Temporal Dynamics of Momentary Mental Resilience, Loneliness and Self-Esteem in Adults from the General Population: An Experience Sampling Study

Henriette Unger (s2538938)

1st supervisor: Dr Thomas Vaessen

2nd supervisor: Dr Jannis T. Kraiss

Bachelor Thesis

Faculty of Behavioural, Management, and Social Sciences

University of Twente

June of 29, 2023

Abstract

Background. Mental resilience is essential to overcome challenges and maintain good mental health. Despite the previous research highlighting a strong association between mental resilience and feelings of loneliness, along with the identification of self-esteem as a potential mediator, the temporal dynamics of these concepts in individuals' daily life remain unclear. This study examines the momentary temporal effects of loneliness and mental resilience mediated by self-esteem using the Experience Sampling Method (ESM) to shed light on potential targets for interventions addressing individuals' capacity to cope with demands of daily life.

Methods. 90 adults participated in a seven-day-long ESM study. Participants responded to the ESM questionnaire, measuring momentary feelings of loneliness (MFL), momentary self-esteem (MS), and momentary mental resilience (MMR) ten times daily. The study investigated the temporal dynamics using linear mixed regression analyses, incorporating time lag effects. Mediator analyses were conducted to test the mediating role of self-esteem.

Results. As expected, a bidirectional temporal effect between low MFL and high MMR exists ($p < .001$). Further analysis confirmed MS as a bidirectional mediator of the reciprocal relationship between MFL and MMR ($p < .001$).

Discussion and Conclusion. The results suggest a bidirectional feedback loop between MFL, MS, and MMR, thus all factors strongly reinforce each other in both directions. It is recommended to explore further mechanisms to understand how these concepts interact to sustain the vicious circle, by also incorporating subjective stress ratings assessment to examine how individuals adapt to these specific stressors. Current findings express the benefit of interventions targeting MFL and MS protect one's mental resilience.

Keywords: momentary mental resilience, self-esteem, loneliness, mediator, ESM study

1. Introduction

In today's fast-paced world, adapting to challenges has become essential to prevent mental health problems such as anxiety and stress disorders (Fergusson et al., 2015; Godinić & Obrenovic, 2020). In this context, previous research identified mental resilience as a central role to restore and protect one's mental health (Alex et al., 2008; Davydov et al., 2010; Hu et al., 2015; Kleim & Westphal, 2011; Mayordomo et al., 2016). Mental resilience encompasses the capacity to adapt and resist threats to mental health by effectively recovering from the harmful effects of stress and adversity (Herrman et al., 2011; Goldmann & Galea, 2014; Kuranova et al., 2020). It can be considered both as a trait, representing a personality characteristic that enhances individual adaption (Blanke et al., 2023), and as a state, reflecting the dynamic process of adapting to specific life challenges (Myin-Germeys et al., 2018; Schultze-Lutter et al., 2016; Verhagen et al., 2017). When investigating mental resilience, previous studies have concentrated on specific groups with distinct characteristics, such as individuals exposed to traumatic life events (Blanke et al., 2023). Less research is conducted on measuring mental resilience from the general population in the context of daily stressors (Blanke et al., 2023; Seery & Quinton, 2016). However, it has been proposed that this intrapersonal resource is not only essential for recovering from major life events but also for effectively bouncing back from stressors encountered in everyday life (Blanke et al., 2023; Montpetit et al., 2010; Seery & Quinton, 2016). Moreover, past studies mainly focused on investigating trait resilience, while recent research stressed the importance of examining factors that influence *momentary mental resilience* (MMR) in daily life (Blanke et al., 2023; Montpetit et al., 2010). By exploring MMR and the various factors that influence it, it can be developed a comprehensive understanding of how this vital quality operates within human beings' complex and dynamic nature (e.g., Blanke et al., 2023; Helmreich et al., 2017). This understanding can guide the development of targeted programs that promote individuals' mental resilience, as it is not an unchangeable trait but can be influenced by preventive strategies and interventions (Helmreich et al., 2017; Hu et al., 2015).

In recent years, research has observed significant fluctuations in MMR due to the high dependency on situational context (Myin-Germeys et al., 2018; Verhagen et al., 2017). In this context, the Experience Sampling Methodology (ESM) approach is a useful tool for assessing individuals' experiences and psychological states multiple times throughout the day in one's natural environment (Myin-Germeys et al., 2018; Scollon et al., 2003; van Os et al., 2017). Using ESM designs enhances self-report accuracy and reduces memory biases due to real-

time measurements (Myin-Germeys & Kuppens, 2021; Scollon et al., 2003). Therefore, employing the ESM to investigate MMR offers valuable insights into the factors and conditions that impact an individual's capacity to manage daily life challenges effectively (Blanke et al., 2023; Montpetit et al., 2010; Seery & Quinton, 2016).

1.1 Temporal Effects of Momentary Mental Resilience and Momentary Loneliness

One potential factor that might influence MMR is the *momentary feeling of loneliness* (MFL). Feelings of loneliness refer to an individual's subjective experience of being socially isolated or disconnected from others (Liang et al., 2019). It typically results from a lack of satisfactory social relationships or deep emotional attachments (Wang et al., 2018). Furthermore, recent studies indicate that loneliness is heavily influenced by daily social interactions, leading to substantial fluctuations throughout daily life (Compernolle et al., 2021; Masi et al., 2011). Hence, similar to MMR, it highlights the importance of investigating feelings of loneliness from a state perspective.

Preliminary evidence suggests the presence of a temporal relationship between MFL and MMR. Individuals who feel lonely tend to use less positive coping styles to overcome adversity, such as actively seeking social support (Hawkley et al., 2003; Matthews et al., 2019; Zhang et al., 2021). The resulting increased stress level might lead to declines in one's mental resilience, thus, suggesting loneliness as potential risk factor for MMR (Labrague et al., 2021). Moreover, the evolutionary theory of loneliness proposed by Cacioppo and Cacioppo (2018) states that feelings of loneliness evolve as an adaptive mechanism that drives individuals to seek social connections. Therefore, in moments when feeling insecure, high MFL is expected to evolve, which is associated with declines in mental resilience (Davydov et al., 2010). Thus, considering previous literature, a bidirectional relationship between MMR and MFL is assumed.

Several past studies found an association between loneliness and mental resilience (Gerino et al., 2017; Jakobsen et al., 2020; Lee et al., 2020; Marchini et al., 2021; Meng et al., 2020). However, due to using cross-sectional survey designs with self-reported, retrospective measurements, they could not explore the temporal effects between MFL and MMR in the context of individuals' real-time daily life experiences. An ESM study enables the assessment of these moment-to-moment dynamics and facilitates a deeper examination of the potentially bidirectional temporal effects between MFL and MMR. This can be achieved by correlating MFL scores from one assessment with MMR scores in the subsequent measurement, as well as vice versa. Regarding the momentary interplay, a relevant ESM study conducted by Fried

et al. (2022) demonstrated that forced social isolation, a condition strongly associated with feelings of loneliness (Leigh-Hunt et al., 2017), predicted an increase in mental health problems. The increase in MFL is strongly correlated with reduced mental resilience, providing further evidence for the anticipated link between elevated MFL and subsequent declines in MMR (Davydov et al., 2010).

Conversely, the ESM study conducted by Weber & Hülür (2022) discovered a temporal effect of interpersonal conflict on subsequent MFL. As interpersonal conflicts lead to increased stress levels, resulting in diminished mental resilience (Kong et al., 2022; Zadok-Gurman et al., 2021), these findings suggest that decreases in MMR predict increases in subsequent MFL. However, despite these previous suggestions for a bidirectional relationship, no study to date has focused on investigating the potential bidirectional temporal dynamics of mental resilience and loneliness in real-time. Therefore, further investigation of whether MFL influences next-moment resilience, and vice versa, is needed.

1.2 Bidirectional Mediating Role of Momentary Self-Esteem on MFL and MMR

Next to the expected bidirectional relationship between MFL and MMR, momentary self-esteem is expected to play a reciprocal explanatory role. *Momentary self-esteem* (MS) refers to the subjective self-evaluation of one's value in a particular situation (Brito et al., 2022; Leary & Baumeister, 2000). Self-esteem was found to partially mediate the relationship between loneliness and well-being (Cicek, 2021), which is strongly associated with one’s mental resilience (Kleim & Westphal, 2011). Further, Çivitci and Çivitci (2009) proved that self-esteem mediate the relationship between loneliness and global life satisfaction, a concept strongly associated with high mental resilience (Lombardo et al., 2018; Samani et al., 2007). Conversely, they could not find a moderating effect, as self-esteem did not seem to buffer the effect of increased MFL on MMR. However, as these studies used cross-sectional survey designs, which measured the concepts from a trait perspective, it remains unclear in which direction MS might explain the relationship between MMR and MFL.

On one hand, there is a suggested temporal effect where experiencing intense feelings of loneliness can potentially trigger negative self-beliefs (Hawkley & Cacioppo, 2010. This, in turn, diminishes one's self-esteem, leading to lower mental resilience due to a reduced perception of efficacy in effectively coping with the daily life challenges (Hawkley & Cacioppo, 2010). Previous research consistently highlights strong associations between low feelings of loneliness and high self-esteem (Cacioppo et al., 2006; Kong & You, 2013) as well as high self-esteem and high mental resilience (Arslan, 2019; Dale et al., 2021; Liu et

al., 2021), as measured retrospectively. Concerning the temporal effect, the experimental study by Cacioppo et al. (2006) provides evidence suggesting that inducing feelings of loneliness harms an individual's subsequent self-esteem. Additionally, an ESM study by Huckins et al. (2020) revealed that lower momentary social support led to subsequent higher levels of anxiety, which is associated with reduced mental resilience (Färber & Rosendahl, 2018). Moreover, a longitudinal study by Lee et al. (2014) identified a bidirectional relationship between elevated MFL and perceived social support, which is strongly linked to increased loneliness (Wang et al., 2018). Overall, these findings support the hypothesis that self-esteem partially explains the temporal relationship between heightened MFL and subsequent lower MMR.

On the other hand, MS is expected to explain the other direction as well. Higher MMR might lead to a more positive self-view, which facilitates to build deeper relationships and reduces feelings of loneliness (Dekovic & Meeus, 1997). This assumption is supported as low mental resilience was found to harm self-esteem (Karairmak & Cetinakaya, 2011), while low self-esteem was found to be associated with high feelings of loneliness (Udachina et al., 2009; Vanhalst et al., 2013). Further, the results of the ESM study by Udachina et al. (2009) revealed that low MS predicted higher subsequent experiential avoidance, which leads to higher perceived loneliness due to social detachment (Shi et al., 2016). However, despite the compelling indications pointing towards self-esteem potentially functioning as a reciprocal mediator, further studies are necessary to clarify whether this is the case by investigating the temporal dynamics of MFL, MS, and MMR in daily life.

1.3 Purpose of the Research

Despite consistent evidence highlighting a strong association between high MMR and low MFL, research exploring the temporal dynamics of how MFL and MMR mutually influence each other in daily life is scarce. Consequently, this research paper investigates the sequential relationship between MFL in one moment and MMR in the next moment and vice versa. In addition, no prior study has examined MS as a bidirectional mediator between MFL and MMR. By addressing this research gap and examining the various factors that potentially influence MMR, valuable insights can be gained for designing future interventions to foster mental resilience. This, in turn, enables individuals to manage daily stressors, ultimately preventing mental health issues effectively. Therefore, this research paper aims to answer the following research questions and hypotheses:

Q1: To what extent is there a bidirectional temporal effect between momentary feelings of loneliness and momentary mental resilience?

- H1a: Moments with high feelings of loneliness are associated with subsequent lower momentary mental resilience.
- H1b: Moments with high mental resilience are associated with subsequent lower momentary feelings of loneliness.

Q2: To what extent does momentary self-esteem operate as a bidirectional mediator between momentary feelings of loneliness and momentary mental resilience?

- H2a: The temporal effect of low momentary feelings of loneliness and subsequent high momentary mental resilience is mediated by momentary self-esteem.
- H2b: The temporal effect of low momentary mental resilience on subsequent high momentary feelings of loneliness is mediated by momentary self-esteem.

2. Methods

2.1 Participants

Participants for this study were recruited through convenience sampling, primarily from the researchers' social environment, utilising social media appeals and direct contact with acquaintances. It was aimed to collect a minimum sample size of 95 participants, which aligns with the recommendations for seven-day ESM studies (Myin-Germeys & Kuppens, 2021). The inclusion criteria for participation possessed sufficient English reading skills, a mobile device with IOS or Android, and a minimum age of above 18. As a form of reimbursement, participants got the opportunity to receive a personalised overview of their reported mood, which was assessed by one of the co-researchers (see Appendix A). This study received approval from the University of Twente BMS Ethics Committee of Behavioural, Management, and Social Sciences (request number: 230631).

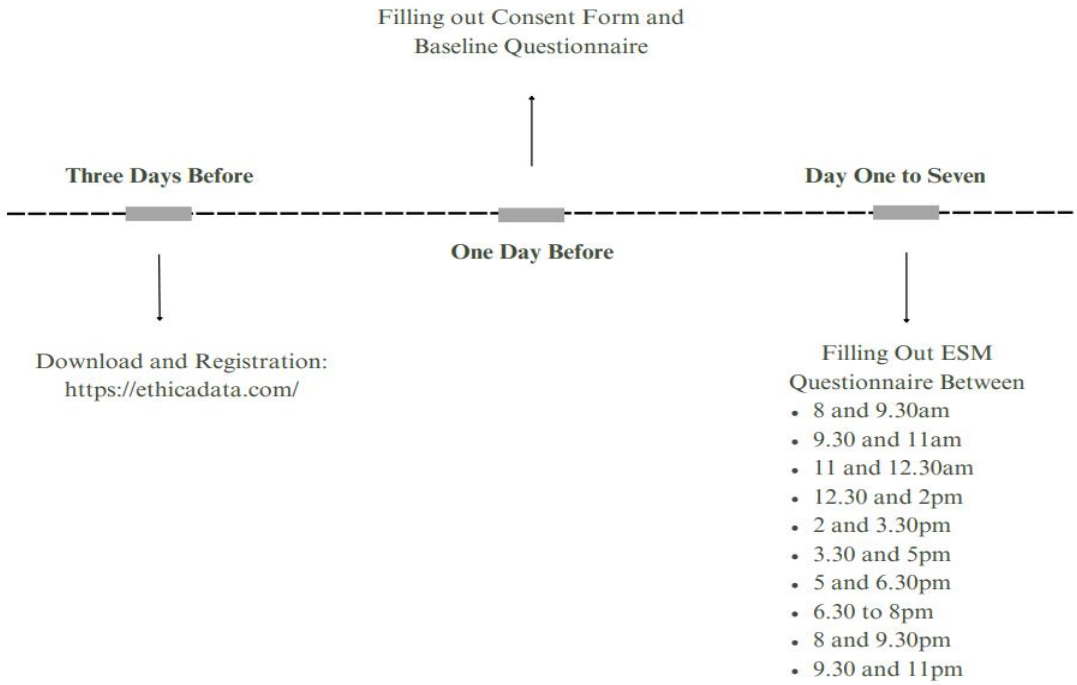
2.2 Procedure

The study followed a longitudinal research design using a signal-contingent ESM which was set up on the experience sampling platform Ethica, starting on April 23, 2023 (Ethica et al., 2022). The procedure of the ESM study is displayed in Figure 1. The ESM questionnaire was sent out ten times daily for seven days, following the recommended guidelines (van Berkel et al., 2017; Myin-Germeys & Kuppens, 2021). This resulted in an overall amount of 70 assessment time points for each person. The sending of the ESM questionnaires followed a semi-random schedule within fixed intervals of 1.5 hours from 8

am to 11 pm. If they did not fill out the questionnaire within 15 minutes, the questionnaire expired.

Figure 1

The Procedure of the ESM Study



2.3 Materials and Measurements

2.3.1 Baseline Questionnaire

Demographics. In the first part of the Baseline Questionnaire, the participants were asked about their gender, age, occupation, and academic degree to assess the sample characteristics.

Trait Resilience. The second part of the Baseline Questionnaire measured the participant's trait resilience using the Brief Resilience Scale (BRS) items rated on a Five-Point Likert scale ranging from "strongly disagree" to "strongly agree" (Evaluating Well-being, 2021). The scale was computed by calculating the items' mean after reversing items 2,4 and 6. This scale was used due to its briefness while still reporting good reliability (α = .71) and construct validity (Evaluating Well-being, 2021). The current study reported a Cronbach's alpha of .94, which was considered as very good (Tavakol et al., 2011).

2.3.2 Experience Sampling Methodology Questionnaire

All concepts were measured by rating the statements on a seven-point Likert Scale ranging from not at all (1) to very (7). Higher scores indicated more significant levels of MFL, MMR, and MS.

Momentary Loneliness. MFL was assessed by using the item “I feel lonely”, which was adapted from the ESM repository (*ESM Item Repository*, z.d.), derived from the ESM study by Bennik et al. (2015). The split-half reliability between the first and second half of the measures reported good internal consistency (r = .65), using the Spearman-Brown prophecy formula and accounting for the random effect variance among and within participants (Parsons, 2021).

Momentary Self-Esteem. MS was measured using the item "I feel good about myself", which was adapted from the ESM repository (*ESM Item Repository*, z.d.), derived from the ESM study by Bennik et al. (2015). The split-half reliability between the first and second half of the measures reported good internal consistency (r = .75).

Momentary Mental Resilience. MMR was measured by calculating the mean of the items “I feel like I can deal with whatever comes” and “I feel like I can handle unpleasant situations”. The items were adapted from the Connor-Davidson Resilience Scale (Connor et al., 2003). The two-item scale reported a Cronbach's alpha of .94, rated as excellent according to the recommendations of Tavakol & Dennick (2011). The split-half reliability between the first and second half of the measures reported good internal consistency (r = .67).

2.4 Data Analysis

2.4.1 Data Preparation

The data analysis was conducted with the statistical software programme RStudio (Version 1.3.1073 © 2009-2020). The R-Script of the data analysis can be found in Appendix F. After the data set was imported, it was cleaned by removing participants with a lower response rate than 30 per cent.

2.4.2 Descriptive Statistics and Psychometric Properties

The data was explored by looking at the demographics, scale descriptives, and average compliance rate. Pearson's Correlation Coefficients were calculated by performing a significance test between the variables based on the mean values grouped by participants. For three example participants (with low, medium, and high self-reported trait resilience), multi-line plots of the scores of MFL, MS, and MMR for each assessment time point were created to get an in-depth insight into the temporal fluctuations and interplay of the concepts (see Appendix B).

The convergent validity of the scale of MMR was assessed by looking at Pearson's Correlation Coefficient between the BRS and the MMR that accounted for the mean values

grouped by participants. A correlation coefficient greater than .70 was classified as recommended (Carlson et al., 2012).

The parametric assumptions of the linear mixed models (LMM) were examined to determine whether a parametric test could be used (see Appendix D; Appendix E; Appendix F; Appendix G; Appendix H). The Variance Inflation Factors (VIF) for the predictor variables MS and MFL on MMR as well as MMR and MS on MFL, were calculated to check for multicollinearity. A maximum VIF of ten was rated as recommended to ensure the stability of the model (O'Brien, 2007).

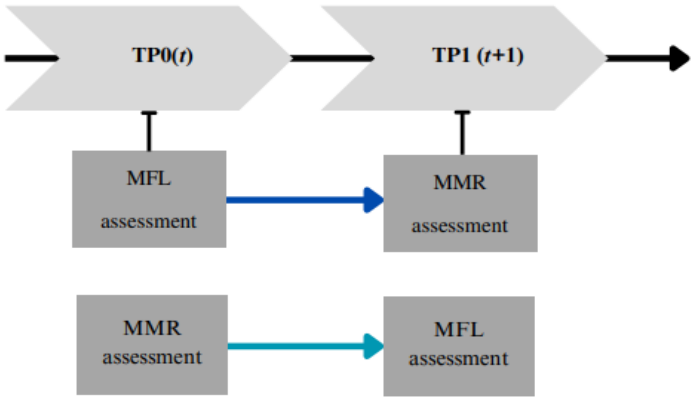
2.4.3 Testing Hypotheses

This study assessed repeated between and within measurements. LMMs with participants as random effects were used to account for the nested structure of the data and person-level differences (Kraiss et al., 2022; Viechtbauer, 2021). The intraclass correlation coefficients (ICC), the marginal R^2 and the conditional R^2 of the LMMs were calculated (Nakagawa & Schielzeth, 2013). The conditional R^2 quantified the proportion of variance in the PV explained by the fixed and random effects when other variables in the model were held constant, while the marginal R^2 represented the proportion of variance explained by the fixed effects alone, excluding the random effects. An alpha level of .05 was used for all statistical tests.

The first (H1a) and second hypothesis (H1b), which addressed the association between MFL with subsequent MMR, and vice versa, were tested by creating a time lag between the predictor variable (PV) and response variable (RV). This means that the association between the score of one concept with the score of the respective other concepts, assessed in the subsequent ESM questionnaire, was analysed (see Figure 2). For testing H1a, MFL at time point (TP) 0 (t) was used as the PV and MMR with a time lag of one TP ($t + 1$) as RV. For testing H1b, MMR at TP 0 (t) was used as PV and MFL with a time lag of one TP ($t + 1$) as RV.

Figure 2

Chart for Time Lags used for Testing Temporal Effects between Momentary Mental Resilience (MMR) and Momentary Feelings of Loneliness (MFL)

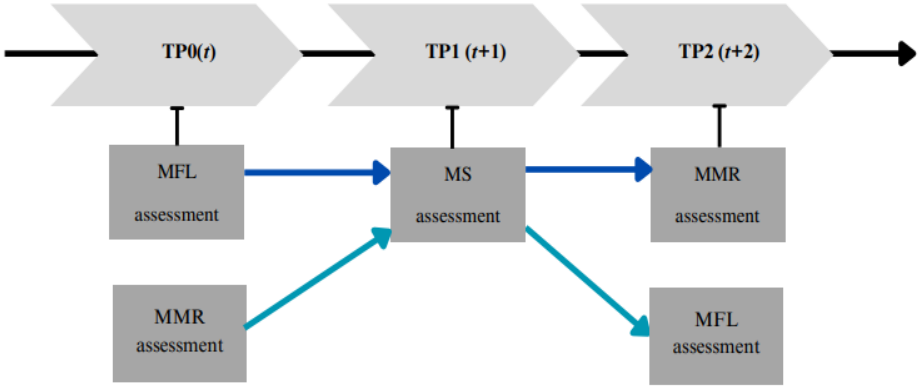


Note. TP = Time Point. The dark blue line displays the time lags used for testing the temporal effect of MFL (*t*) on subsequent MMR (*t*+1), and the light blue line displays the time lags used for testing the temporal effect of MMR (*t*) on subsequent MFL (*t*+1).

Mediation analyses for H2a, whether MS explains the association between high MFL and subsequent low MMR, and vice versa (H2b). For testing the temporal dynamics of H2a, MFL at TP 0 (*t*) was used as PV, MS with a time lag of one TP (*t* + 1) as mediator variable, and MMR with a time lag of two TPs (*t* + 2) as RV (see Figure 3). For assessing the temporal dynamics of H2b, MMR at TP 0 (*t*) was used as PV, MS with a time lag of one TP (*t* + 1) as mediator variable, and MFL with a time lag of two TPs (*t* + 2) as RV (see Figure 3). The mediator analysis was conducted following the Baron and Kenny method (1986). First, a LMM of the PV (*t*) and RV (*t* + 2) was created for modelling the total effect for both hypotheses. Second, a LMM for modelling the effect of the PV (*t*) on the MV (*t* +1) was generated. Third, it was created a multivariate LMM to examine the relationship between MS (*t*+1) and MMR (*t*+2) while controlling for MFL (*t*). Multiplying the regression coefficients of the LMMs of steps 1 and 2 showed the indirect effect. Due to no severe violation of distributional properties, the Sobel test was used to evaluate the significance of the indirect effect of the PV on the RV through the mediator variable (*Interactive Mediation Tests*, n.; Preacher & Hayes, 2004). It compared the estimated indirect effect to a standard normal distribution to determine if it differed substantially from zero, thereby indicating a significant mediation effect.

Figure 3

Chart for Time Lags used for Testing Momentary Self-Esteem (MS) as a Mediator for the Temporal Effects between Momentary Mental Resilience (MMR) and Momentary Feelings of Loneliness (MFL)



Note. TP = Time Point. The dark blue line represents the time lag analysis of MFL (*t*) on MMR (*t*+2) mediated by MS (*t*+1). The light blue line represents the time lag analysis of MMR (*t*) on MFL (*t*+2) mediated by MS (*t*+1).

3. Results

3.1 Descriptive Statistics

Out of the 103 individuals who initially participated in the study, 13 were excluded due to falling below the required response rate (see Table 1). The participants reported a mean age of 30 (*SD* = 13.59) and a compliance rate of 64.29 %. The remaining dataset included 1540 observations. The Descriptives of and Pearson Correlations between trait resilience, MMR, MS, and MFL are displayed in Table 2.

Table 1

Characteristics of Participants (N = 90)

	Amount	Percentage (%)
Gender		
Male	38	42.22
Female	51	56.67
Non-binary	1	1.11
Age		
18-24	44	48.89
25-34	22	24.44
35-44	5	5.56
45-54	5	5.56
55-64	6	6.67
65+	8	8.89
Nationality		
German	46	51.11
Dutch	29	32.22
Other	15	16.67
Occupation		
Student	31	34.44
Working	26	28.89
Studying and Working	23	25.56
Not Working	5	5.55
Self-employed	4	4.44
Other	1	1.11
Degree		
High School	46	51.11
Middle School	16	17.78
Bachelor	15	16.67
Master	7	7.78
Other	6	6.67

Note. This table demonstrates the descriptive statistics of the convenience sample of adults from the general population.

Table 2

Descriptives of and Pearson Correlations between Trait Resilience, Momentary Mental Resilience, and Momentary Loneliness Scores in a Sample of Adults from the General Population (N = 90)

Scales	Mean	SD	Range	1	2	3	4
1.Trait Resilience	3.19	0.80	1-5	--	.68*** [.30, .70]	-.49*** [-.52, -.45]	.51*** [.47,.54]
2.Momentary Mental Resilience	5	1.44	1-7		--	-.66*** [-.70, -.64]	.84*** [.83, .86]
3.Momentary Loneliness	2.52	1.53	1-7			--	-.72*** [-.74, -.70]
4.Momentary Self-Esteem	5	1.43	1-7				--

Note. Non-standardised values on a five-point Likert scale for trait resilience and on a seven-point Likert scale for momentary mental resilience, loneliness, and self-esteem. Numbers between brackets represent 95% confidence intervals. ***$p < .001$.

3.2 Convergent Validity

The convergent validity between trait resilience and MMR was close to the recommended guidelines of .70 (r = .68, 95% CI [.30, .70]). Thus, it provides supportive evidence that the two-item MMR scale was appropriate for effectively measuring the intended concept of MMR.

3.3 Assumption Check

Based on the assumption checks, no severe violations of the assumptions were found, and it was decided for non-parametric tests (see Appendix D; Appendix E; Appendix F; Appendix G; Appendix H). The mild heteroscedasticity was compensated by the relatively large sample size and the robustness of t-tests to mild violations of homoscedasticity (Krzywinski et al., 2013; Wilcox, 2011). The VIFs suggested low multicollinearity (VIF for MS and MS on MMR = 1.75, for MMR and MS on MFL = 1.37).

3.4 Testing Hypotheses

3.4.1 Linear Mixed Regression Analyses

3.4.1.1 *Hypothesis 1A*

In line with H1a, higher scores in MFL (*t*) were significantly associated with subsequent lower scores in MMR (*t* +1) (*b* = -.115, *t*(1537) = -5.04, *p* < .001, CI [-.16, -.07]). The ICC was .496, which showed that a moderate proportion of the total variance in MMR (*t* +1) could be attributed to the clustering variable of participants. The LMM explained 49.6 % of the variance of MMR scores (*t* +1) with a marginal R^2 of .017 and a conditional R^2 of .505 (see Figure 4a).

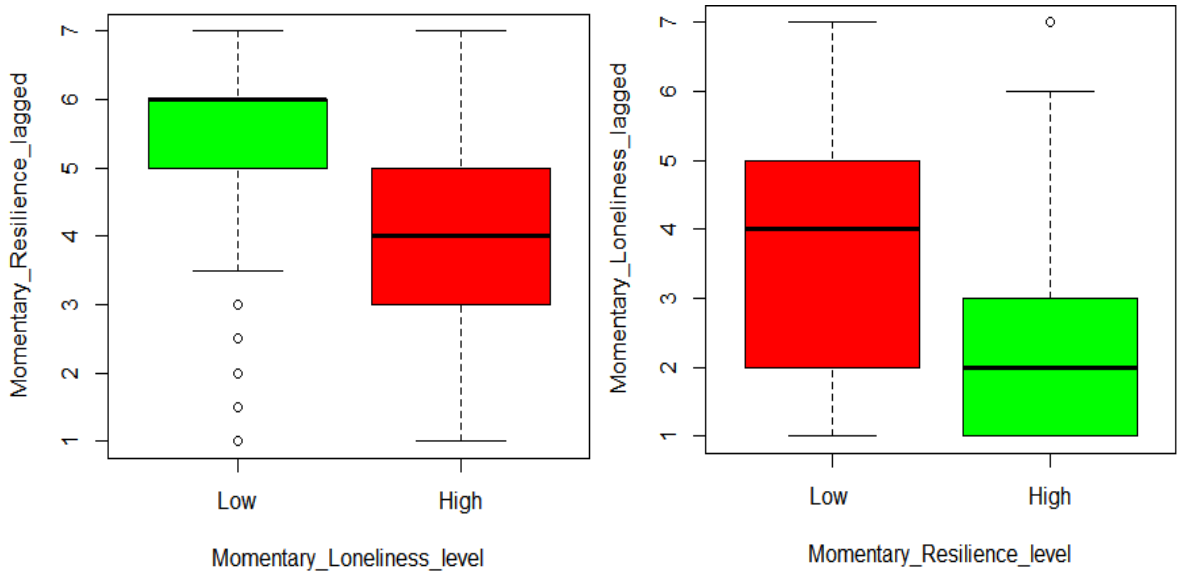
3.4.1.2 Hypothesis 1b

In line with H1b, higher scores in MMR (*t*) were significantly associated with subsequent lower scores in MFL (*t* +1) (*b* = -.131, *t*(1479) = -4.29, *p* < .001, CI [-.19, -.07]). The ICC value of .428 indicated that a moderate portion of the total variance in MFL (*t* +1) could be attributed to the clustering variable of participants. The LMM explained 42,8 % of the variance of MFL scores (*t* +1) with a marginal R^2 of .016 and a conditional R^2 of .437 (see Figure 4b).

Figure 4

Time Series of Momentary Loneliness and Momentary Mental Resilience

Figure 4a ***Figure 4b***



Note. The data was split into two halves based on the median value. Any values equal to or less than the median of 3.5 were assigned to the groups of low MFL and MMR levels, and any values greater than 3.5 were assigned to high MFL and MMR levels. Figure 1a represents the association between MFL in the first moment (*t*) and MMR in the following assessment (*t* +1). Figure 1b shows the association between MMR in the first moment (*t*) and MFL in the subsequent assessment (*t* + 1).

3.4.2 Mediator Analyses

3.4.2.1 Hypothesis 2a and 2b

The multiple regressions for the mediation analyses were significant (see Table 3). The indirect effect for H2a was (-.389) *(.424) = -.165 and for H2b (.583) *(-.316) = -.184. The Sobel test hold significant results for H2a (t (1539) = -14.33, SE = .01, p < .001) and for H2b (t(1539) = -9.91, SE = .02, p < .001). Thus, the temporal effect of MFL (t) on MMR (t +2) and MMR (t) on MFL (t+2) was significantly mediated by MS (t +1) (see Figure 5).

Table 3

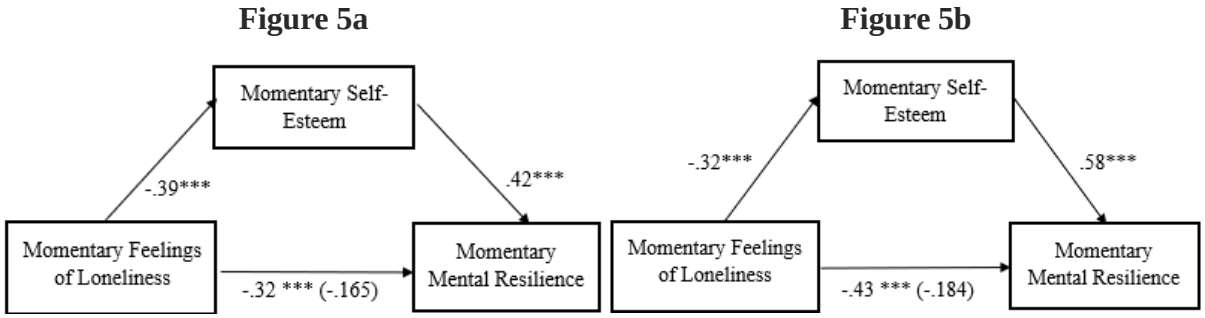
Testing Mediator Effects of MS on MFL and MMR Using Multiple Regression

Testing Steps in mediation models	*b*	*t*	*SE*	*95% CI*
H2a: Mediation of MS (t+1) on MFL (t) and MMR (t+2)				
Step 1 MFL (t) → MMR (t+2)	-.323***	-15.65	.02	-.36, -.28
Step 2 MFL (t) → MS (t+1)	-.389***	-17.81	.02	-.43, -.35
Step 3 MFL (t) → MS (t+1) → MMR (t+2)	.424***	19.71	.02	.38, .47
H2b: Mediation of MS (t+1) on MMR (t) and MFL (t+2)				
Step 1 MMR (t) → MFL (t+2)	-.427***	-15.78	.03	-.48, -.37
Step 2 MMR (t) → MS (t+1)	.583***	25.45	.02	.54, .63
Step 3 MMR (t) → MS (t+1) → MFL (t+2)	-.316***	-11.03	.03	-.37, -.26

Note. b = Standardised Regression Coefficient. *CI* = Confidence Interval. t = t- statistic. *SE* = Standard Error. MFL = Momentary Feelings of Loneliness. MMR = Momentary Mental Resilience. MS = Momentary Self-Esteem. p < .001***.

Figure 5

Mediator Effects of Self-Esteem on Loneliness and Mental Resilience in the Moment



Note. Figure 5a illustrates the mediation effect of MS (*t*+1), which partially explained the temporal effects of MFL (*t*) on MMR (*t* + 2). Figure 5b displays the mediation effect of MS (*t*+1), which partially explained the temporal effect of MMR (*t*) on MFL (*t* +2). The standardised regression coefficients for each path are displayed. $p < .001$***.

4. Discussion and Conclusion

This research paper investigated the temporal dynamics between MFL and MMR and the mediating role of MS within an individual's daily life using the ESM approach. As expected, there was a strong significant reciprocal temporal effect between MFL in one moment and MMR in the next moment, and vice versa. Moreover, MS was identified as a bidirectional mediator for the temporal effect of MFL and MMR, highlighting the existence of a bidirectional feedback loop among these concepts.

4.1.1 Temporal Dynamics of Momentary Loneliness and Momentary Mental Resilience

As hypothesised, a reinforcing nature between MFL and MMR was identified, which creates a downward spiral, where high MFL led to subsequent low MMR, which predicts higher MFL again. These findings align with previous correlational studies (Gerino et al., 2017; Jakobsen et al., 2020; Marchini et al., 2021) that detected strong associations between trait loneliness and mental resilience using retrospective measurements. This ESM study showed that these concepts were also strongly correlated in real-time from a state perspective. Similar results were likely found as latent traits are commonly associated with latent states (Steyer et al., 1999). The consistent nature of these associations indicates that loneliness does not only play a vital role in protecting an individual's mental resilience in a trait-perspective but also when viewing feelings of loneliness as temporary states.

This study contributes further by not only identifying an association between MFL and MMR but also revealing a reciprocal temporal effect between these concepts. These findings align with the ESM study by Fried et al. (2022), which observed that enforced social

isolation due to COVID-19 restrictions led to subsequent declines in MMR. The reduced social interactions are suggested to result in heightened MFL, thus explaining the convergence of the findings. Similarly, during periods of social withdrawal, individuals often experience a lack of deep interpersonal relationships and perceived social support (Jia & Yue, 2023). However, research by Hawkley et al. (2003) and Zhang et al. (2021) highlight the importance of utilising one's social support system as an active coping strategy in managing stressful life events. Exploring the role of social support in context of how MFL contributes to declines in MMR holds potential value for future research.

In addition, the discovery of the temporal effect of high MMR on subsequent declines in MFL supports the idea of the evolutionary theory of loneliness by Cacioppo & Cacioppo (2018). This theory proposed that MFL evolved during threatening times as an adaptive function to stimulate individuals to search for social contacts. Here, seeking social support serves as a mechanism to attain assistance, providing an evolutionary advantage in conquering daunting challenges, which eventually helps to regain one's mental resilience (Cacioppo & Cacioppo, 2018). Thus, while this theory was initially developed in the context of significant adverse events, this research could extend its generalizability by revealing applicability in daily life stressors.

4.1.2 Bidirectional Mediating Role of Momentary Self-Esteem

Moreover, MS elucidates the reinforcing nature of the reciprocal relationship between MFL and MMR. The experience of high MFL is associated with a decrease in MS, leading to subsequent declines in MMR and contributing to further increases in MFL. Conversely, possessing high MMR leads to heightened MS, reducing MFL and eventually decreasing MMR. These findings suggest that self-esteem is a decisive factor that needs to be considered to break the bidirectional vicious circle. Boosting one's self-esteem in the present moment can be instrumental in reducing MFL and simultaneously improving MMR. Addressing the underlying cause of loneliness is crucial while simultaneously prioritising the promotion of self-esteem during periods of loneliness, as it serves as a protective mechanism against the negative impact of MFL on MMR.

The identification of these bidirectional mediating roles is consistent with the findings of previous studies conducted by Çivitci and Çivitci (2009) and Cicek et al. (2021) that identified self-esteem as a mediator in the relationship between loneliness and the outcome variables of life satisfaction, and overall well-being, both closely intertwined with good mental resilience (Kleim & Westphal, 2011; Samani et al., 2007). Due to capturing

momentary fluctuations of the concepts in one's natural environment, this study extends these findings by showing that the mediator effect temporally operates bidirectionally and also exists in the present moment in the context of minor daily life stressors.

These findings confirm that loneliness negatively impacts self-esteem in daily life, aligning with previous studies (Cacioppo et al., 2018; Kong & You, 2013). While prior research by Cacioppo et al. (2018) demonstrated the relationship between elevated MFL and decreased MS, this study extends those findings by observing them in individuals' natural daily settings. Additionally, Cacioppo et al. (2018) explored the fear of negative evaluation concerning negative self-beliefs. Combining these results suggests that MFL may contribute to a negative self-view and fear of judgment. Future research should investigate the role of self-evaluation to understand the interplay between MFL and MS in more depth.

The ESM study by Bentall et al. (2011) aligns with the current findings, indicating that decreased self-esteem is associated with dysfunctional coping styles like rumination. Similarly, Hawkley and Cacioppo (2010) suggest that individuals with decreased self-esteem perceive daily events as overwhelming threats, undermining their belief in coping effectively. Although the focus of the ESM study by Bentall et al. (2011) was to investigate self-esteem in relation to different coping styles, there may be similar findings to these results as MS appears to have a strong influence on the individual's coping style. As coping style predicts one's MMR. Exploring proactive coping strategies, such as utilising social networks to navigate stressors, could further elucidate the underlying mechanisms of the feedback loop.

Considering the other direction of the feedback loop, these findings align with Karairmak & Cetinkaya (2011), who observed a link between low MMR and declines in self-esteem in earthquake survivors. Hence, this study showed that the association between MFL and MMR holds not only significant life events that place considerable demands on mental resilience but also in the general population facing minor stressors. Moreover, these findings fit the outcome of the longitudinal study by Lee et al. (2014) and the ESM study by Udachina et al. (2009), who suggest that low self-esteem predicts lower perceived social support and experiential avoidance. This is likely due to negative self-evaluation leading to decreased self-esteem and reduced opportunities for seeking social support during stress. In support of that, the study's measurement of MS focused on self-liking, indicating that negative self-perception due to low MS may explain increased social detachment and subsequent heightened MFL.

4.2 Strengths and Limitations of the Research

This study used the advantages of the ESM study design, which enhanced ecological validity due to natural settings, minimised recall biases due to real-time data and allowed investigation of the temporal dynamics of the concepts (Myin-Germeys & Kuppens, 2021). While previous studies have already recognised self-esteem as a mediator, this study makes a novel contribution by revealing a bidirectional feedback loop among the concepts of MS, MFL, and MMR in daily life. Due to the high sampling frequency of ten times daily, the study provided a detailed insight into these concepts' momentary and temporary fluctuations (Myin-Germeys & Kuppens, 2021). Moreover, while most studies used interval-contingent sampling, only a few used the signal-contingent sampling method (Yearick, 2017). This method offers a distinct advantage due to the unpredictable timing of participants' anticipated queries, effectively preventing cognitive preparation that may lead to behavioural modifications (Christensen et al., 2003).

However, this research had several limitations. Firstly, the extensive length of the 20 - items questionnaire may have increased the perceived burden, lowered compliance, and resulted in careless responses (Eisele et al., 2022). Secondly, the sample primarily consisted of German and Dutch adults aged 19 to 34 that were recruited via convenience sampling, limiting the findings' generalisability to the broader population. Future research should use a more representative sample of the general population by applying the probability sampling method. Additionally, participation in the study was limited to individuals who were able to fill out the questionnaires shortly after receiving notifications, potentially excluding those without access or with limited attention to smart devices, such as during working hours. Furthermore, the items used in the ESM study were not extensively tested in past studies; thus, it is still being determined whether they measure the concepts as intended and to what extent these results are comparable with other studies using different conceptualisations. As MMR is also defined as the ability to bounce back from adversity (Davydov et al., 2010), it is valuable to additionally assess the subjective stress ratings and examine how individuals adapt to these specific stressors by measuring their stress recovery. A mixed-method approach, including diary studies, should be considered to understand the individual's subjective experience of daily life stressors and the contextual factors that affect these temporal dynamics of the feedback loop. Further, MFL was measured using a single item that assessed only the dimension of self-liking. It is suggested to include additional items

measuring self-competence to address the multidimensional nature of the concept, thereby enhancing construct validity (Abdel-Khalek, 2016; Tafarodie & Swann, 2001).

4.4 Practical Implications

These findings suggest that interventions should focus on promoting self-esteem to enhance MMR and reduce MFL**.** Cognitive Behavioural Therapy-based strategies have proven to be effective in enhancing self-esteem by establishing positive self-beliefs to increase mental resilience (Helmreich et al., 2017). Fostering social interactions, improving social skills, and engaging in positive self-talk were found to alter self-perception while at the same time targeting the reduction of one's feelings of loneliness (Kolubinski et al., 2018; Masi et al., 2011). Interventions should provide practical everyday strategies that can be implemented when an imbalance in these concepts is noticed. Tailored action plans for how one should behave when feeling currently lonely, less worthy, or less resistant towards daily stressors were effective in counteracting in the present moment (Hagger & Luszczynska, 2014). Moreover, these findings show the importance of promoting self-esteem, particularly in individuals who experience higher feelings of loneliness. Thus, targeting groups at higher risk of suffering from loneliness is crucial, such as alone-living individuals, ethnic minorities (Lasgard et al., 2016), and seniors (Poscia et al., 2018).

4.5 Conclusion

Mental resilience is an important protective factor for overcoming daily challenges and maintaining good mental health. This research paper was the first to identify a bidirectional feedback loop between MFL, MS, and MMR by investigating the temporal dynamics of these concepts in daily life. Future research should identify further factors contributing to the sustainment of the feedback loop, such as dysfunctional coping styles, i.e., not seeking social support and negative self-beliefs. This more comprehensive understanding of the reinforcing nature would enable exploring strategies to leverage this feedback loop to one's advantage, ultimately facilitating the development of interventions that effectively harness its dynamics. These findings suggest that future interventions should target feelings of loneliness and self-esteem by promoting, for example, social skills and interactions, positive self-talk and developing concrete action plans for everyday life.

5. References

Abdel-Khalek, A. M. (2016). Introduction to the psychology of self-esteem. *Self-esteem: perspectives, influences, and improvement strategies*, 1-23. ISBN: 978-1-53610-294-9

Akhtar, M., & Bilour, N. (2020). State of mental health among transgender individuals in Pakistan: Psychological resilience and self-esteem. *Community mental health journal*, *56*, 626-634. https://doi.org/10.1007/s10597-019-00522-5

Alex J. Zautra, John S. Hall, Kate E. Murray & the Resilience Solutions Group1 (2008) Resilience: a new integrative approach to health and mental health research, Health Psychology Review, 2:1, 41-64, DOI: 10.1080/17437190802298568

Arslan, G. (2019). The mediating role of the self–esteem and resilience in the association between social exclusion and life satisfaction among adolescents. *Personality and Individual Differences*, *151*, 109514. https://doi.org/10.1016/j.paid.2019.109514

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic and statistical considerations. *Journal of Personality and Social Psychology, 51*, 1173–1182.

Bennik, E.C., Bastiaansen, J.A., Ormel, J., & Oldehinkel, A.J. (2015). Every dark cloud has a coloured lining: The relation between positive and negative affect and reactivity to positive and negative events. University of Groningen.

Bentall, R. P., Myin-Germeys, I., Smith, A., Knowles, R., Jones, S. H., Smith, T., & Tai, S. J. (2011). Hypomanic personality, stability of self-esteem and response styles to negative mood. *Clinical Psychology & Psychotherapy*, *18*(5), 397-410.https://doi.org/10.1002/cpp.780

Blanke, E. S., Schmiedek, F., Siebert, S., Richter, D., & Brose, A. (2023). Perspectives on resilience: trait resilience, correlates of resilience in daily life, and longer-term change in affective distress. *Stress and Health*, *39*(1), 59-73. https://doi.org/10.1002/smi.3164

Brito, T. R. de S., Pereira, C. R., Santos, F. Á. dos, & Nery, N. N. de F. (2022). Measuring the General and Specific Domains of Self-Esteem: The Short-form of the State Self-Esteem Scale. *Psychological Reports*, *0*(0). https://doi.org/10.1177/00332941221077909

Cacioppo, J. T., & Cacioppo, S. (2018). Loneliness in the modern age: An evolutionary theory of loneliness (ETL). In *Advances in experimental social psychology* (Vol. 58, pp. 127-197). Academic press. https://doi.org/10.1016/bs.aesp.2018.03.003

Cacioppo, J. T., Hawkley, L. C., Ernst, J. M., Burleson, M., Berntson, G. G., Nouriani, B., & Spiegel, D. (2006). Loneliness within a nomological net: An evolutionary perspective. *Journal of research in personality*, *40*(6), 1054-1085. https://doi.org/10.1016/j.jrp.2005.11.00

Carlson, K. D., & Herdman, A. O. (2012). Understanding the impact of convergent validity on research results. Organizational Research Methods, 15(1), 17–32. https://doi.org/10.1177/1094428110392383

Çiçek, I. (2021). Mediating Role of Self-Esteem in the Association between Loneliness and Psychological and Subjective Well-Being in University Students. *International Journal of Contemporary Educational Research*, *8*(2), 83-97. DOI:10.33200/ijcer.817660

Çivitci, N., & Çivitci, A. (2009). Self-esteem as mediator and moderator of the relationship between loneliness and life satisfaction in adolescents. *Personality and Individual Differences*, *47*(8), 954-958. DOI:10.1016/j.paid.2009.07.022

Compernolle, E. L., Finch, L. E., Hawkley, L. C., & Cagney, K. A. (2021). Momentary loneliness among older adults: contextual differences and their moderation by gender and race/ethnicity. *Social Science & Medicine*, *285*, 114307. https://doi.org/10.1016/j.socscimed.2021.114307

Connor, K.M. and Davidson, J.R.T. (2003), Development of a new resilience scale: The Connor-Davidson Resilience Scale (CD-RISC). Depress. Anxiety, 18: 76-82. https://doi.org/10.1002/da.10113

Dale, S. K., Reid, R., & Safren, S. A. (2021). Factors associated with resilience among Black women living with HIV and histories of trauma. *Journal of health psychology*, *26*(5), 758-766.

Davydov, D. M., Stewart, R., Ritchie, K., & Chaudieu, I. (2010). Resilience and mental health. *Clinical psychology review*, *30*(5), 479-495. https://doi.org/10.1016/j.cpr.2010.03.003

ESM Item Repository. (z.d.). ESM Item Repository. https://esmitemrepositoryinfo.com/

Ethica Data Services Inc. (2022). Ethica. (Version 560). Apple Store. https://apps.apple.com/ca/app/ethica/id1137173052

Evaluating wellbeing. (2021, March 15). *The Brief Resilience Scale - Evaluating wellbeing*. https://measure.whatworkswellbeing.org/measures-bank/brief-resilience-scale/

Fergusson, D., McLeod, G., Horwood, L., Swain, N., Chapple, S., & Poulton, R. (2015). Life satisfaction and mental health problems (18 to 35 years). *Psychological Medicine, 45*(11), 2427-2436. doi:10.1017/S0033291715000422

Gerino, E., Rollè, L., Sechi, C., & Brustia, P. (2017). Loneliness, resilience, mental health, and quality of life in old age: A structural equation model. *Frontiers in psychology, 8*, 2003. https://doi.org/10.3389/fpsyg.2017.02003

Godinić, D., & Obrenovic, B. (2020). Effects of economic uncertainty on mental health in the COVID-19 pandemic context: social identity disturbance, job uncertainty and psychological well-being model.

Goldmann, E., & Galea, S. (2014). Mental health consequences of disasters. *Annual review of public health*, *35*, 169-183. https://doi.org/10.1146/annurev-publhealth-032013-182435

Hagger, M. S., & Luszczynska, A. (2014). Implementation intention and action planning interventions in health contexts: State of the research and proposals for the way forward. *Applied Psychology: Health and Well-Being*, *6*(1), 1-47. https://doi-org.ezproxy2.utwente.nl/10.1111/aphw.12017

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

Hawkley, L. C., Burleson, M. H., Berntson, G. G., & Cacioppo, J. T. (2003). Loneliness in everyday life: Cardiovascular activity, psychosocial context, and health behaviors. *Journal of Personality and Social Psychology*, *85*(1), 105–120. https://doi.org/10.1037/0022-3514.85.1.105

Helmreich, I., Kunzler, A., Chmitorz, A., König, J., Binder, H., Wessa, M., & Lieb, K. (2017). Psychological interventions for resilience enhancement in adults. *The Cochrane Database of Systematic Reviews*, *2017*(2), CD012527. https://doi.org/10.1002/14651858.CD012527

Herrman, H., Stewart, D. E., Diaz-Granados, N., Berger, E. L., Jackson, B., & Yuen, T. (2011). What is resilience?. *The Canadian Journal of Psychiatry*, *56*(5), 258-265.

Hu, T., Zhang, D., & Wang, J. (2015). A meta-analysis of the trait resilience and mental health. *Personality and Individual differences*, *76*, 18-27. https://doi.org/10.1016/j.paid.2014.11.039

Huckins, J. F., DaSilva, A. W., Hedlund, E. L., Murphy, E. I., Rogers, C., Wang, W. & Campbell, A. T. (2020). Causal factors of anxiety and depression in college students: longitudinal ecological momentary assessment and causal analysis using Peter and Clark momentary conditional independence. *JMIR mental health*, *7*(6), e16684. doi: 10.2196/16684

Interactive Mediation Tests. (n.d.). http://www.quantpsy.org/sobel/sobel.htm

Jakobsen, I.S., Madsen, L.M.R., Mau, M. *et al.* The relationship between resilience and loneliness elucidated by a Danish version of the resilience scale for adults. *BMC Psychol* **8**, 131 (2020). https://doi.org/10.1186/s40359-020-00493-3

Jia, Y., & Yue, Y. (2023). Perceived social support mediates loneliness and social isolation: A cross-sectional study of Chinese older adults relocated for poverty relief. *International Journal of Geriatric Psychiatry*, *38*(5), e5940. https://doi.org/10.1002/gps.5940

Karairmak, Ö., & Cetinakaya, R. S. (2011). The effect of self-esteem and locus of control on resilience: The mediating role of affects. *Turkish Psychological Counseling and Guidance Journal*, *4*(35), 30-41.

Kleim, B., & Westphal, M. (2011). Mental Health in First Responders: A Review and Recommendation for Prevention and Intervention Strategies. *Traumatology*, *17*(4), 17–24. https://doi.org/10.1177/1534765611429079

Kolubinski, D. C., Frings, D., Nikčević, A. V., Lawrence, J. A., & Spada, M. M. (2018). A systematic review and meta-analysis of CBT interventions based on the Fennell model of low self-esteem. *Psychiatry research*, *267*, 296-305. https://doi.org/10.1016/j.psychres.2018.06.025

Kong, X., Cui, L., Li, J. *et al.* (2020). The Effect of Friendship Conflict on Depression, Anxiety and Stress in Chinese Adolescents: The Protective Role of Self-Compassion. *J Child Fam Stud* **31**, 3209–3220 (2022). https://doi.org/10.1007/s10826-022-02413-y. https://doi.org/10.1007/s10826-022-02413-y

Kong, F., & You, X. (2013). Loneliness and self-esteem as mediators between social support and life satisfaction in late adolescence. *Social Indicators Research*, *110*, 271-279. https://doi.org/10.1007/s11205-011-9930-6

Kraiss, J.T., Kohlhoff, M. & ten Klooster, P.M. Disentangling between- and within-person associations of psychological distress and mental well-being: An experience sampling

study examining the dual continua model of mental health among university students. *Curr Psychol* (2022). https://doi.org/10.1007/s12144-022-02942-1

Krzywinski, M., Altman, N. Power and sample size. *Nat Methods* **10**, 1139–1140 (2013). https://doi.org/10.1038/nmeth.2738

Kuranova, A., Booij, S. H., Menne-Lothmann, C., Decoster, J., van Winkel, R., Delespaul, P., ... & Wichers, M. (2020). Measuring resilience prospectively as the speed of affect recovery in daily life: a complex systems perspective on mental health. *BMC medicine*, *18*(1), 1-11. https://doi.org/10.1186/s12916-020-1500-9

Labrague, L. J., De los Santos, J. A. A., & Falguera, C. (2021). Social and emotional loneliness among college students during the COVID-19 pandemic: the predictive role of coping behaviours, social support, and personal resilience. https://doi.org/10.21203/rs.3.rs-93878/v2

Leary, M. R., & Baumeister, R. F. (2000). The nature and function of self-esteem: Sociometer theory. In *Advances in experimental social psychology* (Vol. 32, pp. 1-62). Academic Press. https://doi.org/10.1016/S0065-2601(00)80003-9

Lee, J., Hong, J., Zhou, Y. *et al.* The Relationships Between Loneliness, Social Support, and Resilience Among Latinx Immigrants in the United States. *Clin Soc Work J* **48**, 99–109 (2020). https://doi.org/10.1007/s10615-019-00728-w

Lee, C., Dickson, D. A., Conley, C. S., & Holmbeck, G. N. (2014). A closer look at self-esteem, perceived social support, and coping strategy: A prospective study of depressive symptomatology across the transition to college. *Journal of Social and Clinical Psychology*, *33*(6), 560-585. https://doi.org/10.1521/jscp.2014.33.6.560

Leigh-Hunt, N., Bagguley, D., Bash, K., Turner, V., Turnbull, S., Valtorta, N., & Caan, W. (2017). An overview of systematic reviews on the public health consequences of social isolation and loneliness. *Public health*, *152*, 157-171. https://doi.org/10.1016/j.puhe.2017.07.035

Liang, D., Teng, M., & Xu, D. (2019). Impact of perceived social support on depression in Chinese rural-to-urban migrants: The mediating effects of loneliness and resilience. *Journal of community psychology*, *47*(7), 1603-1613. https://doi.org/10.1002/jcop.22215

Liu, Q., Jiang, M., Li, S., & Yang, Y. (2021). Social support, resilience, and self-esteem protect against common mental health problems in early adolescence: A nonrecursive

analysis from a two-year longitudinal study. *Medicine*, *100*(4), e24334. https://doi.org/10.1097/MD.0000000000024334

Lombardo, P., Jones, W., Wang, L., Shen, X., & Goldner, E. M. (2018). The fundamental association between mental health and life satisfaction: results from successive waves of a Canadian national survey. *BMC public health*, *18*(1), 1-9. https://doi.org/10.1186/s12889-018-5235-x

Marchini, S., Zaurino, E., Bouziotis, J., Brondino, N., Delvenne, V., & Delhaye, M. (2021). Study of resilience and loneliness in youth (18–25 years old) during the COVID-19 pandemic lockdown measures. *Journal of community psychology*, *49*(2), 468-480. https://doi.org/10.1002/jcop.22473

Masi, C. M., Chen, H.-Y., Hawkley, L. C., & Cacioppo, J. T. (2011). A Meta-Analysis of Interventions to Reduce Loneliness. *Personality and Social Psychology Review*, *15*(3), 219–266. https://doi-org.nl/10.1177/1088868310377394

Matthews, T., Danese, A., Caspi, A., Fisher, H., Goldman-Mellor, S., Kepa, A.Arseneault, L. (2019). Lonely young adults in modern Britain: Findings from an epidemiological cohort study. *Psychological Medicine, 49*(2), 268-277. doi:10.1017/S0033291718000788

Mayordomo, T., Viguer, P., Sales, A., Satorres, E., & Meléndez, J. C. (2016). Resilience and coping as predictors of well-being in adults. *The Journal of psychology*, *150*(7), 809-821.https://doi-org.nl/10.1080/00223980.2016.1203276

Meng, J., Wang, X., Wei, D., & Qiu, J. (2020). State loneliness is associated with emotional hypervigilance in daily life: a network analysis. *Personality and Individual Differences*, *165*, 110154. https://doi.org/10.1016/j.paid.2020.110154

Montpetit, M. A., Bergeman, C. S., Deboeck, P. R., Tiberio, S. S., & Boker, S. M. (2010). Resilience-as-process: Negative affect, stress, and coupled dynamical systems. *Psychology and Aging*, *25*(3), 631–640. https://doi.org/10.1037/a0019268

Myin-Germeys, I., & Kuppens, P. (2021). *The Open Handbook of Experience Sampling Methodology: A Step-by-step Guide to Designing, Conducting, and Analyzing ESM Studies*.

Myin-Germeys, I., Kasanova, Z., Vaessen, T., Vachon, H., Kirtley, O., Viechtbauer, W., & Reininghaus, U. (2018). Experience sampling methodology in mental health research: new insights and technical developments. *World Psychiatry*, *17*(2), 123-132 https://doi.org/10.1002/wps.20513

Nakagawa, S., & Schielzeth, H. (2013). A general and simple method for obtaining R2 from generalized linear mixed-effects models. *Methods in ecology and evolution*, *4*(2), 133-142. https://doi.org/10.1111/j.2041-210x.2012.00261.x

O'brien, R.M. A Caution Regarding Rules of Thumb for Variance Inflation Factors. *Qual Quant* **41**, 673–690 (2007). https://doi.org/10.1007/s11135-006-9018-6

of medical education, 2, 53. doi: 10.5116/ijme.4dfb.8dfd

Parsons, S. (2021). Splithalf: Robust estimates of split half reliability. *Journal of Open Source Software*, *6*(60), 3041. DOI: 10.21105/joss.03041

Piekarska, J. (2020). Determinants of perceived stress in adolescence: the role of personality traits, emotional abilities, trait emotional intelligence, self-efficacy, and self-esteem. *Advances in Cognitive Psychology*, *16*(4), 309. doi: 10.5709/acp-0305-z

Poscia, A., Stojanovic, J., La Milia, D. I., Duplaga, M., Grysztar, M., Moscato, U., et al. (2018). Interventions targeting loneliness and social isolation among the older people: An update systematic review. *Experimental Gerontology,102,* 133–144.

Samani, S., Jokar, B., & Sahragard, N. (2007). Effects of resilience on mental health and life satisfaction. *Iranian Journal of psychiatry and clinical psychology*, *13*(3), 290-295. http://ijpcp.iums.ac.ir/article-1-275-en.html

Schultze-Lutter F, Schimmelmann BG, Schmidt SJ. Resilience, risk, mental health and well-being: associations and conceptual differences. *Eur Child Adolesc Psychiatry*. (2016) 25:459–66. doi: 10.1007/s00787-016-0851-4

Scollon, C. N., Kim-Prieto, C., & Diener, E. (2003). Experience sampling: Promises and pitfalls, strengths and weaknesses. *Journal of Happiness studies*, *4*(1), 5-34. https://doi.org/10.1023/A:1023605205115

Seery, M. D., & Quinton, W. J. (2016). Understanding resilience: From negative life events to everyday stressors. In *Advances in experimental social psychology* (Vol. 54, pp. 181-245). Academic Press. https://doi.org/10.1016/bs.aesp.2016.02.002

Steyer, R., Schmitt, M., & Michael, E. (1999). Latent state-trait theory and research in personality and individual differences. European Journal of Personality, 13(5), 389–408. https://doi.org/10.1002/(sici)1099-0984(199909/10)13:53.0.co;2-a

Shi, R., Zhang, S., Zhang, Q., Fu, S., & Wang, Z. (2016). Experiential avoidance mediates the association between emotion regulation abilities and loneliness. *PLoS One*, *11*(12), e0168536. https://doi.org/10.1371/journal.pone.0168536

Tafarodi, R. W., & Swann Jr, W. B. (2001). Two-dimensional self-esteem: Theory and measurement. *Personality and individual Differences*, *31*(5), 653-673. https://doi.org/10.1016/S0191-8869(00)00169-0

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. International journal

Udachina, A., Thewissen, V., Myin-Germeys, I., Fitzpatrick, S., O'kane, A., & Bentall, R. P. (2009). Understanding the relationships between self-esteem, experiential avoidance, and paranoia: structural equation modelling and experience sampling studies. *The Journal of Nervous and Mental Disease*, *197*(9), 661-668. *DOI:* 10.1097/NMD.0b013e3181b3b2ef

van Os, J., Verhagen, S., Marsman, A., Peeters, F., Bak, M., Marcelis, M., ... & Delespaul, P. (2017). The experience sampling method as an mHealth tool to support self-monitoring, self-insight, and personalized health care in clinical practice. *Depression and anxiety*, *34*(6), 481-493. https://doi.org/10.1002/da.22647

Vanhalst, J., Luyckx, K., Scholte, R.H.J. *et al. (2013).* Low Self-Esteem as a Risk Factor for Loneliness in Adolescence: Perceived - but not Actual - Social Acceptance as an Underlying Mechanism. *J Abnorm Child Psychol* **41**, 1067–1081. https://doi.org/10.1007/s10802-013-9751-y

Verhagen, S. J., Berben, J. A., Leue, C., Marsman, A., Delespaul, P. A., van Os, J., & Lousberg, R. (2017). Demonstrating the reliability of transdiagnostic mHealth Routine Outcome Monitoring in mental health services using experience sampling technology. *PloS one*, *12*(10), e0186294. https://doi.org/10.1371/journal.pone.0186294

Viechtbauer, W. (2021). Structuring, checking, and preparing the data. In I. Myin-Germeys, & P. Kuppens (Eds.), *The Open Handbook of Experience Sampling Methodology: A step-by-step guide to designing, conducting, and analyzing ESM studies* (1 ed., pp. 137-152). Center for Research on Experience Sampling and Ambulatory Methods Leuven.

Wang, J., Mann, F., Lloyd-Evans, B., Ma, R., & Johnson, S. (2018). Associations between loneliness and perceived social support and outcomes of mental health problems: a systematic review. *BMC psychiatry*, *18*(1), 1-16. https://doi.org/10.1186/s12888-018-1736-5

Weber, E., & Hülür, G. (2022). The Role of Relationship Conflict for Momentary Loneliness and Affect in the Daily Lives of Older Couples. *Journal of Social and Personal*

Relationships, 02654075221138022.Wilcox, R. R. (2011). *Introduction to robust estimation and hypothesis testing*. Academic press. https://doi.org/10.1177/02654075221138022

Yearick, K. A. (2017). Experience sampling methods (ESM) in organizations: a review.

Zadok-Gurman, T., Jakobovich, R., Dvash, E., Zafrani, K., Rolnik, B., Ganz, A. B., & Lev-Ari, S. (2021). Effect of inquiry-based stress reduction (IBSR) intervention on well-being, resilience and burnout of teachers during the COVID-19 pandemic. *International Journal of Environmental Research and Public Health*, *18*(7), 3689. https://doi.org/10.3390/ijerph18073689

Zhang, Y., Huang, L., Luo, Y., & Ai, H. (2021). The relationship between state loneliness and depression among youths during COVID-19 lockdown: Coping style as mediator. *Frontiers in Psychology*, 3350. https://doi.org/10.3389/fpsyg.2021.701514

Appendix A

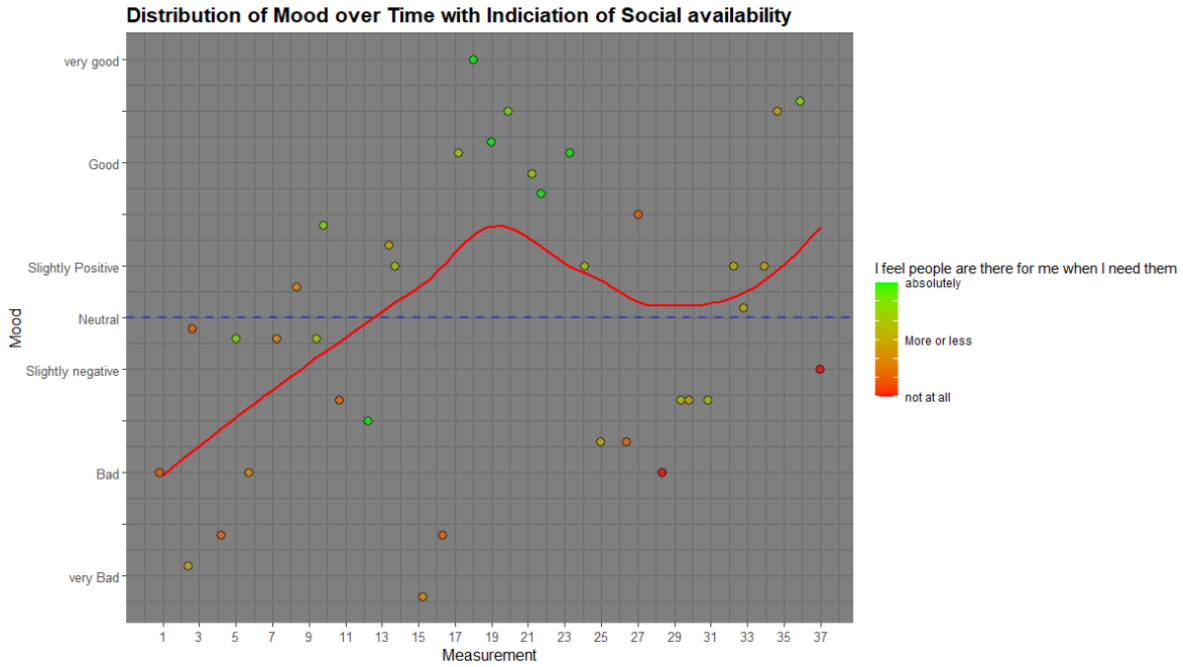
Example of a Personal Report

Personalized Overview: Mental Resilience Study

23.04.23 – 29.04.23

You filled out the regular questionnaire: 37 times

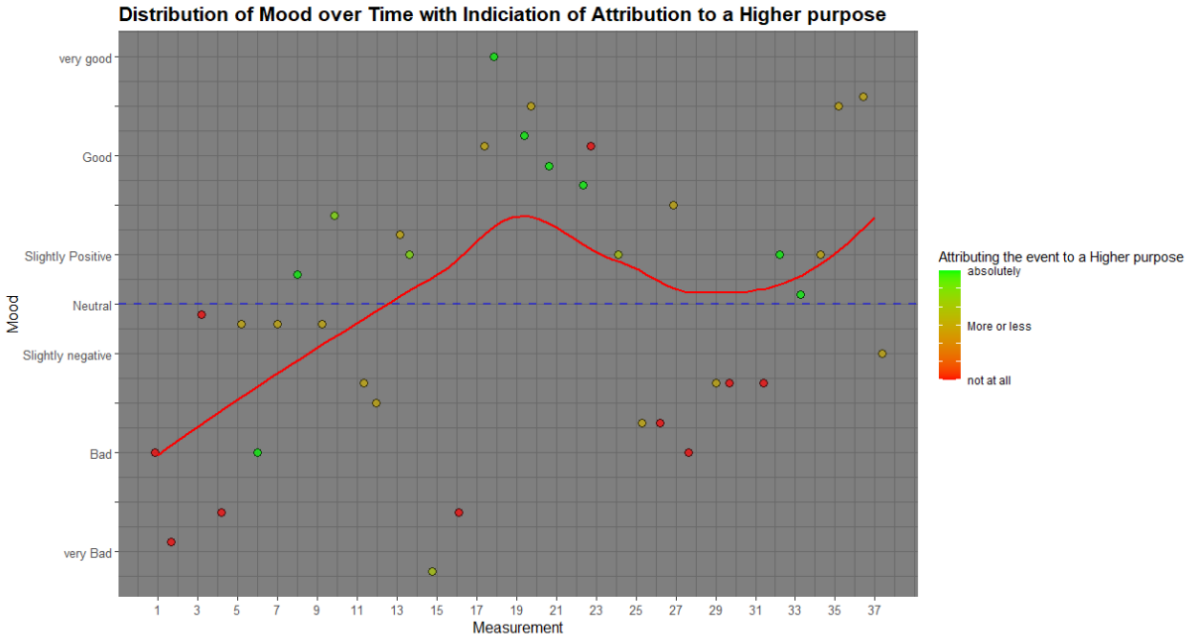
1. The following graph shows how your **mood** was over the course of the whole study (indicated by how high or low the point is displayed in the graph). The **red** line shows how your mood was on average during the course of the study. The colour of the measurement-point shows you how much you thought that people are there for you if you would need them in this moment.



Interpretation: You tend to think that people are more available to you (to speak with them for example) when your mood is high. The higher your mood, the more you think that others have

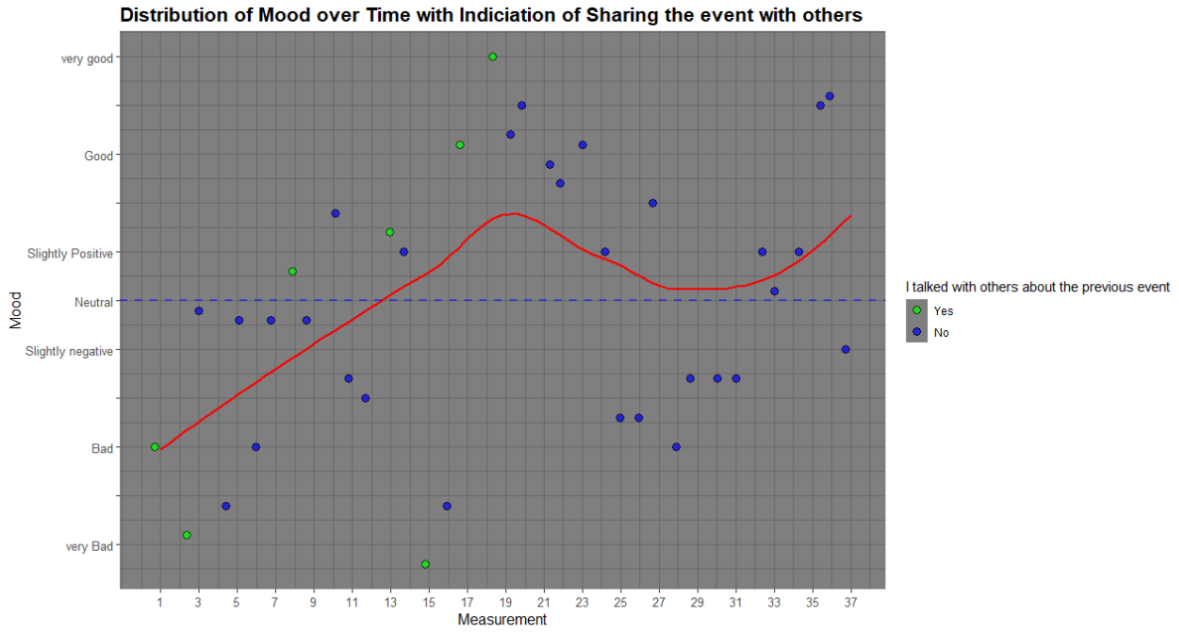
time for you. When believing the report of this study, Your mood therefore strongly influences you how much you think others would be there for you.

2. The following graph shows (again) how your **mood** was over the course of the whole study (indicated by how high or low the point is displayed in the graph). The **red** line shows how your mood was on average during the course of the study. The colour of the measurement-point shows you how much attributed the past event you experienced to having a *higher purpose*.



Interpretation: The better your mood, the more you attribute events to having a higher purpose. If your mood is low, you tend to rather not attribute the event to a higher purpose.

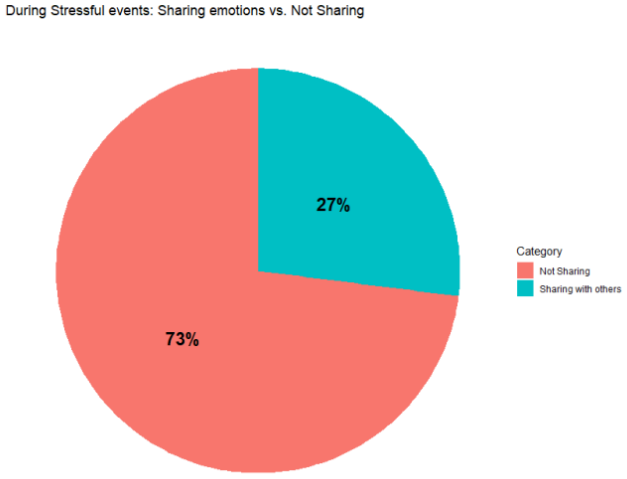
3. The following graph shows (again) how your **mood** was over the course of the whole study (indicated by how high or low the point is displayed in the graph). The **red** line shows how your mood was on average during the course of the study. The colour of the measurement-point shows you whether you talked with others about the previous event or not.



Interpretation: In both extremes (the absolute minimum and maximum mood) you tend to share your event and feelings with others. Besides that, you share your experience of the last event rather randomly, independent of the mood. There is no indication for a tendency here. Lastly, you only shared experiences of a previous event in the first half of the experiment. The second half is not shared.

---

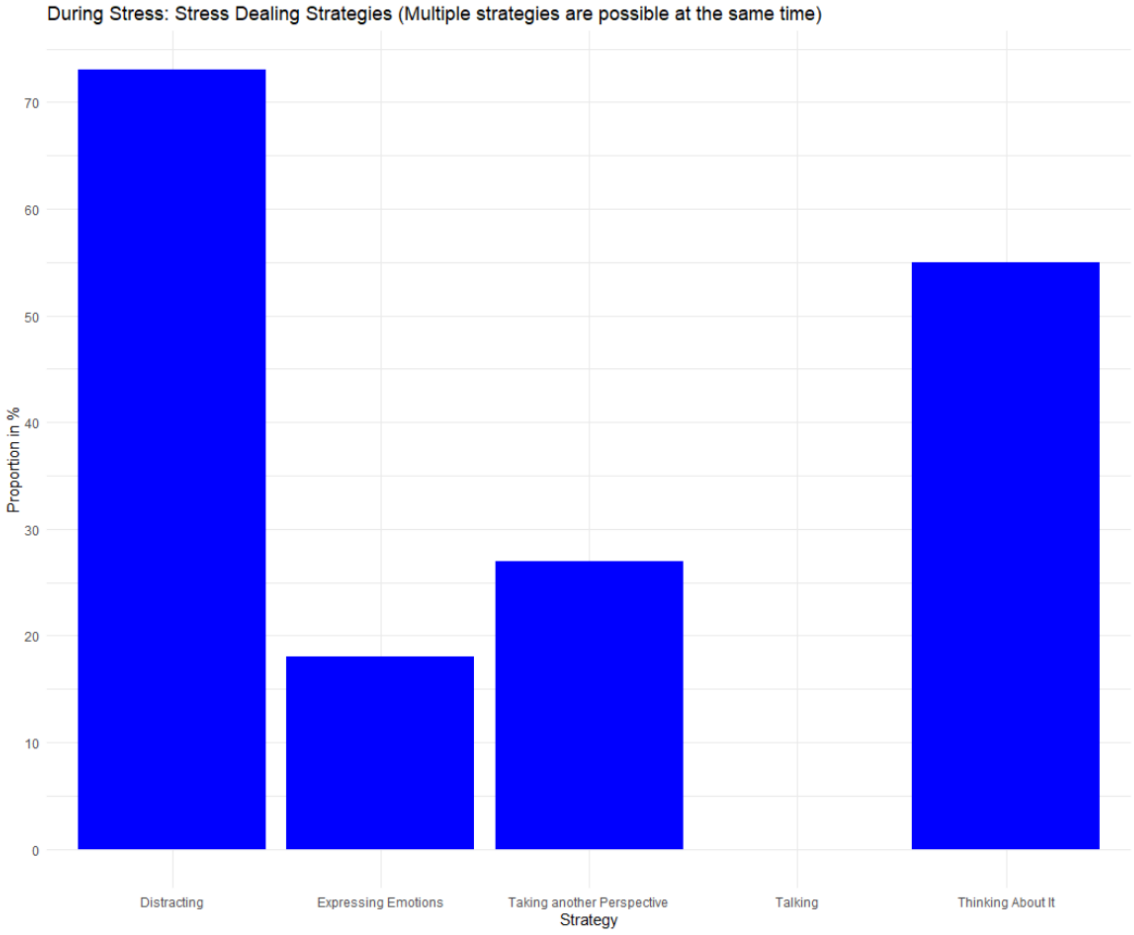
4. The following graph shows how often you **shared your emotions** with others after a *Stressful event*. Note that we look here only at events which you rated as stressful, not at those you found pleasant.



Interpretation: -

---

5. The following graph shows **how you dealt with stressful events**. Note again, that we do only look at stressful events, not at pleasant ones. The higher the stripe, the more often you used this strategy. On the left, it is shown to you how much in % you used the strategy. In total, you rated **11** of the 37 events as *stressful*.



Interpretation: More than 2/3 of the time you distracted yourself from stressful events. Directly after that (little more than 50% of the time) you thought about the event. You indicated that you did not talk with others to deal with stressful events, but rather try to solve them on your own.

One could (tentatively) conclude, this could maybe correlate with your tendency to perceive others as unavailable to you when you are in a bad mood?

_____

Thank you a lot for your participation in the study. You gave valuable input for academic research into resilience and how people deal with small stressful events during their live. You contributed with 37 of possible 70 measurement points over the week. This is a big contribution!!!

Your input increased knowledge about mental health psychology and well-being in general.

If you have any questions about the personalized overview or the study in general, feel free to contact me via m.mertens@student.utwente.nl

Thank you very much!

Appendix B

Informed Consent

Dear participant,

Thank you for agreeing to be part of this research project conducted by students of the University of Twente. This project aims at investigating momentary resilience in relation to other factors by gaining insight into your normal, day-to-day life. To get a thorough insight, it is of great importance that you fill out as many of the questionnaires as possible for our research.

Participation in this research requires active involvement for a duration of one week. You will receive 10 notifications at random moments throughout the day via this Ethic App. It is required that you complete the questionnaires as soon as possible following the notification, but at least within a timeframe of 15 minutes after receiving the notification.

Keep in mind that there are no right or wrong answers since the research solely relies on your feelings and experiences. Therefore, we kindly ask you to honestly answer all questions to get accurate information for further conclusions.

After submitting the questionnaire and finalising the measurements via the application, your responses will be pseudonymized, meaning that any information that could be used to directly identify a person will be replaced with a pseudonym. Also, all information will be handled with confidentiality. This ensures that the data cannot be traced back to you as a participant. Furthermore, when agreeing to participate in this study, you agree to contribute your responses to this research.

We would like to warn you that a few questions could be sensitive and could possibly evoke negative feelings. For this reason, a link to a website where help will be offered is placed at the bottom of this page if needed. Additionally, you have the right to withdraw from the research at any time without giving any reason for your withdrawal.

The study was approved by the BMS Ethics Committee.

If you have any questions after participating, please feel free to contact one of the researchers:
j.libosan@student.utwente.nl
v.barbaros@student.utwente.nl
l.sorgenfrei@student.utwente.nl
m.mertens@student.utwente.nl
h.unger@student.utwente.nl
k.potter@student.utwente.nl
s.eltohamiahmed@student.utwente.nl

If you want to file a complaint, please contact the BMS Ethics Committee:
ethicscommittee-bms@utwente.nl
Link to websites:
https://findahelpline.com/nl
https://www.betterhelp.com

Consent Form

Demographic Information Participant

Age:
Gender: □ Male
□ Female
□ Other
Nationality: □ Dutch
□ German
□ Other: _____

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read the study information dated 24/04/2023, or it has been read to me. I gained understanding of the information provided. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	□	□
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	□	□
Risks associated with participating in the study		
I understand that taking part in the study might result in mild discomfort related to filling out questionnaires.	□	□
Use of the information in the study		
I understand that information I provide will be used for a quantitative research report focusing on mental resilience in the general public.	□	□
I understand that all shared information will be stored pseudonymized, and will not be shared beyond the research team.	□	□
I agree that my pseudonymized information can be used in research outputs.	□	□
Future use and reuse of the information by others I give permission for the information that I provide to be archived in a Microsoft Word file so it can be used for future research and learning.	□	□
I agree that my information may be shared with other researchers working on the same study for future research studies that may be similar to this study or may be completely different. The information shared with other researchers will not include any information that can directly identify me. Researchers will not contact me for additional permission to use this information.	□	□
Signatures		

Name of participant	Signature	Date

For participants unable to sign their name, mark the box instead of sign

Study contact details for further information:

Contact Information for Questions about Your Rights as a Research Participant

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by ethicscommittee-bms@utwente.nl

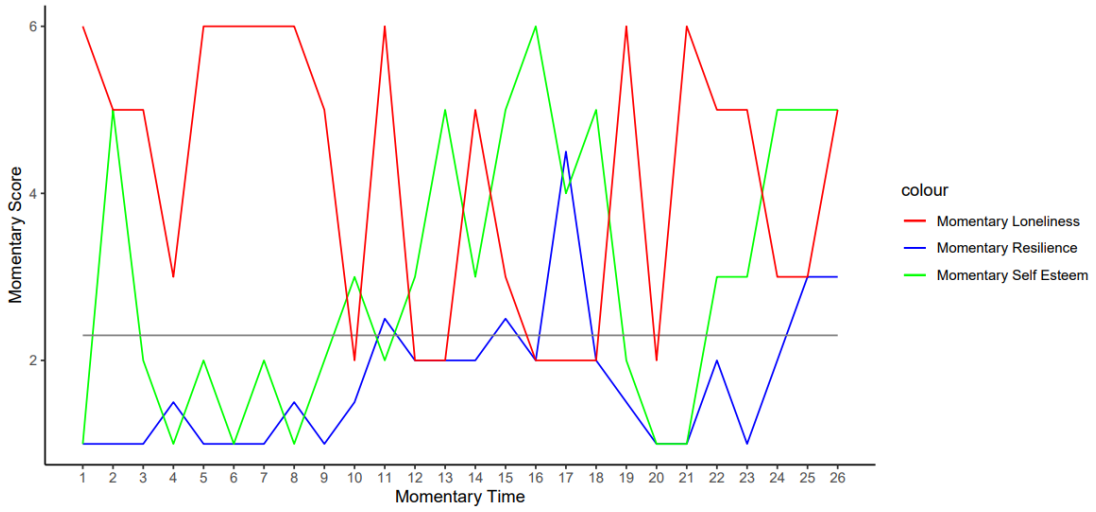
Appendix C

Data Visualization of Example Participants

Figure 4 displays the momentary interplay of loneliness, mental resilience, and self-esteem across the time of the ESM study for Participant 71002. This participant displayed low levels of trait resilience (*M*= 2.34). In general, it can be noticed that the participant reported high levels of loneliness and lower levels of self-esteem and MMR in comparison to the other participants that are displayed in Figure 5 and Figure 6. The multi-plot shows that at time points when low scores of MMR were reported, high scores in loneliness (such as e.g., timepoint 4), as well as high scores in self-esteem (e.g., timepoint 16) were indicated. Further, what can be noticed is that in comparison to MMR and loneliness, there were less consistent associations between MMR and self-esteem when looking at the same time point (e.g., timepoint 4 and 8). However, what can be noticed is that an increase in MMR timely followed an increase in self-esteem (e.g., time points 2 to 3, 16 to 17). This suggested that there was a time-order effect where momentary self-esteem positively predicts subsequent MMR.

Figure 4

Multi-Line Plot for Scores of Momentary Loneliness, Resilience, and Self-Esteem for each Assessment Time Point for Participant 71002

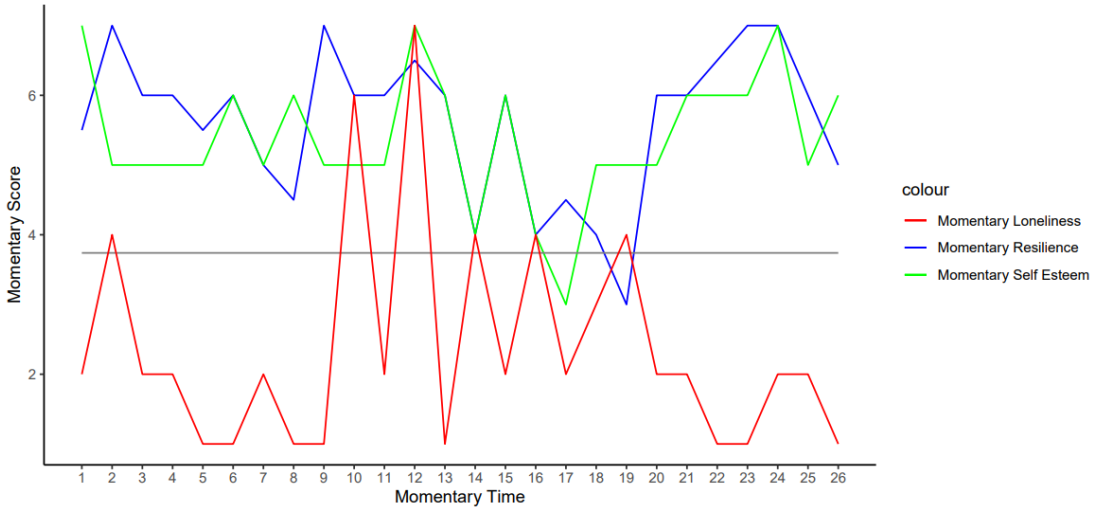


Note. The grey line displays the mean of trait resilience of participant 71002 (*M*= 2.34).

Figure 5 displays the momentary interplay of loneliness, mental resilience, and self-esteem across time for Participant 70978. This participant indicated medium levels of trait resilience (*M*= 3.7). In general, it can be noticed that the participant reported low levels of loneliness and high levels of self-esteem and MMR in comparison to Participant 71002 (figure 4). As for participant 71002, in general, the multi-plot shows that at timepoints when high scores of MMR were reported, low scores of loneliness were indicated (e.g. timepoint 0 to 9, 20 to 25). However, this negative association was not consistently found to be time-related when looking at the scores at the same time points. When looking at time point 10 and 12 for example, high levels of loneliness and high levels of MMR were reported. Moreover, in contrast to Participant 72002, it could not be found a time-order effect in which higher levels of momentary self-esteem would predict higher MMR at a later timepoint. However, what can be noticed is that in general, the scores of self-esteem were higher at times when scores of MMR were also higher. Moreover, lower scores of self-esteem were timely associated with higher scores of loneliness (e.g. time point 2 and 14). Thus, both concepts seem to be strongly timely correlated with each other.

Figure 5

Multi-Line Plot for Scores of Momentary Loneliness, Resilience, and Self-Esteem for each Assessment Time Point for Participant 70978

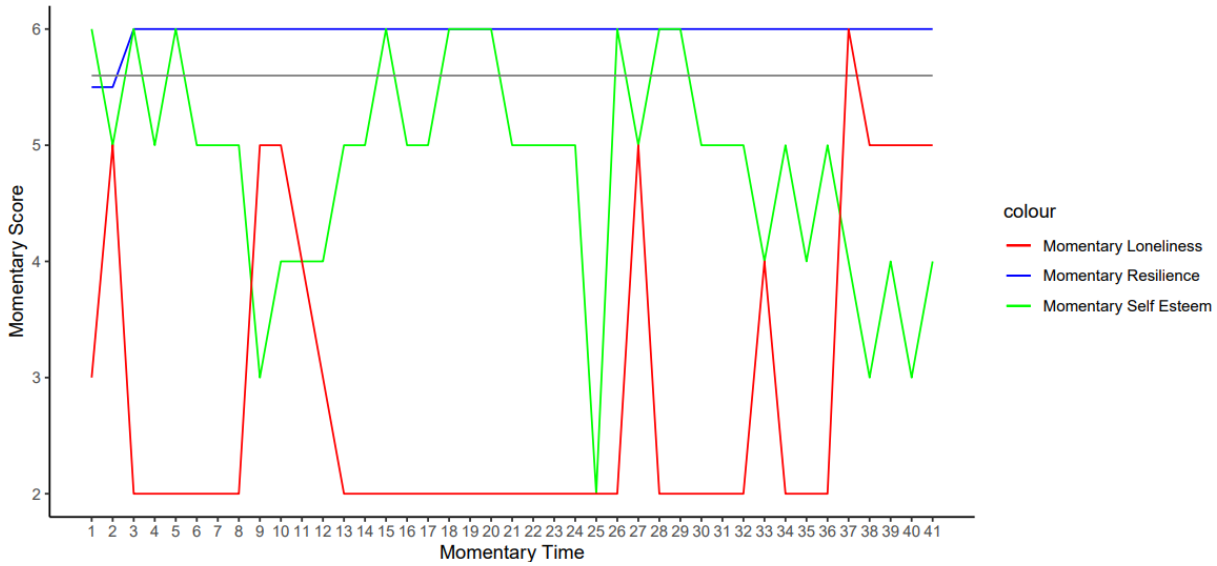


Note. The grey line displays the mean of trait resilience of participant 70978 (*M*= 3.7).

Figure 6 displays the momentary interplay of loneliness, mental resilience, and self-esteem across the time for Participant 71139. This participant indicated high levels of trait resilience (*M*= 5.6). What can be noticed is that the participant showed high levels of MMR and low levels of loneliness with several peaks (e.g., time points 2 and 37). However, these changes in the levels of loneliness and self-esteem did not strongly affect the stable level of MMR which was shown by the straight blue line, indicating a stable level of MMR over time. However, what could be noticed was that even though the participant showed relatively higher levels of self-esteem in comparison to Participant 71002 (Figure 4) and Participant 70978 (Figure 5), he reported great fluctuations in self-esteem across time. In support of the findings of Participant 71002 (Figure 4) and Participant 70978 (Figure 5), higher scores in loneliness were timely associated with decreased levels of self-esteem (e.g., time points 2, 9, and 33).

Figure 6

Multi-Line Plot for Scores of Momentary Loneliness, Resilience, and Self-Esteem for each Assessment Time Point for Participant 71139

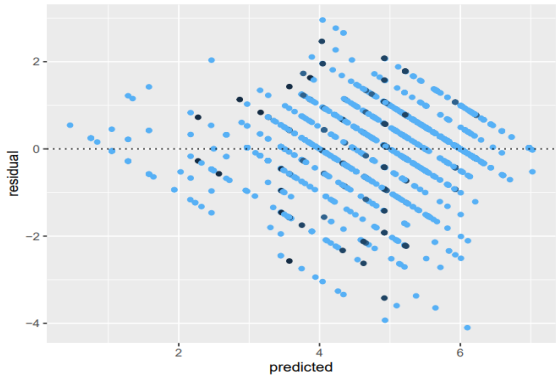


Note. The grey line displays the mean of trait resilience of participant 71139 (*M*= 5.6).

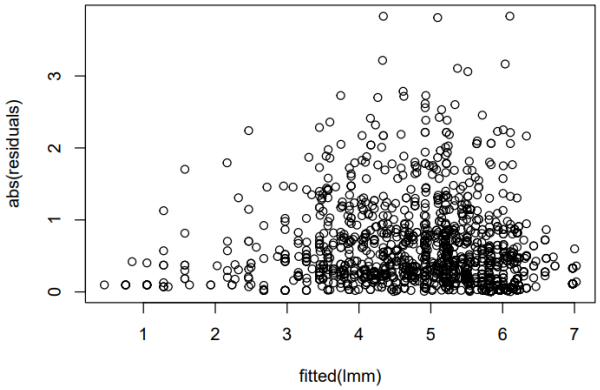
Appendix D

Assumption Check for Model of Momentary Loneliness (*t*) Predicting Subsequent Momentary Mental Resilience (*t* + 1)

Residuals vs. Fitted Values

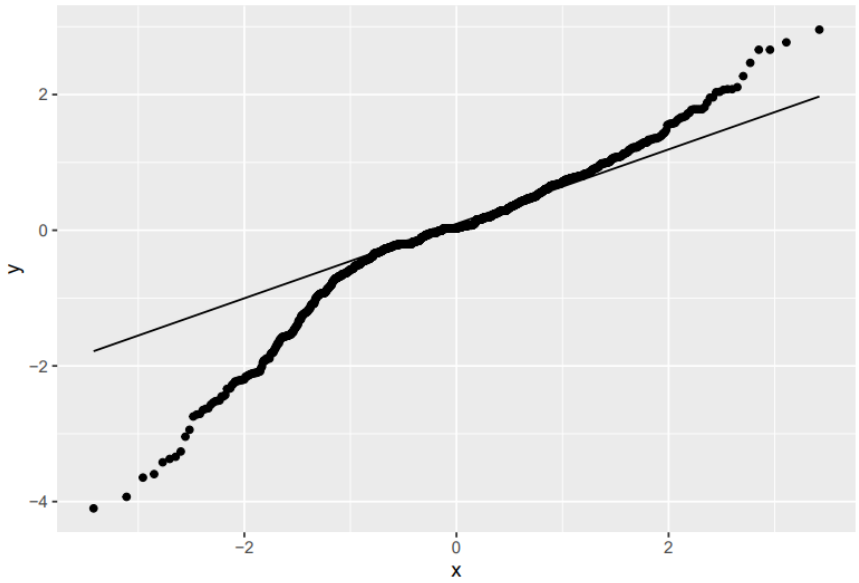


Absolute Residuals vs. Fitted Values



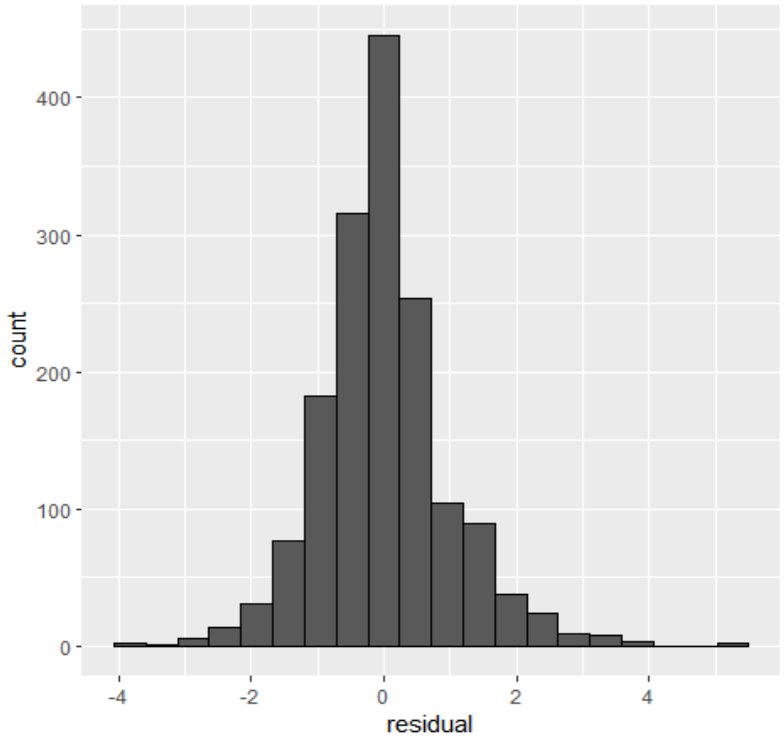
Note. The plot suggests the existence of several outliers with more extreme values. Furthermore, the plot reveals that the variance of the residuals tends to be slightly heteroscedastic as the residuals were more allocated at the upper end of the fitted values.

QQ Plot for Checking Normality of Residuals



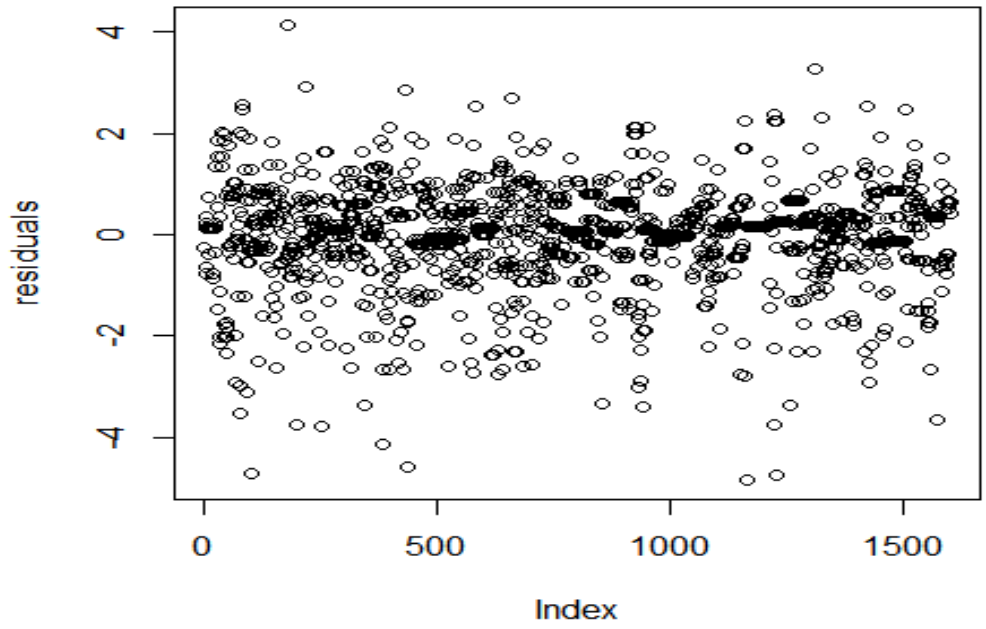
Note. This plot shows that the residuals were slightly heavily tailed that can derived from the deviations from the linear regression line at the beginning and the end of the graph.

Histogram of Residuals



Note. The histogram shows an almost normal distribution of the residuals.

Independence of Residuals

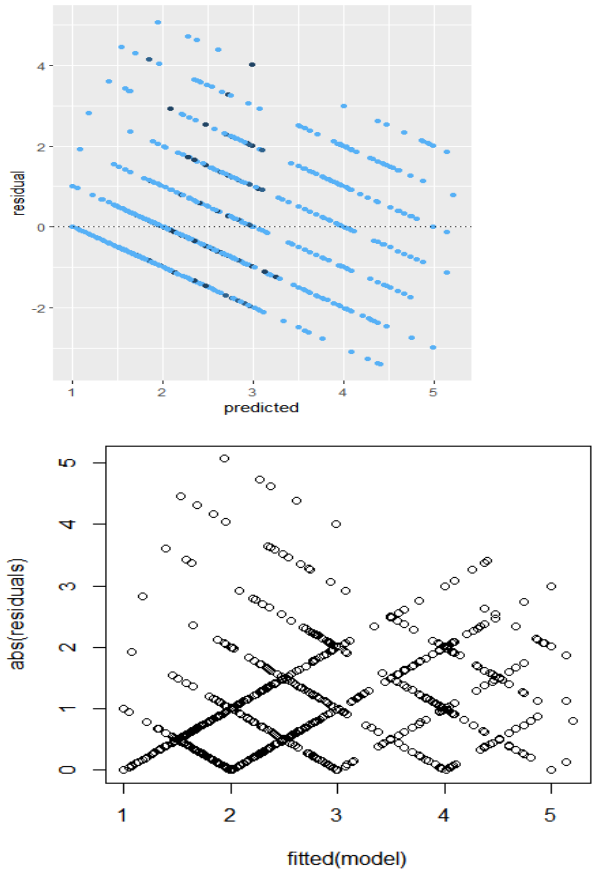


Note. The residuals do not show any patterns, which suggests non-violation of the assumption of independence.

Appendix E

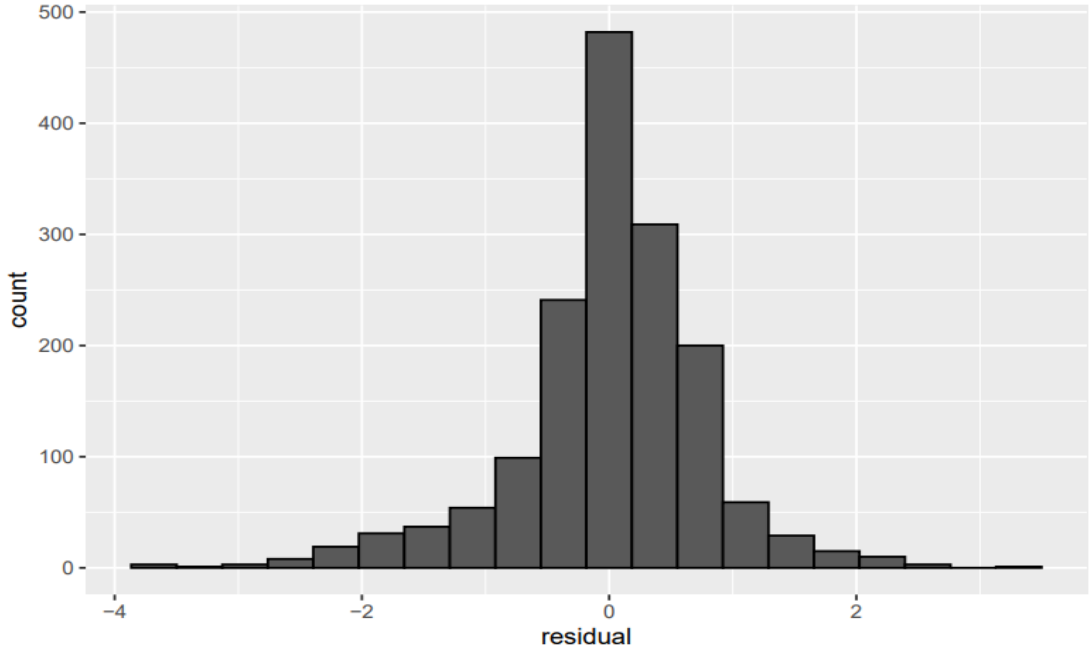
Assumption Check for Model of Momentary Mental Resilience (*t*) Predicting Subsequent Momentary Loneliness (*t* + 1)

Residuals vs. Fitted Values **Absolute Residuals vs. Fitted Values**



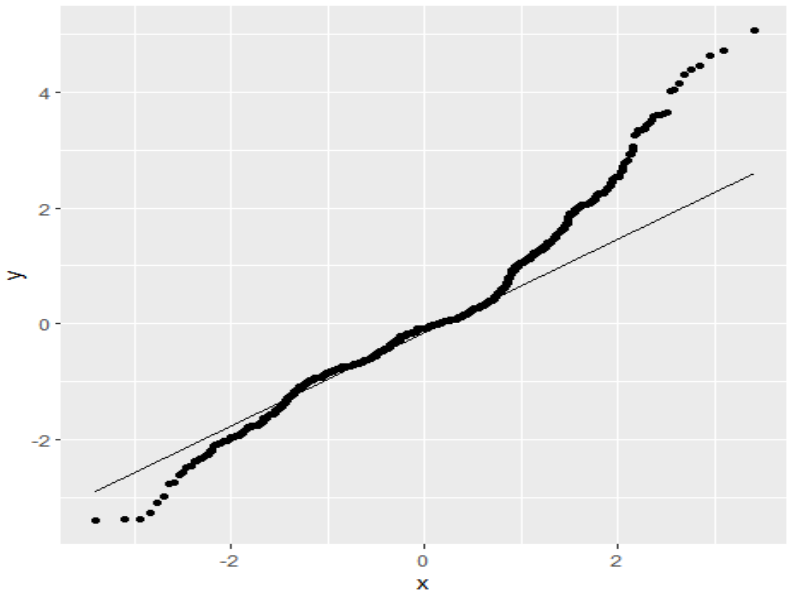
Note. The plot suggests the existence of several outliers with more extreme values. Furthermore, the plot reveals that the variance of the residuals tends to be slightly heteroscedastic.

Histogram of Residuals



Note. The plot shows an almost normal distribution of the residuals that is slightly screwed to the right.

QQ Plot for Checking Normality of Residuals



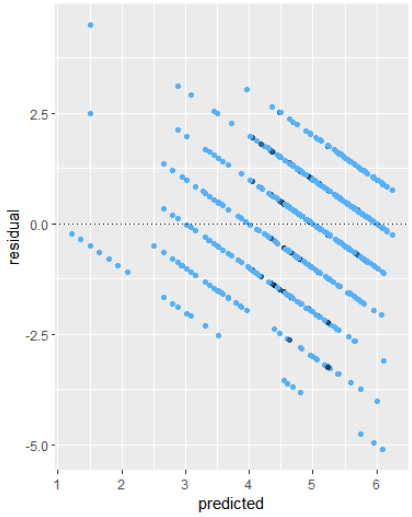
Note. This plot shows that the residuals were slightly heavily tailed that can derived from the deviations from the linear regression line at the beginning and the end of the graph.

Note. The residuals do not show any patterns, which suggests non-violation of the assumption of independence.

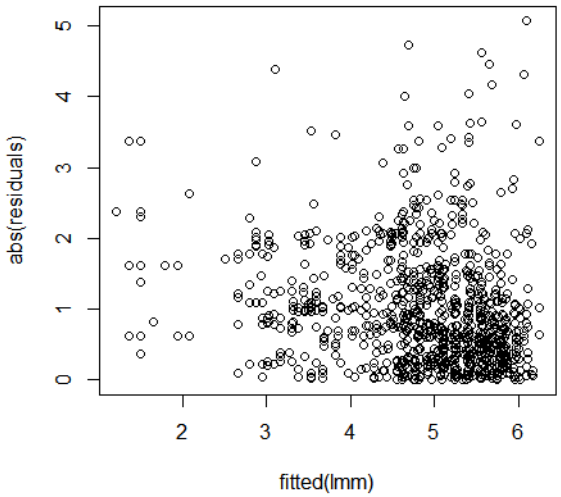
Appendix F

Assumption Check for Model of Momentary Loneliness (*t*) Predicting Subsequent Momentary Self-Esteem (*t* +1)

Residuals vs. Fitted Values

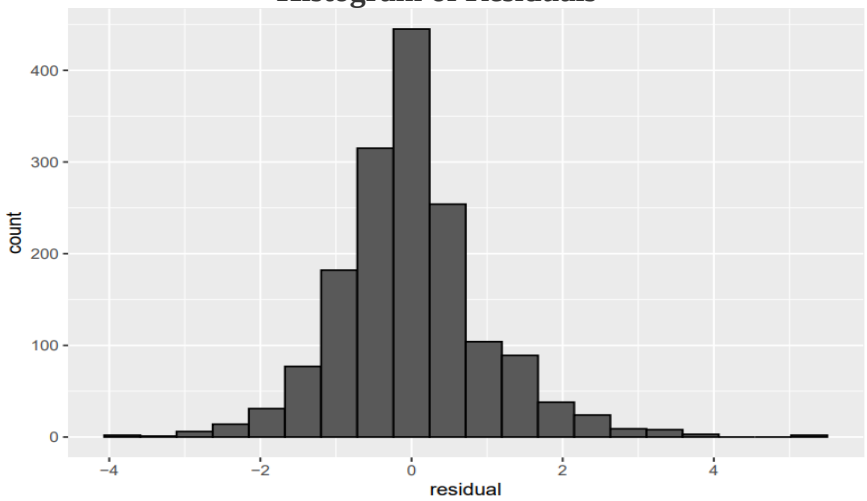


Absolute Residuals vs. Fitted Values



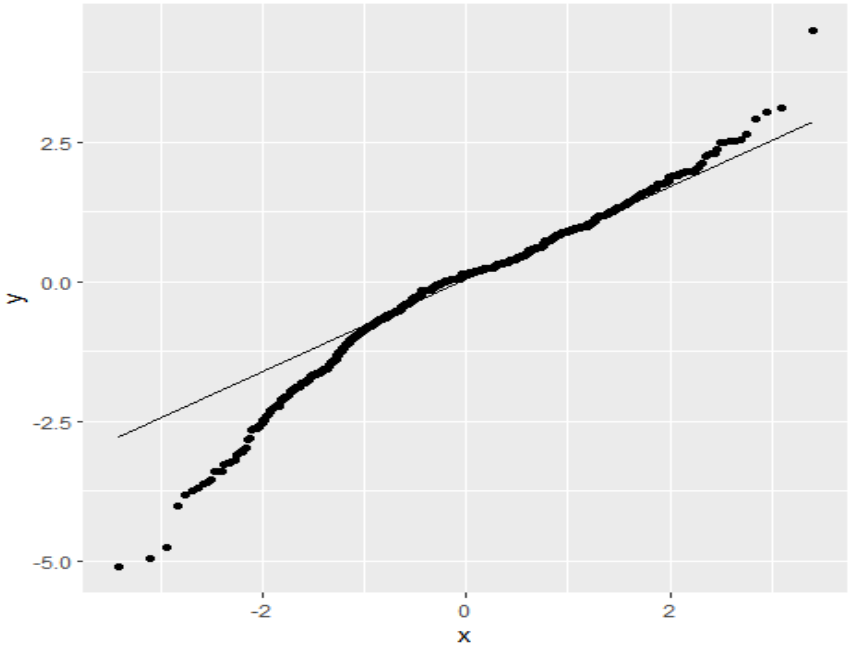
Note. The plot suggests the existence of several outliers with more extreme values. Furthermore, the plot reveals that the variance of the residuals tends to be slightly heteroscedastic as the residuals were more allocated at the upper end of the fitted values.

Histogram of Residuals



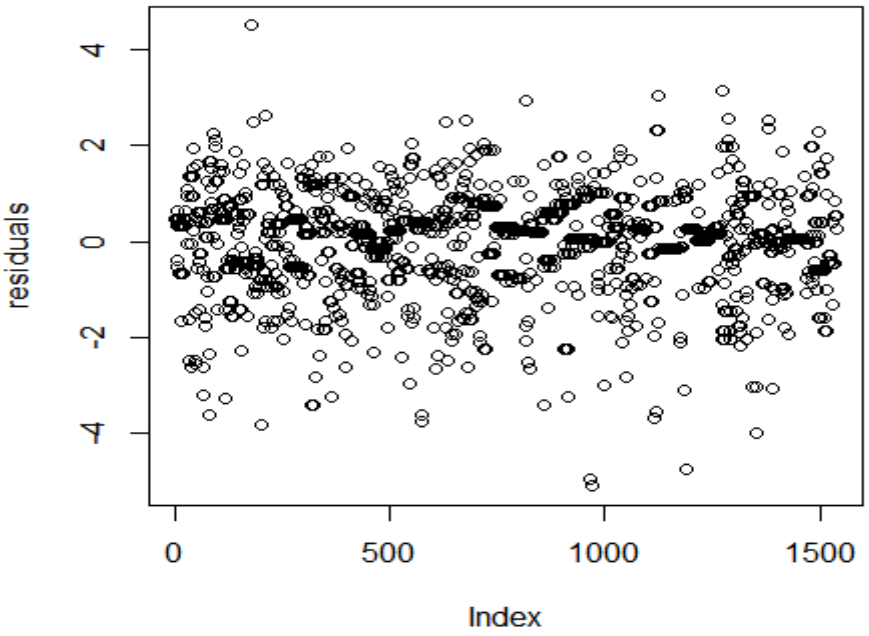
Note. The plot shows an almost normal distribution of the residuals that is slightly screwed to the left.

QQ Plot for Checking Normality of Residuals



Note. This plot shows that the residuals were slightly heavily tailed that can derived from the deviations from the linear regression line at the beginning and the end of the graph.

Independence

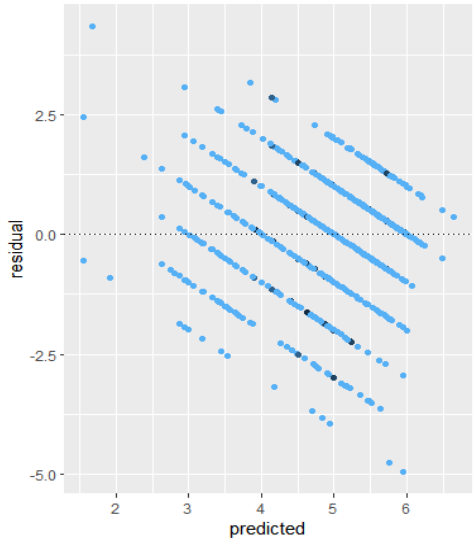


Note. The residuals do not show any patterns, which suggests non-violation of the assumption of independence.

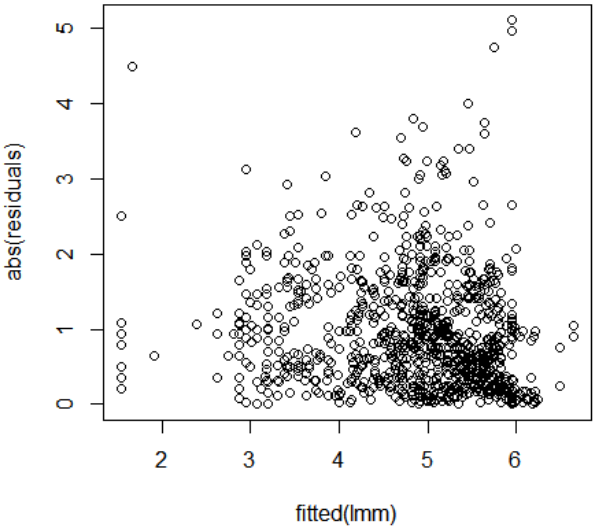
Appendix G

Assumption Check for Model of Momentary Mental Resilience (*t*) Predicting Subsequent Momentary Self-Esteem (*t* +1)

Residuals vs. Fitted Values

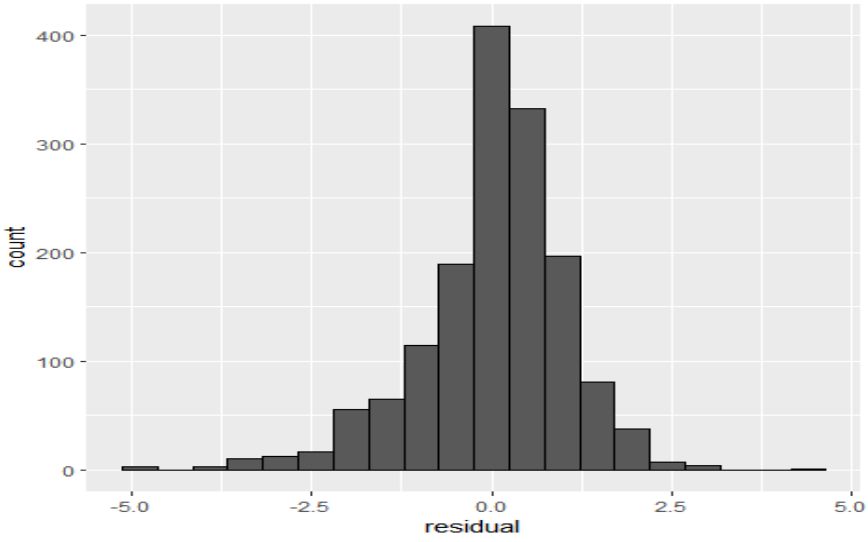


Absolute Residuals vs. Fitted Values



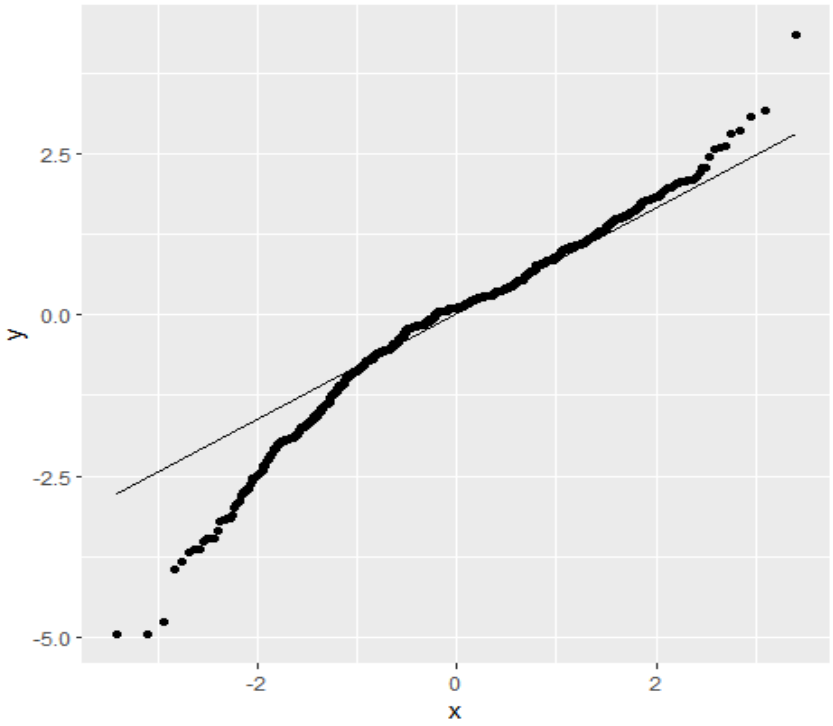
Note. The plot suggests the existence of several outliers with more extreme values. Furthermore, the plot reveals that the variance of the residuals tends to be slightly heteroscedastic as the residuals were more allocated at the upper end of the fitted values.

Histogram of Residuals



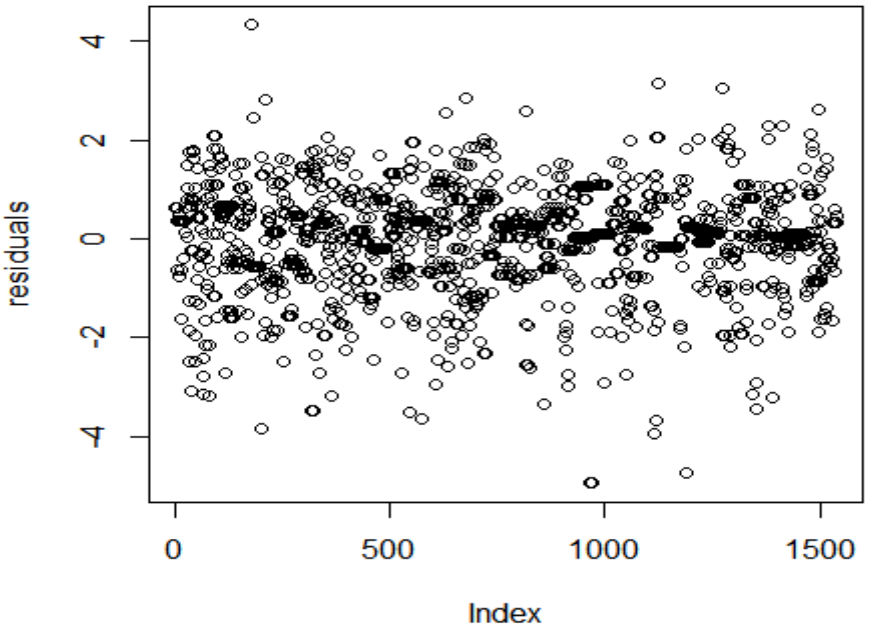
Note. The plot shows an almost normal distribution of the residuals that is slightly screwed to the right.

QQ Plot for Checking Normality of Residuals



Note. This plot shows that the residuals were slightly heavily tailed that can derived from the deviations from the linear regression line at the beginning and the end of the graph.

Independence

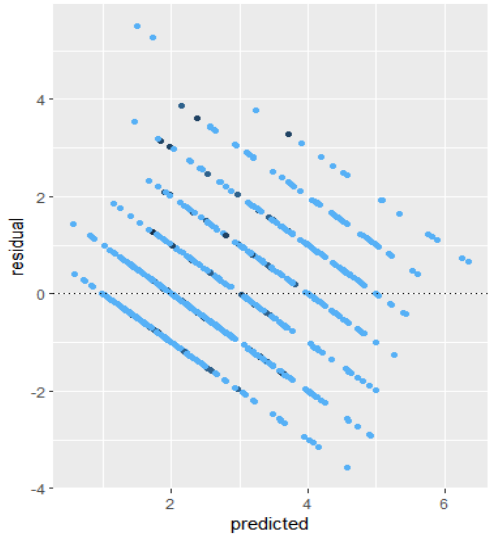


Note. The residuals do not show any patterns, which suggests non-violation of the assumption of independence.

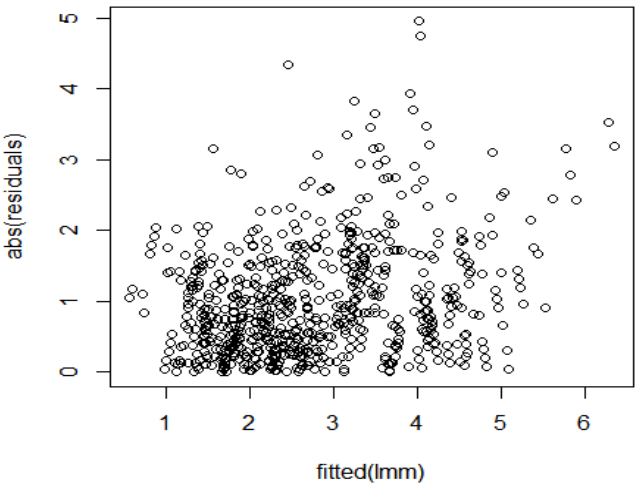
Appendix H

Assumption Check for Model of MMR (*t*) Predicting Subsequent Momentary Loneliness (*t* + 2) Controlling for Momentary Self-Esteem (*t* + 1)

Residuals vs. Fitted Values

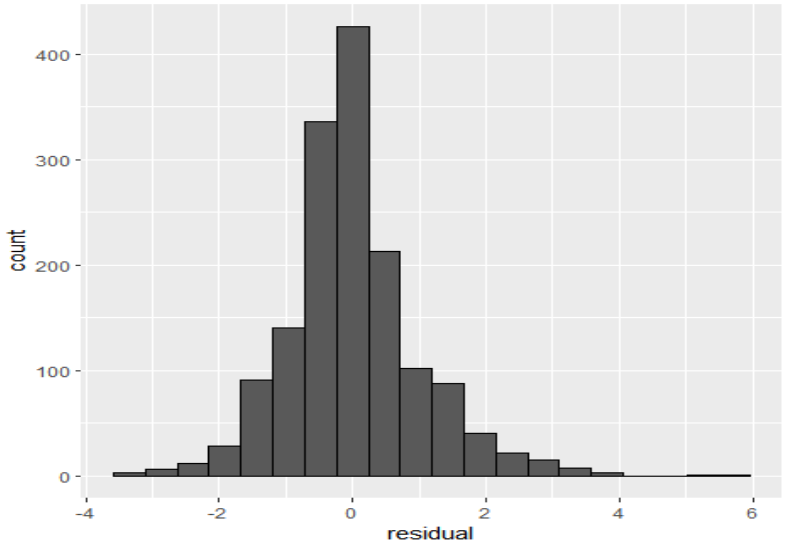


Absolute Residuals vs. Fitted Values

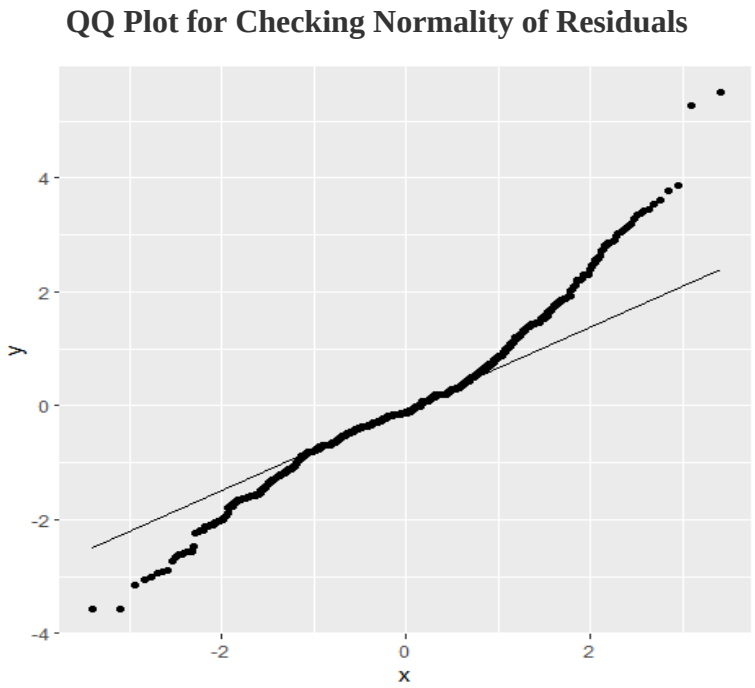


Note. The plot suggests the existence of several outliers with more extreme values. Furthermore, the plot reveals that the variance of the residuals tends to be slightly heteroscedastic as the residuals were more allocated at the lower end of the fitted values.

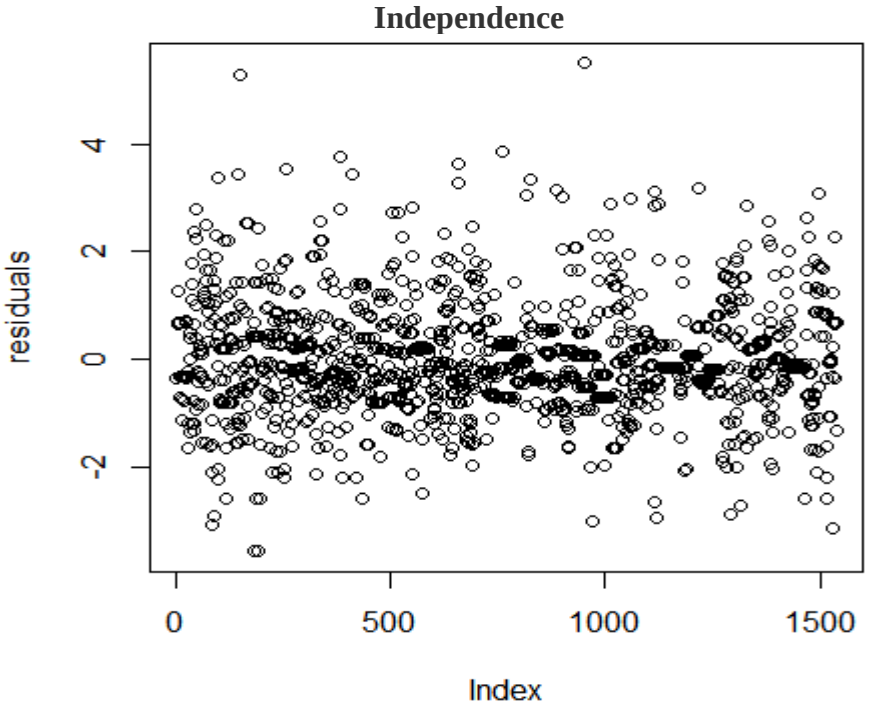
Histogram of Residuals



Note. The plot shows an almost normal distribution of the residuals that is slightly screwed to the right.



Note. This plot shows that the residuals were slightly heavily tailed that can derived from the deviations from the linear regression line at the beginning and the end of the graph.



Note. The residuals do not show any patterns, which suggests non-violation of the assumption of independence.

Appendix I

##Bachelorthesisscript##

```
##Bachelorscript
#load and install packages
library(tidyverse)
library(janitor)
library(dplyr)
library(readr)
library(ggplot2)
library(broom)
library(psych)
library(dplyr)
library(lme4)
library(lmerTest)
library(MuMIn)

#import datasets
baseline <- read_csv("C:/Users/henri/Downloads/21.zip")
esm <- read_csv("C:/Users/henri/Downloads/22.zip")
closing <- read_csv("C:/Users/henri/Downloads/24.zip")

#clean dataset, remove nas
baseline_sub <- baseline %>% select(c("Name", "age", "gender", "nationality", "occupation",
"degree", "base_religion", c(24:29)))

baseline_sub <- baseline_sub[!is.na(baseline_sub$gender),]

baseline_sub <- baseline_sub[!duplicated(baseline_sub$Name),]

esm_sub <- esm[,c("Name","Response.Time",colnames(esm)[9:21])]

#combine dataset
joined <- esm_sub %>% left_join(baseline_sub, by="Name")

#Check how many surveys werde filled out per person
filled_surveys <- joined %>% group_by(Name) %>%
  summarize(n = sum(is.na(ESM_M_1)))

g21_ids <- filled_surveys$Name[filled_surveys$n >= 21]
joined <- joined[joined$Name %in% g21_ids,]
filled_surveys <- joined %>% group_by(Name) %>%
  summarize(n = sum(is.na(ESM_M_1)))

#Drop missing ESMs
```

```
joined <- joined[!is.na(joined$ESM_R_2),]


#Compute scales
#reverse Brief Resilience Score Items (2,4,6)
joined$BRS_2 <- 6 - joined$BRS_2
joined$BRS_4 <- 6 - joined$BRS_4
joined$BRS_6 <- 6 - joined$BRS_6

##calculating alpha Brief Resilience Score
psych::alpha(joined[,22:27])

joined$BRscale <- rowMeans(joined[,22:27])

##calculating alpha resilience score
psych::alpha(joined[,13:14])

### Calculating Split-Half Reliability

# Load required packages
library(lme4)
library(psych)

# Self_esteem
# Fit a linear mixed-effects model with random intercepts for participants
model <- lmer("ESM_M_2 ~ 1 + (1 | Name)", data = joined)

# Extract the random effect variance
participant_var <- attr(VarCorr(model)$Name, "stddev")^2

# Calculate split-half reliability using the Spearman-Brown prophecy formula
reliability <- (2 * participant_var) / (participant_var + var(joined$ESM_M_2))

# Print the split-half reliability
reliability

#momentary mental resilience
# Fit a linear mixed-effects model with random intercepts for participants
model <- lmer("resilience ~ 1 + (1 | Name)", data = joined)

# Extract the random effect variance
participant_var <- attr(VarCorr(model)$Name, "stddev")^2

# Calculate split-half reliability using the Spearman-Brown prophecy formula
reliability <- (2 * participant_var) / (participant_var + var(joined$resilience))
```

```
# Print the split-half reliability
reliability

#momentary loneliness
# Fit a linear mixed-effects model with random intercepts for participants
model <- lmer("ESM_M_9 ~ 1 + (1 | Name)", data = joined)

# Extract the random effect variance
participant_var <- attr(VarCorr(model)$Name, "stddev")^2

# Calculate split-half reliability using the Spearman-Brown prophecy formula
reliability <- (2 * participant_var) / (participant_var + var(joined$ESM_M_9))

# Print the split-half reliability
reliability

joined$resilience <- rowMeans(joined[,13:14])
```

#Descriptives Demographics#

```
##gender
baseline_sub %>% tabyl(gender)

##Nationality
baseline_sub %>% tabyl(nationality)

##age
baseline_sub %>% tabyl(age)

##mean_age
age <- baseline_sub %>%
  select(age)
age_numeric <- as.numeric(age$age)
age_numeric %>% mean()
age_numeric %>% SD()

baseline_sub %>% tabyl(age)
##occupation
baseline_sub %>% tabyl(occupation)

##degree
baseline_sub %>% tabyl(degree)
```

##Descriptives Scales##

```
##self-esteemscore descriptives
joined$ESM_M_2 %>% tabyl()
joined$ESM_M_2 %>% mean()
```

```
joined$ESM_M_2 %>% SD()

##loneliness score descriptives
joined$ESM_M_9 %>% tabyl()
joined$ESM_M_9 %>% mean()
joined$ESM_M_9 %>% SD()

##MMR Score descriptives
joined$resilience %>% tabyl()
joined$resilience %>% mean()
joined$resilience %>% SD()

##Brief Resilience score descriptives
joined <- joined %>% na.omit()
joined$BRscale %>% tabyl()
joined$BRscale %>% mean()
joined$BRscale %>% SD()
```

#Convergent validity

```
means_by_participant <- aggregate(resilience ~ Name, data = joined, mean)
means <- aggregate(joined$resilience, by = list(joined$Name), FUN = mean)
joined$mean_var <- means$x[match(joined$Name, means$Group.1)]
cv <- na.omit(joined)
result <- cor.test(cv$mean_var, cv$BRscale)

# Print correlation coefficient, p-value, and confidence interval
cat("Correlation coefficient: ", round(result$estimate, 2), "\n")
cat("p-value: ", format.pval(result$p.value, digits = 2), "\n")
cat("Confidence interval: ", round(result$conf.int, 2), "\n")

#Base model
#Calculating ICC (variance name: (variance name + residuals))
# Erforderliche Pakete installieren (wenn noch nicht installiert)

# Print correlation coefficient, p-value, and confidence interval
cat("Correlation coefficient: ", round(result$estimate, 2), "\n")
cat("p-value: ", format.pval(result$p.value, digits = 2), "\n")
cat("Confidence interval: ", round(result$conf.int, 2), "\n")
```

 # Calculate Pearson's correlation coefficient

```
#self-esteem with trait resilience
means_by_participant <- aggregate(ESM_M_9 ~ Name, data = joined, mean)
means <- aggregate(joined$ESM_M_9, by = list(joined$Name), FUN = mean)
joined$mean_var <- means$x[match(joined$Name, means$Group.1)]
cv <- na.omit(joined)
result <- cor.test(cv$mean_var, cv$BRscale)
```

```
print(result)

#loneliness with trait resilience
means_by_participant <- aggregate(ESM_M_2 ~ Name, data = joined, mean)
means <- aggregate(joined$ESM_M_2, by = list(joined$Name), FUN = mean)
joined$mean_var <- means$x[match(joined$Name, means$Group.1)]
cv <- na.omit(joined)
result <- cor.test(cv$mean_var, cv$BRscale)
print(result)

#loneliness with self-esteem
means_by_participant2 <- aggregate(ESM_M_2 ~ Name, data = joined, mean)
means <- aggregate(joined$ESM_M_2, by = list(joined$Name), FUN = mean)
joined$mean_var <- means$x[match(joined$Name, means$Group.1)]

means_by_participant <- aggregate(ESM_M_9 ~ Name, data = joined, mean)
means <- aggregate(joined$ESM_M_9, by = list(joined$Name), FUN = mean)
joined$mean_var2 <- means$x[match(joined$Name, means2$Group.1)]
cv <- na.omit(joined)
result <- cor.test(cv$mean_var, cv$mean_var2)
print(result)

#loneliness with state resilience
means_by_participant2 <- aggregate(resilience ~ Name, data = joined, mean)
means <- aggregate(joined$resilience, by = list(joined$Name), FUN = mean)
joined$mean_var <- means$x[match(joined$Name, means$Group.1)]

means_by_participant <- aggregate(ESM_M_9 ~ Name, data = joined, mean)
means <- aggregate(joined$ESM_M_9, by = list(joined$Name), FUN = mean)
joined$mean_var2 <- means$x[match(joined$Name, means2$Group.1)]
cv <- na.omit(joined)
result <- cor.test(cv$mean_var, cv$mean_var2)
print(result)

#self-esteem with state resilience
means_by_participant2 <- aggregate(resilience ~ Name, data = joined, mean)
means <- aggregate(joined$resilience, by = list(joined$Name), FUN = mean)
joined$mean_var <- means$x[match(joined$Name, means$Group.1)]

means_by_participant <- aggregate(ESM_M_2 ~ Name, data = joined, mean)
means <- aggregate(joined$ESM_M_2, by = list(joined$Name), FUN = mean)
joined$mean_var2 <- means$x[match(joined$Name, means2$Group.1)]
cv <- na.omit(joined)

result <- cor.test(cv$mean_var, cv$mean_var2)
```

```
print(result)
##Hypothese 1: loneliness --> resilience

joined$resilience_lagged <- dplyr::lag(joined$resilience, n = 1)
model_lagged <- lmer(resilience_lagged ~ ESM_M_9 + (1|Name), data = joined)
summary(model_lagged)
#ICC
icc <- ICC(model)
print(icc)
#rsquared
library(MuMIn)
r.squaredGLMM(model_lagged)
#confidenceinterval
confint(model_lagged)

#Hypothese 2: resilience -> loneliness
joined$loneliness_lagged <- dplyr::lag(joined$ESM_M_9, n = 1)
model_lagged <- lmer(loneliness_lagged ~ resilience + (1|Name), data = joined)
summary(model_lagged)
#ICC
icc <- ICC(model_lagged)
print(icc)
#rsquared
r.squaredGLMM(model_lagged)
#confidenceinterval
confint(model_lagged)
#Multicollinearity for H3: VIF > 5 bad, VIF > 10 horrible
library(car)
vif(fit.dv)

#Hypothesis 3: Mediator of Self-Esteem, loneliness --> resilience
#Mediation
# Create lagged variables
data <- joined %>%
  mutate(loneliness_lag1 = lag(ESM_M_9),
         self_esteem_lag2 = lag(ESM_M_2),
         resilience_lag3 = lag(resilience))
# Remove NA values
data <- na.omit(data)
#direct effect
lmm <- lmer(resilience_lag3 ~ loneliness_lag1 + (1|Name), data=data)
summary(lmm)
confint(lmm)
#effect of x on m
fit.mediator <- lmer(self_esteem_lag2 ~ loneliness_lag1 +(1| Name), data = data)
summary(fit.mediator)
```

```
confint(fit.mediator)
#effect of mediator on y
fit.dv  <- lmer(resilience_lag3 ~ self_esteem_lag2 +  loneliness_lag1 + (1| Name), data = data)
summary(fit.dv)
confint(fit.dv)
# Perform sobeltest → website
```

#Hypothesis 4: Mediator of Self-Esteem on resilience --> loneliness

```
#Mediation
# Create lagged variables
data <- joined %>%
  mutate(resilience_lag1 = lag(resilience),
         self_esteem_lag2 = lag(ESM_M_2),
         loneliness_lag3 = lag(ESM_M_9))
# Remove NA values
data <- na.omit(data)

#direct effect
lmm <- lmer(loneliness_lag3 ~ resilience_lag1 + (1|Name), data=data)
summary(lmm)
confint(lmm)

#effect of x on m
fit.mediator <- lmer(self_esteem_lag2 ~ resilience_lag1 +(1| Name), data = data)
summary(fit.mediator)
confint(fit.mediator)
#effect of mediator on y
fit.dv  <- lmer(loneliness_lag3 ~ self_esteem_lag2 +  resilience_lag1 + (1| Name), data = data)
summary(fit.dv)
confint(fit.dv)
# Perform Sobel Test → website
#Multicollinearity for H3: VIF > 5 bad, VIF > 10 horrible
library(car)
vif(fit.dv)
################################################
```

#Assumption check

```
library(nlme)
library(stats)

#assumptions for lmm of loneliness --> resiliencelagged
lmm <- lmer(resilience_lagged ~ ESM_M_9 + (1|Name), data=joined)

#equal variance
tdat <- data.frame(predicted=predict(lmm), residual = residuals(lmm), referrer=joined$Name)
```

```
ggplot(tdat,aes(x=predicted,y=residual, colour=referrer)) + geom_point() +
geom_hline(yintercept=0, lty=3)
plot(fitted(lmm), abs(residuals))

# Alternatively, create a residual plot against the predictor variable
plot(lmm, resid(type = "p") ~ ESM_M_9)

#normal distribution of residuals
qqnorm(scale(resid(lmm)))
abline(0,1)
ggplot(tdat,aes(x=residual)) + geom_histogram(bins=20, color="black")
ggplot(tdat,aes(sample=residual)) + stat_qq() + stat_qq_line()

#independence
residuals <- resid(lmm)
plot(residuals)

#outliers
plot(lmm, which = 4)

#---------
#assumption for resilience --> loneliness
model <- lmer(loneliness_lagged ~ resilience + (1 | Name), data = data)
summary(model)

#equal variance
tdat <- data.frame(predicted=predict(model), residual = residuals(model),
referrer=data$Name)
ggplot(tdat,aes(x=predicted,y=residual, colour=referrer)) + geom_point() +
geom_hline(yintercept=0, lty=3)
plot(fitted(lmm), abs(residuals))

residuals <- resid(model)
# Plot residuals against fitted values
plot(fitted(model), residuals)
# Plot absolute residuals against fitted values
plot(fitted(model), abs(residuals))

#normal distribution of residuals
qqnorm(scale(resid(model)))
abline(0,1)
ggplot(tdat,aes(x=residual)) + geom_histogram(bins=20, color="black")
ggplot(tdat,aes(sample=residual)) + stat_qq() + stat_qq_line()

#independence
residuals <- resid(model)
```

```
plot(residuals)

#outliers
plot(model, which = 4)

#assumption check for MFL on MS
lmm <- lmer(self_esteem_lag2 ~ ESM_M_9 + (1|Name), data=data)

#equal variance
tdat <- data.frame(predicted=predict(lmm), residual = residuals(lmm), referrer=data$Name)
ggplot(tdat,aes(x=predicted,y=residual, colour=referrer)) + geom_point() +
geom_hline(yintercept=0, lty=3)
# Plot absolute residuals against fitted values
plot(fitted(lmm), abs(residuals))

#normal distribution of residuals
qqnorm(scale(resid(lmm)))
abline(0,1)
ggplot(tdat,aes(x=residual)) + geom_histogram(bins=20, color="black")
ggplot(tdat,aes(sample=residual)) + stat_qq() + stat_qq_line()

#independence
residuals <- resid(lmm)
plot(residuals)

#outliers
plot(lmm, which = 4)

#linearity
plot(fitted(lmm), residuals(lmm), main = "Residuals vs. Fitted Values", xlab = "Fitted
Values", ylab = "Residuals")

#Multicollinearity for H3: VIF > 5 bad, VIF > 10 horrible
library(car)
vif(fit.dv)

#assumption check for MMR on subsequent MS
lmm <- lmer(self_esteem_lag2 ~ resilience + (1|Name), data=data)


#equal variance
tdat <- data.frame(predicted=predict(lmm), residual = residuals(lmm), referrer=data$Name)
ggplot(tdat,aes(x=predicted,y=residual, colour=referrer)) + geom_point() +
geom_hline(yintercept=0, lty=3)
# Plot absolute residuals against fitted values
plot(fitted(lmm), abs(residuals))
```

```
#normal distribution of residuals
qqnorm(scale(resid(lmm)))
abline(0,1)
ggplot(tdat,aes(x=residual)) + geom_histogram(bins=20, color="black")
ggplot(tdat,aes(sample=residual)) + stat_qq() + stat_qq_line()

#independence
residuals <- resid(lmm)
plot(residuals)

#outliers
plot(lmm, which = 4)

#linearity
plot(fitted(lmm), residuals(lmm), main = "Residuals vs. Fitted Values", xlab = "Fitted
Values", ylab = "Residuals")


#assumption check for MFL on MS
lmm <- lmer(self_esteem_lag2 ~ ESM_M_9 + (1|Name), data=data)


#equal variance
tdat <- data.frame(predicted=predict(lmm), residual = residuals(lmm), referrer=data$Name)
ggplot(tdat,aes(x=predicted,y=residual, colour=referrer)) + geom_point() +
geom_hline(yintercept=0, lty=3)
# Plot absolute residuals against fitted values
plot(fitted(lmm), abs(residuals))

#normal distribution of residuals
qqnorm(scale(resid(lmm)))
abline(0,1)
ggplot(tdat,aes(x=residual)) + geom_histogram(bins=20, color="black")
ggplot(tdat,aes(sample=residual)) + stat_qq() + stat_qq_line()

#independence
residuals <- resid(lmm)
plot(residuals)

#outliers
plot(lmm, which = 4)

#linearity
plot(fitted(lmm), residuals(lmm), main = "Residuals vs. Fitted Values", xlab = "Fitted
Values", ylab = "Residuals")
```

```
#Multicollinearity for H3: VIF > 5 bad, VIF > 10 horrible
library(car)
vif(fit.dv)

#assumption check for MMR on subsequent MS
lmm <- lmer(self_esteem_lag2 ~ resilience + (1|Name), data=data)


#equal variance
tdat <- data.frame(predicted=predict(lmm), residual = residuals(lmm), referrer=data$Name)
ggplot(tdat,aes(x=predicted,y=residual, colour=referrer)) + geom_point() +
geom_hline(yintercept=0, lty=3)
# Plot absolute residuals against fitted values
plot(fitted(lmm), abs(residuals))

#normal distribution of residuals
qqnorm(scale(resid(lmm)))
abline(0,1)
ggplot(tdat,aes(x=residual)) + geom_histogram(bins=20, color="black")
ggplot(tdat,aes(sample=residual)) + stat_qq() + stat_qq_line()

#independence
residuals <- resid(lmm)
plot(residuals)

#outliers
plot(lmm, which = 4)

#linearity
plot(fitted(lmm), residuals(lmm), main = "Residuals vs. Fitted Values", xlab = "Fitted
Values", ylab = "Residuals")


#assumption check for MFL on MS
lmm <- lmer(self_esteem_lag2 ~ ESM_M_9 + (1|Name), data=data)


#equal variance
tdat <- data.frame(predicted=predict(lmm), residual = residuals(lmm), referrer=data$Name)
ggplot(tdat,aes(x=predicted,y=residual, colour=referrer)) + geom_point() +
geom_hline(yintercept=0, lty=3)
# Plot absolute residuals against fitted values
plot(fitted(lmm), abs(residuals))
```

```
#normal distribution of residuals
qqnorm(scale(resid(lmm)))
abline(0,1)
ggplot(tdat,aes(x=residual)) + geom_histogram(bins=20, color="black")
ggplot(tdat,aes(sample=residual)) + stat_qq() + stat_qq_line()

#independence
residuals <- resid(lmm)
plot(residuals)

#outliers
plot(lmm, which = 4)


#assumption check for MMR on subsequent MS
lmm <- lmer(self_esteem_lag2 ~ resilience + (1|Name), data=data)


#equal variance
tdat <- data.frame(predicted=predict(lmm), residual = residuals(lmm), referrer=data$Name)
ggplot(tdat,aes(x=predicted,y=residual, colour=referrer)) + geom_point() +
geom_hline(yintercept=0, lty=3)
# Plot absolute residuals against fitted values
plot(fitted(lmm), abs(residuals))

#normal distribution of residuals
qqnorm(scale(resid(lmm)))
abline(0,1)
ggplot(tdat,aes(x=residual)) + geom_histogram(bins=20, color="black")
ggplot(tdat,aes(sample=residual)) + stat_qq() + stat_qq_line()

#independence
residuals <- resid(lmm)
plot(residuals)

#outliers
plot(lmm, which = 4)


#assumption check for MMR on MFL controlling for MS
lmm <- lmer(loneliness_lag3 ~ resilience + + self_esteem_lag2 + (1|Name), data=data)


#equal variance
tdat <- data.frame(predicted=predict(lmm), residual = residuals(lmm), referrer=data$Name)
```

```
ggplot(tdat,aes(x=predicted,y=residual, colour=referrer)) + geom_point() +
geom_hline(yintercept=0, lty=3)
# Plot absolute residuals against fitted values
plot(fitted(lmm), abs(residuals))

#normal distribution of residuals
qqnorm(scale(resid(lmm)))
abline(0,1)
ggplot(tdat,aes(x=residual)) + geom_histogram(bins=20, color="black")
ggplot(tdat,aes(sample=residual)) + stat_qq() + stat_qq_line()

#independence
residuals <- resid(lmm)
plot(residuals)

#outliers
plot(lmm, which = 4)


plot(fitted(lmm), residuals(lmm), main = "Residuals vs. Fitted Values", xlab = "Fitted
Values", ylab = "Residuals")
```

#Plotting models

```
############################################################
#hypothesis 1
#box plots for people with different levels of loneliness and resilience_lagged

joined$Momentary_Resilience_lagged <- lag(joined$resilience, 1)
joined$Momentary_Loneliness_level <- cut(joined$ESM_M_9, breaks = c(-Inf, 3.5, Inf),
labels = c("Low", "High"))

ggplot(data = joined, aes(x = Momentary_Loneliness_level, y = resilience_lagged)) +
  geom_boxplot()
levels(joined$Loneliness_level) <- c("Low Momentary Loneliness", "High Momentary
Loneliness")

# create boxplot with new group names
boxplot(Momentary_Resilience_lagged ~ Momentary_Loneliness_level, data = joined, col =
c("green", "red"))

#hypothesis 2
#box plots for people with different levels of loneliness and resilience
joined$Momentary_Loneliness_lagged <- lag(joined$ESM_M_9, 1)
joined$Momentary_Resilience_level <- cut(joined$resilience, breaks = c(-Inf, 3.5, Inf),labels
= c("Low ", "High"))
ggplot(data = joined, aes(x = Momentary_Resilience_level, y =
Momentary_Loneliness_lagged)) +
  geom_boxplot()
```

```
levels(joined$Momentary_Resilience_level) <- c("Low Momentary Resilience", "High Momentary Resilience")
# create boxplot with new group names
boxplot(Momentary_Loneliness_lagged ~ Momentary_Resilience_level, data = joined, col = c("red", "green"))

##################################################
#plot MMR, loneliness and self-esteem in one plot to see the correlations as example: 71002
# Select the relevant columns from your data
www <- joined[which(joined$Name == 71002), ]
df <- www[, c("Name", "response_time_1_70", "resilience_lagged", "ESM_M_2", "ESM_M_9")]

# Melt the data into a long format
#df_long <- reshape2::melt(df, id.vars = c("71002", "response_time_1_70"))

# Plot the data as a multi-line plot
www$BRscale <- www$BRscale + 0.8
ggplot(www, aes(x = response_time_1_70)) +
  geom_line(aes(y = resilience, color = "Momentary Resilience")) +
  geom_line(aes(y = ESM_M_2, color = "Momentary Self Esteem")) +
  geom_line(aes(y = BRscale, color = " Trait Resilience")) +
  geom_line(aes(y = ESM_M_9, color = "Momentary Loneliness")) +
  labs(x = "Momentary Time", y = "Momentary Score") +
  scale_color_manual(values = c("Momentary Resilience" = "blue", "Momentary Self Esteem" = "green", "Momentary Loneliness" = "red")) +
  scale_x_continuous(breaks = seq(min(www$response_time_1_70), max(www$response_time_1_70), by = 1),
                     labels = seq(min(www$response_time_1_70), max(www$response_time_1_70), by = 1)) +
  theme_classic()

#plot MMR, loneliness and self-esteem in one plot to see the correlations as example: 70992
# Select the relevant columns from your data
www <- joined[which(joined$Name == 70992), ]
df <- www[, c("Name", "response_time_1_70", "resilience", "ESM_M_2", "ESM_M_9")]

# Melt the data into a long format
#df_long <- reshape2::melt(df, id.vars = c("71139", "response_time_1_70"))

# Plot the data as a multi-line plot
www$BRscale <- www$BRscale + 1.6
ggplot(www, aes(x = response_time_1_70)) +
  geom_line(aes(y = resilience, color = "Momentary Resilience")) +
  geom_line(aes(y = ESM_M_2, color = "Momentary Self Esteem")) +
  geom_line(aes(y = BRscale, color = " Trait Resilience")) +
```

```
  geom_line(aes(y = ESM_M_9, color = "Momentary Loneliness")) +
  labs(x = "Momentary Time", y = "Momentary Score") +
  scale_color_manual(values = c("Momentary Resilience" = "blue", "Momentary Self
Esteem" = "green", "Momentary Loneliness" = "red", "Trait Resilience" = "grey")) +
  scale_x_continuous(breaks = seq(min(www$response_time_1_70),
max(www$response_time_1_70), by = 1),
                     labels = seq(min(www$response_time_1_70), max(www$response_time_1_70),
by = 1)) +
  theme_classic()

#plot MMR, loneliness and self-esteem in one plot to see the correlations as example: 70978
# Select the relevant columns from your data
www <- joined[which(joined$Name == 70978), ]
df <- www[, c("Name", "response_time_1_70", "resilience", "ESM_M_2", "ESM_M_9")]


# Melt the data into a long format
#df_long <- reshape2::melt(df, id.vars = c("71002", "response_time_1_70"))

# Plot the data as a multi-line plot
www$BRscale <- www$BRscale + 1.073
ggplot(www, aes(x = response_time_1_70)) +
  geom_line(aes(y = resilience, color = "Momentary Resilience")) +
  geom_line(aes(y = ESM_M_2, color = "Momentary Self Esteem")) +
  geom_line(aes(y = BRscale, color = " Trait Resilience")) +
  geom_line(aes(y = ESM_M_9, color = "Momentary Loneliness")) +
  labs(x = "Momentary Time", y = "Momentary Score") +
  scale_color_manual(values = c("Momentary Resilience" = "blue", "Momentary Self
Esteem" = "green", "Momentary Loneliness" = "red", "Resilience" = "purple")) +
  scale_x_continuous(breaks = seq(min(www$response_time_1_70),
max(www$response_time_1_70), by = 1),
                     labels = seq(min(www$response_time_1_70), max(www$response_time_1_70),
by = 1)) +
  theme_classic()
```