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Objective: Focusing on temporal associations between momentary (or state) loneliness, appraisal of social company, and being alone in daily life may help elucidate mechanisms that contribute to the development of prolonged (or trait) loneliness and major depressive disorder (MDD). We aim to examine if (a) a self-reinforcing loop between loneliness, negative appraisals of social company, and being alone in daily life may contribute to trait loneliness; (b) this possible self-reinforcing loop may also contribute to the development of MDD, by testing differences in temporal relationships between these social elements in participants who did or did not develop MDD during follow-up; and (c) any of these social elements at baseline predicted a MDD at follow-up. *Methods*: A female general population sample (n = 417) participated in an experience sampling method (ESM) study. Time-lagged analyses between loneliness, appraisal of social company, and being alone were examined at baseline, and their associations with the development of MDD during 20 months follow-up were investigated. *Results*: State

Mark van Winkel, MSc, is affiliated with the Department of Psychiatry and Psychology, School of Mental Health and Neuroscience, Maastricht University Medical Centre, in Maastricht, the Netherlands, and the Institute of Mental Health Care, Eindhoven and the Kempen, the Netherlands. *Marieke Wichers, PhD*, is affiliated with the University of Groningen, University Medical Centre Groningen, Interdisciplinary Center for Psychopathology and Emotion Regulation, Department of Psychiatry, Groningen, the Netherlands. *Dina Collip, PhD*, is affiliated with the Department of Psychiatry and Psychology, School of Mental Health and Neuroscience, Maastricht University Medical Centre, Maastricht, the Netherlands. *Nele Jacobs, PhD*, is affiliated with the Department of Psychiatry and Psychology, School of Mental Health and Neuroscience, Maastricht University Medical Centre, Maastricht, the Netherlands, and the Faculty of Psychology, Open University of the Netherlands, Heerlen, the Netherlands. *Catherine Derom, DSc*, is affiliated with the Centre of Human Genetics, University Hospitals Leuven, Department of Human Genetics, Belgium, and the Department of Obstetrics and Gynaecology, Ghent University Hospitals, Ghent, Belgium. *Evert Thiery, MD*, is affiliated with the Department of Neurology, Ghent University Hospital, Ghent, Belgium. *Inez Myin-Germeys, MD*, is affiliated with the Center for Contextual Psychiatry, KU Leuven, Department of Neuroscience, Leuven, Belgium. *Frenk Peeters, MD*, is affiliated with the Department of Psychiatry and Psychology, School of Mental Health and Neuroscience, Maastricht University Medical Centre, Maastricht, the Netherlands.

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Address correspondence to Mark van Winkel, Department of Psychiatry and Psychology, School of Mental Health and Neuroscience, Maastricht University, Vijverdalseweg 1, PO Box 616 (DRT 10), Maastricht 6200 MD, the Netherlands. E-mail: mark.vanwinkel@maastrichtuniversity.nl

loneliness was followed by an increase in negative appraisals of social company and a higher frequency of being alone. Further, negative appraisals of social company were associated with a higher frequency of being alone afterward. Only the latter was significant in the transition to MDD group. Trait loneliness predicted MDD during follow-up. *Conclusions*: Avoiding social contact after appraising company more negatively may contribute to the development of MDD.

Loneliness is a unique risk factor among the many that are known to contribute to the development of major depressive disorder (MDD) (Cacioppo, Hawkley, & Thisted, 2010; Cacioppo, Hughes, Waite, Hawkley, & Thisted, 2006). Loneliness can be defined as an aversive affective state that occurs when people experience a discrepancy between the relationships they wish to have and how they are currently perceived (Peplau & Perlman, 1982). This definition shows that loneliness is not the same as objective social isolation—being alone—but reflects a perceived and undesired social isolation. This is supported by research showing that being alone and loneliness are only moderately correlated (Cornwell & Waite, 2009).

A large number of studies on loneliness in relation to MDD focus on the association between cross-sectional measurements of loneliness and longitudinal changes in depressive symptoms (Cacioppo et al., 2010; Cacioppo et al., 2006). Although these reports reveal that loneliness is an important risk factor, they do not show why loneliness is related to MDD and how we can prevent MDD. In this article, we first focus on the construct of loneliness and the role of loneliness in daily life, followed by a short discussion of the possible role of loneliness in relation to the development of MDD.

Most studies to date have examined trait loneliness, indicative of the level to which participants feel lonely in general. However, in addition to a stable and heritable component (Boomsma, Willemsen, Dolan, Hawkley, & Cacioppo, 2005), loneliness is strongly influenced by multiple affective, cognitive, and behavioral responses to the environment, contributing to the dynamic state component of loneliness. First, trait loneliness appears to be associated with negative perceptions of social interactions and cognitive hypervigilance for social threats (Gardner, Pickett, Jefferis, & Knowles, 2005). Further, lonely people expect more negative social interactions, anticipate rejection, and show a lower reward response to positive stimuli (Cacioppo & Hawkley, 2009; Hawkley & Cacioppo, 2010). Also, two daily life studies found that trait loneliness is associated with increased negative affect (NA) levels in response to negatively appraised company (Hawkley, Preacher, & Cacioppo, 2007; van Roekel et al., 2013). On the other hand, lonely adolescents report higher positive affect (PA) levels in the presence of positive appraised company in daily life in comparison with less lonely adolescents (van Roekel et al., 2013).

On the behavioral level, loneliness is positively associated with doing things in solitude (Queen, Stawski, Ryan, & Smith, 2014). One study showed that lonely women spent less time interacting with men and women than nonlonely women. Lonely men though, interacted more often with other men but less with women than nonlonely men (Hawkley, Burleson, Berntson, & Cacioppo, 2003).

In concordance with loneliness, objective social isolation is also associated with the development of MDD (Matthews et al., 2016). Further, low social support in interaction with shyness predicted an increase in depressive symptoms and a decrease in positive affect after five weeks, in which loneliness served as a mediator (Joiner, 1997). However, the association of loneliness with MDD appears stronger than the association between objective social isolation and MDD (Matthews et al., 2016). This may be explained by findings that suggest being alone can also have some benefits for well-being (Larson, 1997). For instance, adolescents who spent an intermediate amount of their time

alone in daily life were better adjusted than adolescents who spent little or much time alone (Larson, 1997).

Transactional models emphasize the dynamic nature of loneliness and other social states. For instance, the sociocognitive model of loneliness is based on an evolutionary approach stating that the aversive feelings of state loneliness motivate people to reconnect with others (Cacioppo, Cacioppo, & Boomsma, 2014). Some have referred to this mechanism as the reaffiliation motive (RAM; Qualter et al., 2015). According to the RAM model, state (or transient) loneliness becomes prolonged (or trait) loneliness when people tend to negatively interpret social information after feeling lonely and afterward seek behavioral confirmation through further social withdrawal. These dynamics may maintain or even heighten levels of state loneliness and result in an increase in negative affect (Cacioppo et al., 2014; Qualter et al., 2015). It may be the case, therefore, that the subtle dynamics between feeling lonely, being alone, and negatively appraising social company in daily life are relevant for developing more trait loneliness and subsequently increase the risk for the occurrence of an episode of MDD.

To date, only one study involving adolescents has examined temporal relations, with the use of time lags, between social contexts and fluctuating levels of loneliness in daily life (van Roekel, Scholte, Engels, Goossens, & Verhagen, 2015). This report showed that adolescents experienced higher levels of loneliness when they were alone than in the company of others. Although this study in daily life provides insight into the relationship between (state) loneliness and various environmental factors, no study has examined how this relationship is associated with the development of MDD. Examination of differences in the temporal associations between state loneliness, being alone, and appraisals of social company in participants that do and do not make the transition to a MDD may help elucidate the role of loneliness as a risk factor for MDD.

In the current study, using experience sampling methodology (ESM) (Myin-Germeys et al., 2009), we aimed at addressing three research questions. First, we were interested if daily life dynamics between state loneliness, negative appraisals of social company, and being alone represent a self-reinforcing loop that may contribute to the development of prolonged or trait loneliness. Therefore, we focused on the temporal relation of these social elements in daily life between two consecutive moments, referred to as moment $(t - 1)$ and moment (t).

Second, we were interested if these daily life dynamics between state loneliness, negative appraisals of social company, and being alone play a role in the development of MDD. Therefore, differences are examined in the temporal relation of these social elements between two consecutive moments in individuals who did and did not make the transition to an episode of MDD at 20 months follow-up.

Finally, we examined whether loneliness, negative appraisals of social company, or a high frequency of being alone in daily life predicted the development of MDD after a follow-up period of 20 months.

METHOD

Participants

Data were derived from 621 female individuals who were part of a longitudinal, general population twin study. Subjects were aged 18 to 61 years. They were recruited by mail (for details, see Jacobs, Myin-Germeys, Derom, Vlietinck, & van Os, 2005) from the East Flanders Prospective Twin Survey (EFPTS) and from birth registers of Flemish municipalities in Belgium. The EFPTS population-based survey has prospectively recorded all multiple births in the province of East Flanders since 1964 (Derom et al., 2013). Subjects were White and of Belgian origin. The local ethics committee approved the study. All participants gave written informed consent. Given evidence for qualitative differences in

the type of environmental stressors that are associated with depression in men and women, the sample was female only (Kendler, Thornton, & Prescott, 2001). In this study, the ESM was completed at baseline, as were additional measurements of psychopathology. Furthermore, participants completed a follow-up assessment with measurements of psychopathology. The average number of days between baseline and follow-up was 621 (*SD* = 35 days; min = 520 days, max = 786 days).

Experience Sampling Method Procedure

ESM is a procedure to assess participants in their daily living environment, providing repeated in-the-moment assessments of affect in a prospective and ecologically valid manner (Myin-Germeys et al., 2009). Participants received a digital wristwatch and a set of ESM self-assessment forms collated into a booklet for each day. The wristwatch was programmed to emit a signal (i.e., a beep) at an unpredictable moment during each of ten 90-minute time blocks between 7:30 a.m. and 10:30 p.m., on five consecutive days, resulting in a maximum of 50 beeps per person. The study used a semirandom beep design (random beeps within fixed intervals) to prevent anticipatory behavior of participants. After each beep, participants were asked to fill out the ESM self-assessment, collecting reports of current mood and context. All self-assessments were rated on 7-point Likert scales. Participants were instructed to complete their reports immediately after the beep, thus minimizing memory distortion, and to record the time at which they completed the form. Participants with less than 17 valid reports (out of 50) were excluded from the analysis, as previous work has shown that measures of individuals with less than 30% of completed reports are not reliable (Delespaul, 1995). Further, all reports not completed within 15 minutes of the actual beep were also considered invalid, as previous work (Delespaul, 1995) has shown that reports completed after this interval are less reliable and consequently less valid.

Measurements

Being Alone

At each beep, participants were asked to indicate whether they were alone or in company (hereafter: 0 = not alone; 1 = alone).

Appraisal of Social Company

At each beep, participants appraised pleasantness of the company of others with the item "I like this company," which they rated on a 7-point Likert scale ranging from 1 (*Not at all*) to 7 (*Very much*). The scale was reversed so that higher scores represent higher disliking of being in that company (hereafter referred to as appraisal of social company).

State Loneliness

At each beep, participants were asked "Do you feel lonely?" They rated their answers on a 7-point Likert scale ranging from 1 (*Not at all*) to 7 (*Very*).

Trait Loneliness

The trait loneliness measure was constructed by calculating the mean level of the item "I feel lonely" over the repeated ESM measurements for each participant.

Measurement of Depressive Symptomatology

The Structured Clinical Interview for *DSM*-IV Axis I disorders (SCID-I) (First, Spitzer, Gibbon, & Williams, 1995) was administered to obtain current and lifetime diagnoses of MDD. The SCID was administered at baseline (current and lifetime) and follow-up (current and baseline follow-up interval) yielding current and past diagnoses of MDD. Trained research psychologists or graduate psychological assistants administered all interviews. We created a transition and no transition to MDD group. Participants who did not meet the

Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (*DSM*-IV), criteria of MDD at any time point from baseline to follow-up formed the no transition to MDD group. Participants who did not meet the criteria of MDD at baseline but developed MDD between baseline and follow-up formed the transition to MDD group.

Statistical Approach

Momentary ESM data were analyzed using multilevel regression techniques, which take the hierarchical structure of the data into account. The sample consisted of twin pairs, resulting in a further level of clustering. Thus, in the current study, repeated momentary measurements (level 1) were clustered within subjects (level 2), who were members of a twin pair (level 3). The Stata v.12.1 procedures XTMIXED (StataCorp., 2011) (for continuous variables) and XTMELOGIT (for dichotomous variables) were used to estimate fixed effects with random intercepts, random slopes, and an unstructured covariance matrix. A significance level of $p < 0.05$ was used (two-sided).

For our first research question, we explored the relationships between state loneliness, appraisal of social company, and being alone in daily life with the use of time-lagged analyses within participants. ESM data are ideally suited to explore the dynamic within-subject temporal associations between social states at moment $(t - 1)$ and at moment (t) with the use of time lags. All variables were person-mean centered. A recently developed combination of vector autoregressive modeling (VAR) and multilevel modeling by Bringmann was applied (Bringmann et al., 2013). A multilevel-VAR approach may help overcome the difficulties that accompany the analysis of nested longitudinal data. A VAR model is a multivariate extension of an autoregressive (AR) model. An AR model is typically applied to a repeatedly measured variable obtained from a single subject. In this way, the time dynamics within an individual are modeled. An AR model can be considered a regression model in which a variable at moment (t) is regressed to a lagged, measured at a previous moment $(t - 1)$, version of that same variable (Bringmann et al., 2013). In VAR the time-lagged associations are modeled for multiple variables in our analyses: *being alone, loneliness*, and *appraisal of company*. Thus, these variables are regressed on a lagged version of the same variable and all other variables of the multivariate system. Using a combination of a VAR model with a multilevel model, time dynamics can be modeled at an individual and at a group level, because the multilevel model allows the VAR coefficients to differ across individuals (Bringmann et al., 2013). These dynamics can be visualized as a network, as presented in Figure 1, in which the connections between nodes represent the time-lagged associations between being alone, appraisal of social company, and loneliness.

Second, we explored differences in time-lagged relationships of state loneliness, appraisal of social company, and being alone in daily life between a transition and a no-transition to MDD group at follow-up using multilevel VAR methods.

Last, we investigated which of the daily life social states could predict the transition to MDD at follow-up. For this research aim, the associations between loneliness, appraisal of social company, and being alone on one hand and follow-up *DSM*-IV diagnosis of depression on the other hand were examined with the use of linear regression. These analyses were corrected for the level of depressive symptoms at baseline (SCL-90-R depression subscale, without the item "feeling lonely").

RESULTS

Subject Characteristics

Of the total subject sample of 621 white females, 610 participated in the ESM procedure. Thirty-one subjects were excluded because they filled in less than 30% valid ESM self-reports (Delespaul, 1995). This

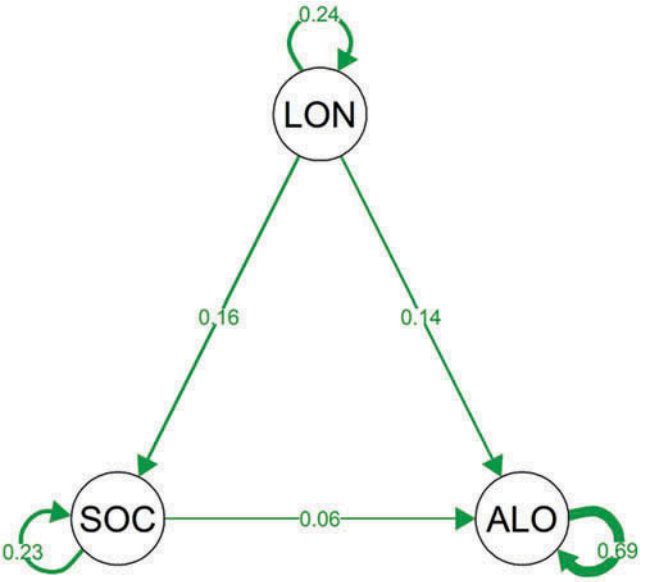

FIGURE 1. The time-lagged associations between loneliness, negative appraisals of social company, and being alone visualized in a network;LON = loneliness; SOC = negative appraisals of social company; ALO = being alone. The arrows indicate the time-lagged effects [moment (t – 1) → moment (t)] between momentary experiences of loneliness, appraisal of social company and being alone. The arrows that start at the same circle as where they end reflect autoregressive coefficients of the particular variable. Only significant effects are shown. The thicker the arrow, the stronger the association is. Positive associations are depicted with a solid line. There were no negative associations present. The fixed effects sizes (the ß coefficients in the multilevel regression analyses) are shown in the figure.

resulted in a subject sample of 579 female participants. Out of 579 participants, 26 participants fulfilled criteria for a major depressive episode at baseline and were therefore excluded. Of the remaining 553 participants, SCID-I diagnoses were available for 417 participants (75%) at follow-up (T4). This resulted in a data set of 417 participants, of which 58 met the *DSM*-IV criteria of MDD at some point in time from baseline to follow-up (transition group).

Table 1 shows the baseline descriptive statistics for the transition group and the no-transition group. The transition group was slightly older and lived significantly more often alone or as a single parent. Further, their level of subthreshold depressive symptoms was significantly higher compared to the no-transition group.

Aim 1: Temporal associations between momentary loneliness, being alone, and appraisal of social company in all participants[1]

Figure 1 visualizes the relationships between being alone, appraisal of social company, and loneliness in the form of a network. The results showed that feeling lonely at moment (t – 1) is associated with a higher frequency of being alone and an increase in negative appraisals of social company at moment (t). Negative appraisals of social company at moment (t – 1) were associated with being more frequently alone at moment (t). Being alone at moment (t – 1) was not associated with feelings of loneliness at moment (t) or appraisal of social company at moment (t). Last, significant self-loops (autocorrelations) were present for all three variables.

TABLE 1. Descriptive Statistics of the No-Transition and Transition Group at Baseline.

	No Transition to MDD Group	Transition to MDD Group	Difference
Age (years, *SD*)	26.9 (7.2)	29.4 (7.3)	$t = -2.434$, $df = 414$, $p = 0.015$
Educational level (%)			$\chi^2 = 4.190$, $df = 3$, $p = 0.242$
College or university degree	64.6	55.1	
Secondary education	33.9	43.8	
Primary education	1.5	1.1	
Being employed (%)	58.50	65.50	$\chi^2 = 1.021$, $df = 1$, $p = 0.312$
Living situation (%)			$\chi^2 = 28.733$, $df = 5$, $p < 0.001$
With partner	48.2	53.8	
With parents	46.4	27.2	
Living alone	3	7.8	
Single parent	0.6	9.2	
Other	1.8	2	
Depressive symptoms (1–5, *SD*)	1.34 (0.02)	1.67 (0.08)	$t = -5.432$, $df = 413$, $p < 0.001$

Note. MDD = major depressive disorder.

Aim 2: Temporal associations between momentary loneliness, being alone, and appraisal of social company, and the development of MDD

Figures 2a and 2b visualize the relationships between being alone, appraisal of social company, and loneliness in the form of a network for the no-transition (Figure 2a) and the transition group (Figure 2b). Negative appraisals of social company at moment ($t - 1$) were associated with an increase in being alone at moment (t) in the transition group but not in the no-transition group. Loneliness at moment ($t - 1$) was associated with an increase in negative appraisals of social company at moment (t) and an increase in being alone at moment (t) in the no-transition group but not in the transition group.

Aim 3: Trait loneliness, appraisal of social company, and being alone, and the development of MDD

Trait loneliness was significantly predictive of MDD at follow-up ($B = 0.235$, $p = 0.001$). Even after controlling for the level of depressive symptoms at baseline the effect was reduced but remained borderline significant ($B = 0.132$, $p = 0.053$). The frequency of being alone ($B = 0.106$, $p = 0.424$) and negative appraisals of social company ($B = 0.160$, $p = 0.315$) were not predictive for the development of MDD at follow-up.

DISCUSSION

This article examined how daily life dynamics between loneliness, appraisal of social company, and being alone are associated with the later development of MDD. This section presents main findings of this study. First, people who made a transition to MDD by follow-up showed different baseline momentary dynamics than those who did not: In the transition group, negative appraisals of social company were followed by the behavioral change of being more frequently alone (avoiding social contact), while this was not the case in the no-transition group. No evidence was found for a self-reinforcing loop between loneliness, negative appraisals of social company, and being alone in the development of MDD. Finally, feelings of loneliness predicted the development of MDD, even after correcting for the

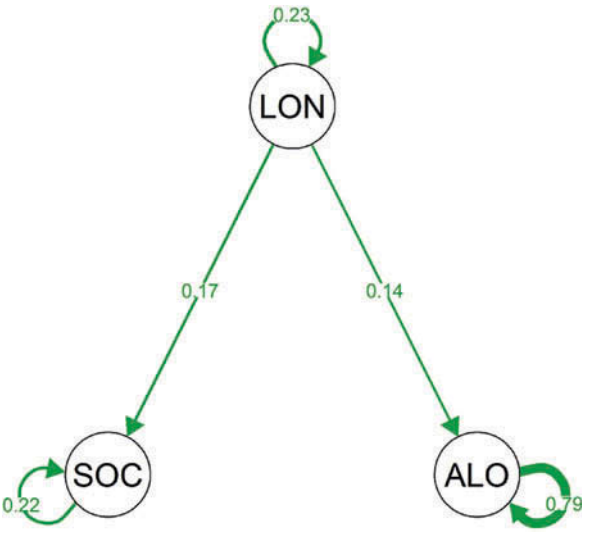

FIGURE 2A. The time-lagged associations between loneliness, negative appraisals of social company, and being alone visualized in a network for the no-transition group. LON = loneliness; SOC = negative appraisals of social company; ALO = being alone. The arrows indicate the time-lagged effects [moment (t – 1) → moment (t)] between momentary experiences of loneliness, appraisal of social company, and being alone. The arrows that start at the same circle as where they end reflect autoregressive coefficients of the particular variable. Only significant effects are shown. The thicker the arrow, the stronger the association is. Positive associations are depicted with a solid line. There were no negative associations present. The fixed effects sizes (the ß coefficients in the multilevel regression analyses) are shown in the figure.

subclinical level of depressive symptoms at baseline.

State Loneliness and the Temporal Associations With Negative Appraisals of Social Company and Being Alone

The temporal associations of interest are snippets (a given moment to the next) and collected at various points in time over the course of five days. These time-lagged associations showed that, on average, people tend to withdraw from social situations and appraise their company more negatively after feeling lonely. According to the RAM model, limited social withdrawal after feeling lonely can be very functional. Withdrawing from the initial social situation may help people increase their attention to social stimuli in order to be able to reconnect with other people (Qualter et al., 2015). It is postulated that by withdrawing from social situations, people are able to determine the level of threat and choose the most appropriate way to reaffiliate with others (Cacioppo & Hawkley, 2009). Nevertheless, according to the RAM model and the sociocognitive model of loneliness, a negative self-reinforcing loop in daily life may be responsible for the transition from state to trait loneliness. It is hypothesized that, in trait lonely people, feeling lonely is followed by an overattentiveness of social cues and a negative interpretation of social information, and next, by further social withdrawal. This may result in an increase of negative affect and, ultimately, the risk of prolonged or trait loneliness (Qualter et al., 2015).

In our study, support was found for the hypotheses that state loneliness is followed by negative appraisals of social company, and also that negative appraisals of social company were associated with a pattern of social withdrawal. No evidence was found for the

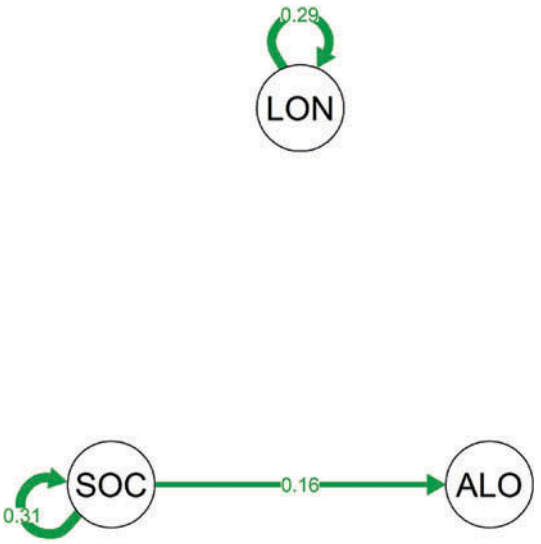

FIGURE 2B. The time-lagged associations between loneliness, negative appraisals of social company, and being alone visualized in a network for the transition group. LON = loneliness; SOC = negative appraisals of social company; ALO = being alone. The arrows indicate the time-lagged effects [moment (t – 1) → moment (t)] between momentary experiences of loneliness, appraisal of social company, and being alone. The arrows that start at the same circle as where they end reflect autoregressive coefficients of the particular variable. Only significant effects are shown. The thicker the arrow, the stronger the association is. Positive associations are depicted with a solid line. There were no negative associations present. The fixed effects sizes (the ß coefficients in the multilevel regression analyses) are shown in the figure.

assumption that social withdrawal leads to an increase in loneliness. Based on the RAM model framework, one can postulate that it could be adaptive to withdraw from social contact with others if the quality of this company is poor. Being together with negatively appraised social company can be more loneliness inducing than the absence of social interactions.

Nevertheless, a pattern of social withdrawal may limit possibilities to reconnect with others. Another study reported, for instance, that trait-lonely children who showed a pattern of general social withdrawal became more deficient in social skills over time, which may have contributed to the maintenance of trait loneliness (Schinka, van Dulmen, Mata, Bossarte, & Swahn, 2013).

Thus, it could be that these microlevel dynamics between loneliness, negative appraisals of social company, and social withdrawal in daily life put people at risk for developing an episode of MDD. Our comparison of the time-lagged analyses, as discussed in the next section, between a transition and a no-transition to MDD group provided more clarity on this issue.

State Loneliness and the Temporal Associations With Negative Appraisals of Social Company and Being Alone in the Development of MDD

Negative appraisals of social company were followed by social withdrawal approximately one and a half hours later in the transition group but not in the no-transition group. Thus, social withdrawal after negative appraisals of social company may be an important component in the trajectory toward developing a depressive episode. These findings are in line with earlier reports showing that a lack of pleasurable engagement and social withdrawal could function as a predictor for depression onset both in

adults as in adolescents (Morgan, Shaw, & Forbes, 2013; Silk et al., 2007).

Several explanations can be formulated for this moment-to-moment microlevel interplay in daily life. According to the operant conditioning paradigm, more negative appraisals of social company may result in the experience that seeking social contact provides no positive reinforcers (Skinner, 1938). Thus, seeking social contact may lessen over time and may lead to a general pattern of social withdrawal. Next, it could be argued that people withdraw to reduce social threat, but after doing so they diminish the possibility to experience positive social interactions, which may increase the risk for depression. Also, participants in the transition to MDD may lack important social skills to reaffiliate with others after appraising their company more negatively (Hames, Hagan, & Joiner, 2013).

Surprisingly, in contrast to the no-transition group, feeling lonely did not have a dynamic impact on being alone or the appraisal of social company in the transition group. In the transition group, state loneliness did not function as a starting point for the onset of a negative self-reinforcing loop that leads to the development of MDD. Nevertheless, multiple reports have shown an association between trait loneliness and the onset of MDD. It could be speculated that trait-lonely people have developed a dysfunctional way of persistent withdrawing during their life span to cope with frequent disappointing social experiences, as described previously (Qualter et al., 2015), independent of their momentary feelings of loneliness. Some eye-tracking studies in children and young adults found some evidence for this assumption (Bangee, Harris, Bridges, Rotenberg, & Qualter, 2014; Qualter et al., 2013). Namely, lonely children showed problems in disengaging, whereas lonely adolescents showed a clear avoidance of social threat.

Although feeling lonely is not associated with changes in appraisal of the company or being alone one moment later in the transition group, high autocorrelations of loneliness and negative appraisals of social company were present. This suggests that levels of loneliness are maintained over time and seemed to be more persistent to change in the transition group than in the no-transition group. These results are in line with earlier research providing evidence that high emotional inertia, which reflects that a current emotional state is predictable from one's prior emotional state (autocorrelations), predicted the development of MDD (Kuppens et al., 2012). High emotional inertia suggests that the emotional state is less easily influenced by the environment or emotion regulation efforts, which results in slower dynamics and can be seen as early warning signs of the development of depression (van de Leemput et al., 2014).

Investigating cumulative patterns over hours or even days between state loneliness, negative appraisals of social company, and being alone may give a perspective on how these social dynamics relate to one another in daily life. Studying multiple snippets over time gives the possibility to come as near as possible to construct a film, rather than a snapshot, of temporal dynamics within (lonely) people that make the transition to MDD.

In terms of prevention of MDD, it could be suggested that it is beneficial to redirect the attention to social cues that contribute to positive interpersonal behavior (Lucas, Knowles, Gardner, Molden, & Jefferis, 2010). Further, interventions could aim to target negative social appraisals and other, more positive, behavioral responses to establish more positive social experiences. This suggestion is supported by evidence showing that it is important in psychotherapies for MDD (e.g., cognitive-behavioral or interpersonal psychotherapy) to highlight and help people discover negative social cognitions, emotions, and behaviors that hinder people from reconnecting with others (Cacioppo et al., 2015; Masi, Chen, Hawkley, & Cacioppo, 2011).

Trait Loneliness, Negative Appraisals of Social Company, and Being Alone in Relation to Follow-Up MDD

The longitudinal design of our study made it possible to explore whether loneliness, negative appraisals of social company, or being alone could predict MDD at follow-up. We replicated that trait loneliness in daily life was associated with MDD at follow-up, even after controlling for depressive symptoms at baseline. This finding is in concordance with some previous reports that found loneliness predicted increases in depressive symptoms, also after correcting for the initial levels of depressive symptoms (Cacioppo et al., 2010; Cacioppo et al., 2006; Heikkinen & Kauppinen, 2004). Our replication is of particular interest because it shows that loneliness in daily life is associated with the development of a depressive episode after 20 months.

Methodological Issues

Some characteristics of this sample that may have influenced the findings should be addressed. Subjects were female with a high mean educational level. Therefore, the results of the study may not generalize to men and those with lower educational level.

Differences in means or variances of the social elements under investigation between the transition and the no-transition group could potentially, by means of floor or ceiling effects, differentially influence the strength of the networks connections in each of the two groups. Only loneliness, however, did differ at baseline between the groups and was higher in mean and variance in the transition group. However, we did not observe stronger connection strengths toward or starting from the node "lonely" in the transition group compared to the no-transition group. Therefore, it is unlikely that this difference biased our results.

Further, we administered a SCID-I at follow-up to assess the development of MDD. It is possible that we missed some participants who fulfilled the diagnostic criteria of a MDD from baseline to follow-up. Our results are therefore a conservative estimate of the differences between the transition and no-transition groups. Next, the definition of trait or chronic loneliness, using the mean level of "I feel lonely," gives some limitations. No test-retest reliability data are available on our measurement of trait loneliness. On the other hand, measuring state loneliness multiple times during consecutive days has also advantages in terms of validity. An attrition rate of 33% from baseline to follow-up can give some limitations to the study. Post hoc analyses showed though that the nonparticipating 136 subjects at T5 did not differ significantly from the other 417 participants on our main outcome measures, which suggests that the attrition rate did not negatively influence the reliability of our results.

NOTES

1 The logistic regression models estimated for the overall network and the network for the no-transition group (outcome variable: being alone) could not be estimated with all random slopes included. This was resolved after removal of the random slope for appraisal of social company (not after removal of other random slopes). For these specific models we thus reported the results without inclusion of the random slope for appraisal of social company.

ORCID

Mark van Winkel http://orcid.org/0000-0002-4669-965X

Inez Myin-Germeys http://orcid.org/0000-0002-3731-4930

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