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Adolescents' depressive symptoms and subsequent technology-based interpersonal behaviors: A multi-wave study

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ABSTRACT

This study examined the longitudinal effects of adolescents' depressive symptoms on engagement in technology-based social comparison and feedback seeking (SCFS) behaviors. A total of 816 adolescents (54.7% girls; M_{age} = 14.1 at Time 1) participated at three times points, each one year apart. Adolescents reported technology-based SCFS, depressive symptoms, and frequencies of technology use (cell phones, Facebook, and Instagram). Multiple group (by gender) latent growth curve models examined concurrent and lagged effects of depressive symptoms on SCFS, controlling for adolescent's underlying trajectories of SCFS and overall frequencies of technology use. Results indicated that higher levels of depressive symptoms were concurrently associated with greater SCFS after accounting for adolescents' typical patterns of SCFS. For boys only, higher depressive symptoms were prospectively associated with later increases in SCFS. Results highlight the importance of social media as a unique context in which depressed adolescents may be at risk for maladaptive interpersonal behavior.

1. Introduction

Adolescence is a developmental risk period for depression, and evidence suggests that this risk may be due, in part, to the normative, developmental reorientation of the social landscape that takes place during this time period (Hankin & Abramson, 2001). Adolescents begin to engage in more frequent, intimate, and autonomous peer relationships during this stage (Choukas-Bradley & Prinstein, 2014) and to rely on peer feedback and experiences as a primary means of identity development and self-esteem (Harter, Stocker, & Robinson, 1996). Adolescents also experience far greater interpersonally-themed stress than do younger youth (Rudolph, 2009). While prior work has emphasized the role of interpersonal difficulties in contributing to the emergence of adolescents' depression (Rudolph, 2009), only recently have researchers begun to examine symptoms-driven models, whereby depressive symptoms precede and predict poor peer relationships (Kochel, Ladd, & Rudolph, 2012). Remarkably little is known regarding the specific maladaptive interpersonal behaviors that may contribute to peer difficulties among those with elevated depressive symptoms, and even less is known regarding the developmental factors that may make adolescents particularly vulnerable. It may be especially important to consider these developmental factors in light of recent changes in the social worlds of adolescents. This study focuses specifically on adolescents' interpersonal experiences online, and a set of behaviors that may be relevant to the type of experiences afforded to this social context.

1.1. Depressive symptoms and interpersonal dysfunction

For many years, research has suggested that individuals experiencing elevated levels of depressive symptoms may be especially likely to engage in maladaptive interpersonal behaviors, perhaps in an effort to augment their self-worth, or alternatively to validate their sense of low self-concept (Coyne, 1976; Hames, Hagan, & Joiner, 2013). For instance, substantial research has suggested that depressed individuals may engage in excessive reassurance seeking (ERS; Joiner & Metalsky, 2001), or the tendency to repeatedly ask others for reassurance of personal worth, leading to interpersonal rejection and poor friendship quality, and ultimately, exacerbation of depressive symptoms (Prinstein, Borelli, Cheah, Simon, & Aikins, 2005). Findings also have suggested that depressed adults and youth may be especially likely to engage in negative feedback-seeking (NFS), or the tendency to seek out criticism or negative feedback in close relationships, as well as to report high levels of sociotropy (Rudolph, 2009). Each of these behaviors contributes to *dependent* interpersonal stressors, or events in which depressed individuals may inadvertently contribute to their own interpersonal difficulties (Flynn & Rudolph, 2011; Rudolph et al., 2000). Depressed adolescents also have been shown to engage in higher levels of social comparisons, particularly unfavorable comparisons that result in negative self-evaluation, compared to non-depressed individuals

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(Allen & Badcock, 2003; Irons & Gilbert, 2005). In the social world of today's teens, a heavy reliance on interpersonal communication within technology-based platforms may make social comparisons and feedback- or reassurance-seeking especially easy.

1.2. Social media use and depressive symptoms

As researchers increasingly turn to symptoms-driven models to explain the ways in which depressed youth engage in maladaptive behaviors with peers, it has become necessary to examine such behaviors as they occur within the developmental contexts most relevant to modern adolescents. Social media, which has become ubiquitous in the lives of adolescents, represents one such context. On an average day, adolescents report spending almost 7 h using screen media (Rideout, 2015) and sending an average of 67 text messages (Lenhart, 2015). Adolescents report that a significant proportion of their social interactions now take place via social media, with 89% belonging to at least one social networking site and 88% engaging in regular text messaging (Lenhart, 2015). Identifying maladaptive interpersonal behaviors that occur via social media has critical implications for understanding how depressed adolescents may inadvertently contribute to their own interpersonal distress and poor peer relationships.

Within research examining social media use, there has been a growing recognition of the importance of identifying such maladaptive online behaviors in the context of adolescents' depressive symptoms (Davila et al., 2012; Feinstein et al., 2013). Although many studies have used cross-sectional data and inferred that certain technology-based behaviors may contribute to depressive symptoms, it is equally plausible that problematic social media use may follow from prior depressive symptoms. For example, studies have indicated concurrent associations between higher levels of depressive symptoms and technology-based behaviors that include: disclosure of personal information online (Ybarra, Alexander, & Mitchell, 2005), sexting (Dake, Price, Maziarz, & Ward, 2012), cyberbullying (Ybarra, 2004), and frequent surveillance behavior, or passively browsing others' photos or posts without actively engaging by commenting or posting (Tandoc, Ferrucci, & Duffy, 2015). In addition to cross-sectional work, a few studies have provided preliminary evidence that depressive symptoms longitudinally predict certain maladaptive online behaviors, including posting inappropriate photos (Mikami, Szwedo, Allen, Evans, & Hare, 2010) and engaging in negative interactions with romantic partners (Feinstein et al., 2013). Although these studies provide an important foundation, further examination of the role that depression may play in predicting adolescents' technology-based social dysfunction remains critical.

One potentially problematic online behavior, which may be conceptually distinct from similar offline behaviors, is technology-based social comparison and feedback seeking (SCFS; Nesi & Prinstein, 2015), or the use of social media to seek out information regarding one's appearance, behaviors, and social status, relative to one's peers. One study indicated that this online behavior was associated concurrently with higher levels of depressive symptoms (controlling for prior levels of depressive symptoms), and that this relationship was particularly strong among females (compared to males) and adolescents lower (versus higher) in popularity (Nesi & Prinstein, 2015). However, no studies have longitudinally examined the ways in which depressive symptoms may precede and predict engagement in technology-based SCFS over the course of multiple years.

It is particularly important to examine technology-based SCFS as a consequence of adolescents' depressive symptoms given the ways in which this behavior may be uniquely facilitated within the environment of social media. As a context for social behaviors, social media encompasses a number of features that create the potential for new and different behaviors than are possible offline. For example, communication on social media is often public, allowing an adolescent's requests for reassurance or feedback to instantaneously reach a vast network of peers (boyd, 2010). Furthermore, communication via social media is immediate and accessible from any location (Peter & Valkenburg, 2013), which may create a constant feedback loop that heightens the frequency and intensity of social comparisons. Other relevant features of social media include its affordances for asynchronous and anonymous communication, perhaps creating a false sense of "safety" for adolescents to engage in problematic social behaviors (boyd, 2010; Peter & Valkenburg, 2013).

Technology-based SCFS may be facilitated by the large, public audience to whom photos and posts are displayed, the opportunity for immediate peer feedback and commentary, and the ease with which information about peers can be accessed and scrutinized (Manago, Graham, Greenfield, & Salimkhan, 2008). Thus, we might expect adolescents who engage in offline excessive reassurance-seeking and social comparison to similarly exhibit higher levels of technology-based

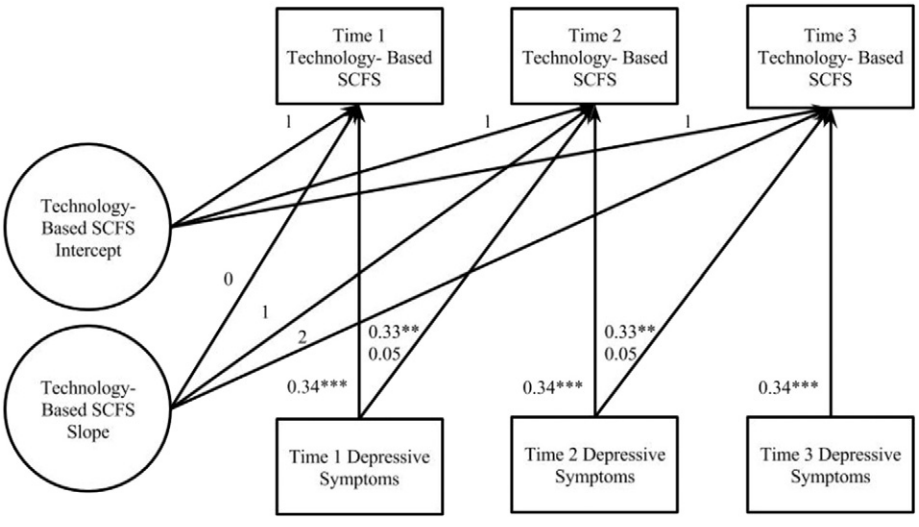

Fig. 1. Final multiple group (by gender) linear latent growth curve model of technology-based social comparison and feedback-seeking (SCFS). To aid visual interpretation, frequency of technology use is not depicted; however, both depression (pictured) and frequency of technology use were included in the final model (see text). For paths moderated by gender, results for boys presented above. Results presented are unstandardized coefficients. Covariances among variables are not depicted for ease of interpretation. For girls, covariances between depressive symptoms and the latent SCFS slope were: −0.05, $p = 0.002$, −0.04, $p = 0.07$, and −0.01, $p = 0.48$ for Times 1, 2, and 3, respectively. For boys, covariances between depressive symptoms and the latent SCFS slope were: −0.02, $p = 0.11$, −0.03, $p = 0.02$, and −0.04, $p = 0.004$ for Times 1, 2, and 3, respectively. There were no significant associations between depressive symptoms and latent SCFS intercepts for boys or girls. $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Table 1
Descriptive statistics and gender comparisons of study variables.

	Full sample		Girls		Boys		Gender comparison
	M (*SD*)	*N*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*t* (df)
Technology-based SCFS							
Time 1	1.71 (0.77)	690	1.82 (0.83)	385	1.57 (0.68)	305	4.35 (687.16)**
Time 2	1.87 (0.87)	754	1.94 (0.89)	409	1.80 (0.84)	345	2.29 (752)*
Time 3	1.90 (0.89)	701	1.98 (0.94)	381	1.82 (0.83)	320	2.34 (699)*
Depressive symptoms							
Time 1	0.46 (0.50)	745	0.60 (0.54)	413	0.28 (0.37)	332	9.26 (724.47)**
Time 2	0.49 (0.54)	764	0.63 (0.59)	415	0.32 (0.41)	349	8.76 (736.59)**
Time 3	0.48 (0.51)	707	0.61 (0.55)	385	0.31 (0.40)	322	8.52 (690.50)**
Frequency of technology use							
Time 1	2.62 (1.67)	703	3.11 (1.64)	393	2.01 (1.52)	310	9.15 (701)**
Time 2	2.43 (1.52)	754	2.85 (1.52)	409	1.94 (1.38)	345	8.53 (752)**
Time 3	2.52 (1.39)	701	2.90 (1.39)	381	2.08 (1.25)	320	8.16 (695.58)**

Note: SCFS = social comparison and feedback-seeking.
* $p < 0.05$.
** $p < 0.001$.

SCFS. However, we might also expect that the features of the social media environment facilitate engagement in technology-based SCFS among adolescents who might otherwise have engaged in fewer maladaptive interpersonal behaviors. Similarly, depressed adolescents, who might previously have withdrawn from social interactions, may find in social media an opportunity to engage in high levels of feedback-seeking and social comparison. The unique affordances of the online environment for depressed adolescents' social interactions render technology-based SCFS a critical area for further investigation.

1.3. Gender differences

In examining the prospective relationship between depressive symptoms and technology-based SCFS, it is critical to consider the role of gender. It is well known that rates of depression are higher among adolescent girls, compared to boys (Nolen-Hoeksema, 2001). The elaborated cognitive vulnerability-transaction stress model of depression suggests that girls are more likely to generate interpersonal stressors than boys, and that they may react to stressors with more ruminative and negative inferential response styles, which may explain these different prevalence rates (Hankin & Abramson, 2001). Furthermore, a meta-analytic review of cross sectional studies showed a stronger relationship between ERS and depressive symptoms for adult women, compared to men (Starr & Davila, 2008). In general, girls may show higher levels of social-evaluative concerns and need for approval, and may engage in greater self-disclosure in the offline context (Rose & Rudolph, 2006). In the online context, girls have been shown to engage in more frequent technology-based SCFS than boys, and the concurrent relationship between SCFS and depressive symptoms may be stronger for girls (Nesi & Prinstein, 2015). However, the literature on gender differences in the association between depressive symptoms and later interpersonal difficulties, both offline and online, remains surprisingly limited. It remains unclear whether depressive symptoms may more strongly predict increased engagement in technology-based SCFS among girls or boys longitudinally.

1.4. The current study

The current study examined longitudinal relationships between depressive symptoms and technology-based social comparison and feedback-seeking (SCFS) among adolescents over a three-year period, and specifically examined whether depressive symptoms were predictive of higher levels of SCFS in the subsequent year. Using latent growth curve modeling techniques, this study offers a unique opportunity to examine intra-individual change in technology-based SCFS over time. Specifically, this approach allows for the examination of individual adolescents' typical levels of engagement in technology-based SCFS, or trajectories, and to test deviations from these patterns at each time point. Each adolescent exhibits a baseline tendency to engage in high or lower levels of technology-based SCFS; latent growth curve modeling examines within-person increases in this behavior, relative to the adolescents' baseline, following higher depressive symptoms at a concurrent or previous time point.

Within this analytic framework, Hypothesis 1 predicted that adolescents who reported higher levels of depressive symptoms at a given time point would engage in greater levels of SCFS at that same time point, controlling for their underlying trajectories of technology-based SCFS and overall frequency of technology use. Hypothesis 2 predicted that adolescents reporting higher levels of depressive symptoms at a given time point would report greater levels of SCFS one year later, above and beyond what would be expected from their underlying trajectories of SCFS and overall frequencies of technology use. Given

Table 2
Bivariate associations by gender.

	1	2	3	4	5	6	7	8	9
1. Time 1 depressive symptoms	–	0.57**	0.41**	0.37**	0.20**	0.07	0.02	0.10*	0.12*
2. Time 2 depression symptoms	0.46**	–	0.54**	0.25**	0.27**	0.11*	0.07	0.16*	0.19**
3. Time 3 depressive symptoms	0.40**	0.57**	–	0.18**	0.18**	0.24**	−0.01	0.08	0.13*
4. Time 1 technology-based SCFS	0.22*	0.07	0.20**	–	0.54**	0.44**	0.28**	0.22**	0.19**
5. Time 2 technology-based SCFS	0.13*	0.10	0.07	0.40**	–	0.55**	0.14*	0.20**	0.20**
6. Time 3 technology-based SCFS	0.03	0.04	0.10	0.37**	0.54**	–	0.09	0.14*	0.24**
7. Time 1 frequency of technology use	0.09	0.00	0.09	0.31**	0.17*	0.28**	–	0.45**	0.45**
8. Time 2 frequency of technology use	0.11	0.07	0.01	0.25**	0.44**	0.38**	0.39**	–	0.59**
9. Time 3 frequency of technology use	0.01	−0.01	0.04	0.18*	0.26**	0.25**	0.33**	0.37**	–

Note: Results for girls reported above the diagonal. Results for boys reported below the diagonal. SCFS = social comparison and feedback-seeking.
* $p < 0.05$.
** $p < 0.001$.

Table 3
Means and variances of unconditional and conditional model of technology-based SCFS.

	Unconditional model				Conditional model			
	Mean		Variance		Mean		Variance	
	b	*se*	*b*	*se*	*b*	*se*	*b*	*se*
Girls								
Slope	0.07**	0.02	0.05*	0.02	0.04	0.04	0.03	0.02
Intercept	1.83***	0.04	0.38***	0.05	1.51***	0.11	0.29***	0.05
Boys								
Slope	0.12***	0.03	0.09**	0.03	0.06	0.03	0.09**	0.03
Intercept	1.59***	0.04	0.25***	0.06	1.24***	0.08	0.19***	0.05

Note: Unconditional model refers to the multiple group model (by gender) of trajectories of technology-based social comparison and feedback-seeking with no predictors. Conditional model refers to the multiple group model (by gender) of trajectories of technology-based SCFS with depressive symptoms and frequency of technology use entered as a time-varying covariate.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

literature suggesting gender differences in rates of depression and technology-based SCFS, we explored whether the longitudinal associations between depression and SCFS differed by gender.

2. Methods

2.1. Participants and procedure

The current study included 816 participants, assessed at three waves, each one year apart. It offers a longitudinal follow up of a sample used in prior work (*citation removed for blind review*). At Time 1, students were eighth and ninth grade students, between the ages of 13 and 16 (mean age = 14.1). Self-report measures were used to assess participants' gender identity (54.7% female) and ethnicity (47.5% White/Caucasian, 24.9% African American/Black, 24.9% Hispanic/Latino, 2.8% other ethnicities). Students came from three, rural, low-income schools in the southeastern United States, and the sample closely matched the demographic makeup of the district from which participants were recruited.

As part of a large, longitudinal study on adolescent health risk behaviors and peer relationships, all students in seventh and eighth grade in these schools were recruited ($n = 1463$). Consent forms were returned by 82.4% of families ($n = 1205$), and of these, 74.7% ($n = 900$; 61.7% of total recruited) consented to participation. Four waves of data were collected from participants, with measures for the current study only collected at the one-year ("Time 1"), two-year ("Time 2"), and three-year ("Time 3") follow-ups. Of the 900 consented students, a total of 92% ($n = 831$) at least partially completed surveys at a minimum of one of the current study's three time points. Of these, six participants did not complete any of the measures used in the current analyses, and thus were excluded. Another six participants were excluded because they indicated that they did not use any technology (cell phones, Facebook, or Instagram) at any of the study's three time points. Three participants were excluded because they did not report their gender, and thus could not be included in multiple group analyses. Thus, the final sample for analyses was 816 participants. Out of these 816 participants, the number who completed at least some of the measures at each time point was $n = 745$ at Time 1, $n = 765$ at Time 2, and $n = 707$ at Time 3.

Following informed assent procedures, surveys were administered during the school day using computer-assisted self-interviews (CASI). All measures were self-reported by participants at each of the three time points. Participants were compensated with $10 gift cards at each time point. All procedures were approved by the university human subjects committee.

2.2. Measures

2.2.1. Depressive symptoms

Depressive symptoms were assessed using the Short Mood and Feelings Questionnaire (SMFQ; Angold et al., 1995). The SMFQ contains 13 items that assess depressive moods and behaviors over the past two weeks, for example, "I felt miserable or unhappy" and "I did everything wrong." Items are endorsed on a 3-point scale (0 for *not true*, 1 for *sometimes true*, 2 for *true*). A mean of all items was computed, with higher scores indicating higher levels of depressive symptoms. Good psychometric properties have been reported for the SMFQ as a reliable and valid measure of depressive symptoms among adolescents (Angold, Erkanli, Silberg, Eaves, & Costello, 2002). In the present sample, the SMFQ demonstrated good internal consistency across all time points: Time 1 ($\alpha = 0.93$), Time 2 ($\alpha = 0.95$), and Time 3 ($\alpha = 0.94$).

2.2.2. Technology-based social comparison and feedback-seeking (SCFS)

The Motivations for Electronic Interaction Scale (MEIS) was designed to assess adolescents' attitudes and behaviors regarding the use of "electronic interaction," defined for participants as "texting, Facebook, and other social media (e.g. Twitter, Instagram, Snapchat, Tumblr"). It was developed through a series of focus groups and pilot testing with over 419 adolescents of similar age, gender, and ethnic composition to the current sample (see Nesi & Prinstein, 2015 for more information on measure development). The social comparison and feedback-seeking subscale is a 10-item measure, loading onto a single factor, which assesses adolescents' use of social media to seek out information regarding one's appearance, behaviors, and social status, relative to one's peers. This subscale includes items such as "I use electronic interaction to compare my life with other people's lives" and "I use electronic interaction to see if others think I am cool, funny, or popular." Participants endorsed the personal relevance of each item on a 5-point Likert scale (1 for *Not at all true* and 5 for *Extremely true*). A mean of all items was computed, with higher scores indicating higher levels of technology-based SCFS. The technology-based SCFS subscale demonstrated good internal consistency across all time points in the current study: Time 1 ($\alpha = 0.92$), Time 2 ($\alpha = 0.93$), and Time 3 ($\alpha = 0.94$).

2.2.3. Frequency of technology use

The Electronic Interaction Scale for Time (EIS_T) was designed to assess average daily frequencies of technology use and other forms of interpersonal communication. This measure was similarly developed using focus groups and pilot testing (see Nesi & Prinstein, 2015), and information on frequencies of use from national surveys of adolescent technology use (e.g. Lenhart, 2015). Participants indicated frequencies of use on a 7-point scale (0 for *I don't use this*, 1 for *<1 h*, and 6 for *5 or more hours*), and were asked about a series of activities, including daily in-person communication, voice communication, non-voice cell phone use (i.e., for "texting, games, or Internet"), Facebook use, and Instagram use. The Frequency of Technology Use variable was created by computing a mean of the final three items (non-voice cell phone use, Facebook use, and Instagram use). Among all participants in the current sample, 92.6%, 92.2%, and 94.6% had engaged in at least one of these activities at each of Time 1, Time 2, and Time 3, respectively. Participants who had not engaged in any of these three activities at any time point were excluded from analyses ($n = 6$). Notably, prior research indicates that Facebook and Instagram were the most popular social media sites used by adolescents, ages 13 to 17, at the time of data collection (Lenhart, 2015).

2.3. Analysis plan

To examine relationships between depressive symptoms and technology-based SCFS over time, latent growth curve models were tested using MPlus 7.0 (Muthén & Muthén, 1998–2016). Full information maximum likelihood estimation was used to handle missing data. An

unconditional latent growth model for technology-based SCFS over three time points was tested, with both depressive symptoms and frequency of technology use at each time point entered as time-varying covariates. This allowed for the examination of Hypothesis 1, that adolescents who reported higher levels of depressive symptoms at a given time point would report greater engagement in SCFS at that same time point, controlling for their underlying, longitudinal trajectories of technology-based SCFS and overall frequency of technology use. In order to examine Hypothesis 2, that adolescents reporting higher levels of depressive symptoms at a given time point would report greater levels of SCFS one year later, above and beyond what would be expected from their underlying trajectories of SCFS and overall frequencies of technology use, the addition of lagged effects of depressive symptoms and frequency of technology use on technology-based SCFS was tested (see Fig. 1). Multiple group models were used to examine gender differences, with a series of likelihood ratio tests used to determine which model parameters should be constrained across groups and which should be left to freely vary.

3. Results

3.1. Descriptive statistics

Descriptive statistics were conducted to examine the means and standard deviations of all study variables (see Table 1). In addition, independent sample *t*-tests were conducted to examine gender differences in the means of all study variables. Results indicated that girls reported higher levels of depressive symptoms, technology-based SCFS, and overall frequencies of technology use at every time point. Pearson correlations were also conducted to examine bivariate associations among all study variables (see Table 2). Additional analyses were run to examine whether, at each time point, adolescents who reported using any technology (cell phones, Facebook, or Instagram) differed in levels of depressive symptoms from those who did not. At Time 1, those who did not use technology ($n = 53$) reported lower levels of depressive symptoms than those who did (n = 659), $t(64.71) = -3.33$, $p < 0.001$. At Time 2, those who did not use technology ($n = 59$) also reported lower levels of depressive symptoms than those who did ($n = 701$), $t(75.83) = -4.32$, $p < 0.001$. At Time 3, the same pattern emerged comparing those who did not use technology ($n = 38$) to those who did ($n = 669$), $t(705) = -2.57$, $p = 0.01$. In addition, boys were more likely than girls to report not using any technology at Time 1 ($\chi^2 = 13.97$, $p < 0.001$), Time 2 ($\chi^2 = 14.23$, $p < 0.001$), and Time 3 ($\chi^2 = 9.14$, $p = 0.003$).

3.2. Latent growth curve models

3.2.1. Unconditional models

First, unconditional latent growth models for technology-based SCFS over three time points were constructed separately for males and females, in order to determine the optimal functional model form prior to testing hypotheses. Intercept only models were first constructed. Model fit was modest for girls [$\chi^2(4) = 15.05$, $p = 0.005$; CFI = 0.96, TLI = 0.97, RMSEA = 0.08, SRMR = 0.05] and poor for boys $\chi^2(4) = 57.36$, $p < 0.001$; CFI = 0.68, TLI = 0.76, RMSEA = 0.19, SRMR = 0.10]. Next, models were fit with both latent intercept and linear slope factors. Model fit was good for both girls [$\chi^2(1) = 0.84$, $p = 0.36$; CFI = 1.00, TLI = 1.00, RMSEA = 0.00, SRMR = 0.01] and boys [$\chi^2(1) = 7.27$, $p = 0.007$; CFI = 0.96, TLI = 0.89, RMSEA = 0.13, SRMR = 0.04]. Thus, likelihood ratio tests confirmed significant improvement in model fit with the addition of the slope factor for both boys [$\Delta\chi^2(3) = 50.09$, $p < 0.001$] and girls [$\Delta\chi^2(3) = 14.21$, $p < 0.01$]. Thus, linear models were identified to be the optimal functional model form for both males and females (Bollen & Curran, 2006).

Next, all participants were combined into a single, unconditional multiple group model in order to examine differences by gender. A multiple group model was first run with all parameters free to vary across groups, showing good fit to the data ($\chi^2(2) = 8.11$, $p = 0.02$; CFI = 0.99, TLI = 0.96, RMSEA = 0.09, SRMR = 0.03). Likelihood ratio tests were conducted to determine which parameters could be set equal across groups (Bollen & Curran, 2006). First, latent factor means (slope and intercept) were set equal across group, resulting in a significant decrement in model fit [$\Delta\chi^2(2) = 18.80$, $p < 0.001$]; thus factor means were left to vary freely across group. Next, within each gender, the heteroscedasticity of residuals was tested. For girls, the addition of equality constraints on the time-specific residuals did not result in a significant decrement in fit [$\Delta\chi^2(2) = 2.92$, $p = 0.23$]; thus, these were retained. For boys, the addition of these equality constraints caused model nonconvergence, and thus a heteroscedastic residual structure was retained for boys. Overall, a linear multiple group model with homoscedastic residuals structure for girls and heteroscedastic residuals for boys was identified to be the optimally fitting functional form.

The unconditional multiple group model, without the addition of depressive symptoms as a time-varying covariate, revealed excellent model fit [$\chi^2(4) = 11.03$, $p = 0.03$; CFI = 0.98, TLI = 0.98, RMSEA = 0.07, SRMR = 0.03]. Results indicated a significant, positive mean slope for both males and females. This means that, on average, participants' levels of engagement in technology-based SCFS increased over time. However, results also indicated significant variances in slope and intercept for both genders, meaning that there was significant individual variability around this mean trajectory, which may be explained by the addition of predictors (i.e., depressive symptoms) in a conditional model (see Table 3).

3.2.2. Addition of depressive symptoms as a time-varying covariate

Depressive symptoms, measured at each of the three time points, were then entered into the model as a time-varying covariate. First, depressive symptoms at each time point were regressed on time-specific measures of SCFS (Hypothesis 1). Initial model fit was excellent [$\chi^2(4) = 6.42$, $p = 0.17$; CFI = 1.00, TLI = 0.97, RMSEA = 0.04, SRMR = 0.02]. In order to test whether the regression parameters of depressive symptoms on time-specific measures of SCFS were equal at each time period, these parameters were constrained to equality (Bollen & Curran, 2006). This did not result in any significant reduction in model fit [$\Delta\chi^2(4) = 6.85$, $p = 0.14$]; thus, these constraints were retained for parsimony. Setting these regression parameters equal across time points *and* across gender also did not result in any significant reduction in model fit [$\Delta\chi^2(1) = 0.82$, $p = 0.37$]; thus, these constraints were also retained for model parsimony. Results indicated that the contemporaneous effects of depressive symptoms on time-specific measures of SCFS were significant for both boys and girls.

In order to test whether depressive symptoms at a given time point predict higher levels of SCFS one year later, controlling for adolescents' underlying trajectories of SCFS *and* the contemporaneous effects of depressive symptoms, lagged effects of depressive symptoms on technology-based SCFS were added to the model (Hypothesis 2). The addition of these lagged effects significantly improved model fit [$\Delta\chi^2(2) = 7.57$, $p = 0.02$], indicating that they should be retained. Likelihood ratio tests indicated that these lagged effects could be constrained to be equal across time [$\Delta\chi^2(2) = 0.15$, $p = 0.93$], but that they should be left to vary freely across gender [$\Delta\chi^2(1) = 4.17$, $p = 0.04$]. Thus, the model supported the inclusion of lagged effects of depressive symptoms on later technology-based SCFS, with effects set equal within gender across time points, but free to vary across gender (see Fig. 1). Model fit was excellent [$\chi^2(7) = 6.73$, $p = 0.46$; CFI = 1.00, TLI = 1.00, RMSEA = 0.00, SRMR = 0.02]. Results indicated significant lagged effects of depressive symptoms on technology-based SCFS for boys only.

3.2.3. Addition of frequency of technology use as time varying covariate

Finally, in order to examine whether the effects of depression on technology-based SCFS remained when controlling for the effects of overall technology use on SCFS, frequency of use was added as a time-varying covariate (Hypotheses 1 and 2). Both contemporaneous and

lagged effects of frequency of technology use on SCFS were included, in order to test for the effects of depression over and above this covariate (see Fig. 1). Likelihood ratio tests indicated that the contemporaneous effects of frequency of technology use on SCFS could be constrained to be equal across time [$\Delta\chi^2(4) = 7.68$, $p = 0.10$], but that they should be left to vary freely across gender [$\Delta\chi^2(1) = 4.37$ $p = 0.04$]. Further likelihood ratio tests indicated that lagged effects could be constrained to be equal across time [$\Delta\chi^2(2) = 0.59$, $p = 0.75$] and gender [$\Delta\chi^2(1) = 0.50$, $p = 0.50$]. Final model fit was excellent [$\chi^2(10) = 13.87$, $p = 0.18$; CFI = 1.00, TLI = 0.98, RMSEA = 0.03, SRMR = 0.02]. Interestingly, frequency of technology use showed a significant, contemporaneous association with time-specific increases in technology-based SCFS for boys only. All other contemporaneous and lagged effects of frequency of technology use on SCFS were non-significant for both genders. The pattern of results regarding the effects of depression on technology-based SCFS remained the same with the addition of frequency of technology use.

3.2.4. Final model results

Overall, results indicated that, for both genders, higher levels of depressive symptoms were uniquely associated with technology-based SCFS at each time point, above and beyond the influence of the underlying growth factors for SCFS and the effects of frequency of technology use. In other words, adolescents who reported higher levels of depressive symptoms at a given time point also reported higher levels of technology-based SCFS at that time point than would be expected solely based on their underlying trajectories of SCFS and technology use frequency (Hypothesis 1). With the addition of lagged effects, the contemporaneous effects of higher depressive symptoms on time-specific elevations in technology-based SCFS remained for both genders. However, lagged effects were significant for boys only. For boys, above and beyond the influence of underlying trajectories of SCFS, the contemporaneous effects of depressive symptoms, and the contemporaneous and lagged effects of frequency of technology use, higher levels of depressive symptoms at Time 1 were associated with higher levels of SCFS at Time 2. The same pattern held for boys between Times 2 and 3. For girls, the lagged effects of depressive symptoms on SCFS were not significant. Thus, boys, but not girls, who report higher levels of depressive symptoms at a given time point reported higher levels of SCFS one year later, over and above what would have been expected based on their underlying trajectories of SCFS and technology use frequency (Hypothesis 2).

3.2.5. Effects of depressive symptoms on frequency of technology use

Although final conditional models controlled for the contemporaneous and lagged effects of frequency of technology use on technology-based SCFS, further exploratory analyses were run to determine whether depressive symptoms were predictive of mere increases in overall technology use, rather than technology-based SCFS in particular. Specifically, latent curve models of frequency of technology use over time were constructed, with depressive symptoms entered as a time-varying covariate. First, unconditional latent growth models for frequency of technology use over three time points were constructed separately for males and females. Intercept only models were compared to models with latent intercept and linear slope factors. For girls, model fit improved significantly with the addition of the slope factor [$\Delta\chi^2(3) = 8.00$, $p < 0.05$]. For boys, however, the addition of the slope factor did not significantly improve model fit [$\Delta\chi^2(3) = 3.211$, $p = 0.36$], indicating that, on average, frequencies of technology use did not change significantly over time for boys. Thus, a linear model was fit for girls, and a separate intercept-only model was fit for boys. Results for girls showed a significant, negative mean slope for frequency of technology use ($b = -0.09$, $se = 0.04$, $p < 0.05$), indicating that, on average, frequencies of use decreased over time.

For both genders, after adding depressive symptoms as a time-varying covariate, results indicated that the contemporaneous effects of depressive symptoms on frequency of technology use, controlling for underlying growth factors, were not significant (p's > 0.12). Further, the addition of lagged effects did not significantly improve model fit for boys [$\Delta\chi^2(3) = 3.211$, $p = 0.36$], or girls [$\Delta\chi^2(3) = 0.78$, $p = 0.85$]. Taken together, these results indicate that depressive symptoms were neither associated concurrently nor across time points with greater frequencies of technology use, controlling for underlying trajectories of technology use.

4. Discussion

The current study provides a novel investigation of the longitudinal role of adolescent depressive symptoms in predicting maladaptive online social behaviors. Findings suggest that depressive symptoms may have important implications for adolescents' engagement in technology-based social comparison and feedback-seeking behaviors (SCFS), or the use of social media to seek out information regarding one's appearance, behaviors, and social status, relative to one's peers. Specifically, results demonstrate that for girls and boys, higher depressive symptoms at a given time point are associated with higher engagement in SCFS after accounting for individuals' typical patterns of SCFS and overall frequency of technology use. Further, results suggested that boys, but not girls, who report higher depressive symptoms at a given time point also prospectively report greater engagement in SCFS at later time points. Importantly, results from the current study suggest that depressive symptoms did not predict overall *frequencies* of social media use, but rather, engagement in the specific behavior of technology-based SCFS. Results have important implications for understanding the ways that social media may present a new context for experiencing interpersonal distress among depressed adolescents.

Understanding the ways in which social media may uniquely contribute to the social experience of depressed adolescents is critical. Symptoms-driven models of depression suggests that, within an offline context, depressed adolescents exhibit a number of social-behavioral deficits, including negative behavioral self-focus (e.g., ERS, NFS), as well as social disengagement and withdrawal (Rudolph, 2009). However, as adolescents increasingly turn to cell phones, text messaging, and social networking sites, these tools represent a primary context within which social interaction with peers now takes place (Lenhart, 2015). With public postings and feedback, large networks that provide an "audience" for online behaviors, and immediate accessibility at any time of day (boyd, 2010; Peter & Valkenburg, 2013), social media represents a fundamentally different social environment for adolescents.

These aspects of social media may create opportunities for engagement in behaviors with particularly problematic interpersonal consequences for depressed adolescents. For example, technology-based SCFS may represent a new, *online* social-behavior deficit, whereby youth with depressive symptoms use social media to seek out information regarding their social standing in relation to peers. Although this behavior may not always involve synchronous, direct peer interaction, it represents a new type of social interaction—with posting requests for reassurance to a larger audience of peers, viewing (and commenting on) the publically available interactions of one's peers, or comparing oneself to peers' photos and the comments on those photos—that is indicative of adolescents' new social landscape.

Importantly, whereas depressed adolescents might have previously withdrawn from social relationships, the advent of social media now allows for engagement in problematic social behaviors like technology-based SCFS, at any time of day, from any location, and, often, in the presence of a large number of online peers. It is thus possible that technology-based SCFS may have unique implications for adolescent adjustment, above and beyond what would be expected of similar offline behaviors, such as ERS or NFS. Indeed, the public and interconnected nature of social media may create an environment in which depressed adolescents' sociobehavioral deficits can be immediately

observed by a large social network, perhaps creating more widespread and severe interpersonal difficulties compared to typical offline ERS or NFS. For example, depressed adolescents' attempts to gain peer feedback online or compare themselves to peers based on posted content may be seen by others as aversive or lacking in social skill. Furthermore, the fact that social media environments provide fewer interpersonal cues than traditional, offline environments (e.g. tone of voice, facial expressions) may lead individuals to feel less inhibited online (Walther & Parks, 2002). This may lead depressed adolescents to feel "safer" engaging with peers online, and to interact with others in potentially maladaptive ways. Together, technology-based SCFS behaviors represent a unique way that depressed adolescents can engage in problematic social behaviors.

Consistent with hypotheses, results indicated that both boys and girls who reported higher depressive symptoms at a given time point also reported time-specific increases in technology-based SCFS at that time point, controlling for their typical patterns of SCFS and overall frequencies of technology use. This finding is consistent with past research indicating concurrent associations between depressive symptoms and other problematic social behaviors on social media (e.g., Tandoc, Ferrucci, & Duffy, 2015; Ybarra et al., 2005). Furthermore, these findings suggest the utility of examining the influence of depressive symptoms on short-term, intra-individual changes in technology-based SCFS, with analyses suggesting that depressive symptoms at a given time point may result in increased levels of technology-based SCFS compared to an adolescent's baseline level of this behavior. Similar to offline depressogenic behaviors like ERS, technology-based SCFS may represent an in-the-moment, maladaptive strategy for coping with stressful negative life events or decreases in self-esteem (Joiner, Katz, & Lew, 1999). Depressed boys and girls may be increasingly turning to social media, which is readily available at all times of day, as a means of seeking reassurance or feedback regarding their standing in relation to peers, likely with negative implications for their self-esteem and relationships with peers more generally.

In addition, results indicated that for boys, but not girls, higher levels of depressive symptoms at a given time point were also associated with higher levels of SCFS *one year later*, controlling for underlying trajectories of SCFS and overall frequency of technology use. These results are interesting, and may be interpreted in light of theories regarding gender differences in both online and offline social behaviors. Prior research indicates that girls, on average, are more likely to generate and experience interpersonal stressors within their relationships in adolescence (Rudolph, 2002). Similarly, results from the current study indicate that overall, girls were more likely to engage in technology-based SCFS than boys. Among girls, overt displays of social comparison and feedback-seeking behaviors may be more normative or socially sanctioned. As such, it may be that this behavior is particularly unusual or problematic for boys, and that only those boys exhibiting the interpersonal deficits characteristic of depression will display long-term increases in this behavior.

In addition, prior work demonstrates that, due to the possibility for asynchronicity and anonymity in communication with peers online, some adolescents may perceive social media as a "safer" environment to engage in personal communication (Schouten, Valkenburg, & Peter, 2007). In general, girls are more likely to engage in interpersonally-based responses to distress, such as social support seeking (Eschenbeck, Kohlmann, & Lohaus, 2007) and co-rumination (Rose, 2002); thus, for girls, seeking *in-person* feedback and reassurance from peers may be more comfortable. Among depressed boys, for whom these types of in-person interactions are less typical, technology-based tools may represent a less threatening means of engaging in these behaviors. Indeed, prior research indicates that while adolescent girls tend to engage in higher levels of self-disclosure with peers in-person compared to online, the difference between offline and online self-disclosure is much smaller for boys (Valkenburg, Sumter, & Peter, 2011). Thus, compared to girls, adolescent boys experiencing depressive symptoms may increasingly turn to social media for problematic interpersonal interactions.

This study employed a three-year longitudinal design and an advanced analytic approach to stringently examine hypotheses. Future research would benefit by addressing issues that were not thoroughly examined in this study. One limitation to the study, as with much current research examining online behaviors, is the inability to empirically distinguish between technology-based SCFS and similar offline behaviors (e.g., ERS, NFS). Although it is likely that the affordances of the social media environment facilitate behaviors, such as SCFS, that may have a unique impact on certain adolescents' social experiences, this cannot be determined without controlling for similar offline behaviors. Prior work has indicated that concurrent associations between depressive symptoms and SCFS remain when controlling for ERS, and that ERS and SCFS are only moderately correlated, suggesting that these may be distinct constructs (Nesi & Prinstein, 2015). However, future work will be necessary to identify the unique role that SCFS may have on social adjustment longitudinally, and whether depressed adolescents are more or less likely to engage in SCFS compared to offline behaviors. In addition, future work should control for other variables that may impact associations between depression and SCFS, such as type of social media used and offline peer social status.

Despite the inclusion of a large adolescent sample, it should be noted that recruitment occurred within a community context with relatively low base rates of depression. Although this provides important information regarding the potential relevance of SCFS for adolescents' experiences more generally, it will be important to repeat this study with a clinical sample to determine whether results may be extended to those experiencing more severe levels of distress. This study also used self-report measures; future research using a variety of assessment techniques (e.g., observational coding of social media pages) will offer a more nuanced view of the specific processes involved in technology-based SCFS. Indeed, novel observational coding systems are beginning to emerge in the assessment of adolescent social media use, and these measures have shown promising results (Moreno, Christakis, Jelenchick, & Villiard, 2012; Underwood, Rosen, More, Ehrenreich, & Gentsch, 2012). Furthermore, although this study benefitted from a large, diverse sample, differences in results by ethnicity or socioeconomic status were not observed in preliminary analyses, and future work should aim to further explore these effects. Finally, future studies with data from a short-term framework, perhaps using ecological momentary assessment (EMA) techniques. It is likely that technology-based SCFS does not act as trait-level risk factor for long-term increases in depressive symptoms among adolescents. However, it is possible that SCFS may cause short-term changes in mood, which in combination with other factors, may accumulate to impact symptoms of pathology in the long-term. Thus, future studies will benefit from examining transactional models to observe how SCFS may be associated with depressive symptoms in the moments immediately following social media participation.

Overall, results from this study suggest that as the social landscape of youth begins to reorganize at the adolescent transition, technology-based behaviors such as technology-based SCFS may become increasingly relevant and worthy of study. Depression may play a key role in determining the extent to which adolescents engage in SCFS, particularly for boys. Findings suggest that studies of interpersonal theories of depression would benefit from examining adolescents' modern social contexts.

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