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Research Paper

Associations between social media use, personality structure, and development of depression

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ABSTRACT

Background: While longitudinal studies demonstrate associations between social media use and development of depression, it is not clear whether these associations differ among people with various personality characteristics.
Methods: Data were obtained from a national sample of 978 individuals ages 18-30. Measures used included the Patient Health Questionnaire assessing depression, the 10-item Big Five Inventory assessing personality, and self-reported use of the top 10 social media platforms. Logistic regression determined associations between each personality characteristic (openness, conscientiousness, extraversion, agreeableness, and neuroticism), social media use, and development of depression over 6 months.
Results: In multivariable analyses that adjusted for all covariates, compared to people with low agreeableness, those with high agreeableness had 49% lower odds for developing depression (OR=0.51, 95% CI=0.33, 0.80). Compared to people with low neuroticism, those with high neuroticism had more than double the odds for developing depression (OR=2.46, 95% CI=1.57, 3.87). For each personality characteristic, increased social media use was significantly associated with developing depression. Interaction terms showed that associations between social media use and developing depression did not vary according to any of the personality characteristics.
Limitations: Because we assessed young adults ages 18-30, inferences cannot be made to other age groups.
Conclusions: The fact that agreeableness and neuroticism were associated with different risks for developing depression may help practitioners target high-risk populations. Because social media use was strongly associated with development of depression for all personality characteristics, it may be useful for interventions to target reduction of social media use overall regardless of personality type.

Depression is at epidemic levels in the United States, and it is now the leading cause of disability (World Health Organization, 2020) and mortality (Walker et al., 2015) worldwide. About one in six people develop depression within their lifetime, and average age of onset appears in the late teens to mid-20's (Wilson et al., 2015). Depression increases the risk for multiple other psychological conditions, including anxiety (Mineka et al., 1998) and suicide (World Health Organization, 2020). It has also been connected to worsening of physical conditions such as heart disease, cancer, and diabetes (Moussavi et al., 2007; Scott et al., 2016). Depression is influenced by many factors, including life circumstances (Fergusson and Horwood, 1987; Kendler et al., 1999), hormone levels (de Kloet et al., 2005), inflammation (Setiawan et al., 2015), and heredity (Kendler et al., 2006). Therefore, it is especially important to further understand the underlying effects of this condition.

Recently, studies also have connected depression with social media use (SMU). Average SMU in the U.S. is 2-4 hours per day (Primack and Escobar-Viera, 2017), and use is especially high among young adults, who are still developing (Pew Research Center, 2021). In fact, the emotional and cognitive regions in the frontal and temporal areas of the brain continue to develop until early adulthood (Lebel and Deoni, 2018), and personal identity development and self-esteem may promote healthy transitions across the lifespan. One national longitudinal study recently found that people who used the most social media were three times as likely to become depressed over the subsequent 6 months compared with people who used the least social media (Primack et al., 2021). There are multiple possible reasons why social media and

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depression might be connected. For example, large amount of time spent on social media might supplant more valuable human face-to-face contact (Whaite et al., 2018). Social media also may encourage problematic social comparison (Lee, 2014). Finally, the milieu of social media may increase miscommunications resulting in relationship difficulties and subsequent risk for developing mental health problems (Mazer and Ledbetter, 2012).

Although numerous factors pertain to the development of depression, personality has been an important area of study for understanding and predicting human behavioral conditions, with one's environment playing a key role in its development (Winne and Gittinger, 1973). Additionally, it is unknown how social media may impact personality development. It may be that social media may become a catalyst for promoting personality awareness. Currently, studies have shown that personality traits have been in the past related to both depression (Kotov et al., 2010) and patterns of consuming media (Finn, 1997; Özgüven and Mucan, 2013; Gil De Zuniga et al., 2017; Brailovskaia and Margraf, 2018). Personality traits are also related to psychological processes that may mediate associations between SMU and depression, such as sensitivity to miscommunications or social comparisons (Correa et al., 2010; Mark and Ganzach, 2014; Hakulinen et al., 2015; Gil De Zuniga et al., 2017; Allen et al., 2018).

The Five-Factor Model (FFM) is a widely accepted theory of personality and includes five broad dimensions: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism (McCrae and Costa Jr., 2008) – each of these key traits has been associated with other psychological factors and behaviors (Klein et al., 2012). For example, neuroticism has been associated with mental health concerns (McCrae and Costa Jr., 2008; Kotov et al., 2010; Watson and Naragon-Gainey, 2014; Speed et al., 2019). Extraversion may act as a protective factor against specific certain mental health conditions (Kotov et al., 2010; Watson et al., 2015; Watson et al., 2019). Openness to experience, an understudied trait (Shiner, 2007; Khoo and Simms, 2018) generally has not been positively or negatively related to depression in prior studies (Malouff et al., 2005; Kotov et al., 2010). Agreeableness is connected with prosocial emotions, cognitions, and behaviors (Habashi et al., 2016) and has been related to lower risk for emotional conditions such as depression (Mongrain et al., 2018). Finally, Conscientiousness may be negatively correlated with depression (Kotov et al., 2010; Bartley and Roesch, 2011; Allen et al., 2018).

However, it is not yet sufficiently known how these various personality characteristics interact with associations between SMU and depression. Better understanding whether those with certain personality profiles are at higher risk for development of depression based on SMU could aid in the development of more effective tailored interventions to reduce the burden of depression.

It may be that people with certain personality characteristics are at particularly high risk for developing depression with increased SMU. For example, Whaite et al. (2018) found that for people who tested as conscientious, there was no association between increased SMU and perceived social isolation. However, for people who tested as lacking in conscientiousness, compared with those with low SMU, those with high SMU were three times likely to have perceived social isolation. Nevertheless, the data used in this study were cross-sectional, and to our knowledge published longitudinal studies have not examined associations among personality type, SMU, and development of depression over time.

Therefore, the purpose of this study was to assess associations between SMU, personality characteristics, and the development of depressive symptoms 6 months later in a national sample of young adults without depression at baseline. Better understanding these relationships will help public health practitioners and policy makers to develop and implement tailored and more effective prevention and treatment programs for depression. Based on prior work in different contexts in this area, including a large meta-analysis (Kotov et al., 2010) and a longitudinal study exploring predictors of depression (Noteboom et al., 2016), we expected that neuroticism would be associated with increased risk of developing depression within 6 months (**Hypothesis 1a**), that conscientiousness and extraversion would be associated with lower risk of development of depression within 6 months (**Hypothesis 1b and 1d**) and that there would be no association for agreeableness and openness to experience, respectively (**Hypotheses 1c and 1e**). Based on prior cross-sectional data, we expected that the association between SMU and development of depression would not significantly differ based on four personality characteristics (**Hypotheses 2a, 2c, 2d, and 2e** for neuroticism, agreeableness, extraversion, and openness to experience). However, based on the results of Whaite et al. (2018), we hypothesized that the association between SMU and development of depression would differ according to conscientiousness, with non-conscientious individuals being more likely than conscientious individuals to develop depression based on similar levels of social media exposure (**Hypothesis 2b**).

1. Method

1.1. Research design, procedures, and participants

Qualtrics Sampling Services was used for participant recruitment and engagement from March to September 2018. Participants were assessed twice; once at baseline and once approximately 6 months later. Prior research related to depression, as well as other related mental health conditions, has commonly used similar time frames (e.g., Angstman et al., 2012; Blomdahl et al., 2021; Craske et al., 2019). Examination of depression at 6 months is clinically supported. For example, the CMS (Centers for Medicare & Medicaid Services) specify in their Merit-Based Incentive Payment System (MIPS) that it is important to examine depression outcomes at 6 months (Centers for Medicare & Medicaid Services, 2019). Exact means and standard deviations were 170 days (5.7 months) and 51 days (1.7 months, respectively). Qualtrics partners with web-based panel providers and specializes in survey data collection among a diverse group of respondents (Ibarra et al., 2018). A "balanced start" sampling methodology was used for recruiting participants to represent the U.S. population in terms of age, sex, race, geographic region, education, and household income. Participants were required to be 18-30 years old, read English, and record their responses using an online interface. Informed consent was provided, and the research was approved by the University of Pittsburgh Institutional Review Board. Survey participants were compensated for their time with redeemable incentives, such as gift cards.

1.2. Measures

1.2.1. Depression

Depression was evaluated at baseline and follow-up using the 9-item Patient Health Questionnaire (PHQ-9), which asks about feelings and/or experiences of depression within the past 2 weeks, such as "thoughts that you would be better off dead, or of hurting yourself." For all items, response options were "none" (0) to "all the time" (3) with two other categories in the middle. All 9 responses were then summed to create a scale that ranged from 0 to 27. Depression was categorized as yes or no using a previously-validated cut point of 10 (10 and above was categorized as depressed, 0-9 as nondepressed) (American Psychiatric Association, 2013).

1.2.2. Social media use

SMU was assessed by asking respondents how much daily time was spent on the top 10 social media platforms in hours and minutes for personal use. Participants were specifically instructed not to include time spent on social media for work. At the time of the study, the top ten social media sites were Facebook, YouTube, Instagram, Snapchat, WhatsApp, Twitter, Pinterest, Reddit, LinkedIn, and Tumblr, and so each of these was asked about separately to improve data quality. For the

purposes of analysis, respondents were divided into quartiles based on SMU

1.2.3. Personality

Personality was measured using the 10-item Big Five Inventory (BFI-10), which assesses the following personality traits: openness, conscientiousness, extraversion, agreeableness, and neuroticism (Gosling et al., 2003). Items were formatted as "I see myself as someone who…" followed by a characteristic of specific personality traits. Participants responded to 2 items for each personality trait on a 5-point likert scale (1="strongly disagree", 5="strongly agree"). Five of the items were reverse coded so that a higher score represented a lower indicator of the personality trait. The sum of the two items of each personality trait ranged from 2 to 10. The score of each item was 3 if the respondents answered "Neither agree nor disagree," which was neutral. Thus, if the respondents provided a neutral answer to both items of the personality trait, the sum of the personality characteristics was 6. Therefore, we used 7 as a cut-off for having the trait (a sum of 7-10) or not having the trait (a sum of 2-6).

1.2.4. Covariates

Covariates for this study included age, gender, ethnicity, and household income. Age was divided into three categories (18-20; 21-24; 25-30) based on clinical implications of development within the field of public health. For example, 18-20 was in the same category—without 21—because 21 is an important marker for the legal age of alcohol/cigarette use. Participants self-reported their sex (male or female) and race/ethnicity (White, non-Hispanic; Black, non-Hispanic; Hispanic-Latino; Asian; or Other). Annual household income (less than $25,000; $25,000-$50,000; $50,000-$75,000; or $75,000 or above) was also assessed.

1.3. Data analysis

Because we were interested in development of depression over time, analyses were restricted to respondents who were nondepressed at baseline. For primary analyses, the dependent variable for each analysis was the dichotomous variable indicating whether a participant had developed depression, defined as a PHQ-9 score of 10 or above by

Table 1
Bivariable associations with development of depression and sociodemographic characteristics from sample (N = 978).

Study Variables	Percent	Developed Depression within 6-Months[a]		
		No 885 (90.5%)	Yes 93 (9.5%)	P Value[b]
SMU[c]				<.05
Q1 (0-120)	30.9	32.2	18.3	
Q2 (121-195)	29.2	30.0	22.6	
Q3 (196-300)	25.0	24.2	32.3	
Q4 (≥301)	15.0	13.7	26.9	
Personality Trait				
Openness				
Yes	47.0	47.0	47.3	
No	53.0	53.0	52.7	
Conscientiousness				
Yes	70.3	71.2	61.3	
No	29.8	28.8	38.7	
Extraversion				
Yes	31.0	30.9	32.3	
No	69.0	69.2	67.7	
Agreeableness				
Yes	58.5	59.9	45.2	
No	41.5	40.1	54.8	
Neuroticism				
Yes	32.4	30.4	51.6	
No	67.6	69.6	48.4	
Age, y				
18-20	3.6	3.3	6.5	
21-24	12.4	12.1	15.1	
25-30	84.1	84.6	78.5	
Sex				
Female	54.6	54.4	57.0	
Male	45.4	45.7	43.0	
Race				
White, non-Hispanic	71.1	71.8	64.5	
Black, non-Hispanic	6.2	6.2	6.5	
Hispanic-Latino	12.2	11.9	15.1	
Asian	9.5	9.2	12.9	
Other[d]	1.0	1.0	1.1	
Annual Household Income				
<$25,000	12.5	12.1	16.1	
$25,000-$50,000	26.6	26.4	28.0	
$50,000-$75,000	22.9	22.6	25.8	
≥$75,000	38.0	38.9	30.1	

Abbreviations.: AOR = adjusted odds ratio; CI = confidence interval.

[a] Development of depression was measured using the 9-item Patient Health Questionnaire (PHQ-9) using a previously-validated cut off of 10. This variable represents the development of depression over 6 months, with non-depressed participants at baseline. Analyses controlled for sociodemographic variables represented within the model.

[b] P value derived from chi square analyses.

[c] Social media use (SMU) includes self-reported data and was divided into quartiles (Q1-Q4) based upon time (in minutes) per day.

[d] American Indian/Native Alaskan, Native Hawaiian/Pacific Islander, and multiracial represent the other race category. Due to the very small sample size for each of these race categories, separating them was not necessary for the purpose of this analysis.

follow-up (American Psychiatric Association, 2013; Levis et al., 2019). Therefore, logistic regression was the appropriate analysis. The primary independent variable was SMU divided into quartiles (Q1=lowest SMU and Q4=highest SMU).

To examine potential interactions between personality traits and SMU, we conducted five separate logistic regression analyses, one for each personality trait. In each model, we included one of the personality traits (e.g., extraversion) as well as the relevant interaction term (e.g., extraversion x SMU). Because no interaction term was statistically significant, in subsequent multivariable logistic regressions interaction terms were not included. Analyses controlled for all measured sociodemographic variables, which included age, gender, ethnicity, and annual household income. Power calculations determined that our sample size of 978 should be sufficient to determine interactions with even small-to-moderate effect sizes.

In order to test the robustness of our results, we conducted three sets of sensitivity analyses, which were determined *a priori*. For the first, we used the depression cutoff of 11 instead of 10 because this has been used in some studies (Manea et al., 2012). For the second set of sensitivity analyses, we treated SMU as a continuous variable instead of an ordered categorical variable. Finally, for a third set of sensitivity analyses we included only covariates with bivariate associations with the outcome of $p<0.15$ (instead of including all sociodemographic factors in all models).

We did not correct for multiple comparisons according to our *a priori* protocol because each analysis tested a specific hypothesis, even if we had corrected for multiple comparisons (using a Bonferroni or other similar correction), all results would have been similar in terms of level of significance.

All statistical analyses used Stata, version 15.0. Statistical significance was represented by a 2-tailed p-value of <0.05.

2. Results

There were 1289 individuals at baseline, but 311 were removed for meeting criteria for depression or for having incomplete data. Among the remaining 978 non-depressed individuals at baseline, 93 (9.5%) developed depression by the 6-month follow-up. Table 1 provides the sample descriptors and compares those who developed depression within 6 months to those who did not in terms of baseline SMU, personality traits, and other sociodemographic characteristics. The sample was 54.6% female, 71.1% White, 6.2% Black, 12.2% Hispanic, and 9.5% Asian, and the median age was 28 years. Overall, 12.5% of respondents reported an annual household income less than $25,000, with 38.0% reporting $75,000 or above.

For each personality trait, there was a strong bivariable association between baseline SMU and the development of depression (Table 2). Increased SMU was strongly and linearly associated with development of depression. For example, compared with those in the lowest quartile of SMU, those in the highest quartile had odds ratios of 3.01 to 3.35 for developing depression (all $p<.01$). Interaction terms between personality traits and SMU were all non-significant, indicating that the strength of the association between SMU and depression did not significantly vary among people with or without each personality characteristic.

In multivariable analyses that adjusted for all covariates, compared to people categorized with low agreeableness, those with high agreeableness had 49% lower odds for developing depression (OR=0.51, 95% CI=0.33, 0.80). Compared to people with low neuroticism, those with

Table 2
Bivariable and multivariable associations for depression based on social media use, personality traits, and sociodemographic variables.

	AOR for Depression (95% CI) [a]				
	Model 1 Openness	Model 2 Conscientiousness	Model 3 Extraversion	Model 4 Agreeableness	Model 5 Neuroticism
SMU [b]					
Q1 (0-120)	ref	ref	ref	ref	ref
Q2 (121-195)	1.35 (0.69, 2.63)	1.32 (0.68, 2.58)	1.35 (0.69, 2.63)	1.37 (0.70, 2.68)	1.28 (0.66, 2.52)
Q3 (196-300)	**2.22 (1.18, 4.17)**	**2.18 (1.16, 4.10)**	**2.22 (1.18, 4.18)**	**2.28 (1.21, 4.30)**	**2.13 (1.12, 4.02)**
Q4 (≥301)	3.25 (1.67, 6.34)	**3.11 (1.59, 6.06)**	**3.25 (1.67, 6.34)**	**3.35 (1.72, 6.54)**	**3.01 (1.54, 5.89)**
Personality Trait	0.97 (0.63, 1.51)	0.71 (0.45, 1.13)	0.99 (0.62, 1.58)	**0.51 (0.33, 0.80)**	**2.46 (1.57, 3.87)**
Age, y					
18-20	1.89 (0.74, 4.84)	1.92 (0.75, 4.91)	1.89 (0.74, 4.84)	1.93 (0.75, 4.97)	2.00 (0.77, 5.17)
21-24	1.12 (0.60, 2.09)	1.08 (0.58, 2.02)	1.12 (0.60, 2.09)	1.06 (0.57, 1.99)	1.05 (0.56, 1.98)
25-30	ref	ref	ref	ref	ref
Sex					
Female	1.04 (0.67, 1.63)	1.09 (0.70, 1.72)	1.04 (0.67, 1.63)	1.11 (0.71, 1.75)	0.90 (0.57, 1.42)
Male	ref	ref	ref	ref	ref
Race					
White, non-Hispanic	ref	ref	ref	ref	ref
Black, non-Hispanic	0.98 (0.40, 2.41)	0.97 (0.39, 2.39)	0.98 (0.40, 2.41)	1.03 (0.41, 2.54)	1.17 (0.47, 2.92)
Hispanic/Latino	1.13 (0.59, 2.15)	1.14 (0.60, 2.17)	1.13 (0.59, 2.15)	1.20 (0.63, 2.28)	1.12 (0.59, 2.14)
Asian	1.43 (0.73, 2.82)	1.40 (0.71, 2.75)	1.43 (0.73, 2.82)	1.45 (0.73, 2.86)	1.54 (0.77, 3.06)
Other [c]	1.00 (0.12, 8.27)	0.95 (0.11, 7.95)	0.99 (0.12, 8.20)	1.07 (0.13, 8.95)	1.20 (0.14, 10.07)
Annual Household Income					
Less than $25,000	ref	ref	ref	ref	ref
$25,000-$50,000	0.82 (0.41, 1.64)	0.83 (0.41, 1.65)	0.82 (0.41, 1.63)	0.83 (0.42, 1.67)	0.88 (0.44, 1.78)
$50,000-$75,000	0.95 (0.47, 1.91)	1.00 (0.49, 2.03)	0.94 (0.47, 1.91)	0.95 (0.47, 1.92)	1.04 (0.51, 2.12)
≥$75,000	0.70 (0.35, 1.40)	0.75 (0.37, 1.50)	0.70 (0.35, 1.40)	0.69 (0.35, 1.39)	0.72 (0.36, 1.44)

Note: Statistical significance ($p<0.05$) appears in boldface.
Abbreviations: AOR = adjusted odds ratio; CI = confidence interval.
[a] Development of depression was measured using the 9-item Patient Health Questionnaire (PHQ-9) using a previously-validated cut off of 10. This variable represents the development of depression over 6 months, with non-depressed participants at baseline. Analyses controlled for sociodemographic variables represented within the model.
[b] Social media use (SMU) includes self-reported data and was divided into quartiles (Q1-Q4) based upon time (in minutes) per day.
[c] American Indian/Native Alaskan, Native Hawaiian/Pacific Islander, and multiracial represent the other race category. Due to the very small sample size for each of these race categories, separating them was not necessary for the purpose of this analysis.

high neuroticism had more than double the odds for developing depression (OR=2.46, 95% CI=1.57, 3.87). As shown in Table 2, there was no association between the other three personality traits (openness, conscientiousness, and extraversion) and development of depression.

As noted above, to examine the robustness of our findings, several sensitivity analyses were conducted. All sensitivity analyses had results similar to those of the primary analyses in terms of levels of significance and effect size. Therefore, only the results from the primary analyses are included here.

3. Discussion

In a large representative sample of young adults, we found that neuroticism was associated with development of depression and agreeableness was associated with a lower risk of developing depression. However, there were no associations between the other three personality traits (openness, conscientiousness, and extraversion) and development of depression. We also found that increased SMU was associated with development of depression in each model that focused on one of the personality characteristics. Finally, interaction terms between SMU and personality characteristics were nonsignificant.

The fact that neuroticism was associated with a higher risk of developing depression supported **H1a**. This finding is consistent with prior studies that describe neuroticism as a strong predictor of depression (Kotov et al., 2010; Noteboom et al., 2016), and being associated with decreased life satisfaction and decreased positive affect (Jensen et al., 2020). It is useful to know that these relationships seem to be borne out in the longitudinal setting. Because these relationships are well established at this point, it would be useful for public health practitioners to determine whether this knowledge can lead to meaningful improvements in identifying and treating individuals with depression.

Although we expected conscientiousness and extraversion to be associated with lower development of depression based on prior research (Kotov et al., 2010), we did not find this to be the case, contradicting **H1b and H1d**. One reason for this difference may be that most prior studies have been cross-sectional in nature, while the current study examined a different outcome—development of depression over the subsequent 6 months instead of simple co-occurring depression. Thus, it may be that conscientiousness and extraversion are indeed associated with a lower risk of co-morbid depression in the cross sectional setting but that it does not protect against depression over the subsequent 6 months. Future longitudinal work would be useful to confirm these findings and to determine if conscientiousness and extraversion protects against development of depression in different time frames, such as 1 year.

The fact that agreeableness was associated with a lower risk of developing depression contradicted **H1c**. Agreeable individuals tend to be more pro-social and to have increased empathy and concern for others (Finley et al., 2017). Thus, it could be that these individuals sustain more positive relationships over time that contribute to lower risk of depression. Interestingly, prior research has been mixed with regard to whether there is an association between agreeableness and depression (Bienvenu et al., 2004; Kotov et al., 2010; Naragon-Gainey and Simms, 2017). However, most work in the past has been cross-sectional. Therefore, it may be of particular interest that, empirically, higher agreeableness is related to lower subsequent development of depression in a longitudinal setting. It would be valuable for future work to examine these factors qualitatively, because there is little high-quality qualitative work in this area.

There was no association between openness and development of depression, supporting hypothesis **H1e**. This result was consistent with most prior work, which has suggested little association between openness and depression (Kotov et al., 2010). However, some prior research suggests that high openness has been associated with higher likelihood of having depression (Bienvenu et al., 2004). Thus, clarification of associations with future examinations may be particularly useful for this characteristic.

The fact that social media was strongly associated with the development of depression regardless of personality characteristics is consistent with prior studies finding SMU to be associated with development of depression (Primack et al., 2021). This finding extends prior research because assessments using interaction terms showed that associations between SMU and development of depression did not vary according to any of the 5 personality characteristics. This finding contradicted **H2b**, which had been based on a prior finding that increases in SMU *were* associated with social isolation for low levels of conscientiousness but *not* associated with high conscientiousness (Whaite et al., 2018).

This difference may reflect the fact that **H2b** was generated based on a cross-sectional study (Whaite et al., 2018), while the current study examined development of depression over 6 months. This difference may lead to different clinical recommendations. For example, based on the prior study, clinicians may have suggested to patients with high conscientiousness that they may not need to worry about use of increased social media being related to development of depression. Because we did not find these same relationships in the longitudinal setting, clinicians may wish to suggest that SMU may be a risk factor for development of depression regardless of personality characteristics. However, it will still be useful for future research to examine these relationships for different lengths of follow-up.

As expected, the association between SMU and development of depression did not differ across neuroticism, agreeableness, extraversion, and openness (**H2a, H2c, H2d**, and **H2e**). While this is consistent with prior research, it is still a useful finding, because it suggests that SMU as an exposure may be useful to consider regardless of underlying personality structure. For example, because neuroticism has been associated with the development of depression, in prior studies and in the current study (**H1a)**, it may be tempting to conclude that people with low neuroticism may not be at risk for development of depression, even if they have high social media exposure. However, because there was not a significant interaction term between social media and neuroticism, the association between social media exposure and development of depression seems to be consistent regardless of level of neuroticism.

In some ways, these findings may make intervention easier, because they suggest that intervention would be useful broadly. However, future research is still needed to confirm these associations and further understand the development of personality and depression across the lifespan. Therefore, it would be valuable for additional research to examine key contextual variables related to social media, including different social media sources, differing frequency of social media use, reasons for using social media (e.g., to obtain specific information vs. for no specific purpose), and social media content. Interventions could then be developed that focus on improving quality of relationships, shared meanings, and to help eliminate miscommunications or misperceptions that may vary by personality trait and use of social media.

4. Limitations

We assessed personality using only the Five-Factor Model. While this is an accepted assessment of personality, it may be useful in future work to use complementary personality measurements. It is also a limitation that we measured social media by self-report using surveys. It would be useful for future work to use more in-depth measurement of SMU, such as with automatic downloads of usage data.

For this initial assessment of interrelationships among social media use, personality traits, and development of depression, it was part of our *a priori* protocol to operationalize variables as categorical and dichotomous based on prior work, and it would be useful for future research to examine these variables in a finer-grained manner. For example, while the focus of the current analysis was to examine development of depression according to an established cut-off for the PHQ-9, resulting in

a dichotomous variable, it may be useful for future work to examine more nuanced outcomes such as the magnitude of depression. Similarly, we established an *a priori* cut-off of 7 or above (on a scale of 2-10) to operationalize personality traits. However, now that these initial analyses have been completed, it would be useful for future research to include continuous and/or ordered categorical operationalization of personality variables to more deeply explore associations among personality variables, social media use, and depression. Longer and more intensive assessments of personality would also be useful.

It is also worth noting that the exposure focused on overall SMU rather than a more nuanced assessment of specific activities on social media. This was an unavoidable part of our protocol, because the questionnaire assessed overall SMU rather than asking for specific time spent on each of the different platforms. We made this decision explicitly, because in pilot studies participants had difficulty accurately assessing individual platform use, while overall use was easier for participants to estimate. However, it would be valuable in future work to improve measurement according to specific platforms.

Finally, because the sample included only young adults ages 18-30, inferences cannot be made for other age groups.

5. Conclusion

This study used longitudinal data to investigate the associations between SMU, personality, and development of depression in young adulthood. Findings suggest that neuroticism was associated with a higher risk of developing depression and agreeableness was associated with a lower risk of developing depression. Strong and linear associations of SMU across personality characteristics suggests that future interventions should focus on reduction of SMU regardless of personality type.

Contributors

R.M., C.C. and B.P. designed the research, performed statistical analyses, interpreted data, and co-wrote the paper. B.P. directed and supervised the study. All authors have approved the final version of the manuscript.

Declaration of Competing Interest

The authors have no conflicts of interest to disclose.

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Data Availability Statement

The data that support the findings of this study are available from the authors upon reasonable request.

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