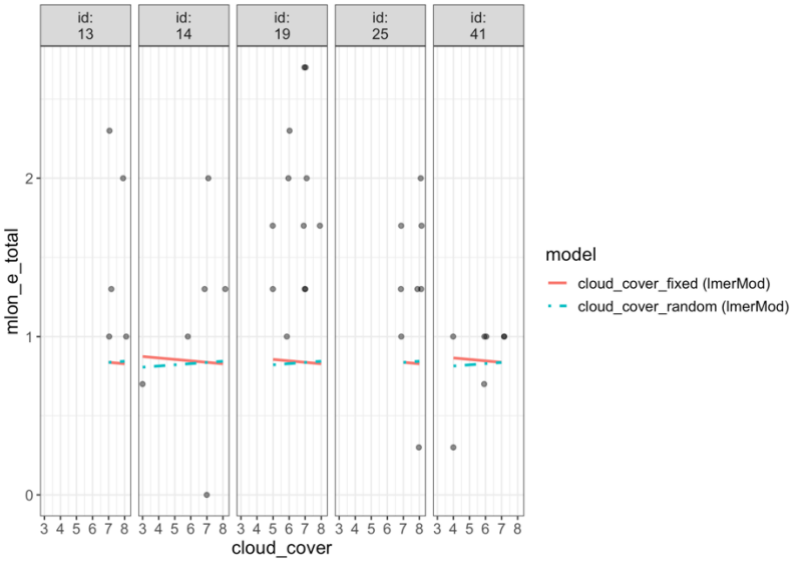
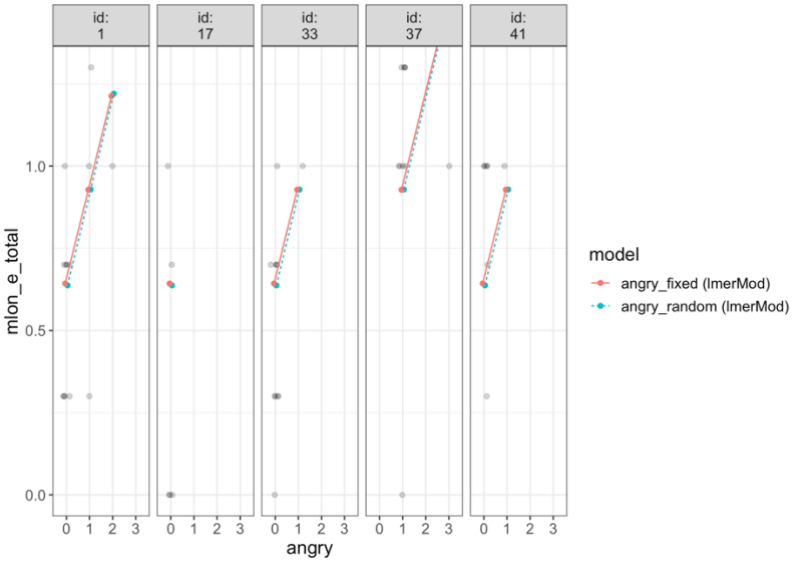
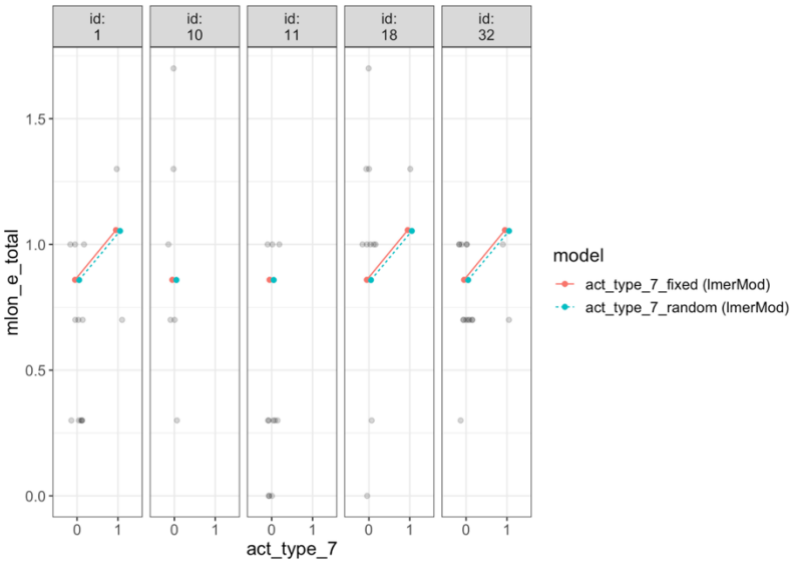
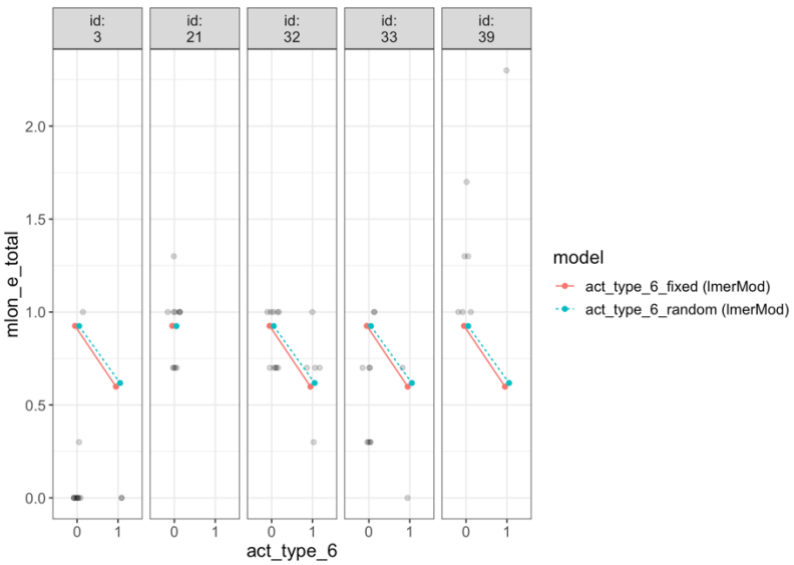
id: 15
id: 21
mlon_e_total
company_1
model
company_1_fixed (lmerMod)
company_1_random (lmerMod)

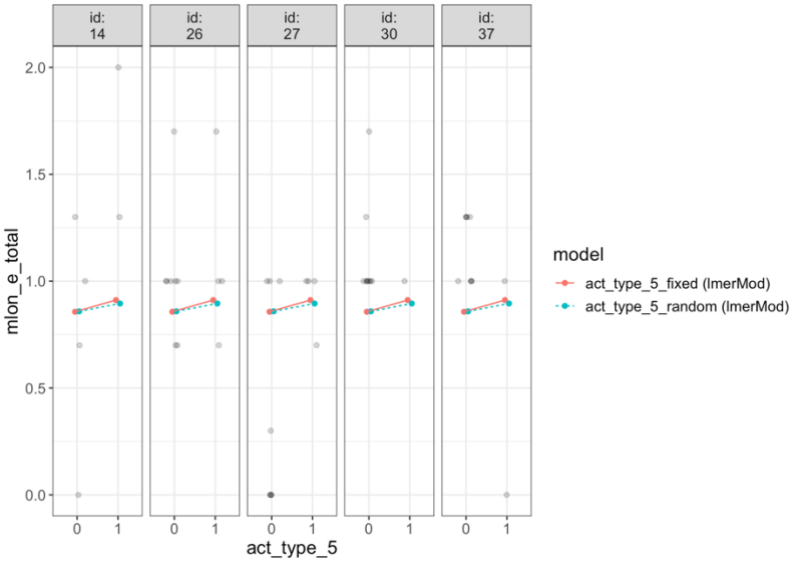

id: 5
id: 13
id: 22
id: 27
id: 41
mlon_e_total
comfortable
model
comfortable_fixed (lmerMod)
comfortable_random (lmerMod)

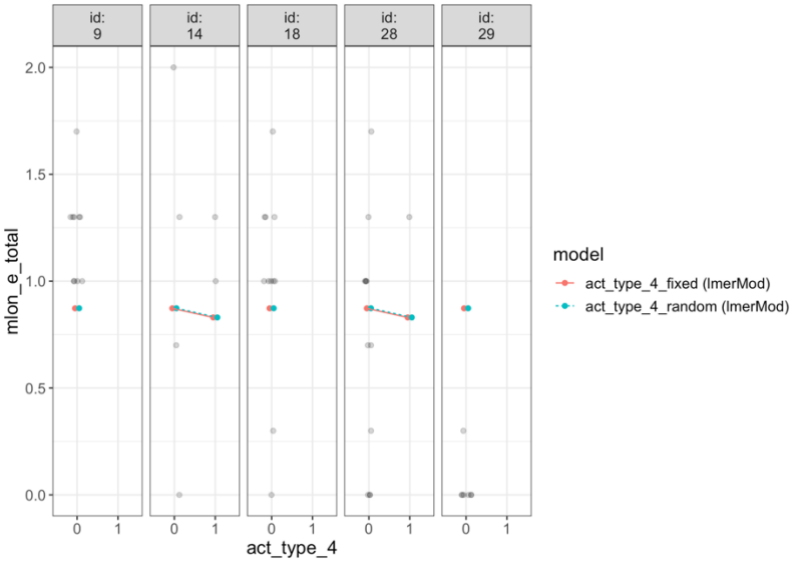

id: 13
id: 14
id: 19
id: 25
id: 41
mlon_e_total
cloud_cover
model
cloud_cover_fixed (lmerMod)
cloud_cover_random (lmerMod)

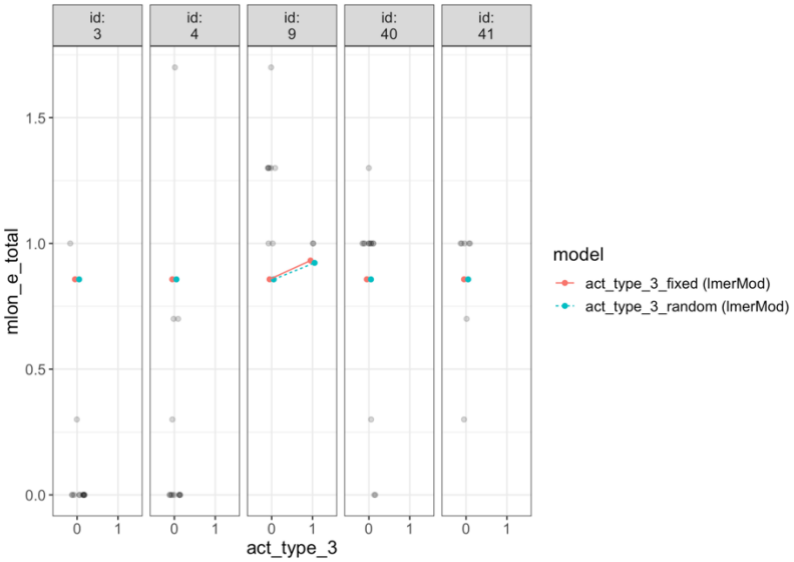

id: 1
id: 17
id: 33
id: 37
id: 41
mlon_e_total
angry
model
angry_fixed (lmerMod)
angry_random (lmerMod)

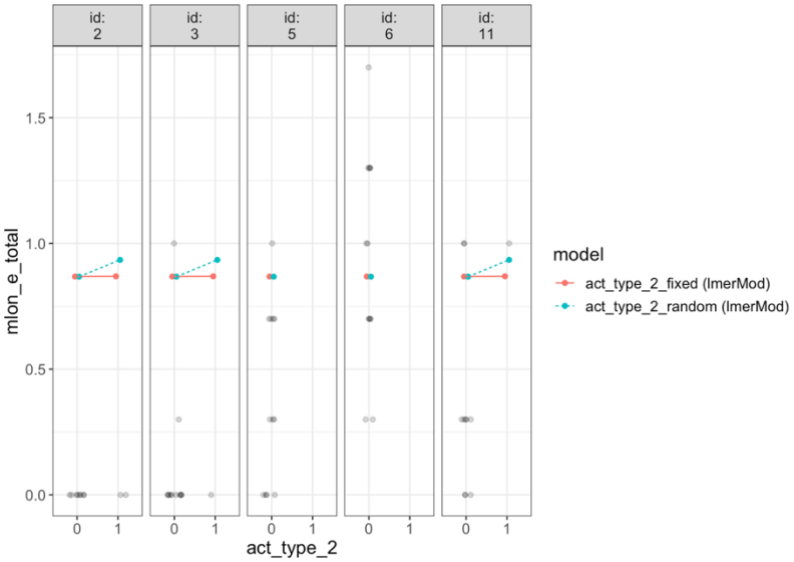

id: 1
id: 10
id: 11
id: 18
id: 32
mlon_e_total
act_type_7
model
act_type_7_fixed (lmerMod)
act_type_7_random (lmerMod)

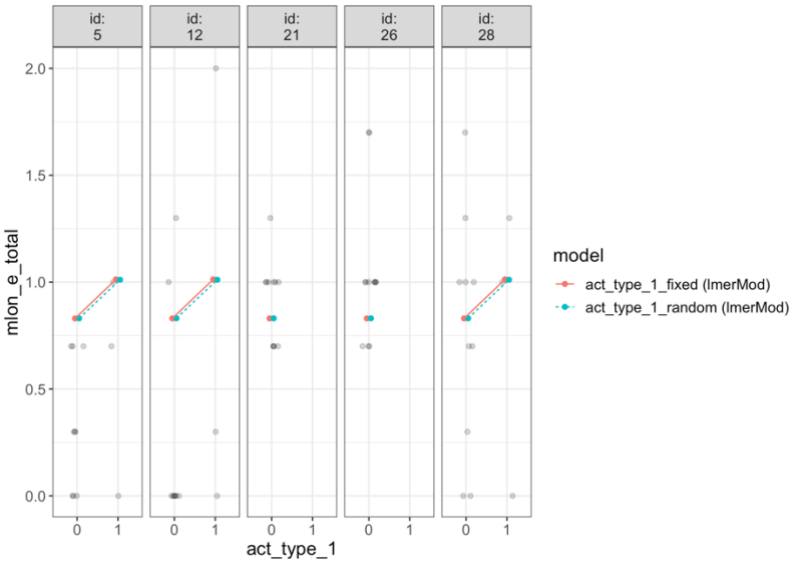

id: 3
id: 21
id: 32
id: 33
id: 39
mlon_e_total
act_type_6
model
act_type_6_fixed (lmerMod)
act_type_6_random (lmerMod)


id: 14
id: 26
id: 27
id: 30
id: 37
mlon_e_total
act_type_5
model
act_type_5_fixed (lmerMod)
act_type_5_random (lmerMod)


id: 9
id: 14
id: 18
id: 28
id: 29
mlon_e_total
act_type_4
model
act_type_4_fixed (lmerMod)
act_type_4_random (lmerMod)


id: 3
id: 4
id: 9
id: 40
id: 41
mlon_e_total
act_type_3
model
act_type_3_fixed (lmerMod)
act_type_3_random (lmerMod)


id: 2
id: 3
id: 5
id: 6
id: 11
mlon_e_total
act_type_2
model
act_type_2_fixed (lmerMod)
act_type_2_random (lmerMod)


id: 5
id: 12
id: 21
id: 26
id: 28
mlon_e_total
act_type_1
model
act_type_1_fixed (lmerMod)
act_type_1_random (lmerMod)

Appendix J: Alternative Model Testing

The test models aim to give insight in the influence a group of variables has on the performance of the model. These models score worse on both the aic and bic values as on the r squared value than the optimal model and the results should be interpreted only in the context of a relationship comparison.

1. Full Model

The full model is the total linear mixed effect model containing all the variables derived from literature and collected during by means of the experience sampling method.
As the full model contains variables that do not 'need' to be in the model, it risks overfitting and is therefore not used as final model.

Full model 4 results	Estimate	Std. Error	t value
Individual layer			
Mood			
angry	0.10	0.03	2.98
happy	-0.13	0.05	-2.70
sad	0.11	0.04	2.97
scared	0.09	0.04	2.08
Baseline Loneliness			
Emotional	0.18	0.04	4.23
Social	-0.08	0.05	-1.78
Household layer			
partner - yes	0.50	0.19	2.69
Education level			
Secondary Education	-0.29	0.13	-2.25
HBO	-0.70	0.32	-2.21
House type			
Row House	-0.77	0.24	-3.26
Apartment/Studio	0.63	0.25	2.53
Household situation			
With friends	0.49	0.24	2.05
With acquaintances	0.43	0.25	1.69
With my partner	-0.71	0.31	-2.25
Study time			
24-40 hours	0.57	0.30	1.91
Social Environment Layer			
Company			
Alone	0.27	0.15	1.86
Strangers	0.34	0.21	1.68
Social Media Applications			

Snapchat	0.59	0.29	2.01
TikTok	-0.47	0.27	-1.74
Twitter	0.90	0.29	3.07
Facebook	0.50	0.19	2.62
Physical Environment Layer			
Location type			
Transportation	0.53	0.20	2.70
Transportation type			
By foot	-0.24	0.11	-2.29
External Factor Layer			
weekend day	-0.10	0.05	-1.87

Table 43: Significant results full model

Overall, there are less variables included as significant in the full model than in the optimal model. For example, gender and personality type did not have a high enough t-value to be significant in this model. All the variables included in the full model show significance as well in the optimal model, except for one: company type: strangers. In the full model, being around strangers shows an increase in the momentary feeling of loneliness (+0.34).
In contrast to the optimal model the full model features no locations attributes in the significant results. The only location type it deems important is the 'transportation/on the road' type, which increases the of loneliness (+0.53).
The estimates of the full model and the optimal model differ as well. These values could be influenced by the overfitting of the model due to the large number of insignificant variables.

2. 'No Mood' Model

In the previous models, the 'mood' variables seem to be the most significant variables. However, as the 'mood' variables could be dependent on the outside variables as well, the 'mood' variables were removed to investigate the effect on the model and the remaining variables.

Model 'no mood'	Estimate	Std. Error	t value
Individual Layer			
Baseline loneliness			
Emotional	0.23	0.04	5.67
Social	-0.11	0.05	-2.25
Household Layer			
partner - yes	0.54	0.20	2.66
Education Level			
Secondary Education	-0.25	0.14	-1.78
HBO	-0.73	0.33	-2.21
House type			

Row House	-0.85	0.24	-3.59
Apartment/studio	0.73	0.27	2.65
Household situation			
With friends	0.49	0.24	2.09
With acquaintances	0.43	0.26	1.65
Study time			
0 hours	0.73	0.43	1.69
24-40 hours	0.55	0.30	1.84
Social Environment Layer			
Company			
Alone	0.32	0.17	1.87
Social Media Applications			
Snapchat	0.70	0.32	2.16
Twitter	0.71	0.30	2.38
Facebook	0.47	0.19	2.43
Physical Environment Layer			
Location type			
Home	0.32	0.19	1.70
Transportation	0.49	0.23	2.10
Location attributes			
Atmosphere	-0.19	0.05	-3.72
Transportation Type			
By car	-0.23	0.12	-1.87
External Factors			
weekendday	-0.11	0.06	-1.81

Table 44: Significant results of the 'no mood' model

As the model intends, there are no mood variables in the results of this model. Removing the 'mood' variables did not only have a result on the coefficients, but the r-squared value of the model was also almost half of the 'optimal model' r-squared value. Wherein the r-squared value of the optimal model was 0.519 and the 'no mood model' reached the r-squared value of 0.209.
The remaining variables do not vary greatly with the full model and the optimal model. However, the t-value of all the variables is lower than in the optimal model, except for the emotional loneliness variables, which scores high in the absence of the 'mood' variables. Removing the 'mood' variables does not seem to have any different influence on the remaining variables.

3. Only Momentary model

By only including the momentary variables in a model, the effect of the control variables on the momentary emotional loneliness is measured.

Model 'only momentary'	Estimate	Std. Error	t value
Individual			
Mood			
angry	0.11	0.03	3.33
happy	-0.17	0.05	-3.35
sad	0.15	0.04	3.70
scared	0.09	0.05	2.09
Social Environment Layer			
Company			
Alone	0.26	0.15	1.76
Physical Environment Layer			
Location Attributes			
Accessibility	-0.06	0.03	-1.92
Location Type			
Transportation	0.44	0.19	2.36
Transportation type			
By foot	-0.25	0.10	-2.37
By car	-0.17	0.10	-1.69
External factors			
weekendday	-0.10	0.05	-2.03

Table 45: Significant results of the 'momentary' model

As to be expected, by the removal of the control variables, the r-squared value of the model dropped slightly to a value of 0.490.

Removing the baseline variables reduced the number of significant variables left in the model. The main significant variables are the 'mood' variables. For the social environment only being alone seems to have any influence on the feeling of momentary emotional loneliness. For the physical environment, the accessibility of a location is important, as are the location type transportation and the transportation types by foot and by car. As in the full and in the optimal models, the weekend day reduces the number of experiences momentary emotional loneliness. Apart from decreasing the remaining number of variables and varying the size of the estimates, the removal of the baseline variables provides little new insight.

4. Only Momentary and No Mood Variables

Lastly, a combination of the two previous models were made to focus on the social and physical environment layer. This aim with this model was to identify the most prominent features of the activity setting that influence the momentary emotional loneliness.

Model 'momentary - no mood'	Estimate	Std. Error	t value
Social Environment Layer			
Company			
Alone	0.32	0.17	1.83
Physical Environment Layer			
Location Attributes			
Accessibility	-0.08	0.04	-1.97
Atmosphere	-0.19	0.05	-3.76
Location Type			
Transportation	0.39	0.23	1.73
Transportation Type			
By car	-0.22	0.12	-1.80
External Factors			
weekendday	-0.12	0.06	-2.04

Table 46: Significant results 'momentary - no mood' model

The model only focussing on the momentary, no mood related variables, the r-squared value dropped to 0.203, which is comparable to the 'no mood' model.
For the variables, in contrast to the previous 'momentary' model, the location atmosphere did seem to be significant in this model, as it was in the optimal model. Surprising is the high t-value of the atmosphere, considering that it was not significant in the 'momentary' model. However, when looking at the 'no mood' model, it was the location accessibility variable that was not significant. There could be a relation between the removal of the 'mood' variables and the significance of the atmosphere and the removal of the baseline variables and the importance of location accessibility. The other variables remain unchanged in both other models.

Appendix K: Complete Results 'Full Model'

Total results full model. The cursive results are these accepted as significant at a level of 1.65.

	Estimate	Std. Error	t value
lon_e_tot	*0.18*	*0.04*	*4.23*
sm_app_6	*0.90*	*0.29*	*3.07*
angry	*0.10*	*0.03*	*2.98*
sad	*0.11*	*0.04*	*2.97*
loc_type_7	*0.53*	*0.20*	*2.70*
partner_1	*0.50*	*0.19*	*2.69*
sm_app_7	*0.50*	*0.19*	*2.62*
h_type_2	*0.63*	*0.25*	*2.53*
scared	*0.09*	*0.04*	*2.08*
hh_sit_2	*0.49*	*0.24*	*2.05*
sm_app_2	*0.59*	*0.29*	*2.01*
study_time_3	*0.57*	*0.30*	*1.91*
company_2	*0.27*	*0.15*	*1.86*
hh_sit_3	*0.43*	*0.25*	*1.69*
company_5	*0.34*	*0.21*	*1.68*
act_type_2	0.25	0.16	1.54
loc_type_5	0.27	0.21	1.30
sm_time_1	0.53	0.41	1.30
sm_app_4	0.29	0.24	1.22
act_type_7	0.15	0.13	1.19
loc_div_act	0.03	0.03	1.10
loc_noise	0.02	0.02	1.00
loc_type_4	0.16	0.17	0.96
sm_app_8	0.18	0.20	0.89
cloud_cover	0.01	0.02	0.87
sm_time_4	0.19	0.22	0.85
Temp_Mean	0.01	0.01	0.85
sec_total	0.03	0.04	0.84
sm_app_9	0.09	0.12	0.82
act_type_5	0.09	0.11	0.79
act_type_3	0.11	0.13	0.78
Sun_Mean	0.00	0.00	0.74
loc_type_6	0.12	0.16	0.72
company_4	0.12	0.17	0.70
loc_type_1	0.11	0.16	0.66
liv_en_2	0.50	0.77	0.65
company_3	0.10	0.15	0.63
liv_en_1	0.44	0.71	0.62

p_neur_total_R	0.02	0.03	0.58
company_1	0.08	0.14	0.58
act_type_1	0.06	0.12	0.49
work_time_3	0.17	0.36	0.47
study_time_1	0.18	0.40	0.46
loc_type_2	0.08	0.18	0.44
loc_smell	0.01	0.03	0.43
study_time_2	0.17	0.41	0.42
act_type_6	0.04	0.11	0.40
loc_type_8	0.06	0.17	0.36
loc_type_3	0.07	0.20	0.34
loc_fam	0.01	0.03	0.32
loc_socsaf	0.01	0.04	0.15
act_type_4	0.01	0.12	0.11
loc_type_9	0.02	0.19	0.09
loc_nat_el	0.00	0.03	0.00
loc_clean	0.00	0.03	-0.02
relaxed	0.00	0.03	-0.07
work_time_2	-0.05	0.44	-0.11
comfortable	-0.01	0.04	-0.17
sm_app_5	-0.04	0.15	-0.26
hh_number	-0.01	0.03	-0.35
sm_time_3	-0.08	0.20	-0.40
hh_sit_6	-0.25	0.61	-0.40
age	-0.02	0.05	-0.46
work_time_1	-0.22	0.45	-0.48
trans_type_1	-0.03	0.06	-0.52
loc_aes	-0.02	0.03	-0.56
(Intercept)	-0.80	1.41	-0.56
loc_trafsaf	-0.03	0.03	-0.83
men	-0.11	0.12	-0.95
sm_time_2	-0.20	0.21	-0.96
loc_maint	-0.04	0.04	-1.09
loc_atms	-0.05	0.05	-1.13
hh_sit_1	-0.37	0.33	-1.14
trans_type_3	-0.13	0.11	-1.15
p_ex_total	-0.04	0.03	-1.42
loc_acc	-0.05	0.03	-1.51
trans_type_4	-0.17	0.10	-1.62
sm_app_3	*-0.47*	*0.27*	*-1.74*
lon_s_tot	*-0.08*	*0.05*	*-1.78*
weekendday	*-0.10*	*0.05*	*-1.87*
educ_3	*-0.70*	*0.32*	*-2.21*

educ_1	*-0.29*	*0.13*	*-2.25*
hh_sit_4	*-0.71*	*0.31*	*-2.25*
trans_type_2	*-0.24*	*0.11*	*-2.29*
happy	*-0.13*	*0.05*	*-2.70*
h_type_1	*-0.77*	*0.24*	*-3.26*

Appendix L: Complete Results 'Optimal Model'

Total results 'optimal' model. The cursive results are these accepted as significant at a level of 1.65.

	Estimate	Std. Error	t value
lon_e_tot	*0.17*	*0.03*	*5.81*
sm_time_1	*0.60*	*0.12*	*4.97*
h_type_2	*0.62*	*0.13*	*4.92*
sm_app_7	*0.34*	*0.08*	*4.31*
sm_app_6	*0.68*	*0.16*	*4.28*
partner_1	*0.48*	*0.12*	*4.10*
study_time_3	*0.39*	*0.10*	*4.02*
company_2	*0.19*	*0.05*	*3.94*
sad	*0.13*	*0.04*	*3.77*
hh_sit_2	*0.43*	*0.12*	*3.56*
sm_app_2	*0.45*	*0.13*	*3.55*
angry	*0.09*	*0.03*	*3.26*
loc_type_7	*0.33*	*0.11*	*3.17*
sm_app_4	*0.28*	*0.09*	*3.16*
hh_sit_3	*0.33*	*0.12*	*2.74*
scared	*0.09*	*0.04*	*2.37*
sec_total	*0.04*	*0.02*	*2.00*
study_time_1	*0.22*	*0.12*	*1.80*
act_type_2	*0.18*	*0.10*	*1.74*
loc_type_1	*0.08*	*0.05*	*1.66*
sm_time_4	0.15	0.09	1.63
Temp_Mean	0.01	0.01	1.45
company_5	0.19	0.13	1.42
loc_div_act	0.03	0.02	1.26
work_time_3	0.14	0.11	1.26
act_type_3	0.08	0.06	1.23
sm_app_8	0.10	0.09	1.19
act_type_7	0.08	0.08	0.99
loc_type_5	0.12	0.14	0.88
(Intercept)	-0.43	0.53	-0.81
loc_maint	-0.03	0.02	-1.19
trans_type_4	*-0.14*	*0.08*	*-1.82*
loc_acc	*-0.05*	*0.03*	*-1.85*
weekendday	*-0.08*	*0.04*	*-1.91*
loc_atms	*-0.07*	*0.03*	*-2.03*
educ_3	*-0.40*	*0.18*	*-2.16*
men	*-0.14*	*0.06*	*-2.20*
trans_type_2	*-0.21*	*0.09*	*-2.41*

lon_s_tot	*-0.05*	*0.02*	*-2.42*
work_time_1	*-0.18*	*0.07*	*-2.49*
p_ex_total	*-0.03*	*0.01*	*-2.51*
hh_sit_6	*-0.39*	*0.14*	*-2.75*
sm_time_2	*-0.24*	*0.09*	*-2.76*
happy	*-0.13*	*0.04*	*-3.09*
sm_app_3	*-0.47*	*0.14*	*-3.35*
hh_sit_4	*-0.51*	*0.15*	*-3.51*
educ_1	*-0.27*	*0.06*	*-4.42*
h_type_1	*-0.64*	*0.11*	*-5.59*

Appendix M: Complete Results 'Emotion model'

Total results 'emotion' model. The cursive results are these accepted as significant at a level of 1.65.

	Estimate	Std. Error	t value
lon_e_tot	*0.23*	*0.04*	*5.67*
partner_1	*0.54*	*0.20*	*2.66*
h_type_2	*0.73*	*0.27*	*2.65*
sm_app_7	*0.47*	*0.19*	*2.43*
sm_app_6	*0.71*	*0.30*	*2.38*
sm_app_2	*0.70*	*0.32*	*2.16*
loc_type_7	*0.49*	*0.23*	*2.10*
hh_sit_2	*0.49*	*0.24*	*2.09*
company_2	*0.32*	*0.17*	*1.87*
study_time_3	*0.55*	*0.30*	*1.84*
loc_type_1	*0.32*	*0.19*	*1.70*
study_time_1	*0.73*	*0.43*	*1.69*
hh_sit_3	*0.43*	*0.26*	*1.65*
sec_total	0.07	0.04	1.62
work_time_3	0.64	0.40	1.62
company_5	0.36	0.24	1.54
loc_type_2	0.30	0.20	1.52
loc_noise	0.04	0.03	1.46
act_type_7	0.21	0.15	1.42
sm_app_4	0.34	0.24	1.38
company_4	0.27	0.19	1.37
loc_type_8	0.26	0.20	1.28
loc_type_4	0.25	0.20	1.27
loc_div_act	0.04	0.03	1.26
loc_type_3	0.29	0.23	1.25
act_type_2	0.23	0.19	1.24
hh_number	0.03	0.03	1.14
loc_type_5	0.26	0.24	1.06
Temp_Mean	0.01	0.01	1.00
sm_app_8	0.19	0.21	0.91
loc_type_6	0.17	0.19	0.90
liv_en_2	0.64	0.79	0.81
sm_time_1	0.33	0.41	0.80
company_1	0.13	0.17	0.78
p_neur_total_R	0.02	0.02	0.60
work_time_2	0.28	0.48	0.59
liv_en_1	0.43	0.74	0.58
act_type_1	0.08	0.13	0.58

act_type_5	0.07	0.12	0.53
loc_type_9	0.11	0.22	0.50
loc_nat_el	0.01	0.03	0.44
company_3	0.07	0.18	0.39
work_time_1	0.18	0.49	0.38
act_type_3	0.06	0.16	0.37
loc_smell	0.01	0.04	0.35
cloud_cover	0.01	0.02	0.35
age	0.01	0.05	0.25
act_type_4	0.03	0.14	0.22
hh_sit_6	0.05	0.63	0.07
sm_time_4	-0.01	0.21	-0.04
sm_app_9	-0.01	0.11	-0.10
trans_type_1	-0.01	0.08	-0.19
sm_app_3	-0.07	0.30	-0.24
study_time_2	-0.12	0.43	-0.28
loc_aes	-0.01	0.04	-0.31
act_type_6	-0.04	0.13	-0.32
Sun_Mean	0.00	0.00	-0.32
trans_type_3	-0.05	0.13	-0.37
sm_app_5	-0.06	0.16	-0.37
loc_socsaf	-0.02	0.04	-0.37
loc_fam	-0.01	0.03	-0.40
loc_trafsaf	-0.02	0.04	-0.46
loc_maint	-0.02	0.04	-0.57
loc_clean	-0.03	0.03	-0.85
men	-0.12	0.13	-0.88
hh_sit_4	-0.32	0.32	-1.01
sm_time_2	-0.23	0.20	-1.12
hh_sit_1	-0.40	0.33	-1.21
sm_time_3	-0.26	0.21	-1.25
trans_type_2	-0.17	0.12	-1.36
p_ex_total	-0.05	0.03	-1.51
(Intercept)	-2.27	1.50	-1.51
loc_acc	-0.06	0.04	-1.56
educ_1	*-0.25*	*0.14*	*-1.78*
weekendday	*-0.11*	*0.06*	*-1.81*
trans_type_4	*-0.23*	*0.12*	*-1.87*
educ_3	*-0.73*	*0.33*	*-2.21*
lon_s_tot	*-0.11*	*0.05*	*-2.25*
h_type_1	*-0.85*	*0.24*	*-3.59*
loc_atms	*-0.19*	*0.05*	*-3.72*

Appendix N: Complete Results 'control variable model'

Total results 'control variable' model. The cursive results are these accepted as significant at a level of 1.65.

	Estimate	Std. Error	t value
sad	*0.15*	*0.04*	*3.70*
angry	*0.11*	*0.03*	*3.33*
(Intercept)	1.07	0.33	3.22
loc_type_7	*0.44*	*0.19*	*2.36*
scared	*0.09*	*0.05*	*2.09*
company_2	*0.26*	*0.15*	*1.76*
company_5	0.26	0.20	1.28
act_type_2	0.18	0.16	1.13
act_type_7	0.14	0.13	1.08
loc_noise	0.02	0.02	0.98
cloud_cover	0.02	0.02	0.91
loc_div_act	0.02	0.03	0.84
relaxed	0.02	0.03	0.82
Temp_Mean	0.01	0.01	0.77
Sun_Mean	0.00	0.00	0.75
act_type_3	0.09	0.13	0.64
company_3	0.09	0.15	0.63
act_type_5	0.06	0.11	0.59
loc_type_4	0.10	0.17	0.58
company_4	0.10	0.16	0.58
loc_type_5	0.12	0.20	0.58
company_1	0.07	0.14	0.52
loc_type_6	0.07	0.16	0.42
loc_type_1	0.07	0.16	0.41
loc_smell	0.01	0.03	0.40
loc_fam	0.01	0.03	0.36
act_type_1	0.03	0.11	0.29
loc_clean	0.01	0.03	0.21
loc_type_9	0.01	0.19	0.08
loc_type_2	0.01	0.17	0.05
act_type_6	0.00	0.11	0.04
loc_type_3	0.00	0.20	0.00
act_type_4	0.00	0.12	-0.04
loc_type_8	-0.02	0.17	-0.12
comfortable	0.00	0.04	-0.13
loc_nat_el	-0.01	0.03	-0.21
loc_aes	-0.02	0.03	-0.57
loc_trafsaf	-0.02	0.03	-0.59

loc_socsaf	-0.03	0.04	-0.72
trans_type_1	-0.05	0.06	-0.78
loc_atms	-0.04	0.05	-0.89
loc_maint	-0.04	0.03	-1.12
trans_type_3	-0.13	0.11	-1.20
trans_type_4	*-0.17*	*0.10*	*-1.69*
loc_acc	*-0.06*	*0.03*	*-1.92*
weekendday	*-0.10*	*0.05*	*-2.03*
trans_type_2	*-0.25*	*0.10*	*-2.37*
happy	*-0.17*	*0.05*	*-3.35*

Appendix O: Complete Results 'momentary – no mood model'

Total results 'momentary – mood' model. The cursive results are these accepted as significant at a level of 1.65.

	Estimate	Std. Error	t value
(Intercept)	1.13	0.35	3.27
company_2	*0.32*	*0.17*	*1.83*
loc_type_7	*0.39*	*0.23*	*1.73*
loc_noise	0.04	0.03	1.51
loc_type_1	0.28	0.19	1.46
company_4	0.26	0.20	1.35
company_5	0.31	0.24	1.32
loc_type_2	0.24	0.20	1.23
act_type_7	0.17	0.15	1.18
Temp_Mean	0.01	0.01	1.13
loc_type_4	0.20	0.20	1.02
act_type_2	0.18	0.19	0.97
loc_div_act	0.03	0.03	0.96
loc_type_3	0.22	0.23	0.93
loc_type_8	0.18	0.20	0.91
company_1	0.12	0.17	0.70
loc_type_6	0.13	0.19	0.68
loc_type_5	0.16	0.24	0.65
loc_smell	0.02	0.04	0.61
cloud_cover	0.01	0.02	0.59
company_3	0.08	0.18	0.43
act_type_1	0.05	0.13	0.41
loc_type_9	0.07	0.23	0.29
act_type_5	0.03	0.12	0.23
loc_nat_el	0.01	0.03	0.22
loc_aes	0.00	0.04	0.03
act_type_3	0.00	0.16	-0.02
act_type_4	-0.01	0.14	-0.05
trans_type_1	0.00	0.08	-0.06
loc_fam	0.00	0.03	-0.15
Sun_Mean	0.00	0.00	-0.28
loc_trafsaf	-0.02	0.04	-0.42
trans_type_3	-0.06	0.13	-0.43
loc_maint	-0.02	0.04	-0.45
act_type_6	-0.08	0.13	-0.62
loc_socsaf	-0.04	0.04	-0.93
loc_clean	-0.03	0.03	-1.00
trans_type_2	-0.17	0.12	-1.40

trans_type_4	*-0.22*	*0.12*	*-1.80*
loc_acc	*-0.08*	*0.04*	*-1.97*
weekendday	*-0.12*	*0.06*	*-2.04*
loc_atms	*-0.19*	*0.05*	*-3.76*