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# Internalizing Problems in Adolescence: Linking Loneliness, Social Anxiety Symptoms, and Depressive Symptoms Over Time

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## Abstract

Adolescents are particularly vulnerable to experiencing loneliness, social anxiety symptoms, and depressive symptoms. These internalizing problems often co-occur but, until now, it remains unclear how they are associated over time. Insight in these temporal sequences is important to enhance our understanding of how internalizing problems arise and may reinforce each other over time. To examine these temporal sequences, three samples of adolescents were used: Sample 1 consisted of 1,116 adolescents (48.97% girls, $M_{age} = 13.59$), Sample 2 of 1,423 adolescents (52.42% girls, $M_{age} = 13.79$), and Sample 3 of 549 adolescents (62.66% girls, $M_{age} = 14.82$). Adolescents filled out well-established self-report measures of loneliness, social anxiety symptoms, and depressive symptoms during regular school hours at three measurement occasions with a 1-year interval. Meta-analytic techniques were used to estimate the average true effects across three-variable autoregressive cross-lagged models in the three samples. In addition, indirect effects and gender differences in the temporal associations were explored in all three samples. The results suggest that social anxiety symptoms play a crucial role as potential antecedent of emerging feelings of loneliness and depression in adolescence. In addition, in line with theoretical expectations, our results suggest the presence of a vicious cycle between adolescents' feelings of loneliness and social anxiety symptoms. The indirect effects were inconsistent across samples and no gender differences were found. These findings shed more light on the unique temporal relationships among different internalizing problems. Clinical interventions should target social anxiety symptoms to prevent feelings of loneliness and vice versa.

**Keywords** Loneliness · Social anxiety symptoms · Depressive symptoms · Temporal sequence · Adolescence

Adolescence is a challenging developmental period that is characterized by multiple social, physical, and cognitive changes (Steinberg and Morris 2001), which may explain the increased prevalence of internalizing symptoms during this phase of life (Reitz et al. 2005). The present study focuses on three types of internalizing problems that are common in adolescence (Graber and Sontag 2009), that is, loneliness, social anxiety symptoms, and depressive symptoms. These internalizing problems often co-occur (Epkins and Heckler 2011; Mahon et al. 2006; Zahn-Waxler et al. 2000) and this co-occurrence has been associated with more social and academic difficulties, greater life dissatisfaction (Newman et al. 1998), and overall impairment (Karlsson et al. 2006).

Although it is well-known that loneliness, social anxiety symptoms, and depressive symptoms co-occur, less is known about the dynamic aspects of the co-occurrence of these internalizing symptoms over time. Insight in the direction of effects among loneliness, social anxiety symptoms, and depressive symptoms is important to enhance our understanding of the developmental ordering of these symptoms. Some symptoms may precede others or there could be a vicious cycle among the different types of internalizing symptoms.

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Therefore, the current study aims to investigate the prospective associations among loneliness, social anxiety symptoms, and depressive symptoms in adolescence. These associations are examined in three large samples of adolescents from the general population in order to test for the robustness of the findings.

## Loneliness, Social Anxiety Symptoms, and Depressive Symptoms in Adolescence

Loneliness is the negative feeling that people experience when they perceive their social relationships as unsatisfying, either quantitatively or qualitatively (Perlman and Peplau 1981). In general, loneliness peaks during adolescence (Qualter et al. 2015) and it is associated with a wide range of maladaptive outcomes, both physical (for a review see Hawkley and Capitanio 2015) and mental (for a review see Heinrich and Gullone 2006).

Social anxiety is characterized by a prominent fear of one or more social situations in which the person is exposed to unfamiliar others or possible scrutiny by others (American Psychiatric Association 2013). Individuals with social anxiety symptoms worry that they will behave in a particular way or show anxiety symptoms (e.g., blushing or a trembling voice) that will elicit negative evaluation by others. Therefore, adolescents with social anxiety symptoms exhibit a tendency to avoid social situations or to endure social situations with intense fear or anxiety (Ranta et al. 2015). Social anxiety symptoms are common in adolescence (Alfano and Beidel 2011), persist throughout as well as beyond adolescence (Kessler et al. 2012; Nelemans et al. 2014), and significantly impair adolescents' well-being, interpersonal relationships, and academic performance (for a review see Ollendick and Hirshfeld-Becker 2002).

Depressive symptoms include, among others, irritability, depressed mood, loss of interest and pleasure in activities, loss of confidence, and sleeping difficulties (American Psychiatric Association 2013). Depressive symptoms are also highly prevalent in adolescence (Saluja et al. 2004; Wartberg et al. 2018) and are associated with a wide range of negative outcomes including adult psychopathology, suicidal behavior, physical health problems (Thapar et al. 2012), and interpersonal difficulties (Allen et al. 2006; Stice et al. 2004; Vujeva and Furman 2011).

Despite their strong associations, factor analytic studies have shown that loneliness, social anxiety, and depression are distinct concepts (Danneel et al. 2019; Fung et al. 2017). In addition, they are differentially associated with various domains of functioning (Hutcherson and Epkins 2009; La Greca and Harrison 2010; Starr and Davila 2008). For instance, social anxiety is more strongly associated with peer variables when controlled for depressive symptoms and depressive symptoms, in turn, are more strongly associated with family variables when controlled for social anxiety (Starr and Davila 2008).

Until now, numerous studies have focused on co-occurrence rates and consequences, but it remains unclear how these internalizing symptoms evolve together over time. In other words, the temporal ordering of these internalizing symptoms and how they reinforce each other in adolescence remains unclear.

## Prospective Associations Among Loneliness, Social Anxiety Symptoms, and Depressive Symptoms

With the exception of a single study (Lim et al. 2016), earlier studies have examined temporal associations between just two, rather than three, types of internalizing symptoms. Regarding the temporal association between social anxiety and depression, most studies indicate that social anxiety disorder precedes clinical depression in adolescents (Aune and Stiles 2009; for reviews see Cummings et al. 2014; Schleider et al. 2014). At the same time, although less consistently found in the literature, depression might also precede social anxiety in adolescence (for a review see Cummings et al. 2014). Empirical findings regarding the temporal association between loneliness and depressive symptoms are mixed. One study found a reciprocal association over time between loneliness and depressive symptoms (Vanhalst et al. 2012), whereas other studies showed no temporal associations (Weeks et al. 1980) or temporal associations in one direction only, either from loneliness to depressive symptoms (Cacioppo et al. 2010) or vice versa (Lasgaard et al. 2011). Empirical studies about the direction of effects between social anxiety symptoms and loneliness, in turn, are scarce. To the best of our knowledge, only two empirical studies were conducted. A study in adults found that loneliness and social anxiety symptoms entertained a reciprocal relationship over time (Lim et al. 2016) and another study on adolescents found that social anxiety symptoms precede loneliness (Gallagher et al. 2014).

Based on theoretical reasoning, it might be expected that all pairs of internalizing symptoms are reciprocally associated over time. Specifically, given the strong interpersonal components of loneliness, social anxiety symptoms, and depressive symptoms (Hankin 2006; Epkins and Heckler 2011; Heinrich and Gullone 2006), several interpersonal mechanisms have been proposed to explain the potential bidirectional associations. For instance, the interpersonal behaviors that are typical for individuals experiencing loneliness, social anxiety symptoms, or depressive symptoms, such as a heightened sensitivity for signs of potential social threat (Qualter et al. 2015), social withdrawal (for reviews see Cummings et al. 2014; Schleider et al. 2014), and excessive reassurance seeking

(for a review see Hankin 2006), respectively, might explain potential temporal relationships among these internalizing symptoms.

Most research has focused on the temporal associations between two types of internalizing symptoms. Examining the three internalizing symptoms simultaneously will provide insight into their unique relations with each other (e.g., loneliness and social anxiety symptoms) while controlling for the other type of problems (e.g., depressive symptoms). This knowledge could inform theoretical models on the development of these internalizing symptoms in youth and could improve clinical work intended to alleviate internalizing problems in adolescents. Specifically, unravelling which internalizing symptoms precede others might guide clinicians in determining their primary focus of intervention and might result in more targeted prevention of subsequent internalizing problems.

## Integrating Earlier Research Into A Comprehensive Three-Problem Model

Theoretical work on the longitudinal associations among loneliness, social anxiety symptoms, and depressive symptoms is limited. However, the cumulative interpersonal risk model of Epkins and Heckler (2011) states that loneliness mediates the temporal relationship from social anxiety to depression. Specifically, the social relationship problems associated with social anxiety, such as the absence of friendships or low-quality friendships, are believed to increase feelings of loneliness, which in turn increase the risk for depressive symptoms (Epkins and Heckler 2011). Similarly, other authors have also hypothesized that loneliness mediates a possible temporal relationship from social anxiety to depression (Schleider et al. 2014). The avoidance behavior typical for individuals with social anxiety might weaken friendships, which might result in loneliness and subsequent feelings of hopelessness and depression. Starr and Davila (2008) also briefly mentioned that loneliness might mediate the temporal relationship between social anxiety and depression, but they did not specify the direction of effects or their underlying mechanisms any further.

Empirical studies on prospective relationships among loneliness, social anxiety symptoms, and depressive symptoms as assessed in a comprehensive three-problem model are scarce, especially in adolescence. Results of one longitudinal study on children and adolescents suggest reciprocal relationships between loneliness and social anxiety as well as loneliness and depression, but not between social anxiety and depression, in terms of bivariate correlations (Prinstein and La Greca 2002). A study on adults that specifically investigated the direction of effects among the three internalizing symptoms (Lim et al. 2016) found that (a) loneliness preceded depressive symptoms, but not vice versa, (b) the relationship between loneliness and social anxiety over time was reciprocal, (c) depressive symptoms preceded social anxiety, but not vice versa, and (d) in line with the theoretical ideas described earlier (Epkins and Heckler 2011; Schleider et al. 2014; Starr and Davila 2008), social anxiety symptoms predicted depressive symptoms through loneliness, but not vice versa.

## Gender Differences

Gender differences in depressive symptoms are well established, with adolescent girls generally experiencing higher mean levels of depressive symptoms compared to boys from approximately age 13 onwards (Twenge and Nolen-Hoeksema 2002; Wade et al. 2002). For social anxiety symptoms, the existing research also suggests higher mean levels for girls compared to boys from early adolescence onwards (Nelemans et al. 2016; Ranta et al. 2007; Storch et al. 2004). By contrast, mean levels of loneliness do not seem to differ between adolescent boys and girls (Maes et al. 2019).

The existence of gender differences in mean levels of social anxiety and depressive symptoms does not necessarily imply that the associations among these internalizing problems differ for boys and girls over time. Clear theoretical predictions regarding gender differences in the temporal patterns among loneliness, social anxiety, and depressive symptoms are lacking. A hypothesis may be that, if these internalizing problems are prospectively linked to one another through interpersonal mechanisms, the prospective associations could be stronger for girls than for boys given the heightened salience of interpersonal relationships in girls (Rose and Rudolph 2006). However, empirical studies investigating gender differences in the temporal patterns among these internalizing problems are limited. Some studies did investigate whether the temporal patterns between adolescent loneliness and depressive symptoms differed for boys and girls and found that this was not the case (Lasgaard et al. 2011; Vanhalst et al. 2012).

## The Current Study

The current study aimed to extend earlier research on adolescents by investigating the temporal sequence among loneliness, social anxiety symptoms, and depressive symptoms in a comprehensive three-variable three-wave autoregressive cross-lagged model. These relations were first examined in three longitudinal samples and subsequently synthesized to obtain an average true effect estimate across the samples. In line with the results of Lim et al. (2016), we tentatively expected that in the comprehensive model social anxiety symptoms, and not depressive symptoms, would be associated with future loneliness. In addition, again in line

with Lim et al. (2016) who found that loneliness is a risk factor for poorer mental health outcomes over time and given that loneliness shows unique associations with both social anxiety and depression (Epkins and Heckler 2011), we tentatively expected loneliness to be associated with future depressive symptoms and social anxiety symptoms (see Fig. 1).

Additionally, the current study examined both indirect effects and gender differences in the temporal associations among the internalizing problems in all three adolescent samples. Regarding indirect effects, in line with the interpersonal risk model of Epkins and Heckler (2011), we expected that loneliness would mediate the temporal relationship from social anxiety symptoms to depressive symptoms (see Fig. 1). In addition to this specific theoretically expected mediational effect, we explored all other possible indirect effects comprising the three internalizing problems. Specifically, we tested whether one of the internalizing problems at the first measurement occasion predicted another internalizing problem at the third measurement occasion through again another internalizing problem at the second measurement occasion. Regarding gender differences, the current study aimed to examine gender differences in the temporal associations among these internalizing problems, again in three-variable three-wave autoregressive cross-lagged models. Given limited research on this matter, we examined gender differences in the temporal associations among loneliness, social anxiety, and depressive symptoms in an exploratory way.

## Method

### Participants

Three independent samples of Belgian adolescents were used. In each sample, adolescents participated in a three-wave longitudinal study with annual measurement waves and followed the academic, technical, or vocational track in different secondary schools in Flanders, the Dutch-speaking part of Belgium.

**Sample 1** Data for the first sample were derived from the STRATEGIES study (i.e., Studying Transactions in Adolescence: Testing Genes in Interaction with Envrionments), a longitudinal study on the development of problem behavior in adolescence for which data collection started in February 2012 (for details see Janssens et al. 2015). The sample consisted of 1,116 adolescents (48.97% girls). At Time 1, adolescents were between 11.38 and 17.40 years old with a mean age of 13.79 years (*SD* = 0.94) and attended Grades 7, 8, and 9. The majority of the adolescents were born in Belgium (94.61%) and lived with both their biological parents (79.21%) at T1. At Time 2 and 3, a total number of 990 and 882 adolescents participated in the study, respectively. A total number of 848 (76.99%) adolescents participated in all three measurement waves, 163 (14.61%) participated in two out of three measurement waves, and 97 (8.69%) participated in one wave only. Six participants were excluded from the current analyses because they did not fill out the questionnaires in a reliable way at the first measurement occasion.

**Sample 2** Data for the second sample were derived from the EDA study (i.e., Emotional Development in Adolescence), a large longitudinal study on the emotional development of adolescents for which data collection started in February 2014 (for details see Bastin et al. 2016; Nelis et al. 2016). The sample consisted of 1,423 adolescents (52.42% girls). At Time 1, adolescents were between 11.42 and 18.17 years old with a mean age of 13.59 years (*SD* = 0.98) and attended Grades 7, 8, and 9. The majority of the adolescents had the Belgian nationality (93.39%) and had parents who were married (81.28%) at T1. At Time 2 and 3, a total number of 1,162 (81.66%) and 957 (68.52%) adolescents participated in the

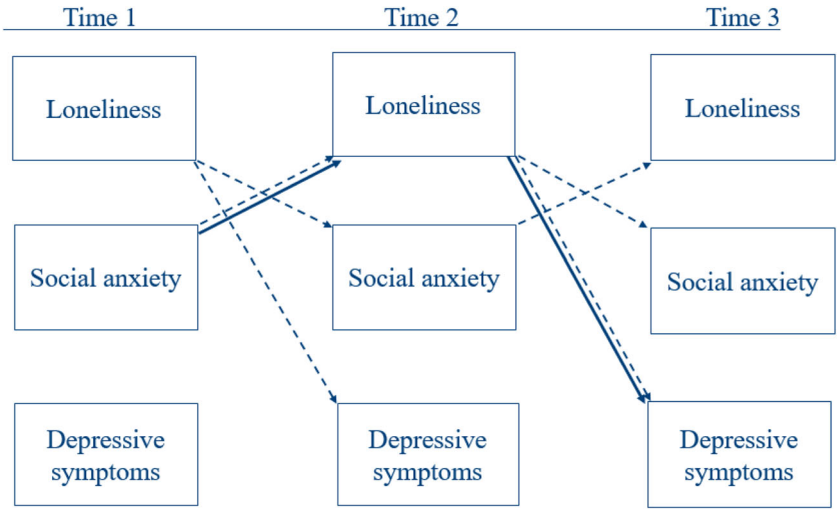


**Fig. 1** Expected temporal associations among loneliness, social anxiety, and depressive symptoms. The expected temporal associations based on the findings of Lim et al. (2016) are depicted using dashed lines. The expected indirect effect stemming from the cumulative interpersonal risk theory of Epkins and Heckler (2011) is depicted in bold

study, respectively. A total number of 916 (64.37%) adolescents participated in all three measurement waves, 305 (21.43%) participated in two out of three measurement waves, and 202 (14.20%) participated in one wave only.

**Sample 3** Data for the third sample were derived from the PALS study (i.e., Personality and Loneliness/Solitude), a large longitudinal study on the development of psychosocial well-being, personality, and identity throughout mid- and late adolescence for which data collection started in February 2010 (for details, see Teppers et al. 2013). The sample consisted of 549 adolescents (62.66% girls). At Time 1, adolescents were between 12 and 17 years with a mean age of 14.82 years (*SD* = 0.79) and attended Grades 9 and 10. The majority of the adolescents lived with both their parents (81.57%) and the majority of adolescents' parents were married (83.06%) at T1. At Time 2 and 3, a total number of 429 (78.14%) and 413 (75.23%) adolescents participated in the study, respectively. A total number of 373 (67.94%) adolescents participated in all three measurement waves, 96 (17.49%) participated in two out of three measurement waves, and 80 (14.57%) participated in one wave only.

**Attrition Analyses** In all three samples, adolescents who dropped out of the study were compared to adolescents who participated in all three measurement waves. As shown in Table 1, in all samples, both groups did not significantly differ from each other in terms of social anxiety symptoms at T1 but adolescents who dropped out reported significantly higher levels of depressive symptoms at T1. Only in Sample 2, adolescents who dropped out of the study reported significantly higher levels of loneliness and a higher average age compared to adolescents who participated in all three measurement waves. In addition, in Samples 2 and 3, a significant difference in gender distribution was found, with more girls than boys participating in all three measurement waves.

**Missing Value Treatment** Across the three measurement waves, 10.98%, 13.95%, and 13.10% of the data were missing in Samples 1, 2, and 3, respectively. In all three samples, participants with and without missing data were compared using Little's missing completely at random test (MCAR; Little 1988). In all samples, the normed $\chi^2$ values were acceptable (i.e., < 3; Ulman 2013). Therefore, data could be considered as missing completely at random and the full information maximum likelihood (FIML) estimator could be used to handle the missing data.

## Procedure

Permission for the STRATEGIES study, the EDA study, and the PALS study was obtained from the Institutional Review Board (IRB) of the Faculty of Medicine, the Social and Societal Ethics Committee (SMEC), and the IRB of the Faculty of Psychology and Educational Sciences, respectively, at the KU Leuven. Prior to data collection, in Samples 2 and 3, adolescents and their parents gave active and passive consent, respectively, and in Sample 1 both adolescents and their parents gave active consent. Participants filled out paper-and-pencil questionnaires in their classroom during regular school hours. A research assistant was present during the test sessions to answer questions and to emphasize the voluntary and anonymous character of participation. Adolescents were informed that they could discontinue their participation at any time. Students who graduated or moved to another school received the questionnaires at home by mail or e-mail in Sample 1 and 3 and were no longer invited to participate in Sample 2.

## Measures

To assess feelings of loneliness, social anxiety symptoms, and depressive symptoms, well-established self-report measures were used in their original or shortened form. In the present study, we used adaptations in Dutch, the native language of the participants. All of these adapted versions have been used extensively in previous studies. Longitudinal measurement invariance has been demonstrated for the various measures used in adolescent[1] (Danneel et al. 2018; Nelemans et al. 2017; Verhoeven et al. 2013) or child samples (Lei et al. 2016), which suggests that meaningful comparisons over time can be made (Vandenberg and Lance 2000).

**Loneliness** In all samples, the peer-related loneliness subscale of the Loneliness and Aloneness Scale for Children and Adolescents (LACA; Goossens 2016) was used to assess feelings of loneliness. The peer-related loneliness subscale consists of 12 items (e.g., "I feel sad because I have no friends" and "I feel left out by my friends"), which are answered on a 4-point Likert scale ranging from 1 (*never)* to 4 (*often).* A total score was computed as the mean of the 12 items with higher scores representing higher levels of loneliness. The percentages of adolescents reporting very high levels of loneliness across the three measurement waves were low (see Online Resource 1). The LACA shows good validity and reliability in terms of internal consistency in samples of Dutch-speaking adolescents with alphas ranging from .87 to .88 (Goossens 2016; Maes et al. 2015). In the present study, Cronbach's alphas across waves were high in all three samples (i.e., 0.86 - 0.91).

[1] Two studies were based on an adolescent sample that was used in the current study as well.

**Table 1** Results of attrition analyses for the main study variables and age and gender in the three samples

| Variable | *F* | *df* | $\eta^2_p$ | $\chi^2$ | *df* | Cramer V |
|---|---|---|---|---|---|---|
| Sample 1 | | | | | | |
| Loneliness T1 | 0.19 | (1, 542) | < 0.001 | | | |
| Social anxiety symptoms T1 | 0.03 | (1, 542) | < 0.001 | | | |
| Depressive symptoms T1 | 6.36** | (1, 542) | 0.012 | | | |
| Age | 0.19 | (1,542) | < 0.001 | | | |
| Gender | | | | 0.90 | 1 | 0.028 |
| Sample 2 | | | | | | |
| Loneliness T1 | 6.84** | (1, 1400) | 0.005 | | | |
| Social anxiety symptoms T1 | 0.07 | (1, 1398) | 0.001 | | | |
| Depressive symptoms T1 | 40.20*** | (1,1421) | 0.030 | | | |
| Age | 11.90** | (1, 1420) | 0.010 | | | |
| Gender | | | | 4.34* | 1 | 0.037 |
| Sample 3 | | | | | | |
| Loneliness T1 | 0.37 | (1, 540) | 0.001 | | | |
| Social anxiety symptoms T1 | 0.93 | (1, 540) | 0.002 | | | |
| Depressive symptoms T1 | 6.79** | (1, 540) | 0.012 | | | |
| Age | 0.35 | (1, 540) | 0.001 | | | |
| Gender | | | | 10.67** | 1 | 0.139 |

** $p < 0.01$. *** $p < 0.001$

**Social Anxiety Symptoms** A Dutch translation of the Social Anxiety Scale for Adolescents (SAS-A; La Greca and Lopez 1998) was used to assess symptoms of social anxiety. In Samples 1 and 2 adolescents filled out the 12-item short version of the SAS-A (see Nelemans et al. 2017) and in Sample 3 the original 18-item version was used (e.g., "I feel shy around people I don't know" and "I worry about what others say about me"). Items are rated on a 5-point Likert scale ranging from 1 *(not at all)* to 4 (*all the time).* A total score was computed as the mean of the 12 or 18 items, with higher scores reflecting higher levels of social anxiety symptoms. The percentages of adolescents reporting clinically significant levels of social anxiety symptoms across the three measurement waves were low (see Online Resource 1). The original version of the SAS-A has shown to be reliable in terms of internal consistency in an English speaking adolescent sample with alphas ranging from 0.76 to 0.91 (La Greca and Lopez 1998). Similar findings have been found for the short version of the SAS-A in two Dutch-speaking samples, that is, Sample 1 and 3 of the current study (Nelemans et al. 2017) with alphas ranging from 0.70 to 0.95. In the present study, Cronbach's alphas across waves were high in all three samples (i.e., 0.90 - 0.92).

**Depressive Symptoms** Depressive symptoms were assessed using the 20-item (Hooge et al. 2000; Radloff 1977) and the 12-item shortened version (Bouma et al. 1995; Roberts and Sobhan 1992) of the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff 1977) in Samples 1 and 3, respectively, and the Child Depression Inventory (CDI; Kovacs 2003; Timbremont and Braet 2002) in Sample 2.

The CES-D measures depressed affect, positive affect, somatic and retarded activity, and interpersonal aspects typical for depressive symptomatology (e.g., "During the past week I enjoyed life", reverse coded, and "During the past week people were unfriendly"). Items are rated on a 4-point Likert scale ranging from 0 (*rarely or never)* to 3 (*mostly or always)*. A total score was computed as the mean of the 12 or 20 items, with higher scores reflecting higher levels of depressive symptoms. Previous research has shown that the 20-item version of the CES-D shows good reliability in terms of internal consistency in a sample of English speaking adolescents (i.e., Cronbach's alpha of 0.88; Siddaway et al. 2017). For the 12-item version of the CES-D acceptable internal consistency has been found in an English speaking sample of adolescents (i.e., Cronbach's alpha of 0.85; Poulin et al. 2005). In the present study, Cronbach's alphas across waves were high (i.e., 0.82 - 0.93).

The CDI consists of 27 items that measure cognitive, affective, and behavioral symptoms of depression during the past two weeks. For each item, adolescents chose one out of three statements describing different levels of symptom severity. Items are rated on a scale ranging from 0 to 2. Higher mean values indicate greater symptom severity. Percentages of adolescents reporting clinically significant levels of depressive symptoms across the three measurement waves were low

(see Online Resource 1). The questionnaire has been shown to be valid an reliable in terms of internal consistency in samples including Dutch speaking adolescents (i.e., Cronbach's alpha of 0.85; Timbremont and Braet 2002). In the present study, Cronbach's alphas across waves ranged between 0.87 and 0.88. The CES-D and the CDI are substantially correlated in adolescence (i.e., $r = 0.52$ and $r = 0.61$; Faulstich et al. 1986; Tatar et al. 2013).

## Plan of Analysis

**Three-Variable Models** To investigate the direction of effects among loneliness, social anxiety symptoms, and depressive symptoms three-wave autoregressive cross-lagged panel models (Jöreskog 1970) were fitted in M*plus* Version 7.31 (Muthén and Muthén 1998-2012) for all three samples separately. The robust maximum likelihood estimator (MLR) and the full information maximum likelihood estimator (FIML) were used to account for non-normality and missing data, respectively. By using autoregressive cross-lagged models, cross-time effects between loneliness and social anxiety symptoms, loneliness and depressive symptoms, and social anxiety symptoms and depressive symptoms, were estimated while controlling for the stability or autoregressive paths of the different study variables and the within-time correlations between the variables. The stability of the autoregressive paths refers to the cross-year continuity obtained by predicting a variable by its value at previous time points. The within-time correlations refer to the cross-sectional associations among the study variables within each time point.

Model fit for the various models was evaluated by several model fit indices. More specifically, we relied on the robust Satorra-Bentler scaled Chi-square statistic (S-B$\chi$2; Satorra and Bentler 2001), the root mean square error of approximation (RMSEA), the standardized root mean square residual (SRMR), and the comparative fit index (CFI) for evaluating model fit (Boomsma 2000). Smaller values for S-B$\chi$2 are indicative of better fit (Kline 2005). In addition, a model is assumed to fit the data well when the RMSEA and SRMR are below 0.06 and 0.08, respectively, and the CFI exceeds 0.95 (Hu and Bentler 1999). Adequate fit is achieved when the RMSEA and SRMR are lower than 0.08 and 0.10, respectively, and the CFI exceeds 0.90 (Kline 2005).

In each sample, we started from a fully constrained baseline model, that is, a model with all stability paths between successive waves, the within-time correlations at Time 2 and Time 3, and all cross-lagged paths between successive waves, constrained to be time-invariant. We tested whether this model showed a good fit to the data. Subsequently, we freed the cross-lagged paths from one construct to another and tested whether freeing these parameters resulted in a better model fit. Specifically, the fully constrained model and the unconstrained model (i.e., models with one of the cross-paths freely estimated over time), were compared using comparative fit indices. A significant difference in model fit between the unconstrained and constrained model indicates that the cross-time effects between two variables vary over time and that the unconstrained model needs to be retained. This is the case when the following two requirements are fulfilled, that is the $p$ value for $\Delta$S-B$\chi$2 is below 0.05 (Satorra and Bentler 2001) and $\Delta$CFI exceeds 0.01 supplemented by $\Delta$RMSEA exceeding 0.015 or $\Delta$SRMR exceeding 0.010 (Chen 2007). In all tested models, we controlled for age.

In addition, potential cohort effects were examined using multiple group analyses. In each sample, we compared a model in which we constrained the within-time correlations at Time 2 and 3, the autoregressive paths, and the cross-lagged paths to be equal across the different grades with a model in which the cross-lagged paths were freely estimated across the different grades. Given that the model fit of the constrained and unconstrained models did not significantly differ from each other in any of the three samples, it was justified to merge adolescents from the different grades together in each case. (Across the three samples S-B$\chi^2$ (6/12) $\geq$ 8.47, $ps \geq 0.21$, $\Delta$CFIs < 0.01, $\Delta$RMSEAs < 0.015, $\Delta$SRMRs $\leq$ 0.010).

**Within-Study Meta-Analysis** To synthesize the results obtained through the three-variable three-wave cross-lagged models in all three samples separately, we used Wilson's (2017) meta-analysis macros in SPSS Version 25.0. Specifically, we fitted fixed effect models to estimate and test the average standardized beta's, using the inversed sampling variance as weight factor.

**Indirect Effects** Indirect effects were tested using the MODEL INDIRECT command in M*Plus* (Muthén and Muthén 1998-2012). Specifically, we tested whether the temporal relationship between two of the three types of internalizing problems across a two-year period was mediated by the remaining internalizing problem measured the year between. All possible combinations were tested in all three samples. Bootstrapped confidence intervals for the indirect effects were not available in M*Plus* given that we used MLR, which already corrects standard errors of estimates (Muthén and Muthén 1998-2012).

**Gender Differences** Gender differences in the temporal associations among loneliness, social anxiety symptoms, and depressive symptoms were examined using similar multiple group analyses as the ones performed to examine cohort effects. Specifically, a model in which we constrained the within-time correlations at Time 2 and 3, autoregressive paths, and cross-lagged paths to be equal for boys and girls, was compared with a model in which the cross-lagged paths were freely estimated for boys and girls.

## Results

### Descriptive Statistics

Means, standard deviations, and correlations among the study variables, for each of the three samples, are presented in Table 2. Regarding cross-year stability of loneliness, medium to high correlations (Cohen 1988) were found in Sample 1 and high correlations were found in Sample 2 and Sample 3. Social anxiety symptoms were very stable in all three samples as indicated by high correlations. In addition, depressive symptoms were very stable as indicated by high correlations in Sample 2 and medium to high correlations in Sample 1 and Sample 3. At each measurement occasion, loneliness, social anxiety symptoms, and depressive symptoms were positively and highly correlated to each other in the three samples.

### Direction of Effects

The fully constrained baseline model, that is, the model including all one-wave stability paths, all cross-lagged paths, and the within-time correlations at Time 2 and 3, constrained to be time invariant, yielded a good fit to the data in all three samples. Therefore, in all three samples the cross-lagged paths were set to be time invariant and the fully constrained model was retained. Similar associations were found in all three samples. (The models for the three samples can be found in Online Resource 2, 3, and 4). The average across the three samples of the estimates of the within-time correlations, stability coefficients, and cross-lagged effects from the fully constrained models, are presented in Fig. 2. Loneliness, social anxiety symptoms, and depressive symptoms were stable over time βs > 0.46, *ps* < 0.001, and the three types of problems were positively associated at each time point. Moreover, loneliness and social anxiety symptoms were found to be reciprocally associated over time above and beyond the stability paths and within-time associations. Specifically, earlier levels of loneliness positively predicted future levels of social anxiety symptoms, βs = 0.10, *ps* < 0.001, and vice versa, βs = 0.15 - 0.16, *ps* < 0.001. In addition, social anxiety symptoms also positively predicted future levels of depressive symptoms, βs = 0.07, *ps* < 0.001 and depressive symptoms positively predicted future levels of loneliness, βs = 0.07, *ps* < 0.001.

### Indirect Effects

In Sample 1, there appeared to be a significant indirect effect from adolescent loneliness through social anxiety symptoms 1 year later to depressive symptoms 2 years later (β = 0.01, 95 % CI = [0.00, 0.02], p = 0.001). In Sample 2, two significant indirect effects were found. More specifically, an indirect effect from adolescent depressive symptoms through loneliness 1 year later to social anxiety symptoms 2 years later was found (β = 0.01, 95 % CI = [0.00, 0.02], p = 0.001) as well as an indirect effect from adolescent depressive symptoms through social anxiety symptoms 1 year later to loneliness 2 years later (β = 0.01, 95 % CI = [0.00, 0.02], p = 0.004). Finally, in Sample 3 no significant indirect effects were found.

### Gender differences

Results of the multiple group analyses indicated that estimates of model fit for the constrained and unconstrained models did not significantly differ from each other in any of the three samples (S-B$\chi^2$ (6) = 9.05, $p$ = 0.17, ΔCFIs < 0.01, ΔRMSEAs < 0.015, ΔSRMRs = 0.010 in Sample 1; S-B$\chi^2$ (6) = 9.19, $p$ = 0.16, ΔCFIs < 0.01, ΔRMSEAs < 0.015, ΔSRMRs < 0.010 in Sample 2; and S-B$\chi^2$ (6) = 4.82, $p$ = .57, ΔCFIs < 0.01, ΔRMSEAs < 0.015, ΔSRMRs < 0.010 in Sample 3). These results suggest that the temporal associations among the internalizing problems are similar for boys and girls in all three samples.

## Discussion

The present study aimed to extend earlier research on the temporal associations among loneliness, social anxiety symptoms, and depressive symptoms in adolescence using a comprehensive model that included all three of these internalizing symptoms simultaneously. Collectively, our findings expand in several ways on the extant knowledge base regarding overtime associations for the various pairs of these problems and offer important suggestions for clinical interventions designed to alleviate them.

### Loneliness and Social Anxiety Symptoms

The bidirectional association between loneliness and social anxiety symptoms in our study suggests the presence of a vicious cycle in adolescence, which maintains and further enhances both these internalizing problems. This cycle gives rise to three different types of recommendations. First, future studies on either loneliness or social anxiety symptoms could pay more attention to both internalizing problems conjointly and research lines on loneliness and social anxiety symptoms could become more integrated (Fung et al. 2017). However, until now, the extensive research lines for either loneliness or social anxiety symptoms do not often take into account the other type of internalizing problem. For example, studies on loneliness and its association with mental health most often focus on depressive symptoms, whereas social anxiety symptoms are often overlooked.

Second, interventions for either loneliness or social anxiety symptoms should pay attention to both internalizing difficulties because they both seem to function as risk

**Table 2** Bivariate correlations among main study variables and means and standard deviations

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Mean | SD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample 1 | | | | | | | | | | | |
| 1. Loneliness T1 | - | | | | | | | | | 1.54 | 0.56 |
| 2. Loneliness T2 | 0.54 | - | | | | | | | | 1.56 | 0.54 |
| 3. Loneliness T3 | 0.47 | 0.62 | - | | | | | | | 1.58 | 0.54 |
| 4. Social anxiety symptoms T1 | 0.53 | 0.40 | 0.43 | - | | | | | | 2.40 | 0.79 |
| 5. Social anxiety symptoms T2 | 0.37 | 0.56 | 0.50 | 0.61 | - | | | | | 2.54 | 0.81 |
| 6. Social anxiety symptoms T3 | 0.35 | 0.48 | 0.59 | 0.60 | 0.69 | - | | | | 2.51 | 0.79 |
| 7. Depressive symptoms T1 | 0.49 | 0.34 | 0.32 | 0.44 | 0.30 | 0.33 | - | | | 0.54 | 0.47 |
| 8. Depressive Symptoms T2 | 0.26 | 0.50 | 0.38 | 0.34 | 0.48 | 0.40 | 0.48 | - | | 0.57 | 0.49 |
| 9. Depressive Symptoms T3 | 0.22 | 0.39 | 0.47 | 0.30 | 0.39 | 0.47 | 0.49 | 0.65 | - | 0.56 | 0.51 |
| Sample 2 | | | | | | | | | | | |
| 1. Loneliness T1 | - | | | | | | | | | 1.65 | 0.60 |
| 2. Loneliness T2 | 0.57 | - | | | | | | | | 1.62 | 0.58 |
| 3. Loneliness T3 | 0.47 | 0.56 | - | | | | | | | 1.81 | 0.49 |
| 4. Social anxiety symptoms T1 | 0.54 | 0.41 | 0.36 | - | | | | | | 2.56 | 0.80 |
| 5. Social anxiety symptoms T2 | 0.47 | 0.57 | 0.44 | 0.66 | - | | | | | 2.57 | 0.78 |
| 6. Social anxiety symptoms T3 | 0.40 | 0.45 | 0.58 | 0.55 | 0.69 | - | | | | 2.60 | 0.75 |
| 7. Depressive symptoms T1 | 0.47 | 0.37 | 0.31 | 0.49 | 0.40 | 0.37 | - | | | 0.33 | 0.25 |
| 8. Depressive Symptoms T2 | 0.39 | 0.50 | 0.41 | 0.40 | 0.49 | 0.45 | 0.70 | - | | 0.32 | 0.24 |
| 9. Depressive Symptoms T3 | 0.31 | 0.36 | 0.48 | 0.34 | 0.40 | 0.50 | 0.63 | 0.74 | - | 0.32 | 0.24 |
| Sample 3 | | | | | | | | | | | |
| 1. Loneliness T1 | - | | | | | | | | | 1.54 | 0.46 |
| 2. Loneliness T2 | 0.60 | - | | | | | | | | 1.59 | 0.48 |
| 3. Loneliness T3 | 0.55 | 0.65 | - | | | | | | | 1.61 | 0.50 |
| 4. Social anxiety symptoms T1 | 0.61 | 0.54 | 0.45 | - | | | | | | 2.43 | 0.64 |
| 5. Social anxiety symptoms T2 | 0.50 | 0.62 | 0.55 | 0.65 | - | | | | | 2.44 | 0.62 |
| 6. Social anxiety symptoms T3 | 0.45 | 0.53 | 0.66 | 0.56 | 0.71 | - | | | | 2.41 | 0.64 |
| 7. Depressive symptoms T1 | 0.36 | 0.31 | 0.23 | 0.45 | 0.28 | 0.24 | - | | | 0.86 | 0.49 |
| 8. Depressive symptoms T2 | 0.28 | 0.49 | 0.37 | 0.34 | 0.50 | 0.32 | 0.52 | - | | 0.83 | 0.50 |
| 9. Depressive symptoms T3 | 0.19 | 0.36 | 0.37 | 0.23 | 0.35 | 0.44 | 0.44 | 0.60 | - | 0.82 | 0.48 |

All correlations significant at $p < 0.01$

factors for each other. So although it is more common to assess or prevent the co-occurrence of loneliness with depression, the current study clearly shows that in the treatment or prevention of loneliness, clinicians should also focus on social anxiety symptoms and not solely pay attention to the potential development of subsequent depressive symptoms. The same line of reasoning is applicable to the treatment of social anxiety symptoms, in the sense that clinicians should also closely monitor and perhaps simultaneously treat early signs of loneliness. Moreover, the cyclical process between loneliness and social anxiety symptoms has been found in adults as well (Lim et al. 2016). Therefore, attention for the development of such a pattern in adolescence and efforts to

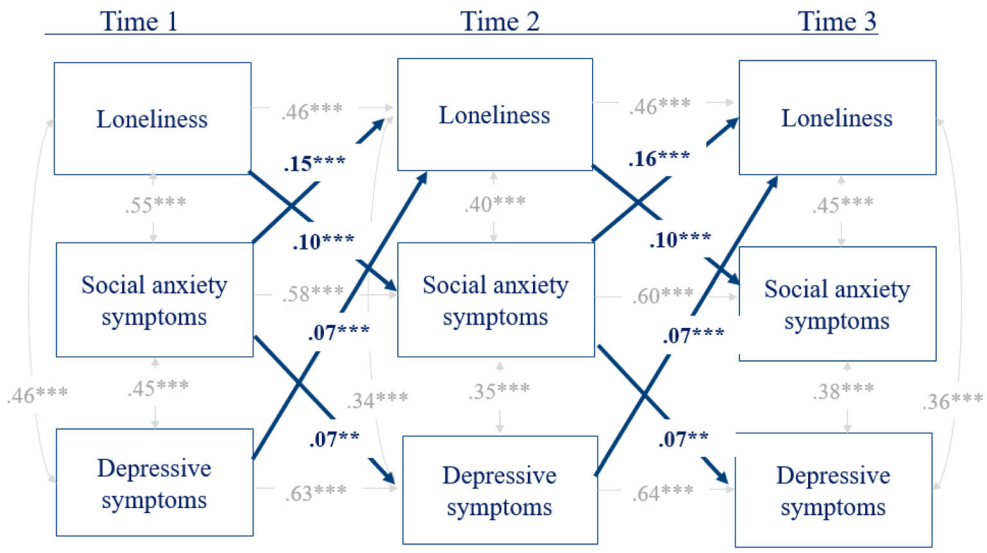


**Fig. 2** Final cross-lagged model predicting longitudinal reciprocal relations among loneliness, social anxiety symptoms, and depressive symptoms across all three samples. Only estimates significant at $\alpha = 0.05$ or less are provided. Cross-lagged paths are depicted in bold. Paths from the control variables gender and age to the different variables at each time point are omitted for reasons of clarity. ***$p < 0.001$

prevent or break through this pattern are important in order to avoid a chronic cyclical process of internalizing difficulties that continues into adulthood.

Third, researchers should be aware that a unique relationship exists between loneliness and social anxiety symptoms when controlled for depressive symptoms. This unique reciprocal relationship between loneliness and social anxiety symptoms might be explained by interpersonal processes. Given that loneliness and social anxiety symptoms both have clear interpersonal components (Epkins and Heckler 2011; Heinrich and Gullone 2006) it is not unlikely that interpersonal behavior typical for loneliness or social anxiety acts as a risk factor for developing social anxiety or loneliness, respectively (Starr and Davila 2008). These interpersonal processes include avoidance of social situations (Schleider et al. 2014), poor social functioning or weak social skills (Alden and Taylor 2004; Miers et al. 2010; Starr and Davila 2008), heightened sensitivity for signs of potential social threat (Ollendick and Hirshfeld-Becker 2002; Spithoven et al. 2017), and peer rejection (Heinrich and Gullone 2006). Specifically, adolescents with social anxiety symptoms often miss opportunities to establish close relationships due to avoidance behavior (Biggs et al. 2012) or experience difficulties with relating to others due to poor social functioning or weak social skills (La Greca and Lopez 1998; Miers et al. 2010; Starr and Davila 2008). Therefore, they might be at higher risk for subsequent loneliness. Lonely individuals, in turn, show a heightened sensitivity to signs of potential social threat (Qualter et al. 2015) and are likely to be confronted with peer rejection (Heinrich and Gullone 2006), which are known risk factors for the development of social anxiety symptoms (Ollendick and Hirshfeld-Becker 2002).

An important first step for future research would be to examine these potential underlying mechanisms that could explain the temporal associations among loneliness and social anxiety symptoms. However, besides the hypothesis that interpersonal features or consequences of a primary internalizing problem mediate the onset of another type of internalizing problem at a later moment in time, the onset of this second type of internalizing problem at a later moment in time might also represent the delayed expression of a risk factor that is shared by both internalizing problems. Knowledge about how these internalizing problems are exactly related to each other can help practitioners to identify key components of interventions designed to alleviate or prevent these internalizing symptoms. Thus, a second step would be to assess the effects of these components on symptom reduction and prevention (Schleider et al. 2014).

## Social Anxiety Symptoms and Depressive Symptoms

The current study also found that social anxiety symptoms positively predicted future depressive symptoms. This finding is in line with most previous studies which indicate that social anxiety measured at the disorder level precedes depression but not vice versa (Cummings et al. 2014; Schleider et al. 2014). This prospective relationship may also be explained by interpersonal processes. For example, social withdrawal or reduced expression of emotions in order to avoid anticipated negative evaluation by others as characteristics of social anxiety could explain associations between social anxiety symptoms and subsequent depressive symptoms (Cummings et al. 2014). Specifically, these anxiety behaviors might weaken friendships and result in rejection, which, in turn, increases feelings of hopelessness and ultimately depressive symptoms (Schleider et al. 2014).

Our findings suggest that social anxiety symptoms play a crucial role in the development of internalizing problem behavior in adolescence. Findings further show that social anxiety symptoms might function as an antecedent for the

development of future feelings of both loneliness and depression. Combining this insight with the earlier described finding of a vicious cycle between loneliness and social anxiety symptoms, our study contributes to a better understanding of the etiology of loneliness, social anxiety symptoms, and depressive symptoms and the extent to which they are risk factors for each other. In addition, this study provides valuable information for the prevention of sequential internalizing comorbidity in adolescents. Specifically, given that loneliness and social anxiety symptoms appear to be risk factors for each other and given that social anxiety symptoms precede depressive symptoms, accurate and timely detection and treatment of loneliness and social anxiety symptoms combined with close monitoring and perhaps treatment of early signs of the internalizing problems they will potentially cause, might aid in preventing the development of these subsequent internalizing problems. Moreover, besides close monitoring and treatment of early signs of secondary internalizing problems, clinicians should also consider integrating a preventive intervention for potential secondary internalizing problems in the early phases of the primary internalizing problem's treatment.

## Depressive Symptoms and Loneliness

Our prospective association from depressive symptoms to loneliness suggest that adolescents who show depressive symptoms are at increased risk to subsequently become lonely. Again, interpersonal behaviors might function as potential underlying mechanisms to explain this temporal association from depressive symptoms to loneliness. Specifically, withdrawal from social interactions (Matthews et al. 2016) or excessive reassurance seeking (Hankin 2006) often resulting in rejection are behaviors frequently displayed by depressed individuals that increase the risk for experiencing loneliness.

However, contrary to our expectations, loneliness was not a predictor of depressive symptoms 1 year later, unless indirectly through social anxiety symptoms. The prospective associations from loneliness to depressive symptoms that were found in earlier studies (e.g., Cacioppo et al. 2010; Vanhalst et al. 2012) might be the result of not measuring or not accounting for social anxiety symptoms (Lim et al. 2016), as was done in the current study. Specifically, it might be that social anxiety symptoms are a more important predictor of subsequent feelings of depression than loneliness. This insight could only be gained after examining the temporal sequence among all three internalizing symptoms in a comprehensive model, as was done in the current study.

## Insights From a Comprehensive Model

A common theme in the previously discussed findings is that different results were obtained when we included multiple internalizing problems in a comprehensive cross-lagged model. Until now, research on the temporal association among loneliness, social anxiety, and depressive symptoms has mainly focused on the association between two types of internalizing problems. Results of these two-variable cross-lagged models often indicate reciprocal links between the two types of internalizing problems (e.g., Vanhalst et al. 2012). However, the current study indicated that testing a more comprehensive model might result in different, or at least more nuanced, findings. The results of the current study were in line with the findings of a comparable study in adults. In this study, depression and loneliness were reciprocally associated with each other in a two-variable cross-lagged model (Lim et al. 2016). However, in a more comprehensive model including social anxiety symptoms in addition to depression and loneliness, social anxiety symptoms better accounted for the prediction of loneliness (Lim et al. 2016). Although we do not want to advocate the practice of including as many variables as possible in future research models, a judicious inclusion of additional potentially relevant variables in the traditional two-variable models might result in more refined insights. Moreover, a comprehensive three-variable cross-lagged model allows to test indirect effects and, therefore, might unravel the potential complex interplay among the internalizing problems.

Results regarding these indirect effects in the temporal associations among loneliness, social anxiety symptoms, and depressive symptoms were inconsistent across the three samples and the significant effects that were found were small. Therefore, we emphasize the need for replication research to clarify the practical relevance and meaning of these isolated effects and we only carefully elaborate on the current study's findings. First, no evidence was found for the hypothesized indirect effect from social anxiety symptoms to depressive symptoms through loneliness. Rather, depressive symptoms appeared to predict social anxiety symptoms through loneliness. This finding suggests that loneliness might mediate the temporal relationship between depressive symptoms and social anxiety symptoms (Starr and Davila 2008), but not necessarily in the direction theorists currently hypothesize. Second, the mediational role of social anxiety symptoms in the temporal association from loneliness to depressive symptoms and from depressive symptoms to loneliness is additional evidence for the current research finding that social anxiety plays an important role in the temporal associations among loneliness, social anxiety, and depressive symptoms. Again, this finding illustrates the importance of examining all three internalizing symptoms simultaneously in a comprehensive model in order to fully grasp the temporal patterns.

## Gender Differences

The results of the current study consistently indicate that the temporal patterns among loneliness, social anxiety symptoms,

and depressive symptoms are similar for adolescent boys and girls. This finding suggests that although adolescent boys and girls have different mean levels for depressive symptoms and social anxiety symptoms, this does not necessarily imply that gender affects the temporal associations among these internalizing symptoms. Similar findings have been found in studies investigating gender differences in the temporal association between loneliness and depressive symptoms (Lasgaard et al. 2011; Vanhalst et al. 2012). Given that research on these gender differences is scarce, replication research is needed to confirm this finding.

### Strengths and Limitations

An important strength of the current study is the statistical integration of findings across three large community samples of adolescents with partly overlapping age ranges and well-established measures of internalizing symptoms. Nonetheless, at least five limitations of our study are noteworthy.

First, given that the participants in the three samples were from a particular region in Belgium and live in families with relatively high socioeconomic status (SES), care should be taken when generalizing the findings of the current study to adolescents who live in other parts of the world or have lower SES. In addition, adolescents who dropped out reported more depressive symptoms and loneliness than those who continued their participation. These small but significant attrition rates also limit the generalizability of our study findings.

Second, the study samples included generally well-functioning adolescents with only a small percentage showing clinically significant levels of internalizing problems (see Online Resource 1). For this reason, any inferences about the clinical implications of the current study's results should be drawn with caution. Nevertheless, given that clinical disorders are considered as merely extremes on a single continuum of internalizing difficulties according to the developmental psychopathology framework (Kerig et al. 2012) and given empirical findings pointing towards a rather dimensional structure of depression (Hankin et al. 2005), to some extent our study results might be relevant for the clinical literature.

Third, we solely relied on self-report measures to assess the different forms of internalizing problems. However, multiple informants often provide different perspectives on adolescents' internalizing problems and therefore may add additional valuable data (De Los Reyes et al. 2012). In addition, the use of a multiple-informant, multiple-method approach to assess internalizing problems in future studies may address potential bias in the observed associations due to shared method or shared informant bias.

Fourth, it is important to emphasize that the relationships that were found in the current study are merely longitudinal associations and that, given the absence of an experimental design, no causal conclusions can be drawn. Although investigating the associations among loneliness, social anxiety symptoms, and depressive symptoms as well as their temporal ordering advanced current understanding of causal processes, we cannot rule out the existence of potentially confounding variables with the current design.

Fifth, some critical comments were recently voiced regarding the use and interpretability of autoregressive cross-lagged panel models. The most important of these comments is that these models do not disentangle between-individual and within-individual variation (Berry and Willoughby 2017; Keijsers 2016). Therefore, care should be taken when interpreting the results of the current study as we cannot draw conclusions about within-person changes.

## Conclusion

This study examined the temporal sequences among loneliness, social anxiety symptoms, and depressive symptoms in adolescence across three large longitudinal samples using three-variable autoregressive cross-lagged models as synthesized through a meta-analytic procedure. The results indicate that a vicious cycle between social anxiety symptoms and loneliness is at work, which suggest that future studies on and interventions for either loneliness or social anxiety symptoms should pay attention to both internalizing problems given their reciprocal associations. Social anxiety symptoms also play a role in the development of future depressive symptoms, which suggests that it is important to reduce social anxiety symptoms to prevent feelings of loneliness or depression. Finally, adolescents experiencing depressive symptoms are at higher risk to subsequently become lonely. No gender differences in these temporal associations were found and indirect effects were inconsistent. Overall, these results represent important first steps towards clarifying the developmental interplay among loneliness, social anxiety symptoms, and depressive symptoms in adolescence.

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### Compliance with Ethical Standards

**Conflict of Interest** The authors declare that they have no conflict of interest.

**Ethical approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

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