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Depressive symptoms predict characteristics of online social networks

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Abstract

Purpose: There is a substantial body of literature that examines depression or well-being as outcomes of social media use, but there are fewer studies that seek to understand how mental health may lead to different patterns of online interactions. The purpose of the current study was to examine how depressive symptoms may predict subsequent structural characteristics of the online social network.

Methods: Data came from Time 3 and Time 5 of a longitudinal study on the effects of maltreatment on adolescent development. At Time 3 adolescents reported on their depressive symptoms (n=319) and at Time 5 a subsample was enrolled in the Facebook data collection (n=133). An application downloaded the friend list and network metrics were computed. Path models examined the main effect of depressive symptoms at Time 3 on Facebook social network measures.

Results: The coefficients indicated that higher levels of depressive symptoms at Time 3 predicted fewer Facebook friends (smaller size), fewer ties between friends (lower average degree), more components, and fewer friends in the main component of the network.

Conclusions: Depression may alter how youth form and maintain online friendships. Using social network characteristics may help identify youth at risk for serious mental illness.

Keywords

social network analysis; Facebook; depression

Due to the increasing use of social media among adolescents and young adults, much attention has been given to the impact on mental health. Depression has frequently been examined as an outcome of frequent or excessive internet or social media use,[1] however many of the studies linking online social networks with depression are cross-sectional

Implications and Contributions: In an examination of how depression may contribute to formation of online social networks, the current study found that higher levels of depressive symptoms predicted smaller, less connected networks. These findings enhance our understanding of how youth with depression use online social networks and may identify those at-risk for mental health problems.

leaving open the possibility that depression may drive specific patterns of online interactions, and those patterns of interaction may reinforce depressive tendencies. The current study examined whether depressive symptoms predicted certain characteristics of Facebook networks that may be useful in identifying youth at risk for serious mental health problems.

The supposition that depression may alter online friendship formation and interactions is supported by the theory of social corrosion,[2] which suggests that individuals with depressive symptoms lack the social skills needed to form and maintain close and supportive relationships, leading to dissolution of close friendships. In an early study using cross-lagged path analyses, researchers found that psychological well-being changed subsequent friendship activity rather than the opposite, supporting the possibility that depression leads to changes in friendships.[3]

The frequency or quality of online interactions has been most commonly studied in relation to mental health.[1] An alternative method, social network analysis, uses the ties between network members to compute metrics that describe the structure of the network.[4] Egocentric networks are regularly used to understand personal social networks where the participant is the focal ego around whom the network is centered. Each person/friend in their network is called an alter, and by mapping the connections between alters (excluding the ego) various measures of network size and cohesion (i.e., connectedness) can be computed. A number of studies have examined how the size and cohesion of egocentric social networks impacts mental health.[5] In studies of adolescents, evidence indicates depressed adolescents report fewer friends than non-depressed youth[6–8] while other studies showed a curvilinear relationship-- both very small and very large networks had a negative impact on depressive symptoms.[9] The authors posit that a very small network does not provide adequate opportunity for social support whereas a large network requires significant effort and energy to maintain, increasing stress and subsequent psychological distress.

Although the number of friends may be an important indicator of mental health, other network measures may provide complementary information about the size, cohesion, and reach of the egocentric network. Density (how connected each of the alters are to one another), the number of components (distinct clusters of alters), the diameter (how many steps between the two farthest alters in the network), and the percent of isolates (those who are not tied to any other alters in the egonetwork) are all linked with health behavior and psychological well-being in offline social networks.[10,11] However, only one study has examined how social network metrics of online networks differ between depressed and nondepressed individuals.[12] Using Twitter data, the authors found that depressed individuals had fewer followers and followees (i.e. network size) and twice the number of components compared to nondepressed adults. In addition, their predictive model found that variables such as a decrease in online posts, raised negative affect in online posts, and highly clustered egonetworks predicted the onset of major depression. Although this study demonstrates the utility in identifying depression using online social networks, no studies have examined how depressive symptoms predict subsequent size and connectedness of the online social network.

Importantly, maltreated youth are an especially vulnerable population both in terms of depression and impairments in social interactions. Studies show that individuals with maltreatment experiences have higher rates of depression[13–16] and diminished social skills which impedes their ability to form healthy interpersonal relationships.[17] The difficulty with offline interactions may transfer into the online environment resulting in substantively different online networks.[18] Importantly, due to these possible differences in how maltreated youth form relationships, it is important to determine whether the association between depressive symptoms and network structure is the same for maltreated and non-maltreated young adults. Knowing that network markers of depression may differ for youth with maltreatment would alter the clinical utility of these findings.

The Current Study

Most of the research on social media use and depression focuses on the frequency or quality of online interactions as key to changes in mental health. None, have examined how depression may contribute to characteristics of the online network. To address this gap in the literature, the purpose of the current study was to examine how depressive symptoms may predict subsequent structural characteristics of the online social network. It was hypothesized that higher levels of depressive symptoms in adolescence would predict Facebook networks with smaller size (fewer friends), less cohesion (lower density, more components, more isolates, lower average degree) less reach (smaller diameter). The data from the current study provide a unique opportunity to understand how depression in adolescence affects the formation of online networks. Because the study took place across the initial public dissemination of Facebook circa (2007), these data may show how depressive symptoms pre-Facebook/social media affect the formation of online social networks. In addition, the study design allows the examination of the link between depressive symptoms and online networks for maltreated versus comparison youth.

Research Design and Methods

Participants

Data for the current study came from Time 3 (M_{age}=13.71; SD=1.39) and Time 5 (M_{age}=21.84; SD=1.46) of an ongoing longitudinal study examining the effects of maltreatment on adolescent development. The original longitudinal study enrolled 454 adolescents aged 9–13 years at baseline (2002–2005; n=303 maltreated, n=151 comparison; 241 males and 213 females). Baseline (Time 1) took place between 2002 and 2005, followed by three additional assessments. Time 2 (2003–2006), Time 3 (2005–2008) and Time 4 (2009–2012) occurred approximately 1 year, 1.5 years and 4.4 years following each prior assessment. Time 5 (2013–2015) was a pilot study with a subsample of enrolled participants that took place an average of 3.7 years after Time 4 (and 8 years after Time 3). The participants for the pilot study were selected from all those enrolled in the larger study and restricted to those participants who had a current Facebook profile. The pilot study design required approximately equal number of maltreated and comparison participants, which deviated from the original proportions of the full sample. This resulted in a sample of n=133 for the current study (n=65 maltreated, n=68 comparison; males=57 females=76). The

ethnic/racial composition of the final pilot sample was Black (39%), Latino (37%), White (11%), and Biracial (13%), which was similar to the distribution at baseline for the full sample. Demographic characteristics of the sample at Time 3 and Time 5 can be found in Table 1.

Recruitment.—The maltreatment group was recruited from active cases in the Children and Family Services (CFS) of a large west coast city. The inclusion criteria were: (1) a new referral to CFS in the preceding month for any type of maltreatment; (2) child age of 9–12 years; (3) child identified as Latino, African-American, or Caucasian (non-Latino) (4) child residing in one of 10 zip codes in a designated county at the time of referral to CFS. With the approval of CFS and the Institutional Review Board of the affiliated university, potential participants were contacted and asked their willingness to participate.

The comparison group was recruited using names from school lists of children aged 9–12 years residing in the same 10 zip codes as the maltreated sample. Comparison caregivers were contacted the same way as the maltreated group. Comparison families confirmed they had no previous or ongoing experience with child welfare agencies.

Procedures

Time 3.—Assessments were conducted at an urban research university. After assent and consent were obtained from the adolescent and caretaker, respectively, the adolescent was administered questionnaires and tasks during a four-hour protocol. The measures used in the following analyses represent a subset of the questionnaires administered during the protocol. Both the child and caretaker were compensated for their participation.

Time 5.—All data collection took place online. After verbal consent was obtained from the participant over the phone, the research staff emailed the participant the URL for the Facebook application (developed for the current study) to access from their personal computer on their own schedule. Upon accessing URL, the participant clicked the button "Login with Facebook" and a window appeared to enter their Facebook login and informed them of the permissions and data accessed by the application. The Facebook application downloaded the list of Facebook friends, the list of mutual friends (i.e., whom on the friend list were friends with each other), and the participants' Timeline data (included posts, comments, likes, etc.). Photos, videos and private messages were not accessed. The mutual friends list was used to create the egocentric Facebook friend network for each participant. All Facebook data was downloaded between 2013 and 2015 and contained information from 2007–2015.

Following the completion of the Facebook application, each participant was sent a link to an online survey, however none of the data from the survey were used for the current analyses. After completion of the Facebook application and Qualtrics survey the participants were compensated for their participation by check or gift card. All procedures were approved by the Institutional Review Board of the affiliated university.

Measures

Independent Variable: Time 3 Depressive Symptoms.—Adolescents completed the 27-item Children's Depression Inventory (CDI;[19,20]). They rated statements such as "I am sad all the time" and "I feel like crying every day," on a three-point scale (range of possible scores = 0–54). The CDI has demonstrated good reliability and been shown to correlate with other measures of childhood depressive symptoms.[20]

Dependent Variables: Time 5 Facebook Friends Egocentric Network Characteristics.—The egocentric Facebook network was created using the mutual friends list downloaded by the Facebook application. This supplied a list (i.e., edgelist) containing all ties between the participants' Facebook friends (excluding the participant). For example, the edgelist may show that Friend 1 was friends with Friend 2, Friend 3, and Friend 7 whereas Friend 2 was friends with Friend 1, Friend 4, and Friend 6. This captured all possible ties between friends in each participant's Facebook network. Although the term "Facebook friends" was used in the present study to refer to the network members, by the convention set by Facebook the "Friend list" includes friends, family members, and acquaintances, i.e., any individual the user has "friended."

For the purpose of the current study seven social network metrics were examined. 1) Size (the number of friends in the network), and in the case of SNSs this was defined as the number of "Facebook friends"; 2) density (the number of total possible links between friends/number of actual links between friends); 3) average degree (average number of ties each friend had to participant's other friends); 4) number of components (number of distinct cluster of groups in individuals); 5) percent in the largest component (the percent of the total number of friends that are in the largest cluster of the Facebook network); 6) diameter (the width of the network, measured by the number of paths between the two farthest alters in the network); 7) percent isolates (percent of friends not connected to any of the participant's other friends).

Data Analysis

Social network techniques were used to compute structural network characteristics for each participant's Facebook network using the Statnet package[21] in the R statistical program. The following network characteristics were calculated (described in measures section): size density, average degree, number of components, percent in the largest component, diameter, and percent isolates. Using Mplus,[22] a path model was tested in which T3 depressive symptoms predicted the seven network variables (size, density, average degree, number of components, percent in largest component, diameter, and percent isolates). Maltreatment status (maltreated vs. comparison) and sex (male vs female), T3 age, and race (minority vs white) were included as covariates. Next, multiple-group path modeling was used to examine whether maltreatment status moderated the effect of depressive symptoms on network structure. Multiple-group analysis estimates the model parameters simultaneously for the maltreated and comparison groups. Moderation is indicated by a significant change in the Chi-square statistic when a specific parameter is constrained to equality across groups. Significance levels were set to $p<.05$.

Results

Preliminary Analyses

Missing data.—Of the 319 participants who completed Time 3, 152 participants were enrolled in the Time 5 pilot study. However, only 133 completed the Facebook app and had available data to compute social network characteristics. Longitudinal missingness was address using Full Information Maximum Likelihood (FIML) estimation. Under assumptions of Missing at Random or Missing Completely at Random FIML results in unbiased parameter estimates and standard errors.[23] Path models were run first with the full sample (n=319) using FIML and compared with models using only the Time 5 sample (n=133). The parameter estimates did not vary appreciably when using the full sample versus the pilot sample, so we have chosen to report the results from the pilot sample to reduce any confusion about the sample size.

Descriptives.—Correlations were computed between all study variables (see Table 2). Depressive symptoms were significantly correlated with size ($r = -.22$, $p < .05$), average degree ($r = -.27$, $p < .01$), number of components ($r = .28$, $p < .01$), percent in largest component ($r = -.30$, $p < .01$), and diameter ($r = .19$, $p < .05$). The direction of the coefficients indicated that higher levels of depressive symptoms was associated with a smaller network, fewer average ties between friends, more components, and larger diameter.

Mean Group Differences.—Independent samples t-tests showed no mean differences between maltreated and comparison groups for any of the study variables (Table 3).

Path Models

Total sample.—All parameter coefficients can be found in Table 4. There was a significant main effect of depressive symptoms on size ($\beta = -.23$, $p < .01$), average degree ($\beta = -.25$, $p < .01$), number of components ($\beta = .28$, $p < .01$), and percent in the largest component ($\beta = -.29$, $p < .05$) See Figure 1. The coefficients indicated that higher levels of depressive symptoms at Time 3 predicted fewer Facebook friends, fewer ties between friends, more components, and fewer friends in the main component of the network.

Moderation analyses.—The multiple-group analysis showed that none of the parameters from depressive symptoms to network outcomes were moderated by maltreatment status.

Discussion

There is a substantial body of literature that examines depression or well-being as outcomes of social media use,[1,24] but there are fewer studies that seek to understand how mental health may lead to different patterns of online interactions. The current study examined whether depressive symptoms in mid-adolescence predicted subsequent Facebook network characteristics. Overall the results show that depressive symptoms may lead to differences in the formation of online friendships and thus markedly different properties of the Facebook network.

Foremost, higher levels of depressive symptoms in mid-adolescence predicted a smaller Facebook network and a higher number of components as indicated by the Facebook friends network accumulated across late adolescence and young adulthood. This is consistent with evidence showing that depressed adolescents report fewer friends than nondepressed adolescents.[7,8] This may be a potential protective mechanism keeping them from having to maintain a large number of relationships, which can cause stress.[9] In addition, other studies found that adolescents who were depressed, socially anxious or lonely in school were more likely to communicate online with strangers or people they did not know well.[25,26] This propensity to engage online with acquaintances rather than close friends likely results in a smaller more fragmented network as shown in the current study.

Because this study took place concurrently with the growth of Facebook, the results may provide insight into how adolescents initially formed their online network. For youth with depressive symptoms, Facebook seems to be a place to form a small, loosely connected friendship network that may serve the purpose of being a place to disclose problems without the repercussions of the information easily reaching all friends in the network (as is more probable with more dense networks with fewer components). The connectedness of the network is an indicator of how quickly information diffuses throughout the network.[27] It is possible that depressed individuals may have less cohesive networks to limit the sharing of personal information. Studies show that lonely or depressed individuals are more likely to disclose online,[26] thus maintaining less connected networks may be protective. Having a separation in Facebook friend groups (i.e., more components) may also be protective as friends in one component may serve as confidants of depressed mood, whereas friends in other components do not. However, in the current study we have no indication of the amount of support received from Facebook friends nor the closeness of the relationships.

We found no differences in the associations between depressive symptoms and network characteristics for maltreated versus comparison youth. This was unexpected given evidence that maltreated youth have more difficulties with interpersonal interactions offline.[17] The online environment may be helpful for maltreated youth because their lack of social skills and inappropriate interpersonal style may not be a hinderance in online interactions.[28–30] Alternatively, evidence suggests that depressive symptoms manifest in similar ways across maltreated and nonmaltreated youth.[31] Because depressive symptoms are likely more severe than the interpersonal deficiencies that typically contribute to poor friendship networks, depressive symptomotology may outweigh the negative effect that maltreatment has on interpersonal relationships, leading to similar effects on the social network for maltreated and nonmaltreated youth.

There are several limitations that should be noted. First, it is likely that the association between depression and social networks is reciprocal. Depression may dictate how the online social network is formed, but then having fewer friends may exacerbate depressive symptoms. Unfortunately, we were unable to test this possibility in the current study due to the lack of depression data at Time 5. Second, the Facebook friends list cannot differentiate friends from family or other types of relationships. It would be useful to know if depression drove a higher proportion of ties to family, friends or acquaintances on Facebook. Other studies have shown that lonely youth were more likely to communicate online with people

they did not know well.[25] If this is the case for depressed youth as well, then the implication for forming small networks comprised of acquaintances does not bode well for their future mental health. The present study was a subsample of those participants enrolled it the parent study. This may have resulted in selection bias, but our analyses indicate the pilot sample was similar in demographic composition to the full sample and we found no meaningful differences in the parameter estimates when using FIML with the full T3 sample. Although we did not examine outcomes subsequent to the social network characteristics, prior studies show that the use of Facebook or the specific attributes of the online network may reinforce depressogenic tendencies. Other studies have shown that larger network size and higher network density were linked with alcohol use in young adults,[32] and higher network density was associated with unprotected sex.[33] Thus, there are implications of specific network characteristics for subsequent risk-taking and mental health.

Overall, the present study supports the use of egocentric social network metrics as indicators of youth with depressive symptoms. Few studies have taken this approach in understanding how mental health affects the structure of online social networks. As a great deal of communication takes place in online venues, understanding how mental health contributes to the formation and maintenance of online friendships may be key in recognizing and treating mental illness.
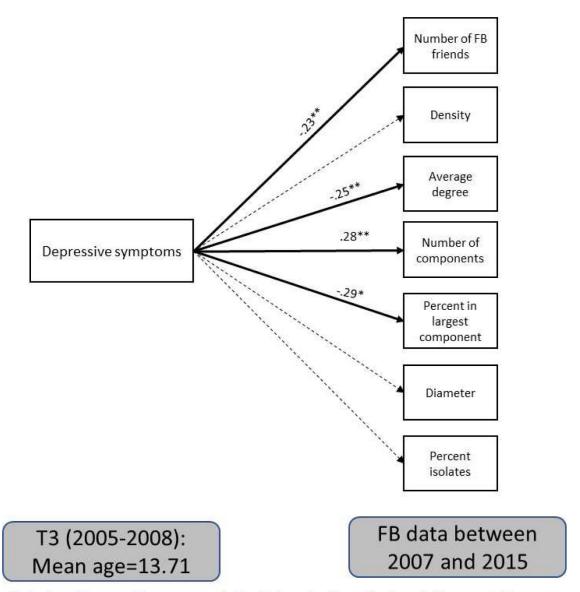
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Figure 1.
Path model showing main effect of depressive symptoms at Time 3 on Facebook network characteristics.
*p<.05; **p<.01

Table 1.

Sample Characteristics For Time 3 and 5

Demographic Variable	Group			
	Maltreated		Comparison	
	Time 3	Time 5	Time 3	Time 5
N	191	65	128	68
Mean Age (std deviation)	13.85 (1.48)	21.72 (1.26)	13.57 (1.38)	21.81 (1.65)
Gender (%)				
Male	46	35	57	50
Female	54	65	43	50
Ethnicity (%)				
African American	47	45	34	34
Latino	29	38	43	39
White	8	9	11	13
Mixed Biracial	16	8	12	14

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Table 2.

Correlations between Study Variables

	Number of FB friends	Density	Average degree	Number of components	Percent in largest component	Diameter	Percent isolates
Number of FB friends	1.00						
Density	−0.35 **	1.00					
Average degree	0.66 **	0.09	1.00				
Number of components	0.09	−0.32 **	−0.24 **	1.00			
Percent in largest component	0.32 **	0.06	0.50 **	−0.50 **	1.00		
Diameter	0.17	−0.53 **	−0.10	0.46 **	−0.11	1.00	
Percent isolates	−0.20 *	−0.14	−0.45 **	0.41 **	−0.65 **	0.23 *	1.00
T3 depressive symptoms	−0.22 *	−0.06	−0.27 **	0.28 **	−0.30 **	0.19 *	0.18
Maltreatment Status	0.12	−0.13	0.00	−0.07	−0.02	0.05	0.13
Sex	−0.06	−0.04	−0.05	−0.10	0.03	0.13	−0.08

Note: Maltreatment status coded 0=comparison, 1=maltreatment; sex coded 1=male 2=female.

*
p<.05;

**
p<.01

Table 3.

Means and standard deviations for study variables

	Maltreated Comparison n=191	Comparison n=128
Depressive symptoms	8.48 (6.53)	7.57 (5.96)
Network chara cteristics	n=65	n=68
Number of friends	595.63 (528.38)	485.44 (389.13)
Density	.08 (.06)	.09 (.06)
Average degree	37.13 (28.56)	36.91 (27.44)
Number of components	2.92 (2.41)	3.34 (3.00)
Percent in largest component	.91 (.09)	.91 (.11)
Diameter	7.27 (2.23)	7.00 (2.48)
Percent isolates	.05 (.05)	.04 (.05)

Note: Independent samples t-test indicated no significant differences between groups (maltreated vs. comparison)

Table 4.

Results of Linear Regression Path Model

	Number of FB friends	Density	Average degree	Number of components	Percent in largest component	Diameter	Percent isolates
Depressive symptoms	−0.23**	−0.01	−0.25**	0.28**	−0.29*	0.15	0.17
Sex	−0.11	0.01	−0.01	−0.17	0.08	0.13	−0.13
Maltreatment status	0.14	−0.13	0.06	−0.12	0.01	0.01	0.08

Note: Maltreatment status coded 0=comparison, 1=maltreatment; sex coded 1=male 2=female. Covariates not shown were T3 age and race (minority/white).